Shifting dollars, saving lives:
What might happen to mortality rates, and socio-economic inequalities in mortality rates, if income was redistributed?

Tony Blakely and Nick Wilson
WSMHS, University of Otago

www.wnmeds.ac.nz/nzcms-info.html
Overview of presentation

• Income-health association
• Expectations of health impact of income redistribution

• NZCMS:
  – Method
  – Income-mortality association

• Modeling mortality change following income change:
  – Picking the counterfactual
  – Best estimate
  – Sensitivity analyses

• Assumptions and limitations
• Policy implications

The income inequality hypothesis (no what we are talking about per se)

How does this compare with tobacco control policy?
THE CONCAVE RELATIONSHIP BETWEEN INCOME AND LIFE EXPECTANCY

Life Expectancy

\[ y_2 \]
\[ y_1 \]

\[ x_1 \]
\[ x_2 \]
\[ x \]
\[ x_3 \]
\[ x_4 \]

Income

Rodgers, 1979
Income transfer argument

- Strong international evidence for lower income being associated with poorer health status
- Convincing evidence of a non-linear association of income with mortality
- Therefore reducing income inequalities should both increase average health status \( \text{and} \) reduce health inequalities
- But nobody (to our knowledge) has actually attempted to quantify these expectations.

- Our aim is to model changes in overall mortality rates and socio-economic inequalities in mortality that might arise from redistribution of income.
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• Assumptions and limitations
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The income inequality hypothesis (no what we are talking about per se)

How does this compare with tobacco control policy?
“Income inequality hypothesis”
“Income inequality hypothesis”
..... it is contentious

• Popularised in health by Wilkinson (BMJ, 1992):
  – Lower life expectancy in OECD countries with higher income
    inequality

• Large body of US evidence:
  – Supportive – State-level, ecological and multi-level studies
  – Variable – metropolitan and community-level

• Majority of non-US studies non-supportive:
  – Including NZ study at level of 35 health regions

• Subject to review for Treasury by Ken Judge (2001)

• … but our modelling does not assume any shift of the whole
  curve – just shifting of people back and forward on the curve
Our aim: To model changes in overall mortality rates and socio-economic inequalities in mortality that might arise from redistribution of income.
New Zealand Census-Mortality Study method in one slide

<table>
<thead>
<tr>
<th>1996 census cohort (0-74 yr olds)</th>
<th>Anonymous and probabilistic record linkage</th>
<th>1996-99 deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
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<td>+</td>
</tr>
<tr>
<td>●</td>
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<td>+</td>
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<tr>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From ALL the sources of income you ticked in question 35, what will the TOTAL income be:

- that you **yourself** got
- **before** tax or anything else was taken out of it
- in the 12 months that will end on 31 March 1996?

- loss
- zero income
- $1–$5,000
- $5,001–$10,000
- $10,001–$15,000
- $15,001–$20,000
- $20,001–$25,000
- $25,001–$30,000
- $30,001–$40,000
- $40,001–$50,000
- $50,001–$70,000
- $70,001–$100,000
- $100,001 or more

---

**Income, 1996 census**

- Summed for each individual in household
- Equivalised for number of children and adults in the household
Abbreviated method notes

- Used 1996-99 cohort – but would get similar results for other cohorts in the NZCMS
- Focused on 25-59 year olds due to income drops in 60-65 year old age range from retirement
- Discarded first 6 months of deaths to reduce any health selection effects
- Baseline models adjust for age and ethnicity – prior determinants of income in any causal model
- Use Poisson regression – person years as the denominator
Association of household income with 25-59 year old mortality

a) Males

Density of people per $1,000 range of income

Observed age/ethnicity adjusted rate ratios
Income-mortality association in NZ

- Strong, as in other countries
- Non-linear, as in other countries
- Mortality risk appears to decrease linearly as a function of the logarithm of income, as in other studies

- But that was just adjusting for age and ethnicity … what about other potential confounders?
- NZCMS includes data on marital status, education, car access, neighbourhood deprivation, allowing multivariable regression analyses to determine ‘independent effect’ of income on mortality risk.

- (Note: whilst we would have liked to also adjust for labour force status, this was problematic as it is also probably a proxy for health status.)
Income-mortality association in NZ

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The income inequality hypothesis (no what we are talking about per se)

How does this compare with tobacco control policy?
What is our counterfactual world?

- We picked a range of possibilities where the total income was fixed, but Gini coefficient for 1996:
  - 10% less
  - 20% less (bit more than the change from mid-1980s to mid-1990s in New Zealand [Forster & d’Ercole, 2005, OECD])
  - 30% less (about the difference between NZ and Sweden)
  - 40% less

- To achieve this, we shift everyone’s income 10% … and 40% to the mean income
How do we determine change in overall mortality rate?

• Using population attributable risk percents, by counterfactual scenario:

$$\text{PAR} = \frac{\sum_i (P_i \times RR_i) - \sum_i (P_i \times RR_i^\wedge)}{\sum_i (P_i \times RR_i)}$$

where:

- $RR_i$ = relative risk of income group $i$ before counterfactual change
- $RR_i^\wedge$ = relative risk of income group $i$ after counterfactual change
- $P_i$ = proportion of population in each income group

• This is a common epidemiological method
Say, a 20% shift to the mean income
How do we determine change in inequalities in mortality?

• Using *age and ethnicity adjusted* rate ratios, by counterfactual scenario, comparing the counterfactual mortality rates for the second to lowest income group and the second to highest income group. (This equates to the relative risk of mortality for, approximately, the 95th compared to 20th percentile of incomes.)

• The age and ethnicity adjusted rate ratios were ‘back-calculated’ from the multivariable rate ratios
# Results – baseline “do nothing”

<table>
<thead>
<tr>
<th>Counterfactual</th>
<th>% reduction in Gini coefficient</th>
<th>PAR%</th>
<th>Estimated RR for 2nd lowest c.f. 2nd highest income group (% decrease)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do nothing</td>
<td>0%</td>
<td>0%</td>
<td>2.21 (0%)</td>
</tr>
<tr>
<td>Income moves ‘X’ percent to the mean household income</td>
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<tr>
<td>X = 10%</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0%</td>
<td>2.11 (0%)</td>
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## Results – assume multivariable model correct

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<tr>
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<td>10%</td>
<td>3.7%</td>
<td>2.06 (12%)</td>
</tr>
<tr>
<td>X = 20%</td>
<td>20%</td>
<td>6.6%</td>
<td>1.95 (22%)</td>
</tr>
<tr>
<td>X = 30%</td>
<td>30%</td>
<td>9.2%</td>
<td>1.85 (29%)</td>
</tr>
<tr>
<td>X = 40%</td>
<td>40%</td>
<td>11.7%</td>
<td>1.77 (36%)</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do nothing</td>
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<td>2.11 (0%)</td>
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<td>30%</td>
<td>10.2%</td>
<td>1.77 (31%)</td>
</tr>
<tr>
<td>X = 40%</td>
<td>40%</td>
<td>12.9%</td>
<td>1.69 (38%)</td>
</tr>
</tbody>
</table>
Sensitivity analysis – assume our multivariable model still over-estimated causal income-mortality association two-fold

<table>
<thead>
<tr>
<th>Counterfactual</th>
<th>% reduction in Gini coefficient</th>
<th>PAR%</th>
<th>Estimated RR for 2nd lowest c.f. 2nd highest income group (% decrease)</th>
<th>Sensitivity analysis – half effect</th>
<th>PAR%</th>
<th>Estimated RR for 2nd lowest c.f. 2nd highest income group (% decrease)</th>
</tr>
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<tbody>
<tr>
<td><strong>Males</strong></td>
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<td>X = 10%</td>
<td>10%</td>
<td>3.7%</td>
<td>2.06 (12%)</td>
<td>1.7%</td>
<td>2.14 (6%)</td>
<td></td>
</tr>
<tr>
<td>X = 20%</td>
<td>20%</td>
<td>6.6%</td>
<td>1.95 (22%)</td>
<td>3.1%</td>
<td><strong>2.08 (10%)</strong></td>
<td></td>
</tr>
<tr>
<td>X = 30%</td>
<td>30%</td>
<td>9.2%</td>
<td>1.85 (29%)</td>
<td>4.4%</td>
<td>2.03 (15%)</td>
<td></td>
</tr>
<tr>
<td>X = 40%</td>
<td>40%</td>
<td>11.7%</td>
<td>1.77 (36%)</td>
<td>5.6%</td>
<td>1.99 (18%)</td>
<td></td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
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</tr>
<tr>
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<td>0%</td>
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<td>10%</td>
<td>3.7%</td>
<td>1.97 (13%)</td>
<td>1.8%</td>
<td>2.04 (6%)</td>
<td></td>
</tr>
<tr>
<td>X = 20%</td>
<td>20%</td>
<td>7.3%</td>
<td>1.86 (22%)</td>
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<td>1.94 (15%)</td>
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<td>40%</td>
<td>12.9%</td>
<td>1.69 (38%)</td>
<td>6.3%</td>
<td>1.90 (19%)</td>
<td></td>
</tr>
</tbody>
</table>
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The income inequality hypothesis (no what we are talking about per se)

How does this compare with tobacco control policy?
Rate ratios of 45-74 year old mortality for nil cf. post-school education, before and after adjusting for smoking

Reduction in ‘excess RR’ (ie RR-1) due to adjusting for smoking

<table>
<thead>
<tr>
<th></th>
<th>Age &amp; Ethnicity adjusted</th>
<th>Plus adjusted for smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>3%</td>
<td>11%</td>
</tr>
<tr>
<td>Males</td>
<td>16%</td>
<td>21%</td>
</tr>
</tbody>
</table>

**Contribution of active smoking to mortality inequalities: 45-74 yr olds**

<table>
<thead>
<tr>
<th></th>
<th>1981-84</th>
<th>1996-99</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td>16%</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>3%</td>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1981-84</th>
<th>1996-99</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Māori:non-Māori relative risk</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>4%</td>
<td>8%</td>
</tr>
</tbody>
</table>
What about contribution to overall 45-74 yr old mortality

Thinking in terms of overall population (1996-99 only):

• If all smokers became ex-smokers, mortality rates might fall by 11% for males and 5% for females

• If all smokers and ex-smokers adopted mortality rates of never smokers, mortality rates might fall by 26% and 25%
Summary: Contribution of **active smoking** for 45-74 yr olds

*Overlay: Income redistribution of 20% to mean, 25-59 yr olds*

Nil:post-school qualification relative risk

Māori:non-Māori relative risk

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Males</td>
<td>21%</td>
<td>5%</td>
<td>21%</td>
<td>5%</td>
</tr>
<tr>
<td>Females</td>
<td>11%</td>
<td>8%</td>
<td>11%</td>
<td>8%</td>
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</tbody>
</table>

**Inequalities**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>11%</td>
<td>25%</td>
<td>5%</td>
<td>26%</td>
</tr>
<tr>
<td>Females</td>
<td>3%</td>
<td>7%</td>
<td>8%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Thinking in terms of **overall** population (1996-99 only):

- If all smokers became ex-smokers, mortality rates might fall by **11%** for males and **5%** for females
- If all smokers and ex-smokers adopted mortality rates of never smokers, mortality rates might fall by **26%** and **25%**
So what does comparing radical tobacco control and income redistribution tell us?

• Choice of counterfactual critical – could have made income redistribution look worse by picking 10% decline in Gini, or made income redistribution look better by picking less radical tobacco control strategy. Nevertheless, health benefits are in similar ball-park.

• Emphasises that both tobacco control and income policies likely to be important for overall health and health inequalities.

• Income redistribution, presumably, would have non-health benefits too.
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  - Sensitivity analyses
- Challenges, assumptions and limitations
- Policy implications

The income inequality hypothesis (no what we are talking about per se)

How does this compare with tobacco control policy?
The challenge we are responding to

“An important role of social epidemiology is to inform policy debates on reducing inequalities in mortality with, where possible, quantified effects. Many researchers have pointed to the non-linear association of income with mortality as a win-win scenario – narrowing income distributions will both improve overall mortality, and reduce inequalities….

However, when challenged as researchers to quantify the impact of income redistribution on overall population health and inequalities in health, we are not aware of any research that has provided such explicit estimates….

Whilst these estimates will inevitably be uncertain, and must come with an ‘uncertainty warning’, in our view the provision of such quantitative estimates sharpen the policy analysis and debate.”

The assumptions we are making

- At least some of the income-mortality association is causal
- That part that is causal has the same non-linear shape as the age & ethnicity adjusted association
- Multivariable models allow an approximation of the residual strength of the causal association
- Findings for 25-59 year olds in 1996-99, using crude household income data, generalisable to:
  - Other age groups
  - Other time periods
Limitations of our modelling

Many, but we focus on five:
1. Asking the right counterfactual question
2. Life-course determination of health
3. Confounding
4. Time lags
5. Deadweight costs
Summarising the presentation in one slide: a 20% reduction in Gini
Overall rate
gap low: high

Income-mortality association 20% of that in multivariable model

20% reduction Gini

Mortality rate
Overall rate gap: low:high income
Multivariable model

Mortality rate

20% reduction in mortality
Gini coefficient
Overall rate

Gap low:high income

Multivariable model

Income-mortality association half that in multivariable model

Mortality rate

20% reduction Gini

Overall rate

Gap low:high income

Overall rate

Gap low:high income

7%

22%

3.3%

1.3%

11%
Mortality rate

<table>
<thead>
<tr>
<th>Overall rate</th>
<th>Gap low:high income</th>
<th>Overall rate</th>
<th>Gap low:high income</th>
<th>Overall rate</th>
<th>Gap low:high income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multivariable model</td>
<td>Income-mortality association half that in multivariable model</td>
<td>Income-mortality association 20% of that in multivariable model</td>
<td></td>
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</table>

- 20% reduction in Gini
- Overall rate: 7%
- Gap low:high income: 3.3%
- Overall rate: 11%
- Gap low:high income: 1.3%
- Overall rate: 4.2%
Shifting dollars, saving lives:
What might happen to mortality rates, and socio-economic inequalities in mortality rates, if income was redistributed?

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Setting the scene – trends in life expectancy and mortality in New Zealand by ethnicity and income
All-cause mortality rates by income

![All-Cause 25-77 yrs Males](chart1)

![All-Cause 25-77 yrs Females](chart2)

Produced from the New Zealand Census-Mortality Study (NZCMS)

[www.otago.ac.nz/NZCMSWebTable](http://www.otago.ac.nz/NZCMSWebTable)
Are inequalities increasing?

Rate difference = 380 per 100,000
Rate ratio = 1.44

Rate difference = 379 per 100,000
Rate ratio = 1.72

Answer: Absolutely not, relatively yes
Ischaemic heart disease

IHD, males

IHD, females

IHD 25-77 yrs Males

IHD 25-77 yrs Females

Low Income  Medium Income  High Income

Produced from the New Zealand Census-Mortality Study (NZCMS)
Lung cancer: rates and rate ratios

Lung cancer, males


Lung cancer, females


Lung Cancer 25-77 yrs Males


Lung Cancer 25-77 yrs Females


Produced from the New Zealand Census-Mortality Study (NZCMS)
Cause of death contributions to total absolute inequality by income

Ages 25-77 years
Question: How might we decide whether health inequalities are increasing or decreasing?

Answer: On a continuum
Reducing inequalities

Type 1
Absolute inequalities = decreasing
Relative inequalities = decreasing

Type 2
Absolute inequalities = decreasing
Relative inequalities = stable

Type 4
Absolute inequalities = stable
Relative inequalities = increasing

Type 5
Absolute inequalities = increasing
Relative inequalities = increasing

Widening inequalities

Trends in mortality when overall downward trend in mortality
Reducing inequalities

Widening inequalities

Trends in mortality, regardless of socio-economic position

A. Decreasing

B. Stable

C. Increasing
Trends in mortality, regardless of socio-economic position

A. Decreasing
- CVD (older females, 1991-94 to 1996-99)

B. Stable
- Injury
- Lung disease and lung cancer (males)

C. Increasing
- All-cause (45-77yrs)
- CVD (up to 1991-94)
- Total cancer
- Non-lung cancers
- Lung cancer (females)
- Suicide (25-44 yrs)
Reducing inequalities

Widening inequalities

Trends in mortality, regardless of socio-economic position

A. Decreasing

B. Stable

C. Increasing

- Characterisation in previous slide based on differences in mortality by **income**
- Using **educational qualifications** as the measure of socio-economic position, same pattern but modest shift away from widening inequalities end of spectrum