The effect of eradicating poverty on childhood unintentional injury mortality in New Zealand: a cohort study with counterfactual modelling

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See Editorial, p 850

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ABSTRACT

Background: The aim of this study was to examine the effect of household income on unintentional injury mortality in children and to model the potential impact of eradicating income poverty as an injury prevention strategy.

Methods: A national retrospective cohort study linking census to mortality records carried out in New Zealand during a 3-year period following the 1991 census and including children aged 0–14 years on census night. The main outcome measures are odds ratios (ORs) for unintentional injury death by equivalised household income category and proportional reductions (population-attributable risk) in unintentional injury mortality from modelled scenarios of nil poverty.

Results: One-third of children lived in households earning less than 60% of the national median household income. Age-adjusted odds of death from unintentional injury were higher for children from any income category compared with the highest, and were most elevated for children from households earning less than 40% of the national median income (OR 2.81, 95% CI 1.73 to 4.55). Adjusting for ethnicity, household education, family status and labour force status halved the effect size (OR 1.83, 1.02 to 3.28). Thirty per cent of injury mortality was attributable to low or middle household income using the highest income category as reference. Altering the income distribution to eradicate poverty, defined by a threshold of 50% or 60% of the national median income, reduced injury mortality in this model by a magnitude of 3.3% to 6.6%.

Conclusions: Household income is related to a child's risk of death from unintentional injury independent of measured confounders. Most deaths attributable to low income occur among households that are not defined as "in poverty". The elimination of poverty may reduce childhood unintentional injury mortality by 3.3% to 6.6%.

Socioeconomic disadvantage is associated with an elevated risk of unintentional injury death in children.[1–14] Injury prevention strategies typically focus on specific mechanisms of injury and can involve a range of different approaches such as legislation, education or environmental modification.[4] However, investigations that concentrate exclusively on immediate mechanisms of injury will not allow a full understanding of common, underlying causes, such as socioeconomic risk factors.[3 4] Furthermore, although injury mortality rates have substantially reduced over time, inequalities have remained a serious issue, the persistence of which illustrates the potential for further reductions in injury mortality.[1–4 15]

The majority of studies investigating the socioeconomic determinants of childhood unintentional injury death have measured social position by parental occupational class,[3 6 7 16 17] or educational status.[18–21] Most of these studies report an up to two- to five-fold greater risk of childhood injury death for children in the lowest social class compared with the highest, although this can vary depending on the specific cause of death, with particularly marked inequalities observed in fire-related and pedestrian injury deaths.[3]

The data available from the New Zealand Census-Mortality Study (NZCMS) provide an opportunity to investigate the effect of the economic dimension of socioeconomic position. Household income is an aspect of social position that may be more amenable to change (eg by changing taxation or welfare policy), and it is feasible that household income should be causally associated with childhood unintentional injury mortality. For example, sufficient income is required to afford a car with enhanced safety features or to maintain a roadworthy car; to afford safer household items (such as nursery furniture or heating appliances); to secure better quality housing or to avoid the need for temporary housing, another risk factor for fire-related injury mortality.[5 6 15 22]

This study aims to describe the independent association between household income and childhood unintentional injury mortality and to quantify, as well as possible, the potential impact of eradicating child poverty as an injury prevention strategy. Socioeconomic disadvantage is important in the aetiology of multiple types of injury, irrespective of the intermediary pathways involved and the immediate cause of death. The relative contribution of different mechanisms of injury varies by age. Our focus is not on the specific proximal components of these pathways, but the impact of poverty on child unintentional injury as a whole. This study aims to quantify the effect of poverty and to inform policy-makers on the extent to which poverty contributes to child injury mortality. The level of childhood poverty can be very sensitive to changes in national social and economic policy, as can be seen from the rapid increase in New Zealand of the proportion of dependent children living in families with net-of-housing cost incomes below 60% of the national median from 13.5% in 1987/8 to 33.9% by 1992/3.[23] At the time of this study (1991/4), rising income inequalities and childhood poverty were becoming major issues in New Zealand society following

Table 1 Census respondents and number of injury deaths (linked and weighted) for the total child population aged 0–14 years at time of census and for each level of restriction to the study population

Cohort description	n (% total)	Number (%) of linked injury deaths	Weighted number (%) of injury deaths
Total 0–14 years census cohort	806463 (100)	222 (100)	330 (100)
At usual residence and private dwelling	742644 (92.1)	213 (95.9)	318 (96.4)
Adult present in household (eligible cohort)	742386 (92.1)	213 (95.9)	318 (96.4)
Excluding those with missing data*	727770 (90.2)	210 (94.6)	312 (94.6)
With household income variable present†	603219 (74.8)	165 (74.3)	243 (73.6)

*Valid household education, family type, labour force status, car access, New Zealand Deprivation Index (NZDep91) level and crowding variable present.
†The study cohort (includes children at usual residence and private dwelling, adult in household and excludes those with missing data).
Note: All numbers are random rounded to a near multiple of three (minimum cell size 6) as per Statistics New Zealand (SNZ) protocol.

extensive public sector, welfare and economic reform.[24] During this period, New Zealand had one of the highest rates of child injury mortality among developed nations.[4]

METHODS

The NZCMS, described in detail elsewhere (http://www.wnmeds.ac.nz/nzcms-info.html), is a large retrospective cohort study of the national population where census records are anonymously and probabilistically linked to national mortality records.[25]

The study cohort included all New Zealand children aged 0 to 14 years on census night 1991 whose census record contained data on household income and confounding and pathway variables (n = 603 219, 75% of the total census cohort). Table 1 presents each step in the restriction from the total census cohort of children aged 0 to 14 years to create the study population. Children residing in non-private dwellings or who were not at their usual residence on census night were excluded.

Measurement of exposure

Gross household income from all sources was equivalised to adjust for economies of scale by dividing by the square root of the number of people living in the household, and then categorised according to the national median equivalised household income (<40%, ⩾40% to <50%, ⩾50% to <60%, ⩾60% to <80%, ⩾80% to <median, ⩾median to <150% median, or ⩾150% of median). The potential confounding variables measured on the census record were: age (classified into four categories: <1 year, ⩾1–4 years, ⩾5 to 9 years, and ⩾10–14 years); education (highest educational qualification of any adult in the household, categorised as tertiary, trade, school and nil); household labour force status (''employed'' if one or more adults were employed; ''unemployed'' if one or more adults were unemployed and actively seeking work; otherwise ''non-active''); family type (categorised as one-parent family or ''other'' family structure); and ethnicity (determined by self-identification: Maori, Pacific or non-Maori non-Pacific). Possible mixed confounding and pathway variables between poverty and injury were household crowding (<1, ⩾1<1.5, ⩾1.5<2, ⩾2 people per bedroom); car access (no cars, one car, ⩾2 cars); and neighbourhood deprivation score (categorised into quintiles). The New Zealand Deprivation Index (NZDep91), derived from data from the 1991 census, is a validated measure of the socioeconomic characteristics of a small area of approximately 100 households.[26] The variable sex was not included in multivariable analyses as the sex of a child is not associated with income and therefore cannot act as a confounder.

Follow-up: census record linkage to mortality data

For a 3-year period from the 1991 census, mortality records from the national mortality register were anonymously and probabilistically linked to census records using the matching variables sex, ethnicity, country of birth, date of birth and area of residence. Unintentional injury was classified using International Classification of Diseases (ICD-9) external cause of injury codes (E codes 800–949). Deaths from intentional injury and injuries from undetermined intent or the adverse effects of medical care were excluded.

Motor vehicle traffic-related injury was by far the most common cause of death (n = 166, 52% of the total), of which motor vehicle occupants accounted for the majority of deaths (n = 92, 29% of the total), followed by traffic-related pedestrian injury (n = 45, 14% of the total) and pedal cyclist injury (n = 16, 5% of the total). Drowning was the next most common cause of injury (n = 54, 17% of the total).

Of the 246 eligible unintentional injury mortality records, 67% were successfully linked, and 98% of these links were estimated to be true links. These linked records were weighted with inverse probability weights by sociodemographic strata to be representative of all deaths, a method shown elsewhere to correct for linkage bias in NZCMS analyses. For example, if 20 out of 30 non-Maori non-Pacific children who lived in moderately deprived areas at the time of their injury death were linked to a census record, they were each assigned a weight of 1.5 (ie, 30/20).

Analytical methods

Odds ratios (ORs) for unintentional injury mortality were calculated using logistic regression (SAS v8.0). Separate analyses by strata of sex, age and ethnicity did not suggest the presence of effect measure modification, although statistical power was limited to confidently detect heterogeneity (results available from the authors on request).

Counterfactual modelling

The modelling approach used to estimate the proportional reduction in injury mortality had there been an alternative (''counterfactual'') population distribution of income is based on population-attributable risk percentage $((\Sigma P_x RR_x - \Sigma P_x' RR_x)/\Sigma P_x RR_x$, where P_x and P_x' = proportion of the population in exposure category x as observed and per counterfactual scenario, respectively; and RR_x = relative risk for exposure level x compared with reference category).[27]

We use a relative measure of poverty, the lack of access to sufficient resources that would allow a minimum adequate standard of living and participation in society, which is

generally considered to be the best indicator of poverty in industrialised nations.[28] International comparative studies of poverty have commonly used a poverty threshold of 50% of the national median household income.[28] For the New Zealand context, studies incorporating data on living standards and household income have found the threshold of 60% of the national median household income to be a more appropriate measure of poverty.[29]

Four counterfactual scenarios of nil income poverty are used to acknowledge two methods of defining relative poverty (thresholds of 50% or 60% of median income) and to model two methods of redistribution (moving those in poverty: (i) to the income group just above the threshold, and (ii) proportionately to all income groups above the threshold).

Three estimates of the odds ratio were used:

- Age-adjusted
- Adjusted for age, ethnicity, household education, family type and household labour force status (the likely confounding variables and therefore the best estimate of the unconfounded relative risk)
- Adjusted as for the previous model plus other covariates that may be both confounders and possible pathway variables (car access, crowding and small area deprivation).

RESULTS

Table 2 presents the demographic characteristics of the total eligible population and the study population. In the study cohort, 33% of children were living in households earning less than 60% of the median equivalised household income.

Table 3 demonstrates the gradient of decreasing risk of injury mortality with increasing household income, with the most dramatic risk reduction occurring between the poorest to next poorest income category. The age-adjusted unintentional injury death rate for children in the lowest household income category was 2.81 (95% confidence interval (CI) 1.73 to 4.55) times higher than for children in the highest income category. When compared with the highest income category, children from all other income groups experienced a higher risk of injury death, although this was only statistically significant in household income categories less than 80% of the national median.

Table 2 Distribution of children and weighted injury deaths by demographic strata for the eligible cohort (usual residence, private dwelling and adults in household) and for the study cohort

	Eligible cohort (n = 742 386)		Study cohort (n = 603 219)	
Demographic variable	**n (% total)**	**Weighted deaths (n = 318)**	**n (% total)**	**Weighted deaths (n = 243)**
Age on census night (years)				
<1	54852 (7.4)	36	42888 (7.1)	24
1–4	208527 (28.1)	81	165375 (27.4)	66
5–9	242853 (32.7)	60	198243 (32.9)	39
10–14	236154 (31.8)	138	196710 (32.6)	117
Sex				
Female	363870 (49.0)	117	295374 (49.0)	87
Male	378519 (51.0)	198	307845 (51.0)	159
Ethnicity				
Maori	150738 (20.3)	93	119331 (19.8)	66
Pacific	51504 (6.9)	27	35457 (5.9)	12
Non-Maori Non-Pacific	540147 (72.8)	201	448431 (74.3)	162
NZDep91 quintile	n = 741 777*			
1 (least deprived)	141732 (19.1)	39	117246 (19.4)	24
2	138945 (18.7)	48	114864 (19.0)	39
3	136719 (18.4)	48	112818 (18.7)	42
4	142971 (19.3)	75	116373 (19.3)	66
5 (most deprived)	181410 (24.5)	108	141912 (23.5)	75
Education	n = 737 925*			
Tertiary	222453 (30.1)	72	189627 (31.4)	60
Trade	205605 (27.9)	72	167307 (27.7)	63
School	163449 (22.1)	72	131409 (21.8)	45
Nil	146418 (19.8)	99	114873 (19.0)	78
Labour force status	n = 741 708*			
Employed	576819 (77.8)	216	474483 (78.7)	165
Unemployed	54876 (7.4)	39	45069 (7.5)	30
Non-active labour force	110013 (14.8)	63	83670 (13.9)	48
Household income	n = 611 622*			
<40% of median	91092 (14.9)	57	88392 (14.7)	57
40% to <50% median	51057 (8.3)	24	50130 (8.3)	24
50% to <60% median	59667 (9.8)	27	58677 (9.7)	24
60% to <80% median	85392 (14.0)	36	84297 (14.0)	36
80% to < median	85572 (14.0)	33	84774 (14.0)	33
Median to <150% median	143664 (23.5)	48	142458 (23.6)	48
⩾150% median	95178 (15.6)	24	94491 (15.7)	24

*Number of children with data available for this variable.
Note: All numbers are random rounded to a near multiple of three (minimum cell size 6) as per SNZ protocol.

Table 3 Odds ratios (95% CI) for unintentional injury mortality by equivalised household income category among 603 219 children aged 0 to 14 years*

	Odds ratios (95% CI)		
Household income category	**Age-adjusted**	**Multivariable†**	**Multivariable plus mixed confounding and pathway variables‡**
<40% of median	2.81 (1.73 to 4.55)	1.83 (1.02 to 3.28)	1.75 (0.96 to 3.21)
40% to <50% median	2.10 (1.19 to 3.72)	1.49 (0.80 to 2.80)	1.40 (0.73 to 2.68)
50% to <60% median	1.81 (1.03 to 3.19)	1.43 (0.79 to 2.60)	1.37 (0.74 to 2.55)
60% to <80% median	1.72 (1.02 to 2.92)	1.48 (0.85 to 2.55)	1.43 (0.82 to 2.52)
80% to <median	1.65 (0.97 to 2.80)	1.52 (0.89 to 2.62)	1.49 (0.86 to 2.59)
Median to <150% median	1.41 (0.86 to 2.32)	1.36 (0.83 to 2.24)	1.34 (0.81 to 2.22)
⩾150% median	1	1	1

*All numbers are random rounded to a near multiple of three (minimum cell size 6) as per SNZ protocol; odds ratios calculated previously.
†Adjusted for age, ethnicity, household education, family type and household labour force status.
‡Adjusted as in the multivariable model plus car access, household crowding and small area deprivation.

For children in the lowest household income category, adjusting for likely confounding variables (age, ethnicity, education, family type and household labour force status) reduced the increased odds of injury death from 2.81 to 1.83 times that of children in the highest income category. There was a trend of reducing risk of injury death with increasing income; however, for other income categories, the confidence intervals included one. Including in the analysis variables that may confound the income—injury association, but which may also be pathway factors (car access, crowding and small area deprivation), modestly reduced the effect sizes and all confidence intervals included one.

The impact of eliminating child poverty

There was a 2.8% to 17.1% reduction in childhood unintentional injury mortality depending on counterfactual scenario (see Table 4). Our best theoretical multivariable model suggests that reducing poverty may reduce childhood injury mortality by 3.3% to 6.6%. This would translate to a possible reduction of 10–21 deaths over the 3-year study period. Using the highest income group as reference, 30% of unintentional injury was attributable to low or moderate household income.

DISCUSSION

Children from the poorest households experienced an almost three-fold higher risk of unintentional injury mortality, and the risk remained elevated across all income categories compared with the highest. Injury-related social mobility is an unlikely explanation. While attenuated, the effect persisted after controlling for confounding by age, ethnicity, education, family type and labour force status. The potential confounding or pathway variables, crowding, car access and neighbourhood deprivation level, accounted for little of the association. The type of neighbourhood within which a family lives is likely to result in part from the amount of household income available for housing costs. Therefore, neighbourhood is likely to be located on the causal pathway from poverty to injury. Other than socioeconomic characteristics, it was not possible to analyse the effect of urban design characteristics or other hazardous properties of a neighbourhood as these factors were not captured in the census. It is likely that these features of neighbourhoods are correlated, ie socioeconomically disadvantaged communities are likely to have aspects of urban design that are more hazardous, such as the presence of major arterial routes or reduced availability of safe playing areas.

Table 4 Proportional reduction in child unintentional injury mortality for four counterfactual scenarios of nil poverty

	Percentage reduction in child unintentional injury mortality		
Counterfactual scenario	**Age-adjusted model**	**Multivariable* model**	**Multivariable plus mixed confounding and pathway variables†**
Poverty threshold <50% of national median equivalised household income			
Scenario 1			
Children from below the poverty threshold placed in the next highest income category	9.9	4.4	4.2
Scenario 2			
Children from below the poverty threshold proportionately distributed to all higher income categories	14.3	5.8	5.0
Poverty threshold <60% of national median equivalised household income			
Scenario 3			
Children from below the poverty threshold placed in the next highest income category	11.6	3.3	2.8
Scenario 4			
Children from below the poverty threshold proportionately distributed to all higher income categories	17.1	6.6	5.6

*Adjusted for age, ethnicity, household education, family type and household labour force status.
†Adjusted as in the multivariable model plus car access, household crowding and small area deprivation.

Using our best estimate of the causal effect of income, modelling suggests that poverty elimination could reduce child unintentional injury mortality by 3.3% to 6.6%. However, most of the deaths attributable to low income occurred among households that do not meet the definition of poverty (ie those above 50% or 60% of median income).

Although many studies have described an association between socioeconomic disadvantage and child injury mortality, few other than the NZCMS[8 9] have investigated the possible causal role of household income. Some studies have relied on an area-level proxy measure for household income and are prone to income misclassification.[12 13 30 31] The studies in which a household income is used have been limited in their ability to sufficiently adjust for confounding by other socioeconomic variables.[10 11 32]

Although a large national cohort study, there are limitations inherent in the estimates presented here. First, it is difficult to quantify the extent of selection bias that may be present. The distribution of covariates between the eligible and the study population was similar. It is possible that selection bias may be modestly influencing the observed effect sizes in the study population.

Second, there is significant potential for non-differential misclassification bias, potentially underestimating the effect of income. The income measure used in this study was cross-sectional and may not accurately represent long-term income (a better measure of wealth and access to resources).[33 34] In addition, the census income measurement is derived from a single question on gross income from all sources, categorised and then assigned the midpoint income of the category. There is limited definition possible for households at the top end of the income distribution. Furthermore, it was not possible to adjust for housing costs; gross income may underestimate the prevalence of poverty.[29]

Third, quantifying the unconfounded effect of income on health from an observational study is notoriously challenging.[35] The modelling depends on an accurate assessment of causation and is based on the notion that altering income, *ceteris paribus*, will change the risk of injury. It is likely that part of the adjusted association observed here might still be due to unmeasured or mismeasured confounders, although this is difficult to quantify. It is possible that there may be child or parent characteristics, not captured on the census, that are associated with low income and a higher risk of injury. Risk perception may be associated with the risk of injury; however, there is evidence that this does not vary significantly by social class.[36]

Additionally, given the complex nature of poverty-reducing policies,[37] it is difficult to characterise the most likely counterfactual scenario and to estimate the wider effect on the population income distribution. This modelling exercise was unable to specify from where the poverty-reducing funds were obtained and how this may have affected the income distribution. For example, effects may differ depending on whether funds were obtained from income redistribution or reduced government spending elsewhere. Another assumption in our study is that the observed risk estimates remain valid for the counterfactual income distribution. It is possible that the risk of injury death may not reduce to the extent expected from the modelling exercise. Resources are not necessarily shared fairly among household members,[38] and the additional income may not be used in ways that contribute to enhanced child safety. An assumption is that eliminating poverty will affect all mechanisms through which low income causes unintentional injury mortality. It is plausible that an increase in income can improve access to safety-promoting resources, such as a safer, well-maintained car or a reliable electricity supply. Increased income may improve access to preventive health care services and injury prevention initiatives. An increase in income may reduce parental psychosocial stress and enhance the implementation of injury prevention practices. However, it is possible that the injury-promoting characteristics of housing or the local neighbourhood are not easily amenable to changes in the income of individual households; initiatives to improve the quality and safety of the neighbourhood environment or housing will also be required.[39]

What is already known on this subject

Socioeconomic disadvantage increases a child's risk of death from unintentional injury.

What this study adds

- Household income exerts an independent effect on the risk of unintentional injury death in children
- The poorest children are at highest risk of death, but the greatest proportion of deaths attributable to low income occurs among households that are not defined as "in poverty"
- In this population, eradicating poverty may reduce childhood unintentional injury mortality by 3.3% to 6.6%.

Policy implications

Modelling suggests that, in this context, a high-income nation with a large middle-income population, increasing income for the households of the most impoverished children who are at highest risk may modestly reduce the population burden of unintentional injury. As well as taking action for the most vulnerable children, policy-makers also need to develop strategies to reduce injury mortality attributed to, or occurring among households with, low or middle income as these categories include a much greater proportion of injury deaths.

Statistics New Zealand summary security statement

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

This study supports the hypothesis that income is a key dimension of social position which shapes a child's risk of injury death. It is postulated that differential exposure to hazards is the most likely explanation for the social gradient in injury mortality, although the exact nature of differential exposure, the relationship to social class and the influence of contextual factors remain unclear.[1 2 13 15 39] It is feasible that the amount of income available to a household is fundamentally related to the ability to provide a sufficiently injury-protective environment. Modelling suggests that, in this context, ie a high-income nation with a substantial middle-income population, increasing income for the households of the most impoverished children who are at highest risk may lead to a modest reduction in the population burden of unintentional injury. Although there may be possible residual confounding and difficulties in translating higher incomes into fewer injuries, we do not believe that this will substantially alter the key findings of this study.

It is of profound importance to reduce inequalities and take action for children in the lowest income bracket, who are individually at the highest risk of injury death. However, from a population perspective, it will also be necessary to develop strategies to reduce injury mortality attributed to, or occurring among households with, low or middle income as these categories include a much greater proportion of injury deaths.

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