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ORIGINAL ARTICLE

Income and individual deprivation as predictors of health over time

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Abstract
Objectives Poverty, often defined as a lack of resources to achieve a living standard that is deemed acceptable by society, may be assessed using level of income or a measure of individual deprivation. However, the relationship between low income and deprivation is complex—for example, not everyone who has low income is deprived (and vice versa). In addition, longitudinal studies show only a small relationship between short-term changes in income and health but an alternative measure of poverty, such as deprivation, may have a stronger association with health over time. We aim to compare low income and individual deprivation as predictors of self-rated health (SRH), using longitudinal survey data, to test the hypothesis that different measures of poverty may have different associations with health.
Methods We used three waves from the longitudinal Survey of Family, Income and Employment and fixed-effect linear regression models to compare low income (<50% median income at each wave) and deprivation (reporting three or more items from the New Zealand individual deprivation index) as predictors of SRH (coded 1–5; SD 1.1–1.2). We also compared the impact of duration of low income and deprivation on SRH using mixed linear models.
Results In the fixed-effect models, moving into deprivation between waves was associated with a larger decline in SRH compared to moving into low income, which persisted in models including both low income and deprivation. Similar findings were observed for duration of low income and deprivation in mixed models.
Conclusions Moving into high levels of individual deprivation is a stronger predictor of changes in SRH than moving into low income. When investigating the association of hardship poverty with health, using alternative measures, in addition to income, is advisable.

Keywords Deprivation · Income · Poverty · Self-rated health · Longitudinal survey · Survey of Family, Income and Employment

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Introduction

Poverty is often defined as a lack of resources to achieve a living standard that is deemed acceptable by society, and includes not only basic or minimum needs such as adequate food, housing and clothing, but access to social services and education (Townsend 1979). Those living in poverty are essentially excluded from meaningful participation in society, and excluded from activities and actions that most would consider normal and customary (Townsend 1979; Krieger 2001). Accurate measurements of poverty are important for the monitoring and creation of social policies and for understanding the prevalence and experience of poverty in various communities. Poverty may be measured indirectly, through level of income or wealth, which gives an estimate of an individual's resources, or directly, through gauging an individual's living standards or level of deprivation, which estimates consumption (Ringen 1988;

Spicker et al. 2006). However, the relationship between income and deprivation measures is complex—not all people with low income are deprived, and not everyone who is deprived has low income (Ringen 1988; Perry 2002). In addition, these different measures of poverty may have different relationships with health outcomes (Pfoertner et al. 2011).

Income poverty, where income falls below a pre-defined cut point or a threshold beyond which individuals/families cannot participate in normal activities (Krieger 2001), is strongly associated with poor health (Galobardes et al. 2008; Tubeuf et al. 2012). This is most evident in the literature from children and cohort studies that have followed groups of people across the life course (Poulton et al. 2002; Kuh and Ben-Shlomo 2004; Tubeuf et al. 2012). However, although exposure to income poverty in childhood has lingering health effects on adults (Poulton et al. 2002; Case et al. 2005; Bechtel et al. 2012), analyses using natural experiments or instrumental variables have found mixed results for the impact of changes in income on *contemporaneous* health, in children or adults (Costello et al. 2003; Lindahl 2005; Apouey and Clark 2009; Schmeiser 2009; Stillman et al. 2012; Kaufman 2011). The large cross-sectional associations between adult income and health reduce markedly upon analyses using longitudinal data (Jones and Wildman 2008). This could be due to a number of reasons. Firstly, income is correlated with both observed and unobserved confounders that are also related to poor health; longitudinal studies that control for these find that the association between current income and health is reduced (Imlach Gunasekara et al. 2011a, b). Secondly, the reverse pathway from health to income, which operates throughout the life course, acts to inflate the cross-sectional association (Sacker et al. 2007; Buddelmeyer and Cai 2009). Thirdly, income may also be affected by significant measurement bias, particularly misreporting of income, which may affect longitudinal income estimates unpredictably.

Given the issues with income-based (indirect) measures of poverty, it is widely accepted that in addition to income, direct measures of living standards or deprivation are important (Ringen 1988; Perry 2002). Individual deprivation indices allow people to report their own needs, express more clearly how they rate against a socially acceptable standard of living, and allow for differences in consumption and expenditure (Perry 2002; Salmond et al. 2006; Butterworth et al. 2009). Most indices include items on forced economising (e.g. not heating the home, wearing worn-out clothes) and privations (e.g. regular meal with meat/other protein) (Townsend 1979). These underpin some part of the material, behavioural and psychosocial pathways that link income with health, particularly that low income equates to a lack of access to health-promoting resources. This means that individual deprivation is on the causal pathway from low income to poor health (Path ab in Fig. 1), as well as being an alternative potential cause of poor health in its own right (Path b compared to Path c in Fig. 1). If we find that income has a weaker association with health than deprivation, this may be because the association of a more proximal event in the causal pathway (individual deprivation) is stronger than that for a more distal event in the causal pathway (income) (Whelan et al. 2003).

Although deprivation measures have not been widely used longitudinally (Georgiades et al. 2009), especially associated with health, it is likely that these measures can reveal important associations above and beyond those with income poverty. High levels of deprivation are associated with worse health cross sectionally (Schulz et al. 2006; Groffen et al. 2008). In longitudinal analyses, deprivation is associated with depression (Lorant et al. 2007; Butterworth et al. 2009), worse self-rated health (Pischke 1995; Lukiyanova and Oshchepkov 2012) and higher smoking and drug use (Gottschalk and Huynh 2010).

While the economic literature compares income and deprivation measures, attempting to evaluate how much income is required to reduce deprivation (Yang et al. 2012) and in what ways they differ (Dowd 2012), what is lacking from these studies is a comparison of how income poverty and deprivation predict another outcome, such as health, with which a causal relationship is expected. Where such comparisons have been done, deprivation measures are found to predict health more strongly than income-based measures (Schulz et al. 2006; Lukiyanova and Oshchepkov 2012). Such analyses could add valuable information to the discussion of the utility of income and deprivation measures in the ongoing monitoring and assessment of poverty. From a policy perspective, if it were found that those in low income, for example, had better health outcomes than people with high deprivation, then more emphasis might be placed on targeting services and actions to the latter group. From a research

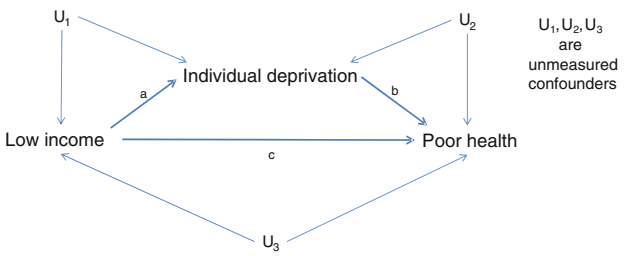

Fig. 1 Directed acyclic graph depicting the relationship between low income, individual deprivation and poor health

perspective, finding a different association between health and these different measures of poverty would support the inclusion of both income and deprivation measures in health and economic surveys.

In this study, we use a longitudinal survey to compare two different measures of poverty—low income and individual deprivation—as predictors of health over time. Although short-term changes in income have not been found to have a significant effect on health (Imlach Gunasekara et al. 2011a), long-term or persistent low income is more consistently associated with poorer health outcomes (Benzeval and Judge 2001). Few studies have looked at the association between persistent deprivation and health or compared measures of persistent low income and persistent deprivation—the results of one such study using the German Socioeconomic Panel found a stronger association of poor subjective health with inadequate living standard at one point in time, over several time periods and at a past time, than with the same measures of income poverty (Pfoertner et al. 2011).

We hypothesise that:

1. Changes in individual deprivation will be more strongly associated with health than changes in low income;
2. Persistent deprivation will be more strongly associated with health than persistent low income.

Methods

Data

We used data from the Survey of Family Income and Employment (SoFIE), wave 1–7 data version 2, a household panel survey which ran from October 2002 to September 2010 (Carter et al. 2010). The panel had an initial adult sample of 22,300 adults from 11,500 households and by wave seven, 16,400 adults remained in the survey. Data were collected annually over each 12-month period on income, self-rated health (SRH), employment status, demographics and household characteristics using computer-assisted face-to-face interviewing. In waves three, five and seven, an additional health module was asked, which included questions about individual deprivation. Our analysis sample included all eligible respondents who were adults (aged 15 and older) from wave three who also responded in waves three, five and seven ($N = 14{,}235$) (see Fig. 2). This led to 42,710 observations over the three waves of analysis, but when small numbers of missing data were dropped, this left 42,685 observations available for the fixed-effect analysis and 42,670 for the mixed analysis.

Measures

Low income and deprivation main exposure variables

Income was before tax, household income, equivalised using the New Zealand Jensen Equivalence Scale (Jensen 1988) and adjusted using the Consumer Price Index from October 2001 (the first income reference period quarter for the survey). Household income was aggregated from annual personal income which was derived from employee earnings, government transfer income, self-employment income, interest, income from investments, private superannuation and pension schemes, and other income over the past 12 months. Low income was defined as being less than or equal to half the gross median household income. At wave three, 50 % of the median household income was $22 220; in wave five, this was $23 390; in wave seven it was $23 585. A sensitivity analysis was done using <60 % of the median income ($26 665 at wave three; $28 070 at wave five; $28 300 at wave seven).

The individual deprivation measure used was the New Zealand Individual Deprivation Index (NZiDep), which was a composite score from eight items (Salmond et al. 2006), including whether the person in the past 12 months had: been forced to buy cheaper food; been unemployed for four or more weeks; put up with feeling cold; received help in the form of clothes or money from a community organisation; gone without fresh fruit and vegetables; continued wearing shoes with holes; received an income-tested benefit and made use of special food grants or food banks. This deprivation measure was collected at the three waves of analysis (three, five and seven).

The deprivation index was dichotomised into 'deprived' if scoring three or more items; else 'not deprived'. Previous work on the NZiDep has identified that people scoring three or more items on the NZiDep have two or three times higher prevalence of smoking compared to those with no deprivation (Salmond et al. 2006). Sensitivity analyses were done using different definitions of deprivation ('deprived' if reporting either two or more items or at least one item).

We created a measure of 'severe' poverty by interacting (time-varying) low income and deprivation variables (de Castro et al. 2010; Nedjat et al. 2012). This classified people as those who were in both deprivation and low income as being in 'severe poverty'; those who were in either deprivation or in low income as in 'intermediate poverty' states and those who were neither in deprivation or low income to the reference group.

We created variables of low income and deprivation duration by assigning people who were in low income or deprivation at all three waves to the category of 'persistent', those who never experienced low income or

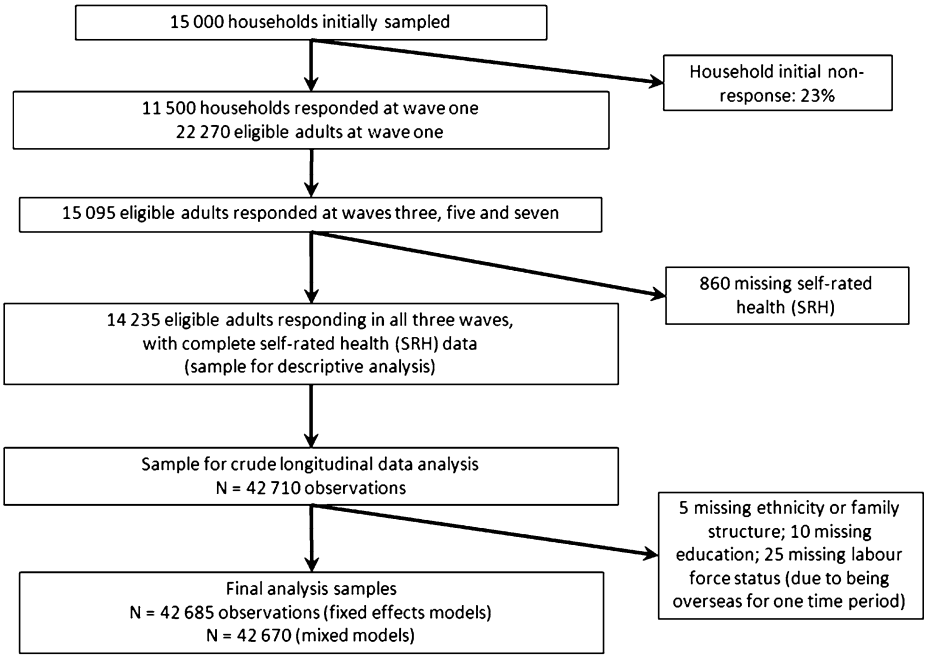

Fig. 2 Data flow of respondents from initial sampling of the New Zealand Survey of Family Income and Employment in 2002/03 (wave 1) to data analysis of waves 3, 5 and 7 (2004/05, 2006/07, 2008/09)

All respondent numbers in this figure are rounded to the nearest multiple of five with a minimum value of five as per Statistics New Zealand protocol.

deprivation to the category of 'never' and those who were in low income or deprivation in one or two waves to the category of 'transitory'.

Health outcome variable

The health outcome was self-rated health, based on the question, 'In general, would you rate your health as excellent, very good, good, fair or poor?' This was treated as a linear variable, where '5' was excellent health and '1' was poor health.

Other variables

Other descriptive and confounding variables included time-invariant age, sex, ethnicity, education and time-varying labour force status and family structure. Ethnicity was prioritised as Māori, Pacific, Asian or NZ European/Other. Education was the highest achieved educational level at wave seven.

Statistical analyses

We conducted two types of analysis (fixed-effect and mixed-effect models) to compare how income poverty and deprivation predicted SRH in repeated measures longitudinal models using waves three, five and seven of SoFIE, since deprivation was collected at these time points. All analyses were performed using SAS version 8.2.

Fixed-effect linear regression models

We used fixed-effect models to examine whether changes in deprivation were more strongly associated with health than changes in low income. In initial models, low income and deprivation were the main exposure variable(s) and the final model included both income poverty and deprivation together. The fully adjusted model included time-varying confounders labour force status and family structure.

Fixed-effect models control for individual heterogeneity or the fixed unobserved characteristics of individuals, as only the within-individual changes over time are used in these models. This has the advantage of controlling for all observed (and unobserved) time-invariant confounders (Allison 2005) but the disadvantage is that estimates for time-invariant parameters of interest cannot be directly obtained, except through interactions. We tested for interactions between age, sex and ethnicity (as a binary Māori/non-Māori variable) with both low income and deprivation, hypothesising that there could be variation in low income and deprivation effects on SRH for Māori, younger people and women. We established that around 15 % of people moved in or out of income poverty and around a quarter moved in or out of deprivation between waves, which is a sufficient change for the fixed-effect model. We used the Hausman test to ascertain whether significant individual heterogeneity was present in the final fixed-effect model (Wooldridge 2002).

Table 1 Baseline (wave 3, 2004/05) mean self-rated health by baseline characteristics of the New Zealand Survey of Family Income and Employment respondents

Characteristics	Self-rated health (5 = Excellent)		
	N (%)	Mean	SD
Low income (<50 % median income)			
Not in low income	12,005 (84)	4.0	1.0
In low income	2,230 (16)	3.6	1.1
Deprivation (3 or more deprivation indices)			
Not in deprivation	13,370 (94)	4.0	1.0
In deprivation	865 (6)	3.4	1.2
Duration of low income (<50 % median income)			
Never in low income (0 waves)	10,155 (71)	4.0	1.0
Transient low income (1–2 waves)	3,340 (23)	3.8	1.1
Persistent low income (3 waves)	745 (5)	3.5	1.1
Duration of deprivation			
Never in deprivation (0 waves)	12,680 (89)	4.0	1.0
Transient deprivation (1–2 waves)	1,290 (9)	3.6	1.1
Persistent deprivation (3 waves)	265 (2)	3.1	1.2
Interaction of deprivation and low income at wave 3 (2004/05)			
Not in deprivation or low income	11,560 (81)	4.0	1.0
Not in deprivation but in low income	1,815 (13)	3.7	1.0
In deprivation but not in low income	445 (3)	3.4	1.2
In deprivation and low income (severe)	420 (3)	3.3	1.2
Age at wave 3 (2004/05)			
15–24	1,845 (13)	4.2	0.9
25–34	1,940 (14)	4.2	0.9
35–44	2,990 (21)	4.1	0.9
45–54	2,910 (20)	3.9	1.0
55–64	2,275 (16)	3.8	1.0
65+	1,400 (10)	3.4	1.0
Sex			
Male	6,405 (45)	4.0	1.0
Female	7,830 (55)	3.9	1.0
Ethnicity			
Māori	1,475 (10)	3.9	1.0
Pacific	505 (4)	3.8	1.1
Asian	660 (5)	3.9	1.0
European/other	11,595 (81)	4.0	1.0
Highest education achieved			
No qualification	3,015 (21)	3.6	1.1
School qualification	3,460 (24)	4.0	1.0
Post-school vocational qualification	5,345 (38)	4.0	1.0
Degree or higher	2,410 (17)	4.2	0.9
Family structure at wave 3 (2004/05)			
Couple only	4,230 (30)	3.9	1.0
Couple with children	5,995 (42)	4.1	0.9
Sole parent	1,260 (9)	3.9	1.0
Not in a family nucleus	2,755 (19)	3.7	1.1
Labour market activity at wave 3 (2004/05)			
Employed	9,630 (68)	4.1	0.9
Not employed	4,600 (32)	3.6	1.1
Total	14,235	3.9	1.0

All numbers are rounded to the nearest five as per Statistics New Zealand confidentiality protocol. The sum of totals may not equal the overall total due to rounding error

Mixed linear regression models

To test whether persistent deprivation was more strongly associated with health than persistent low income, we used mixed linear regression models rather than fixed-effect models, since people in unchanging states (e.g. persisting or never deprived) were not identifiable. In the initial models, duration of income poverty or deprivation was the main exposure variable, then the final models included both duration of income poverty and duration of deprivation together. The mixed models were adjusted for demographic factors, sex, age, ethnicity and family structure, and then socioeconomic factors, labour force status and education were also added to give a fully adjusted model.

Mixed models use both within-individual changes and between-individual differences (individual heterogeneity) in its model estimation. This means that estimates from the mixed model may be biased if the individual heterogeneity is correlated with exposures of interest (deprivation and income poverty) and the outcome (health)—that is, if there is time-invariant confounding (Allison 2005). However, our research question is concerned primarily about the comparison between the estimates for persistent low income and persistent deprivation, rather than the absolute magnitude of the estimates themselves (which may be biased upwards).

Results

Descriptive analysis and baseline characteristics

Table 1 shows how the mean health of respondents at baseline (wave three) varied by sample characteristics. At baseline, 15.7 % of the population were classified as being in low income and 6.1 % reported three or more measures of deprivation. Only 3.0 % of the population were in both low income and deprivation. As expected, SRH was lower in those with low income and deprivation, declined with

Table 2 Duration of low income and deprivation by baseline characteristics of the New Zealand Survey of Family Income and Employment respondents (at wave 3, 2004/05)

Baseline characteristics	Duration of low income (waves)			Duration of deprivation (waves)			
	No waves in low income *N* (row %)	Transient (1–2 waves)	Persistent (3 waves)	No waves in deprivation	Transient (1–2 waves)	Persistent (3 waves)	Total
Age at wave 3 (2004/05)							
15–24	1,130 (61.2)	625 (33.9)	85 (4.6)	1,580 (85.6)	245 (13.3)	20 (1.1)	1,845
25–34	1,475 (76.0)	380 (19.6)	85 (4.4)	1,635 (84.3)	245(12.6)	65 (3.4)	1,940
35–44	2,285 (76.4)	575 (19.2)	135 (4.5)	2,545 (85.1)	360 (12.0)	85 (2.8)	2,990
45–54	2,325 (79.9)	475 (16.3)	110 (3.8)	2,630 (90.4)	225 (7.7)	55 (1.9)	2,910
55–64	1,580 (69.5)	535 (23.5)	160 (7.0)	2,075 (91.2)	165 (7.3)	30 (1.3)	2,275
65+	1,355 (59.6)	755 (33.2)	165 (7.3)	2,215 (97.4)	50 (2.2)	10 (0.4)	2,275
Sex							
Male	4,815 (75.2)	1,335 (20.8)	250 (3.9)	5,900 (92.1)	435 (6.8)	65 (1.0)	6,405
Female	5,335 (68.1)	2,000 (25.5)	495 (6.3)	6,780 (86.6)	855 (10.9)	195 (2.5)	7,830
Ethnicity							
Māori	900 (61.0)	440 (29.8)	140 (9.5)	1,140 (77.3)	255 (17.3)	85 (5.8)	1,475
Pacific	310 (61.4)	145 (28.7)	50 (9.9)	355 (70.3)	135 (26.7)	15 (3.0)	505
Asian	400 (60.6)	215 (32.6)	50 (7.6)	605 (91.7)	50 (7.6)	5 (0.8)	660
European/other	8,545 (73.7)	2,540 (21.9)	505 (4.4)	10,580 (91.2)	855 (7.4)	160 (1.4)	11,595
Highest education achieved							
No qualification	1,765 (58.5)	955 (31.7)	295 (9.8)	2,600 (86.2)	330 (10.9)	85 (2.8)	3,015
School qualification	2,460 (71.1)	850 (24.6)	150 (4.3)	3,090 (89.3)	325 (9.4)	45 (1.3)	3,460
Post-school vocational qualification	3,935 (73.6)	1,160 (21.7)	250 (4.7)	4,735 (88.6)	490 (9.2)	120 (2.2)	5,345
Degree or higher	1,990 (82.6)	375 (15.6)	45 (1.9)	2,250 (93.4)	145 (6.0)	15 (0.6)	2,410
Family structure at wave 3 (2004/05)							
Couple only	3,150 (74.5)	875 (20.7)	205 (4.8)	4,055 (95.9)	155 (3.7)	20 (0.5)	4,230
Couple with children	4,650 (77.6)	1,180 (19.7)	165 (2.8)	5,450 (90.9)	490 (8.2)	55 (0.9)	5,995
Sole parent	655 (52.0)	450 (35.7)	155 (12.3)	810 (64.3)	330 (26.2)	120 (9.5)	1,260
Not in a family nucleus	1,700 (61.7)	835 (30.3)	220 (8.0)	2,365 (85.8)	315 (11.4)	75 (2.7)	2,755
Labour market activity at wave 3 (2004/05)							
Employed	7,780 (80.8)	1,630 (16.9)	220 (2.3)	8,875 (92.2)	670 (7.0)	85 (0.9)	9,630
Not employed	2,375 (51.6)	1,705 (37.1)	525 (11.4)	3,805 (82.7)	620 (13.5)	175 (3.8)	4,600
Self-rated health at wave 3 (2004/05)							
Excellent	3,775 (77.8)	940 (19.4)	145 (3.0)	4,525 (93.2)	300 (6.2)	30 (0.6)	4,855
Very good	3,650 (72.6)	1,155 (23.0)	220 (4.4)	4,545 (90.4)	410 (8.2)	70 (1.4)	5,030
Good	2,070 (65.9)	825 (26.3)	245 (7.8)	2,720 (86.6)	340 (10.8)	80 (2.5)	3,140
Fair	750 (71.1)	325 (33.0)	105 (10.7)	750 (71.1)	180 (18.3)	50 (5.1)	985
Poor	140 (60.9)	90 (39.1)	30 (13.0)	140 (60.9)	60 (26.1)	30 (13.0)	230
Total	10,150 (71.3)	3,345 (23.5)	740 (5.2)	12,680 (89.1)	1,290 (9.1)	265 (1.9)	14,235

All numbers are rounded to the nearest five and a minimum of five as per Statistics New Zealand confidentiality protocol. The sum of totals may not equal the overall total due to rounding error

increasing age, was lower in the unemployed and showed a gradient by education. Mean health for those in deprivation and in low income was similar but for those in persistent deprivation, mean health was slightly lower (3.1) compared to those in persistent low income (3.5).

Table 2 describes the duration of low income and duration of deprivation by baseline sample characteristics. A high proportion of elderly had persistent low income but very few reported persistent or even transient deprivation. However, for most others, such as sole parents, Māori and

the unemployed, experiencing persistent low income and persistent deprivation went hand-in-hand.

Fixed-effect linear regression models examine whether changes in individual deprivation are more strongly associated with health than changes in low income

In Table 3, we present the results of the longitudinal fixed-effect models of how changes in deprivation and low income predict SRH. The models showed that both low income and deprivation had a negative association with SRH, meaning that moving into low income or deprivation led to a decline in SRH. After adjusting for measured and unmeasured confounders in the final model, the low income estimate reduced slightly but the deprivation estimate remained unchanged and was five times the magnitude of the low income estimate. In the model which included both low income and deprivation, deprivation still had the largest effect size and the income estimate was unchanged, providing little evidence for deprivation mediating the association between contemporaneous income change and health. The Hausman test was highly significant (*m* value 268, $p < 0.001$), suggesting that a fixed-effect model, which controls for individual heterogeneity, was the preferred specification over a mixed model.

Table 3 Self-rated health and deprivation/low income, fixed-effect linear regression models (using three waves of the New Zealand Survey of Family Income and Employment, 2004/05; 2006/07; 2008/09)

	Crude model $N = 42{,}710$ ß (95 % CI)	Fully adjusted model[a] $N = 42{,}685$ ß (95 % CI)
Low income (as main exposure)		
In low income	−0.03 (−0.05 to 0.00)	−0.02 (−0.05 to 0.01)
Not in low income	0	0
Deprivation (as main exposure)		
In deprivation	−0.10 (−0.14 to −0.06)*	−0.10 (−0.14 to −0.06)*
Not in deprivation	0	0
Low income and deprivation (both in the same model)		
In low income		−0.02 (−0.05 to 0.01)
Not in low income		0
In deprivation		−0.10 (−0.14 to −0.06)*
Not in deprivation		0

* p value < 0.001

[a] Includes family structure and labour force status (time-varying confounders). All models include time/wave

We tested for interactions between the main effects of low income (or deprivation) and age (as a linear variable), sex and ethnicity in the fully adjusted fixed-effect model. However, none of these interaction terms were statistically significant at the 5 % level.

When investigating severity of poverty, we found that the individuals in severe poverty (both low income and high deprivation) and the individuals in an intermediate poverty state (high deprivation but not in low income) were those who had the greatest decline in health compared to individuals neither deprived nor in low income (see Table 4). This suggests that it was those reporting a shift into deprivation, either alone or in combination with a shift into low income, who were at the greatest risk of an deteriorating health. However, an interaction between low income and deprivation was not significant ($p = 0.11$).

We performed a number of sensitivity analyses to check the robustness of the results. Firstly, sensitivity analyses including only people aged 20–60 years at wave three (limiting the sample to those of 'working age' to remove potential effects of retirement and superannuation on both the exposures and outcome) gave similar results to the models using the whole adult sample (results available from authors). We also tested for whether the association between change in deprivation and SRH was predominantly due to a strong relationship between labour market activity and health by removing the 'benefits' and 'unemployment' components of the NZiDep score (including only the remaining six components). However, a strong association remained even with this condensed deprivation index (−0.14, SE 0.03 in the fully adjusted fixed-effect model).

Other sensitivity analyses tested different cut points of the low income and deprivation variables. When a cut point of two or more deprivation measures was used to define individual deprivation, the estimate from the final model for those moving into deprivation was −0.12 (SE 0.02). Even with a cut point of only one deprivation measure, the

Table 4 Self-rated health showing result of an interaction between low income and deprivation, fixed-effect linear regression model (using three waves of the New Zealand Survey of Family Income and Employment, 2004/05; 2006/07; 2008/09)

	Fully adjusted[a] $N = 42{,}685$ ß (95 % CI)
In deprivation and low income	−0.15 (−0.21 to −0.09)*
Low income, not in deprivation	−0.01 (−0.03 to 0.01)
Not in low income, in deprivation	−0.07 (−0.13 to −0.01)**
Not in deprivation or low income	0

* p value < 0.001; ** $p < 0.01$

[a] Includes labour force status and family structure. All models include time/wave

Table 5 Self-rated health and duration of low income/deprivation, mixed linear regression models (using three waves of the New Zealand Survey of Family Income and Employment, 2004/05; 2006/07; 2008/09)

	Crude model $N = 42,710$ ß (95 % CI)	Adjusted for demographics[a] $N = 42,705$ ß (95 % CI)	Fully adjusted[b] $N = 42,670$ ß (95 % CI)
Duration of low income (as main exposure)			
Persistent low income	−0.51 (−0.58 to −0.45)*	−0.41 (−0.47 to −0.35)*	−0.27 (−0.33 to −0.21)*
Transitory low income	−0.27 (−0.30 to −0.23)*	−0.22 (−0.26 to −0.18)*	−0.14 (−0.17 to −0.11)*
Never in low income	0	0	0
Duration of deprivation (as main exposure)			
Persistent deprivation	−0.85 (−0.95 to −0.74)*	−0.92 (−1.02 to −0.83)*	−0.81 (−0.91 to −0.72)*
Transitory deprivation	−0.42 (−0.47 to −0.37)*	−0.53 (−0.57 to −0.48)*	−0.46 (−0.51 to −0.41)*
Never in deprivation	0	0	0
Poverty and deprivation (both in same model)			
Persistent low income			−0.13 (−0.19 to −0.07)*
Transitory low income			−0.08 (−0.11 to −0.04)*
Never in low income			0
Persistent deprivation			−0.77 (−0.87 to −0.67)*
Transitory deprivation			−0.43 (−0.48 to −0.39)*
Never in deprivation			0

* p value < 0.001

[a] Includes age, sex, ethnicity and family structure

[b] Includes age, sex, ethnicity and family structure, labour force status and education. All models include time/wave

estimate from the final model for those moving into deprivation was −0.07 (SE 0.01), suggesting that even reporting a few markers of deprivation was significantly correlated with health. Using a low income cut point of <60 % of median income (rather than <50 % of median income), the association with SRH for those in low income was −0.03 (SE 0.01) in the final model.

Mixed linear regression models examining whether persistent deprivation is more strongly associated with SRH than persistent low income

The models examining the relationship between duration of low income and deprivation with SRH are given in Table 5. In the crude models, both persistent low income and persistent deprivation had a strong (negative) association with SRH (−0.51 and −0.85, respectively). However, this association was halved with the introduction of measured confounding variables for persistent low income. However, the relationship between persistent deprivation and SRH remained similar even after the inclusion of measured confounding variables. When both persistent low income and persistent deprivation were included in the same model, the persistent low income estimate reduced again by over half, suggesting that persistent deprivation may mediate the association of persistent low income with poor health. These models are almost certainly affected by residual confounding, which means only the relative size of the low income and deprivation estimates should be interpreted.

Discussion

Substantive findings and interpretation

In this study, we found that short-term changes in low income were not significantly associated with SRH, whereas short-term changes in deprivation led to a decline in SRH in the order of 10 % of an SD. We used fixed-effect models to control for time-invariant confounding, which contributes to bias in analyses of poverty and health. It could be for low income that it is the length of time in income poverty that is important for health and persistent low income is considered a more robust reflection of poverty (Whelan et al. 2003). However, we also found that persistent deprivation was more strongly associated with SRH than persistent low income.

Our results are consistent with a similar analysis done using the German Socioeconomic Panel, which also found that a living standard measure was more strongly associated with subjective health over time than income poverty (Pfoertner et al. 2011). They are also consistent with the observation that income poverty and deprivation are often

not highly correlated (Townsend 1979; Perry 2002), which has led to the development of a multidimensional poverty index by the United Nations Development Programme, to monitor poverty and its association with diverse outcomes (United Nations Development Programme 2010). The observed association for SRH is likely to hold for other health outcomes, particularly mental health (Schulz et al. 2006; Lorant et al. 2007; Butterworth et al. 2009). Deprivation or living standard measures may have a larger impact than income measures in this context because they directly measure an individual's consumption, providing a stronger and more proximal link to health than income (see Fig. 1). Of note is that very few elderly reported persistent or transient deprivation, despite moderate numbers experiencing low income. This phenomenon has been explained as being due to New Zealand's universal superannuation policy, which is successful in protecting older people from deprivation, and because older people are more likely to own a home, with fewer housing costs (Every Child Counts 2010; Perry 2011). However, other groups of people, such as sole parents, Māori and the unemployed, were more likely to experience both low income and deprivation.

Limitations and potential sources of bias

Our analyses had some limitations. Although time-invariant confounding was well controlled for in the fixed-effect models, some residual confounding may still be present from unmeasured time-varying confounders, although the inclusion of some other known potential measured time-varying confounders (such as area deprivation and marital status) led the models to become unstable and over-specified. None of the models could control for the reverse pathway from health to deprivation/low income, but this is likely to have a similar effect for both deprivation and low income. A subjective measure, such as individual deprivation, may be more prone to dependent measurement error with a subjective outcome such as SRH, than income. In this analysis, both the outcome of SRH and deprivation are subjective, and dependence may be induced by external factors that are correlated with both measurement errors. This could result in an elevated deprivation–SRH association compared to the income–SRH association. Although income is also self-reported, it does not rely on an individual's judgment about their own deprivation status, so may be less affected by this type of bias. Note that individuals who are by nature pessimistic or optimistic and consistently under- or over-estimate their health and deprivation do not contribute measurement error to the fixed-effect model, as long as their rating is constant over time, as each individual's change is only compared to themselves.

The subjectivity of living standards or deprivation measures has led some researchers to conclude that their primary use is to establish or assess a poverty line, rather than be used on their own as an indicator of poverty (Yang et al. 2012). However, in longitudinal analyses of poverty and health, when deprivation measures are more strongly associated with health than income poverty, it would seem prudent to include deprivation as an alternative poverty measure, else run the risk of concluding (erroneously) that there is little short-term association between poverty and health. More investigation into the longitudinal associations between income poverty, deprivation and health is required.

Income in longitudinal surveys has known problems of regression to the mean and misreporting (non-differential measurement errors) (Bound et al. 2001; Yoo et al. 2009). However, some studies of measurement error in repeated measures of income conclude that estimates may be reasonably accurate, due to different measurement biases cancelling each other out (Gibb et al. 2012; Sedgwick 2012). In SoFIE, a component of personal income data (from which the household income was derived) was missing in 10 % of cases, more commonly in respondents from lower income groups. Therefore, household income may be slightly underestimated, leading to a small overestimation of those in low income. However, as long as this error is either random or unchanging over time, it should not introduce bias into the fixed-effect models. We have used before tax income, which may also affect the incomes of those in the lower income bracket. However, using gross income consistently over time should not have greatly affected most people's relative low income position and we used <50 % of median income as a way of picking out those most deeply in poverty.

Conclusions

Measures of poverty are important for many reasons. They are needed to determine the relative incidence of poverty and deprivation among social groups so that interventions can be developed and targeted to those in need; to monitor and evaluate the effect of policies on poverty and standards of living; to provide a basis to assess the adequacy of benefit levels; to remind governments and organisations of the effect of poverty on social and economic development. While most surveys of health and socioeconomic position include income routinely, our findings support the inclusion (in addition to income) of alternative measures of poverty, such as individual deprivation-based indices, particularly when evaluating the impact of socioeconomic factors on health. They also highlight the need for more research linking deprivation with health outcomes, including objective health outcomes, which would overcome possible bias from dependent measurement error, as well as mental health, child health and health outcomes in

minority groups, which all have the potential to be exacerbated by deprivation.

The stronger association of changes in individual deprivation with changes in SRH, than for income and SRH, is consistent with past research and theoretical knowledge, as individual-level deprivation or material hardship is probably more proximal in any causal model to health than income. Although measurement bias may affect the deprivation–SRH analyses, this highlights a useful feature of individual-level deprivation measures—greater study power to detect an association with a given sample size. Finally, if deprivation is the most important pathway between poverty and poor health (at least in the short-term), then policies to prevent deprivation (e.g. through good provision of free health services and adequate access to housing and food) may also alleviate income-related health inequalities.

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