Do changes in income, deprivation, labour force status and family status influence smoking behaviour over the short run? Panel study of 15 000 adults

TC Online First, published on September 3, 2013 as 10.1136/tobaccocontrol-2012-050944

Do changes in income, deprivation, labour force status and family status influence smoking behaviour over the short run? Panel study of 15 000 adults

Tony Blakely,[1] Frederieke S van der Deen,[1] Alistair Woodward,[2] Ichiro Kawachi,[3] Kristie Carter,[1] Re-revised and resubmitted to Tobacco Control 10 June 2013

[1]Department of Public Health, University of Otago, Wellington, New Zealand
[2]Faculty of Medical and Health Sciences, School of Population Health, University of Auckland, Auckland, New Zealand
[3]Department of Society, Human Development, and Health, Harvard School of Population Health, Boston, Massachusetts, USA

Correspondence to
Professor Tony Blakely, Department of Public Health, University of Otago, Wellington, PO Box 7343, Wellington 6021, New Zealand; tony.blakely@otago.ac.nz

Received 19 December 2012
Accepted 14 August 2013

ABSTRACT

Background Improving social circumstances (eg, an increase in income, finding a job or moving into a good neighbourhood) may reduce tobacco use, but robust evidence on the effects of such improvements is scarce. Accordingly we investigated the link between changing social circumstances and changing tobacco smoking using repeated measures data.

Methods 15 000 adults with at least two observations over three waves (each 2 years apart) of a panel study had data on smoking status, family, labour force, income and deprivation (both neighbourhood and individual). Fixed effects regression modelling was used.

Findings The odds of smoking increased 1.42-fold (95% CI 1.16 to 1.74) for a one log-unit increase in personal income among 15–24-year-olds, but there was no association of increased smoking with an increase in income among 25+ year olds. Moving out of a family nucleus, increasing neighbourhood deprivation (eg, 1.83-fold (95% CI 1.18 to 2.83) increased odds of smoking for moving from least to most deprived quintile of neighbourhoods), increasing personal deprivation and moving into employment were all associated with increased odds of smoking. The number of cigarettes smoked a day changed little with changing social circumstances.

Interpretation Worsening social circumstances over the short run are generally associated with higher smoking risk. However, there were counterexamples: for instance, decreasing personal income among young people was associated with decreased odds of smoking, a finding consistent with income elasticity of demand (the less one's income, the less one can consume). This paper suggests that improving social circumstances is not always pro-health over the short run; a more nuanced approach to the social determinants of health is required.

INTRODUCTION

Social position determines health status.[1] In most rich countries, lower socioeconomic position is associated with worse health status and a 'poorer' risk factor profile. For example, smoking is more common among low-income groups and deprived populations in New Zealand.[2 3] A standard or generalised social determinants perspective[1] might suggest that improving peoples' education, income and other socioeconomic resources will result in improved health, including, presumably, through pathways such as quitting smoking. For example, according to Lawlor *et al*[4]: "Persistent smoking among the most deprived members of society may represent a rational response to their life chances.... Health promotion initiatives designed to reduce smoking among members of these groups may continue to fail unless the general health and life chances of such individuals are first improved."

However, the connection between social circumstances and smoking is not straightforward. Consider income. A large body of evidence exists that increasing the *price* of tobacco will reduce consumption and more so among lower socioeconomic groups.[5 6] The corollary of this is that, all other things equal (*ceteris paribus*), increasing income will be associated with increased smoking as one's disposable income goes up. Indeed, for young adolescents, a positive association has been found between a higher disposable income and smoking.[7–9] This equates to an 'income elasticity' of demand for tobacco that, presumably, mirrors the price elasticity and, at least in the short term, runs contrary to the notion that health (or in this case, risky behaviour) uniformly improves with improving socioeconomic position. The aim of this paper is therefore to test the short-run causal associations of a change in social circumstances with a change in smoking behaviour.

Causal associations between social determinants and health can be thought of over the short run and long run, and they may be in opposite directions. For example, a short-term increase in income may be associated with a temporary increase in consumption of 'bad' behaviours (eg, smoking more, eating too much and drinking too much). However, if the increase in income is sustained over a longer time horizon, this may change the incentives faced by the individual. In other words, the *expectation* of a more comfortable existence stretching into the future may increase the marginal utility of investing in health and longevity (ie, by stopping smoking).[10 11]

Generating robust evidence free of confounding on either the short-run or (especially) long-run causation is difficult. Randomised trials are difficult to conduct. Therefore, we have to rely on other study designs. One such study design for testing short-run associations is a panel study or repeated measures.[12 13] As the same individuals are repeatedly assessed over time, it is assumed that all time-invariant covariates (eg, intelligence, early childhood exposures, personality, etc.) are controlled,

To cite: Blakely T, van der Deen FS, Woodward A, *et al*. *Tob Control* Published Online First: [*please include* Day Month Year] doi:10.1136/tobaccocontrol-2012-050944

and one can make stronger causal inference interpretations about any *change* in outcome (in this study, smoking behaviour) associated with *change* in exposure (in this study, social position determinants: family status, labour force status, income and deprivation).

There is surprisingly little published evidence using such a panel study design wherein both a change in social exposure and a change in health outcome are studied. The studies that have researched the temporal relation between a change in social determinants and a change in smoking behaviour have generally focused on change in marital status, suggesting marital dissolution increases the risk of smoking in both men and women.[14–18] The association between changes in employment status, income and deprivation and smoking patterns is less clear. For example, while Virtanen *et al*[19] found employment trajectory to be (variably) associated with alcohol consumption, body weight, physical activity and sleep duration, it was not significantly associated with smoking. Stable employment has been linked with moving from smoking into non-smoking, although the same study found no association of changes in individual or household income with changes in smoking behaviour.[17] Increasing exposure to financial strain (a similar measure to deprivation) has been demonstrated to be associated with a higher likelihood of smoking, particularly among the young–old generation (65–74 years old).[20] But overall evidence on the association between changes in employment status, income and deprivation on changes in smoking seems to be scarce.

In the present study, we examine the association of changing social circumstances (family status, labour force status, income and deprivation) with two aspects of smoking behaviour in a panel study of 15 000 adults (aged 15+), namely, (1) smoking: yes (current) or no (ex-smoker or never-smoker); and (2) number of cigarettes smoked per day. We used fixed effects analyses that remove all observable and unobservable time-invariant confounding, allowing a more robust assessment of causal associations than is possible with non-repeated measures data—at least over the short run.

METHODS

Data

This study is a longitudinal analysis of waves 3, 5 and 7 from the Survey of Families, Income and Employment (SoFIE). This nationally representative longitudinal survey of the usually resident population living in private households was conducted from 2002 to 2010 in New Zealand.[21] Information on individual and family factors such as labour force status, education, marital status and income was obtained during annual face-to-face interviews. In waves 3, 5 and 7 of SoFIE, a detailed health module included smoking questions. The initial SoFIE sample comprised approximately 11 500 responding private households (response rate of 77% at wave 1). Over 22 000 adults responded in wave 1 and just over 16 000 in wave 7. In this paper, eligible respondents were those aged 15+ years who responded to all of waves 3, 5 and 7, plus those responding to just waves 3 and 5 and just waves 5 and 7 (N=17 140).

Exposure measures

Income

Annual personal income was derived by adding up gross annual incomes from employment earnings, self-employment earnings, government transfers, interest from bank and/or other accounts, personal investments, private superannuation and pension schemes and other regular or irregular received income sources. We modelled both total household income (equivalised for economies of scale using a New Zealand-specific index) and personal income. Both measures were adjusted for inflation and log-transformed prior to modelling.

Family status

The family status of a respondent was based on circumstances at the time of the survey and included a couple without child(ren), a couple with child(ren), sole parent with child(ren) or not living in a family nucleus (eg, living alone or in a flatting/house share situation). If a young person, aged 16, is living at home with his/her parents, he/she will be classified as living in a couple with child(ren) family.

Labour force status

Respondent's labour force status was classified as employed, unemployed (but actively seeking for a job) or inactive. The latter inactive category is heterogeneous, including those people 'out of work' but not actively seeking work, caregivers (eg, parents), students and the retired.

Neighbourhood deprivation

A 2006 census-based measure of neighbourhood deprivation, using an index of nine census variables (eg, benefit receipt, income) averaged across about 100 people living in the smallest census enumeration area (ie, meshblock),[22] was assigned to each respondent and classified as quintiles—and allowed to change if respondents moved between waves. This variable is therefore a relative ranking of neighbourhood deprivation.

Personal deprivation

An eight-item measure of personal deprivation (eg, not being able to afford fruit and vegetables, using a food bank)[23] was asked of all respondents at each of waves 3, 5 and 7. The questions address moderate-to-severe personal deprivation, meaning that the measure can be considered akin to an absolute measure of hardship. The majority of people answered 'no' to all eight questions and were classified in the referent 'nil' personal deprivation category. The remaining respondents were classified as 1 to 2, or 3+ 'yes' answers with the 3+ category being the minority of people with severe personal deprivation.

Self-rated health

Five category answer to the question: "In general would you say your health is: excellent, very good, good, fair or poor?"

Outcome measures

Smoking status

Respondent's smoking status was classified as never-smoker, ex-smoker or current smoker based on two questions: "Do you regularly smoke one or more tobacco cigarettes a day?" and "Ever been a regular smoker of one or more cigarettes a day?". For the fixed effects analysis, never-smokers and ex-smokers were grouped together, meaning that predictors of change from not currently to current smoker were modelled.

Number of cigarettes smoked per day

For current smokers, the number of cigarettes per day was determined by asking: "About how many cigarettes do you usually smoke a day?" Response categories were up to 4 per day, 5–9 per day, …., 40–44 per day and 45 or more per day. These were coded into midband rates, 2, 7, …., 42 and 47, and modelled as a continuous outcome in linear fixed effects regressions.

Analyses

All analyses were conducted using individual unit data in Statistical Analysis System (SAS) Enterprise Guide in the Statistics New Zealand data laboratory. Fixed effects regression models were used to estimate the relationship between a change over time in each of the exposure variables and a change in the two outcome variables. For example, for a logistic regression model of the outcome variable smoking/non-smoking, an OR of 1.5 for the natural logarithm of personal income means that someone who increases his/her income by 170% (exp[1]=2.7) has a 50% higher odds of becoming a smoker than someone who has experienced no change in his/her personal income. (Interpreting parameters for categorical variables is more complicated and will be elucidated in the results below using family status.)

We used a sequence of models: (1) family and labour force status (modelled first as considered causally prior to any impact on change in remaining socioeconomic factors); (2) plus household income; (3) as household income is usually not important, we substitute it with personal income; and (4) model 3 plus remaining deprivation variables.

We also split the sample into 15–24-year-olds and 25+ year olds. As most initiation of smoking has occurred by age 25,[24] the fixed effects regression among 25+ year olds will reflect the net 'flow' of cessation (current to ex) and relapse (ex to current), and among 15–24 years, it will reflect more (but not exclusively) initiation.

RESULTS

The distribution of smoking at each wave, and transitions between waves, is shown in table 1.

Among respondents with complete data, 19.2% were current smokers at wave 3 reducing to 17.0% at wave 7, although these cross-sectional prevalences hide many of the between-wave transitions. Around 2% of respondents either started or stopped smoking between waves—with slightly more stopping, leading to the modest reduction in smoking prevalence over time. The mean number of cigarettes consumed was relatively stable over time at about 13 cigarettes per day. Over half of continuous current smokers changed the number of cigarettes they smoked between waves and were equally split between increasing and decreasing.

The distribution of covariates is similarly shown in table 2.

Of most importance for the fixed effects analyses are those respondents experiencing change over time. Slightly more than 10% of respondents experienced a change in labour force status between waves, and up to a third of respondents experienced either a decrease or increase in log income (be it household or personal) of greater than half an SD. About 15% of respondents experienced some change in family status between waves. A quarter of respondents reported a change in personal deprivation level between waves, and 15% to 20% a change in neighbourhood deprivation between waves.

Odds of smoking

Table 3 shows the results for sequential logistic fixed effects models with smoking status as the outcome variable.

As results change little for sequential addition of covariates, we first focus on model 4, including all covariates. The results for a categorical independent variable in a fixed effects model for panel data require careful interpretation. Consider the 'not in family nucleus' OR of 1.77 (95% CI 1.26 to 2.47). This means that someone changing from the referent category of 'couple only' to 'not in family nucleus' has a 77% greater odds of becoming a smoker than someone not changing his/her family status between waves. And conversely, someone shifting the other way ('not in family nucleus' to 'couple only') has a

Table 1 Distribution and transitions of smoking status for all 15+ year olds (n=17 140; percentages in parentheses for non-missing respondents and data)

Smoking variable/ transition	Wave 3	Wave 3–5 transition	Wave 5	Wave 5–7 transition	Wave 7
Smoking status	(N=16 835 non-missing)	(N=16 580 non-missing)	(N=16 855 non-missing)	(N=14 920 non-missing)	(N=15 100 non-missing)
Never	8875 (52.7%)		8775 (52.1%)		7775 (51.5%)
Ex-smoker	4735 (28.1%)		4920 (29.2%)		4760 (31.5%)
Current	3225 (19.2%)		3160 (18.7%)		2565 (17.0%)
Missing smoking data	310		290		120
Stopped smoking*		445 (2.4%)		490 (2.1%)	
Started smoking		380 (2.3%)		280 (1.9%)	
Stayed smoking		2660 (16.2%)		2195 (15.0%)	
Stayed non-smoking†		13 110 (79.1%)		11 955 (81.0%)	
Missing ≥1 wave		525		180	
Number of cigarettes smoked‡	(N=3225 current smokers)	(N=2660 smokers in both waves)	(N=3160 current smokers)	(N=2195 smokers in both waves)	(N=2565 current smokers)
Mean (SD)	13.17 (7.78)		13.04 (7.79)		13.46 (7.98)
Increase by >0.5 SD		765 (28.8%)		620 (28.2%)	
No change		1150 (43.2%)		1000 (45.5%)	
Decrease by >0.5 SD		735 (27.6%)		565 (25.7%)	

Note that all counts are random rounded to a near multiple of five as per Statistics New Zealand requirements; therefore, numbers in each column do not sum to exactly 17 140.
*Includes 'current to ex' (n=390 for waves 3–5 and 420 for waves 5–7) and 'current to never' (n=55 and 70; while a nonsense transition disclosing some misclassification, we assumed they were truly 'current to ex').
†Includes 'ex to ex' and 'never to never' transitions, but also nonsense transitions (less than 1% of observations) of 'ex to never' and 'never to ex', which, while disclosing some classification errors, are still within the 'stayed non-smoking' category.
‡Missing cases not shown.

Table 2 Distribution of independent covariates data for all 15+ year olds with data at each wave or both waves for transitions (n=17 140; percentages in parentheses for non-missing respondents and data)

Variable*	Wave 3	Wave 3–5 transition	Wave 5	Wave 5–7 transition	Wave 7
Labour force status					
Working	11 320 (66.2%)		11 585 (67.7%)		10 225 (67.7%)
Not active	5485 (32.2%)		5260 (30.6%)		4630 (30.6%)
Unemployed	290 (1.7%)		260 (1.7%)		255 (1.7%)
Stayed working		10 335 (60.6%)		9460 (62.7%)	
Stayed not working		4550 (26.7%)		3920 (26.0%)	
Working to not working		965 (5.7%)		960 (6.4%)	
Not working to working		1215 (7.1%)		745 (4.9%)	
Log equiv household income (CPI adjusted)					
Mean (SD)	10.64 (0.84)		10.68 (0.82)		10.71 (0.81)
Increase by >0.5 SD		3075 (18.2%)		2410 (15.9%)	
No change		11 315 (66.8%)		10 355 (68.4%)	
Decrease by >0.5 SD		2550 (15.1%)		2370 (15.7%)	
Log personal income (CPI adjusted)					
Mean (SD)	9.75 (1.25)		9.92 (1.11)		10.03 (1.05)
Increase by >0.5 SD		3475 (20.3%)		2755 (18.6%)	
No change		11 700 (68.3%)		10 025 (67.6%)	
Decrease by >0.5 SD		1945 (11.4%)		2045 (13.8%)	
Family status					
Couple only	4875 (28.5%)		5045 (29.5%)		4765 (31.5%)
Couple with children	7035 (41.2%)		6570 (38.4%)		5785 (38.3%)
Sole parent	1555 (9.1%)		1495 (8.7%)		1265 (8.4%)
Not in a family nucleus	3320 (19.4%)		3700 (21.6%)		3445 (22.8%)
Couple only both waves		4120 (25.0%)		3930 (26.2%)	
Couple with children both waves		5845 (35.5%)		5130 (34.2%)	
Sole parent both waves		1095 (6.6%)		945 (6.3%)	
Not in a family both waves		2700 (16.4%)		2585 (17.2%)	
Change in family status		2715 (16.5%)		2405 (16.0%)	
Personal deprivation					
Nil (least deprived)	12 075 (70.6%)		12 445 (72.8%)		10 455 (69.2%)
1 to 2	3390 (19.8%)		3290 (19.2%)		3615 (23.9%)
3 or more (most deprived)	1065 (6.2%)		895 (5.2%)		1015 (6.7%)
Increasing deprivation		1975 (12.3%)		2715 (18.5%)	
No change		11 610 (72.2%)		10 435 (71.1%)	
Decreasing deprivation		2490 (15.5%)		1530 (10.4%)	
Neighbourhood deprivation					
Quintile 1 (least)	3540 (20.7%)		3560 (20.8%)		3380 (22.4%)
Quintile 2	3530 (20.6%)		3615 (21.1%)		3350 (22.2%)
Quintile 3	3100 (18.1%)		3170 (18.5%)		2935 (19.4%)
Quintile 4	3515 (20.6%)		3440 (20.1%)		3065 (20.3%)
Quintile 5 (most)	3095 (18.1%)		3020 (17.7%)		2565 (17.0%)
Increase		1630 (9.9%)		1305 (8.7%)	
No change		13 080 (79.4%)		12 285 (81.7%)	
Decrease		1760 (10.7%)		1440 (9.6%)	

*Non-respondents or missing cases on each variable not shown.
CPI, consumer price index;

44% lesser odds (100%—100%×1/1.77). The interpretations for the two other non-referent categories are similar, and the OR for moving from 'couple only' to 'couple with children' is protective with a 95% CI just including the null (0.73, 0.53 to 1.02). Next, given the imposed mathematical structure of the fixed effects model, one can also calculate other transitions of interest, for example, the OR for 'couple with children' to 'not in family nucleus' is 1.77/0.73=2.42. Finally, one can assess the statistical significance of the overall family status variable with the type III p value, which in this case is highly statistically significant ($p<0.001$).

Transition between waves from employed to inactive was associated with a 32% decrease in the odds of smoking (95% CI 12 to 47). The transition from employed to unemployed was associated with a 57% increase in the odds of smoking, but the 95% CI included the null (ie, 1.0). It is plausible that time-varying health status is confounding the association of moving into the inactive group with decreasing odds of smoking (eg, those becoming unwell may both move out of active labour force and stop smoking due to poor health). Therefore, we also ran model 4, including self-rated health, but the results barely changed (data not shown).

Table 3 Fixed effects logistic regression model of smoking status (current vs ex and never combined)

	1: family and LFS		2: 1 plus household income		3: 1 plus personal income		4: 3 plus deprivation		5a: 4 restricted to <25 years*		5b: 4 restricted to 25+ years*	
Model Variable	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Family status												
Not in family nucleus	1.80	1.29 to 2.50	1.83	1.31 to 2.55	1.77	1.27 to 2.47	1.77	1.26 to 2.47	1.56	0.85 to 2.89	1.63	1.07 to 2.49
Sole parent	0.98	0.64 to 1.49	0.98	0.64 to 1.50	0.99	0.65 to 1.51	1.03	0.68 to 1.58	0.79	0.39 to 1.62	1.58	0.90 to 2.80
Couple with children	0.63	0.46 to 0.87	0.63	0.46 to 0.87	0.68	0.49 to 0.94	0.73	0.53 to 1.02	0.54	0.29 to 1.00	1.03	0.68 to 1.56
Couple only (ref.)	1		1		1		1		1		1	
p Value†		*<0.001*		*<0.001*		*<0.001*		*<0.001*		*<0.001*		*0.063*
Labour force status (LFS)												
Inactive	0.60	0.47 to 0.76	0.60	0.47 to 0.77	0.70	0.54 to 0.90	0.68	0.53 to 0.88	0.93	0.60 to 1.45	0.67	0.48 to 0.94
Unemployed	1.58	0.95 to 2.64	1.59	0.95 to 2.65	1.75	1.04 to 2.93	1.57	0.92 to 2.66	1.71	0.76 to 3.84	1.42	0.68 to 2.96
Employed (ref.)	1		1		1		1		1		1	
p Value†		*<0.001*		*<0.001*		*<0.001*		*0.001*		*0.353*		*0.026*
Log household income			1.06	0.94 to 1.20								
p Value†				*0.314*								
Log personal income					1.23	1.12 to 1.36	1.22	1.11 to 1.35	1.42	1.16 to 1.74	0.99	0.87 to 1.11
p Value†						*<0.001*		*<0.001*		*<0.001*		*0.726*
Individual deprivation‡												
Nil							1		1		1	
1 to 2							1.18	0.97 to 1.44	1.27	0.87 to 1.85	1.01	0.80 to 1.29
3 or more							1.60	1.12 to 2.27	1.63	0.85 to 3.12	1.37	0.89 to 2.10
p Value†								*0.028*		*0.276*		*0.298*
Neighbourhood deprivation§												
Quintile 1 (least)							1		1		1	
Quintile 2							0.96	0.64 to 1.45	0.92	0.46 to 1.84	1.06	0.63 to 1.81
Quintile 3							1.38	0.92 to 2.09	1.30	0.64 to 2.64	1.32	0.77 to 2.24
Quintile 4							1.47	0.99 to 2.18	1.19	0.61 to 2.30	1.35	0.80 to 2.28
Quintile 5 (most)							1.83	1.18 to 2.83	1.31	0.64 to 2.66	1.80	1.00 to 3.25
p Value†								*0.022*		*0.819*		*0.341*

*In addition to these models run separately for <25 and ≥25 year olds, a model was run with all ages combined with interaction terms of age (dichotomous, <25 vs ≥25 years) with all time-varying covariates shown in this table. Only the interaction with the logarithm of personal income was statistically significant (p<0.001). p Values for other interactions were family status 0.12; labour force status 0.38; individual deprivation 0.31; and neighbourhood deprivation 0.94.
†Type III Wald tests, which for multichotomous categorical variables (eg, labour force status) provides a statistical test of the whole construct (not just one non-referent compared with referent comparison).
‡Models were also run with NZiDep as a continuous variable, coded 0,1,2 for the three levels. The OR (95% CI) by model were 4=1.23 (1.05 to 1.44); 5a=1.28 (0.96 to 1.73); and 5b=1.12 (0.92 to 1.36). Coefficients for other covariates in the model change little.
§Models were also run with NZDep as a continuous variable, coded 0,1,2,3,4 for the five levels. The OR (95% CI) by model were 4=1.17 (1.06 to 1.30); 5a=1.08 (0.92 to 1.27); and 5b=1.14 (1.00 to 1.31). Coefficients for other covariates in the model change little.

As changes in smoking status up to 25 years of age are largely driven by initiation, and beyond the age of 25 largely by cessation and relapse, we tested for interactions of all time-varying covariates in model 4 with this age dichotomisation (see footnotes to table 3) and ran models separately by age (models 5a and 5b). The only statistically significant interaction was with personal income ($p<0.001$), whereby a one-unit increase in the log of personal income (a 2.72-fold increase in personal income) was associated with a 1.42 increased odds of smoking among 15–24-year-olds (95% CI 1.16 to 1.74) but had no association among 25+ year olds (OR 0.99).

Regarding deprivation, if someone transitioned from nil to high personal deprivation between waves, his/her odds of smoking increased by 60% compared with someone with no change in deprivation (OR 1.60, 95% CI 1.12 to 2.27; model 4, table 3) and the type III p value was 0.028. Increasing neighbourhood deprivation, from shifting residence, was also strongly associated with increased odds of smoking for all ages combined. For example, moving from quintile 1 to quintile 5 was associated with a 1.83 increased odds of smoking (95% CI 1.18 to 2.83), and treating deprivation quintile as a continuous variable (given the mostly monotonic and linear association for the categorical specification) a one quintile increase in deprivation was associated with a 1.17 increased odds of smoking (1.06–1.30; footnotes to table 3).

Number of cigarettes per day among smokers

Table 4 shows the linear regression results for the number of cigarettes smoked per day, restricted to respondents smoking in two adjacent waves.

Strong patterns are not evident. However, there is a strong impact of family status on the number of cigarettes consumed (type III p value=0.004 in the fully adjusted model). There is evidence that transitioning from couple only to becoming a sole parent is associated with an increase of smoking of 0.78 more cigarettes per day (95% CI −0.01 to 1.57) compared with no change in family status. The more conceptually relevant comparison though is moving from a couple with children to sole parent family. After changing the reference group in this analysis only, respondents transitioning from 'couple with children' to 'sole parent' family have an expected increase of 1.21 cigarettes (95% CI 0.53 to 1.89). Increasing personal deprivation was

Table 4 Fixed effects linear regression model of number of cigarettes smoked per day (among continuing smokers)

Model	1: family and LFS		2: 1 plus household income		3: 1 plus personal income		4: 3 plus deprivation	
Variable	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Family status								
Not in family nucleus	0.31	(−0.32 to 0.93)	0.35	(−0.28 to 0.97)	0.30	(−0.32 to 0.93)	0.31	(−0.31 to 0.94)
Sole parent	0.75	(−0.04 to 1.53)	0.69	(−0.10 to 1.48)	0.74	(−0.05 to 1.53)	0.78	(−0.01 to 1.57)
Couple with children	−0.43	(−1.05 to 0.19)	−0.43	(−1.06 to 0.19)	−0.43	(−1.05 to 0.20)	−0.43	(−1.06 to 0.19)
Couple only (ref.)	0		0		0		0	
p Value*		*0.005*		*0.005*		*0.006*		*0.004*
Labour force status (LFS)								
Inactive	−0.74	(−1.21 to −0.27)	−0.75	(−1.22 to −0.27)	−0.72	(−1.20 to −0.23)	−0.70	(−1.18 to −0.21)
Unemployed	−0.58	(−1.37 to 0.22)	−0.60	(−1.39 to 0.20)	−0.56	(−1.36 to 0.24)	−0.46	(−1.27 to 0.35)
Employed (ref.)	0		0		0		0	
p Value*		*0.008*		*0.008*		*0.013*		*0.018*
Log household income			0.04	(−0.21 to 0.29)				
p Value*				*0.912*				
Log personal income					0.04	(−0.15 to 0.23)	0.04	(−0.16 to 0.23)
p Value*						*0.703*		*0.707*
Individual deprivation								
Nil							0	
1 to 2							−0.11	(−0.47 to 0.27)
3 or more							−0.42	(−1.00 to 0.17)
p Value*								*0.369*
Neighbourhood deprivation								
Quintile 1 (least)							0	
Quintile 2							0.10	(−0.74 to 0.94)
Quintile 3							−0.01	(−0.79 to 0.77)
Quintile 4							0.11	(−0.70 to 0.92)
Quintile 5 (most)							0.10	(−0.75 to 0.95)
p Value*								*0.995*

*Type III Wald tests, which for multichotomous categorical variables (eg, labour force status) provides a statistical test of the whole construct (not just one non-referent compared with referent comparison).

associated with reducing the number of cigarettes per day smoked, but the CI included the null. There was no clear association with increasing neighbourhood deprivation.

DISCUSSION

In the absence of randomised trials on the association of social circumstances with health, repeated measures data where one can observe whether changes over time in social circumstances are associated with changing health status present a strong study design for causal inference. We find strong associations of changing social circumstances with the odds of smoking, but only modest to moderate associations of changing social circumstances with the number of cigarettes smoked per day among respondents who continue to smoke. Table 5 gives a stylised summary of changes in smoking behaviour for what would be usually considered deterioration in social circumstances.

First, the odds of smoking in response to income varies by age: increasing income increases the odds of smoking among young people (almost certainly through an initiation pathway) but has no detectable effect among older people. Decreasing income seemingly has no effect on the number of cigarettes smoked.

Second, increasing deprivation (both personal level and neighbourhood level) is associated with increased odds of smoking. Similar results were found by Shaw *et al*[20], who showed that an increased experience of financial strain was associated with increased odds of both smoking and heavy drinking. Deprivation is not a synonym for income but is rather the consequence of income and many other determinants (eg, hardship, social exclusion). It seems plausible that the stress of personal deprivation, and perhaps, the contagion of neighbourhood deprivation (as deprived neighbourhoods in New Zealand have much higher smoking prevalence) cause people to start smoking—or make it less likely that they can stop.

Third, and as also shown previously in other studies, moving out of the family nucleus was also associated with increased odds of smoking in the present study. Sharing your life with a spouse or starting family life seems to have a positive impact on smoking behaviour[16 18] possibly due to concerns about second-hand smoking or experiencing the support of a partner when

Table 5 Summary of findings

	Change in smoking behaviour	
Change in social circumstance	Odds of smoking	Number of cigarettes per day
Decreasing personal income	↓↓ for 15–24 years—for 25+ years	–
Increasing personal deprivation	↑	– or ↓
Increasing neighbourhood deprivation	↑↑	–
Moving out of a family nucleus	↑↑	–
Moving from employment to 'inactive'	↓	↓
Moving from employment to unemployed	– or ↑	–

trying to quit, whereas dissolution of family life seems to encourage smoking[14 15] possibly as a result of not experiencing such support mechanisms. Moving out of the active labour force, however, was associated with reduced odds of smoking and did not appear to be due to time-varying confounding by health status. Other studies have either found no association between employment trajectories and changes in smoking behaviour[19] or associations between stable employment and trajectories from smoking to non-smoking.[17]

Regarding the number of cigarettes smoked per day, associations were largely null.

Limitations

The advantages of fixed effects analyses of panel data come at a cost; statistical power is usually much diminished as the power now arises from people changing on *both* the exposure of interest and the outcome of interest. CIs in our study are accordingly much wider than they would be for a cross-sectional (but hopelessly confounded) analysis of 15 000 people. That said, our study was still powerful enough to detect associations (and many more than expected purely by chance) with CIs excluding the null.

Initial non-response and subsequent attrition (as is inevitable in a repeated measures study) means that about half of the initially intended population were still in the study by wave 7. Thus, selection bias, whereby the associations between variables observed among those remaining in the study are different from those not participating, is possible. However, we have shown elsewhere for the association of income with self-rated health that there appears to be no difference in the association among those leaving compared with those staying in the study.[25]

Residual time-varying confounding is possible. But if one tracks the associations of each covariate with the outcome across models 1–4 in tables 3 and 4, the strengths of association hardly alter with addition of more and more covariates (and potential time-varying confounders). Thus, if our findings were prone to time-varying confounding, it would have to be for a variable uncorrelated with those we have already adjusted for, and with strong (time varying) associations with both exposure and outcome. This seems unlikely.

Policy implications

Price elasticity of demand is the foundation stone for tobacco taxation. Our study finds a consistent income elasticity of demand for young people only. This adds further support to the view that price and income are particularly important for initiation among young people. As young people leave home and increase their income, the risk of starting smoking increases, pointing to the importance of policies that restrict supply and marketing that acts as a trigger for youth with new money in their pockets.

Supporting a social determinant of health paradigm, we find that increasing deprivation (personal or neighbourhood) is deleterious for the odds of smoking. More generally, simplistic expectations that improving social circumstances will always improve health are challenged by the findings in this paper (at least in the short run) and consistent with recent calls for more nuanced understandings of social determination and inequalities in health.[26] Particularly relevant in this instance are time scale (eg, the acute effects of changes in financial circumstances may differ from the long-run impacts on smoking of greater affluence) and the modifying effects of age. Regarding changes in income, our study is consistent with increased odds of smoking among young people experiencing an increase in income. Over the long run, we would anticipate longstanding improvements in income are more health promoting, consistent with social determinants theory. Longer duration follow-up of repeated measures than we were able to achieve is warranted by researchers with access to such data.

What this paper adds

- Social position determines health status. But the causal associations of changes in social factors with change in smoking behaviour are not well researched or understood.
- This paper uses a panel study with repeated measures to examine changes in smoking with fixed effects regression.
- Worsening social circumstances over the short run are generally deleterious for smoking behaviour, but not always so. For example, decreasing personal income among young people was associated with decreased odds of smoking, consistent with income elasticity of demand (the less one's income, the less one can consume).
- This paper suggests that improving social determinants is not always pro-health over the short run; a more nuanced approach to the social determinants of health is required.

Acknowledgements Access to the data used in this study was provided by Statistics New Zealand in a secure environment designed to give effect to the confidentiality provisions of the Statistics Act, 1975.

Contributors TB initiated the study and obtained funding, and led the conception and design, interpretation and drafting of the paper. FSvdD undertook literature reviews and contributed to interpretation and drafting of the paper. IK and AW contributed to interpretation and drafting of the paper. KC co-leads the SoFIE-Health study, led the analyses and contributed to interpretation and drafting of the paper.

Funding The Health Research Council of New Zealand (grant number: 08/048).

Competing interests None.

Ethics approval Ethics approval was obtained for the SoFIE Health module from the University of Otago Ethics Committee, Wellington. The results in this study and any errors contained therein are those of the author, not Statistics New Zealand.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The SoFIE-Health data are available to bona fide researchers (upon application and approval) in the data laboratory at Statistics NZ. But the unit-level data are not available without Statistics NZ.

REFERENCES

1 Commission on Social Determinants of Health. *Closing the gap in a generation: health equity through action on the social determinants of health*. Geneva: The World Health Organization, 2008.
2 Hill S, Blakely T, Fawcett J, *et al*. Could mainstream anti-smoking programmes increase inequalities in tobacco use? New Zealand data from 1981–1996. *Aust N Z J Public Health* 2005;29:279–84.
3 Ministry of Health. *A portrait of health: key results of the 2006/07 New Zealand health survey*. Wellington: Ministry of Health, 2008.
4 Lawlor D, Frankel S, Shaw M, *et al*. Smoking and ill health: does lay epidemiology explain the failure of smoking cessation programs among deprived populations? *Am J Public Health* 2003;93:266–70.
5 Thomas S, Fayter D, Misso K, *et al*. Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. *Tob Control* 2008;17:230–7.
6 Kostova D, Ross H, Blecher E, *et al*. Is youth smoking responsive to cigarette prices? Evidence from low- and middle-income countries. *Tob Control* 2011;20:419–24.
7 Soteriades S, DiFranza J. Parent's socioeconomic status, adolescents' disposable income, and adolescents' smoking status in Massachusetts. *Am J Public Health* 2003;93:1155–60.
8 Scragg R, Laugesen M, Robinson E. Cigarette smoking, pocket money and socioeconomic status: results from a national survey of 4th form students in 2000. *N Z Med J* 2002;115:U108.

9 Jensen R, Lleras-Muney A. Does staying in school (and not working) prevent teen smoking and drinking? *J Health Econ* 2012;31:644–57.
10 Grossman M. On the concept of health capital and the demand for health. *J Polit Econ* 1972;80:223–55.
11 Zandstra E, Miyapuram K, Tobler P. Understanding consumer decisions using behavioral economics. In: Pammi VSC, Srinivasan N, eds. *Progress in brain research*. Elsevier, 2013:197–211.
12 Allison PD. *Fixed effects regression analysis for longitudinal data using SAS*. Cary, North Carolina: SAS Institute Inc, 2005.
13 Gardiner J, Luo Z, Roman L. Fixed effects, random effects and GEE: What are the differences? *Statist Med* 2009;28:221–39.
14 Lee S, Cho E, Grodstein F, *et al*. Effects of marital transitions on changes in dietary and other health behaviours in US women. *Int J Epidemiol* 2005;34:69–78.
15 Eng PM, Kawachi I, Fitzmaurice G, *et al*. Effects of marital transitions on changes in dietary and other health behaviours in US male health professionals. *J Epidemiol Community Health* 2005;59:56–62.
16 McDermott L, Dobson A, Owen N. Occasional tobacco use among young adult women: a longitudinal analysis of smoking transitions. *Tob Control* 2007;16:248–54.
17 Giordano GN, Lindström M. The impact of social capital on changes in smoking behaviour: a longitudinal cohort study. *Eur J Public Health* 2011;21:347–54.
18 McDermott L, Dobson A, Owen N. Smoking reduction and cessation among young adult women: a 7-year prospective analysis. *Nicotine Tob Rese* 2008;10:1457–66.
19 Virtanen P, Vahtera J, Broms U, *et al*. Employment trajectory as determinant of change in health-related lifestyle: the prospective HeSSup study. *Eur J Public Health* 2008;18:504–8.
20 Shaw BA, Agahi N, Krause N. Are changes in financial strain associated with changes in alcohol use and smoking among older adults? *J Stud Alcohol Drugs* 2011;72:917–25.
21 Carter KN, Cronin M, Blakely T, *et al*. Cohort profile: Survey of Families, Income and Employment (SoFIE) and Health Extension (SoFIE-health). *Int J Epidemiol* 2009;39:653–9.
22 Salmond C, Crampton P, Atkinson J. *NZDep2006 index of deprivation*. Wellington: Department of Public Health, University of Otago, 2007.
23 Salmond C, Crampton P, King P, *et al*. NZiDep: a New Zealand index of socioeconomic deprivation for individuals. *Soc Sci Med* 2006;62:1474–85.
24 Edwards R, Peace J, Carter K, *et al*. An examination of smoking initiation rates by age: results from a large longitudinal study in New Zealand. *Aust & NZ J Public Health*. In press.
25 Carter K, Imlach Gunasekara F, Mckenzie S, *et al*. Differential loss of participants does not necessarily cause selection bias. *Aust N Z J Public Health* 2012;36:218–22.
26 Mackenbach JP. The persistence of health inequalities in modern welfare states: the explanation of a paradox. *Soc Sci Med* 2012;75:761–9.

TC

Do changes in income, deprivation, labour force status and family status influence smoking behaviour over the short run? Panel study of 15 000 adults

Tony Blakely, Frederieke S van der Deen, Alistair Woodward, et al.

Tob Control published online September 3, 2013
doi: 10.1136/tobaccocontrol-2012-050944