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Is cost-related non-collection of prescriptions associated with a reduction in health? Findings from a large-scale longitudinal study of New Zealand adults

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Abstract

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Objective

To investigate whether cost-related non-collection of prescription medication is associated with a decline in health

Methods

Data from 17,363 participants with at least two observations in three waves (2004-05, 2006-07, 2008-09) of a panel study were analysed using fixed effects regression modelling.

Self-rated health (SRH), physical health (PCS) and mental health summary scores (MCS) were the health measures used in this study. The main exposure, not collecting one or more prescription items because of cost, was dichotomised as 'collection' versus 'non collection'.

Results

After adjusting for time-varying confounders, non-collection of prescription items was associated with a 0.11 (95% CI 0.07 - 0.15) unit worsening in SRH, a 1.00 (95% CI 0.61 - 1.40) unit decline in PCS, and a 1.69 (95% CI 1.19 - 2.18) unit decline in MCS. The interaction of the main exposure with gender was significant for SRH and MCS. Non-collection of prescription items was associated with a decline in SRH of 0.18 (95% CI 0.11 - 0.25) units for males and 0.08 (95% CI 0.03 - 0.13) units for females, and a decrease in MCS of 2.55 (95% CI 1.67 - 3.42) and 1.29 (95% CI 0.70 - 1.89) units for males and females respectively. The interaction of the main exposure with age was significant for SRH. For respondents aged 15-24 years and 25-64 years, non-collection of prescription items was associated with a decline in SRH of 0.12 (95% CI 0.03 - 0.21) and 0.12 (95% CI 0.07 - 0.17) units respectively, but for respondents aged 65 years and over non-collection of prescription items had no significant effect on SRH.

Conclusion

Our results show that those who do not collect prescription medications because of cost have an increased risk of a subsequent decline in health.

Keywords: Primary health care; Prescription medicine; Health; Cost-related medication non-adherence; Longitudinal; Fixed effects; New Zealand

Article Summary

Article focus

- Whether cost-related non-collection of prescription medication is associated with a decline in health

Key messages

- Non-collection of prescription medications because of cost was associated with an increased risk of poorer self-rated health, and physical and mental health summary scores.
- Non-collection of prescription items because of cost was associated with significantly poorer self-rated health and mental health summary scores for males than for females.
- Non-collection of prescription items was associated with significantly poorer self-rated health for respondents aged 15-24 years and 25-64 years, but had no significant effect for respondents aged 65 years and over.

Strengths and limitations of this study

- A panel study design and a large sample of adult population.
- Use of fixed effects regression which controls for all unmeasured time-invariant and known time varying confounders.
- Use of multiple measures of health outcome
- Measurement errors in self-reported health measures
- Residual selection bias due to attrition of respondents from the survey
- Violation of fixed effects assumptions

Introduction

Since the Rand study in the 1980s it has been clear that prices significantly affect consumption of healthcare [1] even in countries that have generous drug coverage [2-5]. Increasing charges for prescription medicines and or cost barriers to collecting prescription medication have been associated with lower rates of use [6-9], lower prescription medicine compliance [6], more frequent discontinuation [6] and increased use of health services amongst some groups [6 8].

Less is known about the extent to which cost-related restriction of medications is associated with adverse health outcomes. The evidence is limited to cross-sectional studies of selected groups, such as elderly persons and welfare recipients [10], the elderly [11], adults with disabilities [12], older adults with diabetes [13 14], Medicare beneficiaries [15] and indigent patients with heart disease [16]. Since these are cross-sectional in design, they are susceptible to unmeasured confounding bias. Developing a better understanding of the impact of non-collection or deferral of prescription medication requires longitudinal data on both prescription medication deferral and health. One of the few studies to explore the longitudinal relationship between cost-related deferral of prescription medicines and health showed that for middle-aged and elderly Americans, deferral led to poorer self-rated health, and higher rates of some cardiovascular events amongst those with existing cardiovascular disease [17]. This group was also more likely to be hospitalised within two years of reported prescription deferral [18]. However, Heisler et al. focussed on adults aged 51 to 61 and 70 or older, and had a relatively short follow up period (2-3 years). It also had methodological limitations, such as not accounting for time-invariant unmeasured confounding or serial correlation.

Apart from being cross-sectional, much of the research on the impact of prescription charges has been done in the US, where people pay large amounts for prescription medicines, particularly if they are uninsured or under-insured. Even people covered by the Medicare Prescription Drug Benefit (known as Part D) pay significant amounts for prescription medicines and there is a coverage gap [19]. In countries with public health systems prescription charges are generally lower, and those on low incomes and/or with high healthcare needs are often exempted [20]. In the UK, prescriptions are free of charge in Wales, Ireland and Scotland, whereas in England, people under 16, over 60, or dependent on government benefits receive free prescriptions [21 22]. In New Zealand, prescription charges are low (N$3.00 (£1.46) during the study and currently NZ$5.00 (£2.43) per item) but only children under 6 years of age are currently exempted. There is evidence that even these low charges lead to cost-related deferral [23], but not whether this deferral leads to poor health outcomes. Although it is likely that increases in relatively high initial prices (such as in the US) could lead to people deferring medicines that are crucial for maintaining health, there is no evidence about whether increases in relatively low prices might have the same effect.

In this study, we examine the association of cost-related non-collection of prescription medication with health status using a national panel study of adult New Zealanders. We used fixed effects analyses that remove all observed and unobserved time-invariant confounding, allowing a more robust assessment of causal associations than is possible with non-repeated-measures data. We hypothesise that after adjusting for demographic, socioeconomic and behavioural factors, and accounting for unmeasured time-invariant confounders (unobserved fixed characteristics of individuals such as intelligence or beliefs that are likely to be associated with both deferral and health), those who do not collect one or more prescription

medication would be more likely to experience a decline in self-rated, physical, and mental health.

Methods

Data

This research used data from three waves of the SoFIE-Health survey, which is an add-on to the Statistics New Zealand Survey of Family, Income and Employment SoFIE Version 2, Wave 1 to 7: [24]. SoFIE is an 8 year (2002-2010) longitudinal household panel survey. Computer-assisted face-to-face interviews were used to collect data annually on income levels and sources, and on the major influences on income such as employment and education, household and family status, demographic factors, and health status.

The population covered by SoFIE are those living in private dwellings i.e., excluding people living in institutions or establishments such as boarding houses and rest homes. The initial SoFIE sample comprised approximately 11,500 responding private households (response rate 83%) with 22,200 adults (aged 15 years and older) responding in wave 1, reducing to just over 20,000 in wave 2 (91% of wave 1 responders) and over 19,000 in wave 3 (86% of wave 1 responders). By wave 7, there were almost 17,000 (76% of wave 1) from the original sample still participating. Higher rates of attrition occurred in youth, ethnic minorities and people on lower income and reporting poor health [25]. On average, 17,377 respondents contributed information from at least 2 waves to this analysis.

The SoFIE-Health add-on is comprised of 20 minutes of questionnaire time in waves 3 (2004-05), 5 (2006-07) and 7 (2008-09), in the following health-related domains: SF-36

(Short-Form health survey), Kessler-10 (K-10), perceived stress [26], chronic conditions (heart disease, diabetes, and injury-related disability), tobacco smoking, alcohol consumption, access and continuity of primary health care, and an individual socioeconomic deprivation score.

Measures

The main exposure, not collecting a prescription, was measured by the following question: 'In the past 12 months, have there been any times when a doctor gave you a prescription, but you did not collect one or more of these items because you could not afford the cost? If yes, how many times have you done this in the last 12 months? We dichotomised responses into collection/ non-collection (or not deferred/deferred) for each of waves 3, 5, and 7..

The three health outcome measures used in this study are all derived from the SF-36 questionnaire. The SF-36 is one of the most widely used self-completion measures of health status (Coons et al. 2000), has been validated for the detection of changes in health over time (Hemingway et al. 1997), and is considered to be reliable for use in the NZ population [27]. It consists of 36 questions about the health related quality of life of respondents. These are formed into eight domains of health, which are then used to create two psychometrically-based physical and mental health summary measures: the Physical Component Summary (PCS) and the Mental Component Summary (MCS) (Ware & Kosinski, 2001). The PCS and MCS vary between 0 (worst health) and 100 (best health) and are standardised to the NZ population with a mean of 50 and a standard deviation of 10. Both PCS and MCS were modelled as continuous outcomes in regression analyses. A score of 100 in physical functioning indicates an ability to perform all activities without limitations due to health; whereas a score of 100 in mental health indicates an ability to function without personal or emotional problems. Global SRH was based on the question "In general would you say your

health is: excellent, very good, good, fair, or poor?" In this study, SRH was coded to have values between 1 (excellent health) and 5 (poor health) and for consistency with PCS and MCS was also modelled as a continuous variable.

Time varying confounders measured at each wave were labour force status, marital status, family structure, NZ Deprivation Index 2001 a measure of small area deprivation, categorized into quintiles, where quintile 5 corresponds to high deprivation: [28], wave (accounting for the effect of time), and NZiDep a measure of individual deprivation: [29].

Also used in the analysis were the time-invariant covariates age (at first interview), sex, and ethnicity. The ethnicity variable was constructed using a "prioritised" definition. Each respondent was assigned to a mutually exclusive ethnic group by means of a prioritisation system commonly used in New Zealand: Māori (the indigenous people of New Zealand), if any of the responses to self-identified ethnicity was Māori; Pacific, if any one response was Pacific but not Māori; Asian, if any one response was Asian but not Māori/Pacific; the remainder non-Māori non-Pacific non-Asian (nMnPnA; mostly New Zealanders of European descent, but strictly speaking not an ethnic group). The reference group was nMnPnA. Early adulthood is a time of important transitions and the same is true of the period post-retirement. Thus the age covariate was categorised into those less than 25 years, 25-65 years, and 65 years or over to see whether these life-course events impacted on the association between non-collection of prescriptions and health.

Analyses

Analyses were conducted on an unbalanced panel of eligible wave 1 respondents (17,677) who responded in at least 2 of waves 3, 5 or 7, and were aged more than 15 years. We hypothesised that the health of those who defer paying for prescription medication would get

worse, and to determine if this was the case we computed means and standard deviations of health outcomes for respondents who did not collect a prescription in at least one of 2 or 3 waves. Transition probabilities for prescription deferral averaged over waves 3, 5 and 7 were computed to show the typical proportion of SoFIE respondents that changed prescription collection status between waves.

We modelled health outcomes using a linear fixed effects model. Such models eliminate variables representing time-invariant unobserved confounding, modelled as a set of fixed parameters (one for each respondent), by mean differencing [30 31]. Parameter estimates can be interpreted as the response to a 1-unit change in exposure (continuous exposure) or relative to the reference group (categorical exposure) considered contemporaneously.

Fixed effects analysis only uses changes occurring within the same individuals over time to estimate effects and ignores observations on variables that do not change temporally. However, it is possible to fit interactions between time-varying and time-invariant variables in a fixed effects model. We tested for interactions between age and prescription collection status, gender and prescription collection status, ethnicity and prescription collection status, and number of longitudinal observations for each respondent, to detect differences between younger and older age groups, between men and women, between ethnic groups, and between respondents with 2 or 3 responses over waves 3, 5, and 7 respectively in the association between prescription collection status and the three health outcomes.

All counts presented in this paper are rounded means of sample counts from waves 3, 5 and 7 and comply with the Statistics New Zealand protocols for such quantities. Analyses were carried out within the Statistics NZ data laboratory using the R statistical environment (http://www.r-project.org) for statistical computation, version 3.0.1, available from the

Comprehensive R archive Network (CRAN) website (http://cran.r-project.org). The R package *plm* version 1.4-0 was used to fit fixed effects models.

Results

Mean values for the three health outcomes and empirical distributions of covariates are shown in Tables 1a and 1b by the proportion of waves where respondents reported not-collecting a prescription item. For all outcome measures, health got worse as the proportion of waves in which non-collection of a prescription item was reported increased.

Overall, most respondents collected all prescription items (i.e., did not report non-collecting any prescription items because of cost) in every wave for which they responded (Table 1b), but there were some variations in this pattern within covariates. For example, relatively more married respondents collected all prescription items in every wave (92.1%) than previously married (87.3%) or never married (87.1%) respondents. Within levels of family status, the highest proportion of collecting all prescription items in every wave occurred for couple-only families (95.8%) and the lowest for sole parents (76.3%). Working and not-working respondents had similar levels of prescription item collection in every wave (about 90%). A higher proportion of respondents from the least deprived areas collected all prescription items in every wave (93.1%) than respondents from the most deprived areas (82.5%). Similarly, a higher proportion of the least individually deprived respondents collected all prescription items in every wave (96.1%) than the most individually deprived (50.5%), and relatively more respondents with degree or higher qualifications collected all prescription items in every wave (93.8%) than those with no qualifications (88.3%). Amongst the time-invariant covariates, a larger proportion of respondents older than 65 years collected all prescription items in all waves (98%) than respondents aged 15-24 years (88.3%), males collected all prescription items in every wave more often than females (93.4% and 87.7% respectively),

and Asian respondents collected all prescription items more often (93.8%) than European (92.2%), Maori (80.8%) or Pacific respondents (76.0%). Typically, these patterns reversed for respondents who did not collect prescription items in every wave, though the number of respondents tended to be small in this case.

Empirical transition probabilities between prescription collection status (collection or non-collection) in successive waves are provided in Table 2. A respondent who collected all prescription items in wave 3 (say), was very likely to have also collected all prescription items in wave 5 (average probability 97.4%). Since prescription item collection status has 2 levels, it follows that in only 2.6% of cases did a respondent collect a prescription item in wave 3 but not in wave 5. However, a respondent that did not collect a prescription item in wave 3 was more likely to collect all (68.8%) than not collect all (31.2%) prescription items in waves 5. The same remarks apply to exposure transitions between waves 5 and 7.

Covariate effects for linear fixed effects panel models with no time-invariant interactions (i.e., averaged across age, gender and ethnicity) are presented in Table 3 for each health outcome. Non-collection of prescription items was associated with a 0.11 (95% CI 0.07 - 0.15) unit decline in SRH, a 1.00 (95% CI 0.61 - 1.40) unit decline in PCS, and a 1.69 (95% CI 1.19 - 2.18) unit decline in MCS.

For SRH, interactions of the main exposure with gender and age were significant. Allowing for those interactions, non-collection of prescription items was associated with a decline in SRH of 0.18 (95% CI 0.11 - 0.25) for males and 0.08 (95% CI 0.03 - 0.13) for females. For respondents aged 15-24 years or 25-64 years, non-collection of prescription items was associated with a decline in SRH of 0.12 (95% CI 0.03 - 0.21) and 0.12 (95% CI 0.07 - 0.17)

units respectively, but for respondents aged 65 years and over non-collection of prescription items had no significant effect on SRH. The interaction of the main exposure with gender was significant for MCS. Allowing for this, non-collection of prescription items was associated with a decrease in MCS of magnitude 2.55 (95% CI 1.67 - 3.42) and 1.29 (95% CI 0.70 - 1.89) units for males and females respectively. Interactions of the main exposure with age, gender, and ethnicity were not significant for PCS, and interactions of the main exposure with the number of observations per respondent were not significant for any health outcome.

Discussion & Conclusion

Principal findings

First, those who did not collect prescription medications because of cost had an increased risk of poorer health. Second, non-collection of prescription items was associated with significantly poorer SRH and MCS for males than for females. Third, non-collection of prescription items was associated with significantly poorer SRH for respondents aged 15-24 years and 25-64 years, but had no significant effect for respondents aged 65 years and over. Fourth, these results are net of all time-invariant confounding

Strengths and weaknesses

The strengths of the study are the panel study design based on 18,000 adults, and fixed effects analysis that removes all time invariant confounding (known or unknown) and known time varying confounders (e.g. household composition, labour force status). To our knowledge, this is the first longitudinal study to specifically examine the association between cost-related non-collection of prescription items and health, net of all but unknown time varying confounders. The main limitation with fixed effects analysis is that these models do not allow for either the effect of current health on future prescription collection status (reverse causation), or past health on future health (state dependence) which violate the strict exogeneity condition required by fixed effects methods [31 32]. Additionally, our analyses may be affected by selection bias if those who dropped from the study reported substantially more or less deferral. However, we found no evidence that exposure-outcome associations differed between those that contributed information to 2 or 3 waves. If those that dropped out from the study before wave 3 or contributed to only one of waves 3, 5, or 7 were more likely to report non-collection of prescription medication, then the true population relationship between

prescription deferral and declining health would be stronger than found in this study. However, the collection-health relationship in these "drop-outs" would need to be very different to the "stay-ins" to change our conclusions. As with other self-reported surveys, health status is measured using self-reported data which rely on the ability of respondents to recall information accurately. While SRH is widely used in the social sciences and is a well-established and reliable instrument in cross-sectional studies [33 34], its longitudinal reliability is less well-studied. Thus in longitudinal studies SRH may suffer from a variety of biases including measurement error e.g., from ceiling effects [32].

Strengths and weaknesses in relation to other studies

As mentioned in the introduction, few previous studies have considered the health impact of not collecting prescription drugs. Even fewer have provided longitudinal evidence. This work extends findings from the previous longitudinal study of Heisler et al. 2004 which had only middle-aged or older adults and a shorter follow-up. Our study included the total adult population over 15 and had a longer follow up (5 years). Moreover, in Heisler et al. 2004, over half of those who restricted medicines use because of cost had no insurance coverage for medicines and therefore are likely to have faced far higher prescription costs than those in our study.

Our finding that non-collection of prescriptions had a more significant effect on the health of males than females, particularly in terms of mental health, has not been reported previously. Another study using the same dataset found food insecurity had greater impacts on mental health amongst women [35]. In general females consult general practitioners more frequently and take more prescription medicines [36 37]. It is possible that, on average, the medicines that males take are more crucial to maintaining their health status in the short to medium term,

and therefore deferral has a more dramatic effect. An alternative interpretation could be that, within households, medicines for men are prioritised over those for women. Such a pattern has been reported for food within households in some developing countries [38]. If this is the case, then not being able to afford men's medicines may indicate more severe financial hardship. Further research is needed to confirm this finding and explore these interpretations.

In our study non collection of prescription medicines did not result in a decline in self-reported health amongst elderly people, unlike Heisler et al 2004. Non-collection of a prescription item due to cost seems to be relatively uncommon amongst the elderly in New Zealand (2% in this study) probably because universal superannuation ensures relatively low rates of poverty amongst the elderly [39]. Non-collection of prescription medication could therefore be less commonly experienced by those elderly people so that the effect on health is harder to measure, or perhaps high levels of prescribing to the elderly mean that drugs that do not affect their (self-rated) health can be deferred [40]. In contrast, rates of poverty amongst young people (15-24) and the working age population (25-64) are higher [41], and people in these age groups are likely to face higher charges for primary care. During the study period extra funding was provided to primary health organisations to reduce fees for those over 65 years from 2004, while for those 19-65 years the fee reduction was introduced in tranches from 2005 to 2007 [42]. Therefore younger people who do not collect all their prescriptions may defer more of them than elderly who do not collect all of theirs.

Meaning of the study

The study findings increase understanding of the importance of cost-related non-collection of prescription drugs in the context of addressing and improving the health of the population. Given the importance of prescription medication in maintaining health and treatment of both

acute and chronic illness, it is important to design a co-payment regime that ensures that prescriptions are affordable. Co-payments in New Zealand are low by international standards and most people in each of the waves did not report having to not-collect prescription items because of cost. However for the subset of the population who did have to defer prescription items this resulted in poorer health. Ensuring access to prescription medicines for this group needs attention. In Quebec the public insurer has eliminated co-payments for people on low incomes, and as a result such people are more likely to pick up prescription medicines [43].

Governments and insurance companies in many countries are battling with increasing prescription medicines expenditure. One common response has been to shift costs onto patients and at the same time to discourage 'unnecessary' use by increasing prescription charges [7 44-46]. This study's finding that even very modest prescription charges lead to non-collection of prescription medication that is associated with a measurable decline in health status should be weighed against the modest income the New Zealand government generates from such charges. The New Zealand Treasury estimated the recent increase in prescription charges from $3 to $5 could lead to an additional $45-50 million in revenue [47]. Their discussion of the costs and benefits did not include any potential negative health outcomes from increasing charges: this study shows that these could be significant. The increase in revenue from an increase in co-payments has to be weighed against the evidence that higher co-payment for prescription drugs lead to reduction in demand for pharmaceuticals (and or increase in non-collection of prescription medication) with a simultaneous increase in the demand for acute care [48] which may be more costly. Even a marginal increase in non-collection of prescription medication is likely to increase rates of poor health (and in a public health system, higher costs for treatment elsewhere). The additional revenue generated by an

increase in prescription charges could be partly or wholly offset by the cost increased associated with higher hospitalisation and demand for acute care.

Unanswered questions and future research

First, our study did not ask about the perceived need or type of medication that was deferred because of cost. Second, this study did not identify other reasons for deferring prescription medicines, such as geographical distance, or the cost of medical care for other family members. Future research should also look at the accumulated exposure to non-collection, i.e., how many prescription items or how many times one needs to not-collect prescription medication to have an effect on health. More general models (e.g., g-method estimators) can provide unbiased results when there are complex dynamics of evolving exposures and outcomes [49-51], but such methods are beyond the scope of this analysis which focussed on the association between health and deferral of prescriptions net of measured time-varying and unmeasured time-invariant confounding.

What is already known on this subject?

- Cost-related non-collection/restriction of medications is associated with adverse health outcomes. However, evidence is limited to selected groups, such as elderly persons and welfare recipients, and adults with disabilities, and comes from cross sectional studies which are susceptible to unmeasured confounding bias.
- Studies have previously been carried out in countries where people face high costs for medicines.
- There is limited research evidence on the health consequences of not collecting prescription medications because of cost from longitudinal studies.

What this paper adds?

- This study used longitudinal data and fixed effects methods to investigate whether cost-related non-collection of prescription medication is associated with a decline in self-rated health (SRH), physical health (PH), and mental health (MH)in a large sample of adults collected over 5 years.
- The study found that those who do not collect prescription medications because of cost have an increased risk of a decline in all health measures.
- This study also found significant differences in the exposure-health association by gender and age for SRH, and by gender for MCS.
- Even small prescription charges can prevent people obtaining medicines that are important for their health.

Statistics New Zealand Security Statement

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. The results in this study and any errors contained therein are those of the authors, not Statistics New Zealand.

Disclaimer

Opinions expressed in this paper are those of the authors only and do not necessarily represent the views of peer reviewers or the University of Otago.

Contributors

SJ conceived the study, and planned the analyses, interpretation and drafting of the paper. KR led the analyses, and contributed to interpretation and drafting of the article. PN and PC contributed to drafting of article. All authors approved the final version.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethics approval University of Otago Human Ethics Committee.

Transparency

SJ affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

CK affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Data sharing

The SoFIE-Health unit record data are available to bona fide researchers (upon application and approval) in the data laboratory at Statistics NZ.

Copyright Licence Statement

Table 1a: Means and standard errors of health outcomes where respondents did not collect one or more prescription items for financial reasons in at least one of waves 3, 5, and 7 for the unbalanced SoFIE-Health panel.

	Proportion of waves where one or more prescription items were not collected				
	100%[1]	**67%[2]**	**50%[3]**	**33%[4]**	**0%[5]**
SRH	2.805(0.054)	2.616(0.037)	2.410(0.049)	2.431(0.020)	2.101(0.005)
PCS	47.501(0.520)	48.131(0.370)	50.370(0.465)	49.675(0.194)	51.536(0.044)
MCS	36.072(0.843)	41.993(0.521)	43.233(0.683)	44.451(0.271)	51.375(0.047)

1. Two non-collections in two waves or three non-collections in three waves
2 Two non-collections in three waves
3. One non-collection in two waves
4. One non-collection in three waves
5. No non-collections in two or three waves

Table 1b: Sample counts and proportions for the number of occasions where respondents did not collect one or more prescription items for financial reasons in at least one of waves 3, 5, and 7 by demographic strata for the unbalanced SoFIE-Health panel.

	Proportion of waves where one or more prescription items were not collected deferred				
	100%[1]	**67%[2]**	**50%[3]**	**33%[4]**	**0%[5]**
Total	460(0.9)	900(1.8)	49010.0)	2885(5.9)	44150(90.3)
Marital status					
Never Married	135(1.3)	265(2.6)	200(1.9)	745(7.1)	9080(87.1)
Previously Married	120(1.6)	195(2.7)	70(1.0)	535(7.4)	6300(87.3)
Married	205(0.7)	440(1.4)	220(0.7)	1600(5.1)	28770(92.1)
Family Status					
Couple Only	25(0.2)	100(0.7)	65(0.5)	410(2.9)	13815(95.8)
One Person	110(1.1)	205(2.0)	120(1.1)	655(6.3)	9230(89.5)
Sole Parent	145(3.3)	245(5.5)	125(2.8)	540(12.2)	3380(76.3)
Couple with Dependents	180(0.9)	355(1.8)	185(0.9)	1280(6.5)	17730(89.9)
Labour Force Status					
Working	260(0.8)	525(1.6)	290(0.9)	1890(5.8)	29690(90.9)
Not Working	205(1.3)	375(2.3)	200(1.2)	995(6.1)	14460(89.1)
NZ Deprivation					
Least Deprived	165(0.5)	355(1.2)	180(0.6)	1375(4.5)	28190(93.1)
Medium Deprived	125(1.3)	200(2.0)	145(1.5)	680(6.8)	8850(88.5)
Most Deprived	170(2.0)	345(4.0)	165(1.9)	825(9.6)	7110(82.5)
NZ Individual Deprivation					
0	55(0.2)	155(0.4)	140(0.4)	1020(2.9)	34205(96.1)
1-2	150(1.4)	370(3.6)	210(2.0)	1170(11.3)	8455(81.7)
3-7	260(8.7)	375(12.7)	135(4.6)	690(23.4)	1495(50.5)
Highest Qualification					
Degree or Higher	50(0.7)	60(0.8)	50(0.7)	305(4.1)	6990(93.8)
No Qualification	135(1.2)	260(2.3)	150(1.3)	765(6.8)	9910(88.3)
School Qualification	85(0.6)	205(1.6)	125(1.0)	760(5.9)	11810(90.9)
Vocational Qualification	195(1.1)	370(2.1)	160(0.9)	1055(6.1)	15435(89.7)
Age					
15-24	75(1.0)	155(2.0)	145(1.8)	545(6.9)	6975(88.3)
25-64	375(1.1)	715(2.1)	320(1.0)	2245(6.7)	29665(89.0)
> 65	10(0.1)	30(0.4)	20(0.3)	95(1.2)	7510(98.0)
Sex					
Male	130(0.6)	235(1.1)	170(0.8)	935(4.2)	20820(93.4)
Female	330(1.2)	665(2.5)	320(1.2)	1950(7.3)	23335(87.7)
Ethnicity					
nMnPnA	285(0.7)	550(1.4)	265(0.7)	1965(5.0)	35985(92.2)
Maori	130(2.4)	215(3.9)	135(2.4)	580(10.5)	4435(80.8)
Pacific	40(2.1)	105(5.4)	75(3.7)	250(12.8)	1480(76.0)
Asian	10(0.3)	30(1.2)	20(0.8)	90(3.7)	2255(93.8)

Note: Total counts are rounded means

1. Two non-collections in two waves or three non-collections in three waves
2 Two non-collections in three waves
3. One non-collection in two waves
4. One non-collection in three waves
5. No non-collections in two or three waves

Table 2: Empirical transition probabilities (%) computed from counts of the number of times respondents reported the indicated pair of prescription collection states in successive observations over 3 waves. Transition probabilities were derived by dividing these counts by row totals.

	To (wave *w+2*)	
from (*w*)	*Collection*	*Non-Collection*
Collection	**97.4**	2.6
Non-Collection	68.8	**31.2**

Table 3: Estimates with 95% confidence intervals from linear fixed effects regression models for three health outcomes. Main exposure was prescription collection status. P-values represent the significance of each covariate level.

Characteristics	SRH		PCS		MCS	
	Estimate (CI)	p-value	Estimate (CI)	p-value	Estimate (CI)	p-value
Collection status						
Collection	1		1		1	
Non-Collection	0.11 (0.07,0.15)	0.00000	-1.00 (-1.40,-0.61)	0.00000	-1.69 (-2.18,-1.19)	0.00000
Wave						
3	1		1		1	
5	0.07 (0.05,0.08)	0.00000	0.03 (-0.11,0.16)	0.70634	0.24 (0.08,0.41)	0.00488
7	0.16 (0.14,0.17)	0.00000	-0.66 (-0.80,-0.51)	0.00000	0.23 (0.05,0.41)	0.01194
Marital status						
Never Married	1		1		1	
Previously Married	-0.02 (-0.08,0.05)	0.62482	-0.56 (-1.16,0.05)	0.07313	-0.80 (-1.55,-0.04)	0.03903
Married	0.00 (-0.05,0.06)	0.88864	-0.82 (-1.35,-0.30)	0.00224	0.75 (0.10,1.40)	0.02466
Family Type						
Couple Only	1		1		1	
One Person	0.01 (-0.03,0.06)	0.62878	0.18 (-0.26,0.62)	0.42776	-0.30 (-0.85,0.24)	0.27493
Sole Parent	-0.04 (-0.10,0.03)	0.24965	0.76 (0.15,1.38)	0.01517	-0.23 (-0.99,0.53)	0.56022
Couple with Children	-0.01 (-0.05,0.02)	0.48955	0.05 (-0.29,0.40)	0.76646	-0.06 (-0.49,0.37)	0.78074
Labour force status						
Employed	1		1		1	
Not Employed	0.05 (0.03,0.08)	0.00018	-0.71 (-0.97,-0.44)	0.00000	-0.77 (-1.10,-0.44)	0.00000
NZDep						
Least Deprived	1		1		1	
Middle Deprived	-0.02 (-0.06,0.01)	0.20890	0.23 (-0.12,0.58)	0.19233	-0.13 (-0.57,0.30)	0.55401
Most Deprived	0.03 (-0.01,0.07)	0.18671	-0.06 (-0.48,0.36)	0.79575	-0.56 (-1.08,-0.04)	0.03667
NZiDep						
0 dep	1		1		1	
1-2 dep	0.06 (0.03,0.08)	0.00000	-0.12 (-0.34,0.10)	0.28342	-1.27 (-1.54,-0.99)	0.00000
3-7 dep	0.13 (0.09,0.17)	0.00000	-0.64 (-1.07,-0.21)	0.00363	-3.24 (-3.77,-2.71)	0.00000
Education						
Degree or Higher	1		1		1	
No Education	0.02 (-0.09,0.12)	0.74736	-0.66 (-1.66,0.34)	0.20022	0.40 (-0.84,1.65)	0.52918
School	0.05 (-0.03,0.14)	0.22827	-0.17 (-0.99,0.65)	0.69131	-0.72 (-1.74,0.29)	0.16528
Post-School	0.02 (-0.07,0.11)	0.69048	0.06 (-0.81,0.93)	0.89149	0.01 (-1.07,1.10)	0.97857

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Research checklist

There is not a template with which to perform this type of study. We used STROBE guidelines for cohort studies where possible since the criteria seem generally relevant to a longitudinal study as well. However, the match is imperfect and could not adhere to it rigidly.

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Is cost-related non-collection of prescriptions associated with a reduction in health? Findings from a large-scale longitudinal study of New Zealand adults

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Is cost-related non-collection of prescriptions associated with a reduction in health? Findings from a large-scale longitudinal study of New Zealand adults

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Is cost-related non-collection of prescriptions associated with a reduction in health? Findings from a large-scale longitudinal study of New Zealand adults

Abstract

Abstract

Objective

To investigate whether cost-related non-collection of prescription medication is associated with a decline in health

Settings

New Zealand Survey of Family, Income and Employment (SoFIE)-Health

Participants

Data from 17,363 participants with at least two observations in three waves (2004-05, 2006-07, 2008-09) of a panel study were analysed using fixed effects regression modelling.

Primary outcome measures

Self-rated health (SRH), physical health (PCS) and mental health summary scores (MCS) were the health measures used in this study.

Results

After adjusting for time-varying confounders, non-collection of prescription items was associated with a 0.11 (95% CI 0.07 - 0.15) unit worsening in SRH, a 1.00 (95% CI 0.61 - 1.40) unit decline in PCS, and a 1.69 (95% CI 1.19 - 2.18) unit decline in MCS. The interaction of the main exposure with gender was significant for SRH and MCS. Non-collection of prescription items was associated with a decline in SRH of 0.18 (95% CI 0.11 - 0.25) units for males and 0.08 (95% CI 0.03 - 0.13) units for females, and a decrease in MCS of 2.55 (95% CI 1.67 - 3.42) and 1.29 (95% CI 0.70 - 1.89) units for males and females respectively. The interaction of the main exposure with age was significant for SRH. For respondents aged 15-24 years and 25-64 years, non-collection of prescription items was associated with a decline in SRH of 0.12 (95% CI 0.03 - 0.21) and 0.12 (95% CI 0.07 - 0.17) units respectively, but for respondents aged 65 years and over non-collection of prescription items had no significant effect on SRH.

Conclusion

Our results show that those who do not collect prescription medications because of cost have an increased risk of a subsequent decline in health.

Keywords: Primary health care; Prescription medicine; Health; Cost-related medication non-adherence; Longitudinal; Fixed effects; New Zealand

Article Summary

Strengths and limitations of this study

- A panel study design and a large sample of adult population.
- Use of fixed effects regression which controls for all unmeasured time-invariant and known time varying confounders.
- Use of multiple measures of health outcome
- Measurement errors in self-reported health measures
- Residual selection bias due to attrition of respondents from the survey
- Violation of fixed effects assumptions

Introduction

Since the Rand study in the 1980s it has been clear that prices significantly affect consumption of healthcare including medicines [1] even in countries that have generous drug coverage [2-5]. Increasing charges for prescription medicines and or cost barriers to collecting prescription medication have been associated with lower rates of use [6-9], lower prescription medicine compliance [6], more frequent discontinuation [6] and increased use of health services amongst some groups [6 8].

Less is known about the extent to which cost-related restriction of medications is associated with adverse health outcomes. The evidence is limited to cross-sectional studies of selected groups, such as elderly persons and welfare recipients [10], the elderly [11], adults with disabilities [12], older adults with diabetes [13 14], Medicare beneficiaries [15] and indigent patients with heart disease [16]. Since these are cross-sectional in design, they are susceptible to unmeasured confounding bias. Developing a better understanding of the impact of non-collection or deferral of prescription medication requires longitudinal data on both prescription medication deferral and health. One of the few studies to explore the longitudinal relationship between cost-related deferral of prescription medicines and health showed that for middle-aged and elderly Americans, deferral led to poorer self-rated health, and higher rates of some cardiovascular events amongst those with existing cardiovascular disease [17]. This group was also more likely to be hospitalised within two years of reported prescription deferral [18]. However, Heisler et al. focussed on adults aged 51 to 61 and 70 or older, and had a relatively short follow up period (2-3 years). It also had methodological limitations, such as not accounting for time-invariant unmeasured confounding or serial correlation.

Apart from being cross-sectional, much of the research on the impact of prescription charges has been done in the US, where people pay large amounts for prescription medicines, particularly if they are uninsured or under-insured. Even people covered by the Medicare Prescription Drug Benefit (known as Part D) pay significant amounts for prescription medicines and there is a coverage gap [19]. In countries with public health systems prescription charges are generally lower, and those on low incomes and/or with high healthcare needs are often exempted [20]. In the UK, prescriptions are free of charge in Wales, Ireland and Scotland, whereas in England, people under 16, over 60, or dependent on government benefits receive free prescriptions [21 22]. In New Zealand, prescription charges are low (N$3.00 (£1.46) during the study and currently NZ$5.00 (£2.43) per item) but only children under 6 years of age are currently exempted. There is evidence that even these low charges lead to cost-related deferral [23], but not whether this deferral leads to poor health outcomes. Although it is likely that increases in relatively high initial prices (such as in the US) could lead to people deferring medicines that are crucial for maintaining health, there is no evidence about whether increases in relatively low prices might have the same effect.

In this study, we examine the association of cost-related non-collection of prescription medication with health status using a national panel study of adult New Zealanders. We used fixed effects analyses that remove all observed and unobserved time-invariant confounding, allowing a more robust assessment of causal associations than is possible with non-repeated-measures data. We hypothesise that after adjusting for demographic, socioeconomic and behavioural factors, and accounting for unmeasured time-invariant confounders (unobserved fixed characteristics of individuals such as intelligence or beliefs that are likely to be associated with both deferral and health), those who do not collect one or more prescription

medication would be more likely to experience a decline in self-rated, physical, and mental health.

Methods

Data

This research used data from three waves of the SoFIE-Health survey, which is an add-on to the Statistics New Zealand Survey of Family, Income and Employment SoFIE Version 2, Wave 1 to 7: [24]. SoFIE is an 8 year (2002-2010) longitudinal household panel survey. Computer-assisted face-to-face interviews were used to collect data annually on income levels and sources, and on the major influences on income such as employment and education, household and family status, demographic factors, and health status.

The population covered by SoFIE are those living in private dwellings i.e., excluding people living in institutions or establishments such as boarding houses and rest homes. The initial SoFIE sample comprised approximately 11,500 responding private households (response rate 83%) with 22,200 adults (aged 15 years and older) responding in wave 1, reducing to just over 20,000 in wave 2 (91% of wave 1 responders) and over 19,000 in wave 3 (86% of wave 1 responders). By wave 7, there were almost 17,000 (76% of wave 1) from the original sample still participating. Higher rates of attrition occurred in youth, ethnic minorities and people on lower income and reporting poor health [25]. On average, 17,377 respondents contributed information from at least 2 waves to this analysis.

The SoFIE-Health add-on is comprised of 20 minutes of questionnaire time in waves 3 (2004-05), 5 (2006-07) and 7 (2008-09), in the following health-related domains: SF-36

(Short-Form health survey), Kessler-10 (K-10), perceived stress [26], chronic conditions (heart disease, diabetes, and injury-related disability), tobacco smoking, alcohol consumption, access and continuity of primary health care, and an individual socioeconomic deprivation score.

Measures

The main exposure, not collecting a prescription, was measured by the following question: 'In the past 12 months, have there been any times when a doctor gave you a prescription, but you did not collect one or more of these items because you could not afford the cost? If yes, how many times have you done this in the last 12 months? We dichotomised responses into collection/ non-collection (or not deferred/deferred) for each of waves 3, 5, and 7..

The three health outcome measures used in this study are all derived from the SF-36 questionnaire. The SF-36 is one of the most widely used self-completion measures of health status (Coons et al. 2000), has been validated for the detection of changes in health over time (Hemingway et al. 1997), and is considered to be reliable for use in the NZ population [27]. It consists of 36 questions about the health related quality of life of respondents. These are formed into eight domains of health, which are then used to create two psychometrically-based physical and mental health summary measures: the Physical Component Summary (PCS) and the Mental Component Summary (MCS) (Ware & Kosinski, 2001). The PCS and MCS vary between 0 (worst health) and 100 (best health) and are standardised to the NZ population with a mean of 50 and a standard deviation of 10. Both PCS and MCS were modelled as continuous outcomes in regression analyses. A score of 100 in physical functioning indicates an ability to perform all activities without limitations due to health; whereas a score of 100 in mental health indicates an ability to function without personal or emotional problems. Global SRH was based on the question "In general would you say your

health is: excellent, very good, good, fair, or poor?" In this study, SRH was coded to have values between 1 (excellent health) and 5 (poor health) and for consistency with PCS and MCS was also modelled as a continuous variable.

Time varying confounders measured at each wave were labour force status, marital status, family structure, NZ Deprivation Index 2001 a measure of small area deprivation, categorized into quintiles, where quintile 5 corresponds to high deprivation: [28], wave (accounting for the effect of time), and NZiDep a measure of individual deprivation: [29].

Also used in the analysis were the time-invariant covariates age (at first interview), sex, and ethnicity. The ethnicity variable was constructed using a "prioritised" definition. Each respondent was assigned to a mutually exclusive ethnic group by means of a prioritisation system commonly used in New Zealand: Māori (the indigenous people of New Zealand), if any of the responses to self-identified ethnicity was Māori; Pacific, if any one response was Pacific but not Māori; Asian, if any one response was Asian but not Māori/Pacific; the remainder non-Māori non-Pacific non-Asian (nMnPnA; mostly New Zealanders of European descent, but strictly speaking not an ethnic group). The reference group was nMnPnA. Early adulthood is a time of important transitions and the same is true of the period post-retirement. Thus the age covariate was categorised into those less than 25 years, 25-65 years, and 65 years or over to see whether these life-course events impacted on the association between non-collection of prescriptions and health.

Analyses

Analyses were conducted on an unbalanced panel of eligible wave 1 respondents (17,677) who responded in at least 2 of waves 3, 5 or 7, and were aged more than 15 years. We hypothesised that the health of those who defer paying for prescription medication would get

worse, and to determine if this was the case we computed means and standard deviations of health outcomes for respondents who did not collect a prescription in at least one of 2 or 3 waves. Transition probabilities for prescription deferral averaged over waves 3, 5 and 7 were computed to show the typical proportion of SoFIE respondents that changed prescription collection status between waves.

We modelled health outcomes using a linear fixed effects model. Such models eliminate variables representing time-invariant unobserved confounding, modelled as a set of fixed parameters (one for each respondent), by mean differencing [30 31]. Parameter estimates can be interpreted as the response to a 1-unit change in exposure (continuous exposure) or relative to the reference group (categorical exposure) considered contemporaneously.

Fixed effects analysis only uses changes occurring within the same individuals over time to estimate effects and ignores observations on variables that do not change temporally. However, it is possible to fit interactions between time-varying and time-invariant variables in a fixed effects model. We tested for interactions between the exposure (prescription collection status) and age, gender, ethnicity, individual deprivation, chronic disease/comorbidity status, and number of longitudinal observations for each respondent, to detect differences between younger and older age groups, between men and women, between ethnic groups, between respondents who are more and less deprived, between respondents who have or do not have a chronic or comorbid disease, and between respondents with 2 or 3 responses over waves 3, 5, and 7 respectively in the association between prescription collection status and three health outcomes.

All counts presented in this paper are rounded means of sample counts from waves 3, 5 and 7 and comply with the Statistics New Zealand protocols for such quantities. Analyses were

carried out within the Statistics NZ data laboratory using the R statistical environment (http://www.r-project.org) for statistical computation, version 3.0.1, available from the Comprehensive R archive Network (CRAN) website (http://cran.r-project.org). The R package *plm* version 1.4-0 was used to fit fixed effects models.

Results

Mean values for the three health outcomes and empirical distributions of covariates are shown in Tables 1a and 1b by the proportion of waves where respondents reported not-collecting a prescription item. For all outcome measures, health got worse as the proportion of waves in which non-collection of a prescription item was reported increased.

Overall, a large majority collected all prescription items (i.e., did not report non-collection of any prescription items because of cost) in every wave for which they responded (Table 1b), but there were some variations in this pattern within covariates. For example, relatively more married respondents collected all prescription items in every wave (92.1%) than previously married (87.3%) or never married (87.1%) respondents. Within levels of family status, the highest proportion of collecting all prescription items in every wave occurred for couple-only families (95.8%) and the lowest for sole parents (76.3%). Working and not-working respondents had similar levels of prescription item collection in every wave (about 90%). A higher proportion of respondents from the least deprived (i.e. wealthiest) areas collected all prescription items in every wave (93.1%) than respondents from the most deprived areas (82.5%). Similarly, a higher proportion of the least individually deprived (i.e. wealthiest) respondents collected all prescription items in every wave (96.1%) than the most individually deprived (50.5%), and relatively more respondents with degree or higher qualifications collected all prescription items in every wave (93.8%) than those with no qualifications (88.3%). Amongst the time-invariant covariates, a larger proportion of respondents older than

65 years collected all prescription items in all waves (98%) than respondents aged 15-24 years (88.3%), males collected all prescription items in every wave more often than females (93.4% and 87.7% respectively), and Asian respondents collected all prescription items more often (93.8%) than European (92.2%), Maori (80.8%) or Pacific respondents (76.0%). Typically, these patterns reversed for respondents who did not collect prescription items in every wave, though the number of respondents tended to be small in this case.

Empirical transition probabilities between prescription collection status (collection or non-collection) in successive waves are provided in Table 2. Estimates represent an average for transitions (in collection states) between waves 3 and 5, and between waves 5 and 7. Given those estimates, a respondent who collected all prescription items over the last 12 months before wave 3 (say) was very likely to have also collected all prescription items in the 12 months before wave 5 (average probability 97.4%). In only 2.6% of cases did a respondent collect all prescription items in the 12 months before wave 3 but not in the 12 months before wave 5. However, a respondent that did not collect all prescription items in the 12 months before wave 3 was more likely to collect all (68.8%) than not collect all (31.2%) prescription items in the 12 months before wave 5.

Covariate effects for linear fixed effects panel models with no time-invariant interactions (i.e., averaged across age, gender and ethnicity) are presented in Table 3 for each health outcome. Non-collection of prescription items was associated with a 0.11 (95% CI 0.07 - 0.15) unit decline in SRH, a 1.00 (95% CI 0.61 - 1.40) unit decline in PCS, and a 1.69 (95% CI 1.19 - 2.18) unit decline in MCS.

For SRH, interactions of the main exposure with gender and age were significant. Allowing for those interactions, non-collection of prescription items was associated with a decline in SRH of 0.18 (95% CI 0.11 - 0.25) for males and 0.08 (95% CI 0.03 - 0.13) for females. For respondents aged 15-24 years or 25-64 years, the effect of non-collection of prescription items on SRH was not significantly different, and was associated with a decline in SRH of 0.12 (95% CI 0.03 - 0.21) and 0.12 (95% CI 0.07 - 0.17) units respectively. There was a significant difference in the association of non-collection and SRH for respondents aged 65 years and over (relative to respondents aged 15-24 years), and as a result non-collection of prescription items had no significant effect on SRH for this age group. The interaction of the main exposure with gender was significant for MCS. Allowing for this, non-collection of prescription items was associated with a decrease in MCS of magnitude 2.55 (95% CI 1.67 - 3.42) and 1.29 (95% CI 0.70 - 1.89) units for males and females respectively. Interactions of the exposure with age, gender, and ethnicity were not significant for PCS, and interactions of the exposure with individual deprivation, chronic/comorbid disease status, and the number of observations per respondent were not significant for any health outcome.

Discussion & Conclusion

Principal findings

First, those who did not collect prescription medications because of cost, while a relatively small proportion of the population (less than 10%), had an increased risk of poorer health. Second, non-collection of prescription items was associated with significantly poorer SRH and MCS for males than for females. Third, non-collection of prescription items was associated with significantly poorer SRH for respondents aged 15-24 years and 25-64 years, but had no significant effect for respondents aged 65 years and over. Fourth, these results are net of all time-invariant confounding

Strengths and weaknesses

The strengths of the study are the panel study design based on 18,000 adults, and fixed effects analysis that removes all time invariant confounding (known or unknown) and known time varying confounders (e.g. household composition, labour force status). To our knowledge, this is the first longitudinal study to specifically examine the association between cost-related non-collection of prescription items and health, net of all but unknown time varying confounders. The main limitation with fixed effects analysis is that these models do not allow for either the effect of current health on future prescription collection status (reverse causation), or past health on future health (state dependence) which violate the strict exogeneity condition required by fixed effects methods [31 32]. Additionally, our analyses may be affected by selection bias if those who dropped from the study reported substantially more or less deferral. However, we found no evidence that exposure-outcome associations differed between those that contributed information to 2 or 3 waves. If those that dropped out from the study before wave 3 or contributed to only one of waves 3, 5, or 7 were more likely to report

non-collection of prescription medication, then the true population relationship between prescription deferral and declining health would be stronger than found in this study. However, the collection-health relationship in these "drop-outs" would need to be very different to the "stay-ins" to change our conclusions. As with other self-reported surveys, health status is measured using self-reported data which rely on the ability of respondents to recall information accurately. While SRH is widely used in the social sciences and is a well-established and reliable instrument in cross-sectional studies [33 34], its longitudinal reliability is less well-studied. Thus in longitudinal studies SRH may suffer from a variety of biases including measurement error e.g., from ceiling effects [32].

Strengths and weaknesses in relation to other studies

As mentioned in the introduction, few previous studies have considered the health impact of not collecting prescription drugs. Even fewer have provided longitudinal evidence. This work extends findings from the previous longitudinal study of Heisler et al. 2004 which had only middle-aged or older adults and a shorter follow-up. Our study included the total adult population over 15 and had a longer follow up (5 years). Moreover, in Heisler et al. 2004, over half of those who restricted medicines use because of cost had no insurance coverage for medicines and therefore are likely to have faced far higher prescription costs than those in our study.

Our finding that non-collection of prescriptions had a more significant effect on the health of males than females, particularly in terms of mental health, has not been reported previously. Another study using the same dataset found food insecurity had greater impacts on mental health amongst women [35]. In general females consult general practitioners more frequently and take more prescription medicines [36 37]. It is possible that, on average, the medicines that

males take are more crucial to maintaining their health status in the short to medium term, and therefore deferral has a more dramatic effect. An alternative interpretation could be that, within households, medicines for men are prioritised over those for women. Such a pattern has been reported for food within households in some developing countries [38]. If this is the case, then not being able to afford men's medicines may indicate more severe financial hardship. Further research is needed to confirm this finding and explore these interpretations.

In our study non collection of prescription medicines did not result in a decline in self-reported health amongst elderly people, unlike Heisler et al 2004. Non-collection of a prescription items due to cost seems to be relatively uncommon amongst the elderly in New Zealand (2% in this study) probably because universal superannuation ensures relatively low rates of poverty amongst the elderly [39]. Non-collection of prescription medication could therefore be less commonly experienced by those elderly people so that the effect on health is harder to measure, or perhaps high levels of prescribing to the elderly mean that drugs that do not affect their (self-rated) health can be deferred [40]. In contrast, rates of poverty amongst young people (15-24) and the working age population (25-64) are higher [41], and people in these age groups are likely to face higher charges for primary care. During the study period extra funding was provided to primary health organisations to reduce fees for those over 65 years from 2004, while for those 18-65 years the fee reduction was introduced in tranches from 2005 to 2007 [42]. Therefore younger people who do not collect all their prescriptions may defer more of them than elderly who do not collect all of theirs.

Meaning of the study

The study findings increase understanding of the importance of cost-related non-collection of prescription drugs in the context of addressing and improving the health of the population.

Given the importance of prescription medication in maintaining health and treatment of both acute and chronic illness, it is important to design a co-payment regime that ensures that prescriptions are affordable. Co-payments in New Zealand are low by international standards and a majority in each of the waves did not report not-collect prescription items because of cost. However for the relatively small subset of the population who did have to defer prescription items this resulted in poorer health. While only a small proportion of the population report non-collection of prescription items due to cost, reporting this in one wave means that there was a reasonable probability (31.2%, Table 2) of reporting it again in the next wave. This suggests that some people were repeatedly unable to afford their prescriptions, and, as discussed previously in relation to Table 1a, were therefore likely to experience increasing ill-effects on their health. Ensuring access to prescription medicines for this group needs attention. While it is encouraging that in a publicly-funded system only a small proportion of the population was not collecting prescription medication, it is important to note that even small prescription charges can have a deleterious effect on health. In Quebec the public insurer has eliminated co-payments for people on low incomes, and as a result such people are more likely to pick up prescription medicines [43].

Governments and insurance companies in many countries are battling with increasing prescription medicines expenditure. One common response has been to shift costs onto patients and at the same time to discourage 'unnecessary' use by increasing prescription charges [7 44-46]. This study's finding that even very modest prescription charges lead to non-collection of prescription medication that is associated with a measurable decline in health status should be weighed against the modest income the New Zealand government generates from such charges. The New Zealand Treasury estimated the recent increase in prescription charges from $3 to $5 could lead to an additional $45-50 million in revenue [47]. Their

discussion of the costs and benefits did not include any potential negative health outcomes from increasing charges: this study shows that these could be significant. The increase in revenue from an increase in co-payments has to be weighed against the evidence that higher co-payment for prescription drugs lead to reduction in demand for pharmaceuticals (and or increase in non-collection of prescription medication) with a simultaneous increase in the demand for acute care [48] which may be more costly. Even a marginal increase in non-collection of prescription medication is likely to increase rates of poor health (and in a public health system, higher costs for treatment elsewhere). For example, Tamblyn et al 2001 found that significant increases in serious adverse events and emergency department visits amongst both elderly people and welfare recipients after the introduction of cost-sharing in Quebec [8]. The additional revenue generated by an increase in prescription charges could be partly or wholly offset by the cost increased associated with higher hospitalisation and demand for acute care.

Unanswered questions and future research

First, our study did not ask about the perceived need or type of medication that was deferred because of cost. Second, this study did not identify other reasons for deferring prescription medicines, such as geographical distance, or the cost of medical care for other family members. Future research should also look at the accumulated exposure to non-collection, i.e., how many prescription items or how many times one needs to not-collect prescription medication to have an effect on health. More general models (e.g., g-method estimators) can provide unbiased results when there are complex dynamics of evolving exposures and outcomes [49-51], but such methods are beyond the scope of this analysis which focussed on the association between health and deferral of prescriptions net of measured time-varying and unmeasured time-invariant confounding.

Statistics New Zealand Security Statement

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. The results in this study and any errors contained therein are those of the authors, not Statistics New Zealand.

Disclaimer

Opinions expressed in this paper are those of the authors only and do not necessarily represent the views of peer reviewers or the University of Otago.

Contributors

SJ conceived the study, and planned the analyses, interpretation and drafting of the paper. KR led the analyses, and contributed to interpretation and drafting of the article. PN and PC contributed to drafting of article. All authors approved the final version.

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethics approval University of Otago Human Ethics Committee.

Transparency

SJ affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

CK affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Data sharing

The SoFIE-Health unit record data are available to bona fide researchers (upon application and approval) in the data laboratory at Statistics NZ.

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Table 1a: Means and standard errors of health outcomes where respondents did not collect one or more prescription items for financial reasons in at least one of waves 3, 5, and 7 for the unbalanced SoFIE-Health panel.

	Proportion of waves where one or more prescription items were not collected				
	100%[1]	**67%[2]**	**50%[3]**	**33%[4]**	**0%[5]**
SRH	2.805(0.054)	2.616(0.037)	2.410(0.049)	2.431(0.020)	2.101(0.005)
PCS	47.501(0.520)	48.131(0.370)	50.370(0.465)	49.675(0.194)	51.536(0.044)
MCS	36.072(0.843)	41.993(0.521)	43.233(0.683)	44.451(0.271)	51.375(0.047)

1. Two non-collections in two waves or three non-collections in three waves
2 Two non-collections in three waves
3. One non-collection in two waves
4. One non-collection in three waves
5. No non-collections in two or three waves

Table 1b: Sample counts and proportions for the number of occasions where respondents did not collect one or more prescription items for financial reasons in at least one of waves 3, 5, and 7 by demographic strata for the unbalanced SoFIE-Health panel.

	Proportion of waves where one or more prescription items were not collected deferred				
	100%[1]	**67%[2]**	**50%[3]**	**33%[4]**	**0%[5]**
Total	460(0.9)	900(1.8)	49010.0)	2885(5.9)	44150(90.3)
Marital status					
Never Married	135(1.3)	265(2.6)	200(1.9)	745(7.1)	9080(87.1)
Previously Married	120(1.6)	195(2.7)	70(1.0)	535(7.4)	6300(87.3)
Married	205(0.7)	440(1.4)	220(0.7)	1600(5.1)	28770(92.1)
Family Status					
Couple Only	25(0.2)	100(0.7)	65(0.5)	410(2.9)	13815(95.8)
One Person	110(1.1)	205(2.0)	120(1.1)	655(6.3)	9230(89.5)
Sole Parent	145(3.3)	245(5.5)	125(2.8)	540(12.2)	3380(76.3)
Couple with Dependents	180(0.9)	355(1.8)	185(0.9)	1280(6.5)	17730(89.9)
Labour Force Status					
Working	260(0.8)	525(1.6)	290(0.9)	1890(5.8)	29690(90.9)
Not Working	205(1.3)	375(2.3)	200(1.2)	995(6.1)	14460(89.1)
NZ Deprivation					
Least Deprived	165(0.5)	355(1.2)	180(0.6)	1375(4.5)	28190(93.1)
Medium Deprived	125(1.3)	200(2.0)	145(1.5)	680(6.8)	8850(88.5)
Most Deprived	170(2.0)	345(4.0)	165(1.9)	825(9.6)	7110(82.5)
NZ Individual Deprivation					
0	55(0.2)	155(0.4)	140(0.4)	1020(2.9)	34205(96.1)
1-2	150(1.4)	370(3.6)	210(2.0)	1170(11.3)	8455(81.7)
3-7	260(8.7)	375(12.7)	135(4.6)	690(23.4)	1495(50.5)
Highest Qualification					
Degree or Higher	50(0.7)	60(0.8)	50(0.7)	305(4.1)	6990(93.8)
No Qualification	135(1.2)	260(2.3)	150(1.3)	765(6.8)	9910(88.3)
School Qualification	85(0.6)	205(1.6)	125(1.0)	760(5.9)	11810(90.9)
Vocational Qualification	195(1.1)	370(2.1)	160(0.9)	1055(6.1)	15435(89.7)
Age					
15-24	75(1.0)	155(2.0)	145(1.8)	545(6.9)	6975(88.3)
25-64	375(1.1)	715(2.1)	320(1.0)	2245(6.7)	29665(89.0)
> 65	10(0.1)	30(0.4)	20(0.3)	95(1.2)	7510(98.0)
Sex					
Male	130(0.6)	235(1.1)	170(0.8)	935(4.2)	20820(93.4)
Female	330(1.2)	665(2.5)	320(1.2)	1950(7.3)	23335(87.7)
Ethnicity					
nMnPnA	285(0.7)	550(1.4)	265(0.7)	1965(5.0)	35985(92.2)
Maori	130(2.4)	215(3.9)	135(2.4)	580(10.5)	4435(80.8)
Pacific	40(2.1)	105(5.4)	75(3.7)	250(12.8)	1480(76.0)
Asian	10(0.3)	30(1.2)	20(0.8)	90(3.7)	2255(93.8)

Note: Total counts are rounded means
1. Two non-collections in two waves or three non-collections in three waves
2 Two non-collections in three waves
3. One non-collection in two waves
4. One non-collection in three waves
5. No non-collections in two or three waves

Table 2: Empirical transition probabilities (%) computed from counts of the number of times respondents reported the indicated pair of prescription collection states in successive observations over 3 waves. Transition probabilities were derived by dividing these counts by row totals.

	To (wave *w+2*)	
from (*w*)	*Collection*	*Non-Collection*
Collection	**97.4**	2.6
Non-Collection	68.8	**31.2**

Table 3: Estimates with 95% confidence intervals from linear fixed effects regression models for three health outcomes. Main exposure was prescription collection status. P-values represent the significance of each covariate level.

Characteristics	SRH		PCS		MCS	
	Estimate (CI)	p-value	Estimate (CI)	p-value	Estimate (CI)	p-value
Collection status						
Collection	1		1		1	
Non-Collection	0.11 (0.07,0.15)	0.00000	-1.00 (-1.40,-0.61)	0.00000	-1.69 (-2.18,-1.19)	0.00000
Wave						
3	1		1		1	
5	0.07 (0.05,0.08)	0.00000	0.03 (-0.11,0.16)	0.70634	0.24 (0.08,0.41)	0.00488
7	0.16 (0.14,0.17)	0.00000	-0.66 (-0.80,-0.51)	0.00000	0.23 (0.05,0.41)	0.01194
Marital status						
Never Married	1		1		1	
Previously Married	-0.02 (-0.08,0.05)	0.62482	-0.56 (-1.16,0.05)	0.07313	-0.80 (-1.55,-0.04)	0.03903
Married	0.00 (-0.05,0.06)	0.88864	-0.82 (-1.35,-0.30)	0.00224	0.75 (0.10,1.40)	0.02466
Family Type						
Couple Only	1		1		1	
One Person	0.01 (-0.03,0.06)	0.62878	0.18 (-0.26,0.62)	0.42776	-0.30 (-0.85,0.24)	0.27493
Sole Parent	-0.04 (-0.10,0.03)	0.24965	0.76 (0.15,1.38)	0.01517	-0.23 (-0.99,0.53)	0.56022
Couple with Children	-0.01 (-0.05,0.02)	0.48955	0.05 (-0.29,0.40)	0.76646	-0.06 (-0.49,0.37)	0.78074
Labour force status						
Employed	1		1		1	
Not Employed	0.05 (0.03,0.08)	0.00018	-0.71 (-0.97,-0.44)	0.00000	-0.77 (-1.10,-0.44)	0.00000
NZDep						
Least Deprived	1		1		1	
Middle Deprived	-0.02 (-0.06,0.01)	0.20890	0.23 (-0.12,0.58)	0.19233	-0.13 (-0.57,0.30)	0.55401
Most Deprived	0.03 (-0.01,0.07)	0.18671	-0.06 (-0.48,0.36)	0.79575	-0.56 (-1.08,-0.04)	0.03667
NZiDep						
0 dep	1		1		1	
1-2 dep	0.06 (0.03,0.08)	0.00000	-0.12 (-0.34,0.10)	0.28342	-1.27 (-1.54,-0.99)	0.00000
3-7 dep	0.13 (0.09,0.17)	0.00000	-0.64 (-1.07,-0.21)	0.00363	-3.24 (-3.77,-2.71)	0.00000
Education						
Degree or Higher	1		1		1	
No Education	0.02 (-0.09,0.12)	0.74736	-0.66 (-1.66,0.34)	0.20022	0.40 (-0.84,1.65)	0.52918
School	0.05 (-0.03,0.14)	0.22827	-0.17 (-0.99,0.65)	0.69131	-0.72 (-1.74,0.29)	0.16528
Post-School	0.02 (-0.07,0.11)	0.69048	0.06 (-0.81,0.93)	0.89149	0.01 (-1.07,1.10)	0.97857

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Research checklist

There is not a template with which to perform this type of study. We used STROBE guidelines for cohort studies where possible since the criteria seem generally relevant to a longitudinal study as well. However, the match is imperfect and could not adhere to it rigidly.