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Associations of serial negative income shock and all-cause mortality: a longitudinal study in China

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ABSTRACT

Introduction With a precarious economic outlook and increasing income volatility in current times, understanding the association between negative income shock and health is crucial. However, few studies have examined such associations in developing countries. Using data from China, this study aimed to examine associations of both serial absolute income drops and relative income trajectory and mortality.

Methods We included 4757 participants from the China Health and Nutrition Survey, a large prospective cohort study. Data between 1989 and 1997 were used to define income drops and relative income trajectories. We defined income drop as a decrease of ≥50% between two consecutive interviews and defined relative income trajectory using a latent class model. All-cause mortality between 2000 and 2015 was ascertained by participants' family members.

Results A total of 2066 (43.43%) experienced 1 income drop and 477 (10.03%) experienced ≥2 income drops. A total of 535 deaths occurred (incidence rate 8.88 per 1000 person-years). Income drops were associated with a greater risk of mortality after adjusting for baseline income, comorbidities, sociodemographic and behavioural factors (HR 1.42 (95% CI 1.04 to 1.93) for ≥2 income drops vs no income drop). The downshift in relative income was also associated with increased mortality risk (HR 3.61 (95% CI 1.45 to 8.96) for always low; HR 3.36 (95% CI 1.36 to 8.32) for decreasing; HR 2.92 (95% CI 1.14 to 7.51) for increasing vs always high relative income). The associations between income drops and mortality were observed only among individuals with low wealth and low household income.

Conclusion In a large sample of the Chinese population with repeated income measurement and over 14 years of follow-up, both serial absolute income drops and a downward relative income trajectory were associated with higher risks of mortality in China. Priority should be given to policies aimed at enhancing resilience against serial income shocks and financial burdens.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Although the association between negative income shock and health has been studied in various epidemiological literature, few studies have examined such associations in developing countries or examined long-term income changes.

WHAT THIS STUDY ADDS

⇒ This study demonstrates that independent of baseline income, both serial drops in absolute income and downshift in relative income were associated with higher risks of mortality. The associations were observed only among individuals with low wealth and low household income.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings underscore the enduring significance of experiencing negative income shock as a predictor of mortality. In current times with increasing income volatility, these evidences call for strategies and policies to mitigate the health consequences of income drops.

INTRODUCTION

Income volatility, specifically negative income shocks, has been associated with a higher risk of adverse outcomes such as depression,[1] cardiovascular disease[2] and all-cause mortality.[3] Income volatility can occur due to factors such as seasonality of jobs, changes in work hours, voluntary or involuntary job changes and exits from work due to certain life events. Studies have found that more than one-third of US families experienced income volatility.[4 5] Individuals and households with lower socioeconomic status are more likely to experience income volatility,[6 7] which contributes to higher income inequality in the population.[8]

Although the association between negative income shock and health has been examined in many epidemiological studies, several research gaps remain. First, most prior literature originates from developed countries.[3 9] The social welfare systems in developing countries, such as healthcare assistance and unemployment compensation, are

weaker, rendering individuals more vulnerable to negative income shock.[10] In addition, developing countries generally have larger income inequality,[11] which is associated with worse health outcomes.[12 13] Therefore, there is a need for more evidence from developing economies to inform efforts aimed at lowering health disparity. Second, the association between long-term income volatility and health outcomes was inadequately explored. Many studies measure income at a single time point, and only a few have examined income change between two time points.[9 14 15] Incorporating multiple time points and providing a detailed characterisation of long-term income trajectories over the life course may better reflect individuals' time-varying financial status, which potentially has a stronger association with health.[14 16 17] Third, most studies have solely focused on absolute income trajectory shift. However, relative deprivation in income rankings has been associated with worse health outcomes, independent of absolute income drops.[18–20]

As a developing country, China is experiencing increasing income volatility.[21] Using longitudinal data from the Chinese population with nearly two decades of follow-up, we aimed to examine the association between long-term income volatility and all-cause mortality in China, a country with rapid income changes and high-income inequality.[22] While income volatility can arise from both decrease and increase in income, the current study focused on downward volatility because previous studies found that income drops had a greater impact on health.[1 23] We examined the associations between both absolute income drops and changes in relative income and mortality.

METHODS

Study population

The China Health and Nutrition Survey (CHNS) is a prospective cohort study initiated in 1989. The CHNS sample was not designed to be nationally representative since CHNS has not obtained data to create a representative provincial-level sample by its inception.[24] Instead, the study sample was to be randomly selected to capture a range of economic and demographic circumstances. The original survey in 1989 used a multistage, random cluster process to draw the sample in each of eight provinces. Counties and cities in each province were stratified by income (low, middle and high) and four counties and two cities were selected in each province using a weighted sampling scheme. Villages and townships within the counties and urban and suburban neighbourhoods within the cities were also selected randomly. By 2011, the CHNS included 12 provinces and municipal cities, covering 288 communities, which accounted for 47% of China's population.[25] Participants have been followed up every 2–4 years with a total of 10 survey rounds by 2015.[26]

The current study included participants who attended the 1989 or 1991 interview, participated in at least 3 interviews between 1989 and 1997 (a total of 4 surveys), were aged 16–65 in 1989 and had complete income and history of comorbidity information between 1989 and 1997. Among 6340 participants, 4757 had complete mortality information by 2015 and were included in the final analysis, resulting in a lost to follow-up rate of 24.97% (see patient flow chart in online supplemental figure 1). Major causes of lost to follow-up included missing people (such as travel, hour of work or play), school children who were in boarding schools, migrant work for those aged above 16, and natural disaster and major redevelopment of housing in all large urban centres.[24]

Additional information on the data and study materials is available on the CHNS official website (https://www.cpc.unc.edu/projects/china). This cohort study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline.

Income predictor

Absolute income change

During CHNS interviews in the years 1989, 1991, 1993 and 1997, participants self-reported pretax individual income for the past 12 months, encompassing all sources, including business, farming, fishing, gardening, livestock, non-retirement wages and retirement pension. Reported incomes for each wave were inflated to RMB1989. An income drop was defined as a decrease of 50% or more in deflated income between two consecutive interviews. The predictor of interest in our analysis was the number of income drops between 1989 and 1997 (range 0–3), categorised into 0, 1 or ≥2 drops.

Relative income trajectory

We examined the trajectory of individuals' relative income over time. The relative income here denotes individuals' relative position or rank compared with others. We grouped individuals based on their income quartile at each interview between 1989 and 1997 to measure their relative income hierarchy within the population. A latent class model was employed to identify subgroups characterised by similar underlying trajectories across income quartiles over the study period. This model used the maximum likelihood method to estimate the posterior probabilities of membership for each participant in each trajectory class. Participants were assigned to the class with the highest probability of membership.[27–29]

Mortality

Our primary outcome was all-cause mortality. Participants who were alive in 1997 were followed from the year 2000 until death, lost to follow-up or the last interview in 2015, whichever occurred first. In the CHNS, mortality status was updated in each survey round. Participants' family members provided information on whether they were alive or deceased, and if deceased, the year of death.

Covariates

Covariates were selected if previous studies suggested potential associations with both income shock and mortality.[2 3] Baseline characteristics collected in 1989 or

1991 included age at enrolment, ethnicity, sex, completion of middle school education, occupation (farmer, civil servant, self-employment or others), health insurance status and *hukou* status. In China, all households have to be registered in the locale where they reside and their *hukou* status is categorised as either 'rural' or 'urban'. Residents with urban *hukou* enjoy better health insurance, housing, pensions and other privileges, and rural-to-urban migration was heavily restricted. Additionally, we included participants' self-reported smoking status (yes/no), alcohol consumption (yes/no) and physical activity. Physical activity (yes/no) was determined by whether participants reported spending time weekly in six categories of physical activity (martial arts, running, gymnastics, soccer or basketball, badminton or volleyball and ping pong). In addition, we included the history of comorbidities (ie, myocardial infarction, stroke, diabetes and hypertension) and overweight. Overweight was defined as a body mass index greater than 24 kg/m^2 in the Asian context,[30] calculated as weight in kilograms divided by height in metres squared.

Categorical covariates that could vary over time, such as health conditions, were defined at baseline between 1989 and 1997. For comorbidities, smoking, alcohol consumption and overweight status, participants were categorised based on whether they ever exhibited the condition or behaviour during the period from 1989 to 1997.

Statistical analysis

We presented participants' baseline characteristics between 1989 and 1997 by the number of income drops and by relative income trajectory classes. Continuous variables were presented as mean (SD) or median (IQR) and categorical variables were presented as number (percentage) as appropriate. We used global χ^2 tests to compare categorical variables and analysis of variance to compare continuous variables across income categories.

We compared baseline characteristics between participants lost to follow-up and those included in analyses to examine potential impact of lost to follow-up on results. For the latent class model in the relative income analysis, the model was fitted with 2–6 classes, and the best fitting model was selected based on criteria including Akaike information criterion (AIC), Bayesian information criterion (BIC) and entropy. We calculated the incidence rate of all-cause mortality (per 1000 person-years) by income predictor category. Log-rank test was used to compare unadjusted Kaplan-Meier curves across categories of income predictors. We then assessed the association between income change and all-cause mortality using Cox proportional hazards models. The proportional hazard assumption was tested by checking the Schoenfeld's partial residuals and no violation was found. We fit an unadjusted model, a model adjusted for sociodemographic characteristics and logarithm of 1997 income, and a model further adjusted for lifestyle factors and self-reported history of comorbidities. All data analyses were conducted with Stata, V.17 MP. A two-sided $p<0.05$ was considered statistically significant.

Subgroup analyses

Given the potential buffering effect of wealth and household income on individual income shocks, we stratified individuals by the median of baseline wealth and household income. Additionally, we explored heterogeneity in the associations between income shock and mortality by age and sex.

Secondary analyses

We conducted the following sensitivity analyses to validate our results. First, we re-examined the association between income drops and mortality using alternative 25% and 75% drops in absolute income as cut points. Second, because income may change over time, we adjusted for time-dependent income levels as covariates from 2000 to 2015 to account for the impact of income on mortality. Third, because individuals living in one household may share resources and household income volatility could also be associated with risk of mortality, we replicated our analyses using household per capita income.

To explore potential mechanisms, we further conducted several secondary analyses. First, we assessed whether the effect of income shock on mortality was mediated by health-related factors by comparing behaviour profiles among participants with different numbers of income drops. We constructed a healthy lifestyle score which included smoking, alcohol consumption and physical activity. Each indicator was assigned 1 point for a healthy behaviour (never smoking, no alcohol consumption and ever being physically active) and 0 points for unhealthy alternatives. The healthy lifestyle score was the sum of the points and ranged from 0 to 3, with higher scores indicating healthier lifestyles. Second, we assessed whether the effect of income shock on mortality was mediated by healthcare access. As there is no direct measurement of healthcare accessibility in CHNS, we defined individuals reporting higher illness frequency but lower medical expenditure as having limited healthcare access. Illness frequency was defined as the number of reported sickness or injuries in the last 4 weeks during the follow-up period, while medical expenditure encompassed total treatment costs incurred when seeking medical care. Associations between illness frequency, medical expenditure and income drops were assessed separately using an analysis of variance.

RESULTS

Baseline characteristics

Among the 4757 participants, the mean (SD) age was 37.68 (12.67) years, with 2512 (52.81%) being men. Of these participants, 2214 (46.54%) experienced no income drop at baseline, 2066 (43.43%) experienced 1 income drop and 477 (10.03%) experienced ≥2 income drops (table 1). Compared with participants with no income drops, individuals with income drops were more likely

Table 1 Baseline characteristics of participants by number of income drops, CHNS

	Income drops, n				
	Overall	0	1	≥2	P value
Number of individuals	4757	2214	2066	477	
Age, years	37.68 (12.67)	38.29 (12.15)	37.32 (13.15)	36.38 (12.78)	<0.001
Male, n (%)	2512 (52.81)	1152 (52.03)	1084 (52.47)	276 (57.86)	0.06
Ethnicity, Han, n (%)	4156 (87.37)	1928 (87.08)	1811 (87.66)	417 (87.42)	0.85
Hukou, urban, n (%)	1120 (23.54)	686 (30.98)	363 (17.57)	71 (14.88)	<0.001
Education, completion of middle school, n (%)	1629 (34.24)	817 (36.90)	670 (32.43)	142 (29.77)	<0.001
Health insurance, n (%)	1793 (37.69)	1038 (46.88)	641 (31.03)	114 (23.90)	<0.001
Occupation, n (%)					
Farmer	3154 (66.30)	1224 (55.28)	1536 (74.35)	394 (82.60)	<0.001
Civil servant	1339 (28.15)	882 (39.84)	394 (19.07)	63 (13.21)	<0.001
Self-employment	158 (3.32)	71 (3.21)	75 (3.63)	12 (2.52)	0.43
Other	106 (2.23)	37 (1.67)	61 (2.95)	8 (1.68)	0.01
1997 income, RMB, median (IQR)	2819 (1233–4919)	2765 (1385–4527)	2780 (1064–5142)	3538 (1034–6978)	<0.001
Ever smoker, n (%)	2167 (45.58)	975 (44.04)	958 (46.37)	234 (49.06)	0.09
Ever drinker, n (%)	932 (19.60)	444 (20.05)	389 (18.84)	99 (20.75)	0.48
Ever exercise, n (%)	400 (8.41)	205 (9.26)	168 (8.13)	2 (5.66)	0.03
Ever overweight, n (%)	1020 (21.45)	512 (23.13)	406 (19.66)	102 (21.38)	0.02
Comorbidities, n (%)					
Myocardial infarction	113 (2.38)	62 (2.80)	45 (2.18)	6 (1.26)	0.10
Stroke	164 (3.45)	82 (3.70)	67 (3.24)	15 (3.14)	0.66
Diabetes	216 (4.54)	124 (5.60)	76 (3.68)	16 (3.35)	<0.001
Hypertension	257 (5.40)	128 (5.78)	117 (5.67)	12 (2.52)	0.01

Continuous variables were presented as mean (SD). Categorical variables were presented as number (percentage).
CHNS, China Health and Nutrition Survey.

to be younger, less likely to have urban *hukou*, complete middle school or have health insurance (p<0.001 for all). Individuals experiencing income drops were more likely to be farmers and less likely to be civil servants. Furthermore, they had a lower prevalence of overweight, diabetes and hypertension. No significant difference was observed in other characteristics.

Participants included in the current study were similar to those lost to follow-up for most demographic characteristics (online supplemental table 1). However, participants lost to follow-up were more likely to have urban *hukou*, be civil servants and less likely to be farmers.

Associations between income drops and all-cause mortality

A total of 535 death events occurred between 2000 and 2015, with a median follow-up time of 14 (IQR 9–18) years, resulting in 60232 person-years. Participants with ≥2 income drops were at significantly greater risk of mortality compared with those with no income drop (log-rank p<0.05, figure 1A). The incidence rate for all-cause mortality increased with the number of income drops (10.43 (95% CI 8.14 to 13.36) per 1000 person-years for individuals with ≥2 income drops vs 8.47 (95% CI 7.46 to 9.62) per 1000 person-years for those with 0 drop, table 2). In the Cox proportional model, compared with participants with no income drops, those with ≥2 income drops had greater unadjusted hazards of all-cause mortality, although the association was not statistically significant (HR 1.23; 95% CI 0.93 to 1.63). After adjusting for baseline income, demographic, socioeconomic status, lifestyle and history of comorbidities, participants with ≥2 drops had a significantly higher risk of mortality (HR 1.42 (95% CI 1.04 to 1.93)). We did not find a significant difference in risk of mortality between participants with one income drop and those with 0 drop (HR 1.06 (95% CI 0.86 to 1.32)).

Associations between relative income trajectory and all-cause mortality

In the latent class analysis of relative income change between 1989 and 1997, we found that the model best fit with four classes based on the values of AIC, BIC, adjusted BIC, entropy and p value of the Vuong-Lo-Mendell-Rubin likelihood test (online supplemental table 2 and figure 2). The four groups were categorised as follows: always high income (271 participants, 5.70%), increasing income (730, 15.35%), decreasing income (1042, 21.90%) and always low income (2714, 57.05%).

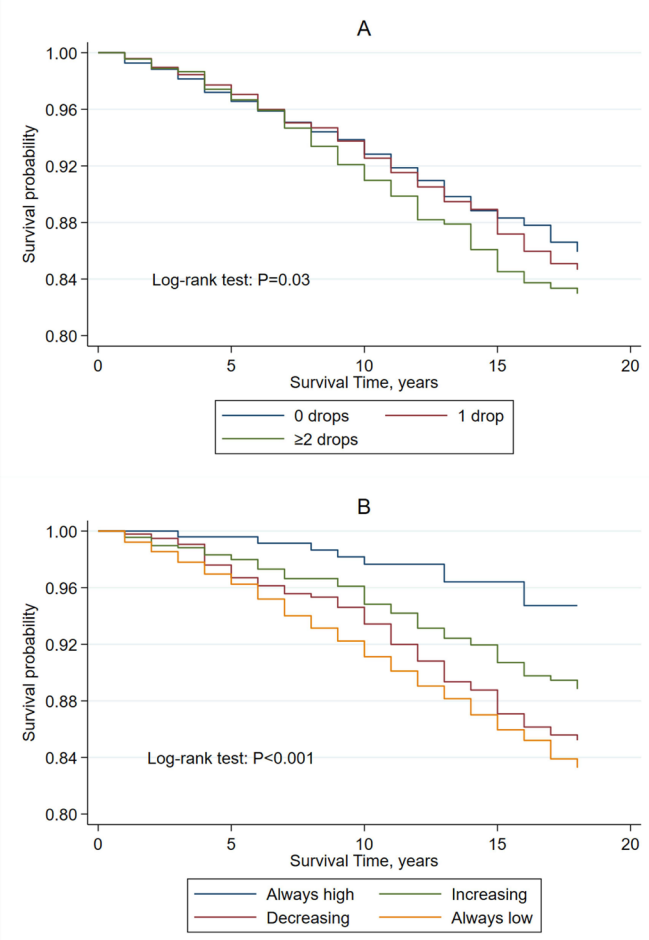

Figure 1 Kaplan-Meier curves for all-cause mortality by the number of income drops (A) and by relative income trajectory groups (B).

Compared with individuals with always high relative income, those with decreasing and always low relative income were older, and less likely to have urban *hukou* (p<0.001 for all, online supplemental table 3). They were also less likely to have health insurance, to be civil servants, to drink alcohol, to smoke and to be overweight (p<0.001 for all).

Participants with always low income had the highest mortality risk, followed by those with decreasing, increasing and always high income (figure 1B). Compared with always high income, always low income, decreasing income and increasing income were associated with significantly higher risks of mortality (unadjusted HR=3.67 (95% CI 1.90 to 7.12) for always low; HR=3.12 (95% CI 1.58 to 6.16) for decreasing and HR=2.29 (95% CI 1.13 to 4.64) for increasing, table 3). After adjusting for baseline income and other potential confounders, the associations remained (compared with always high, adjusted HR=3.61 (95% CI 1.45 to 8.96) for always low; adjusted HR=3.36 (95% CI 1.36 to 8.32) for decreasing; adjusted HR=2.92 (95% CI 1.14 to 7.51) for increasing). Individuals with increasing income were at lower risks of mortality when compared with those with decreasing relative income (adjusted HR=0.84 (95% CI 0.54 to 1.31)) and always low relative income (adjusted HR=0.82 (95% CI 0.55 to 1.23)), but the associations were not statistically significant.

Subgroup analyses

In subgroup analyses, the association between ≥2 income drops and mortality was only significant among those who had lower wealth (HR 1.90; 95% CI 1.21 to 2.99 for lower wealth vs HR 1.04; 95% CI 0.68 to 1.61 for higher wealth, p for interaction=0.02, figure 2). Similarly, the association was only significant among those with lower household income (HR 1.56; 95% CI 1.04 to 2.34 for lower household income vs HR 1.30; 95% CI 0.79 to 2.12 for higher household income, p for interaction=0.02). In contrast, the associations between ≥2 income drops and mortality were similar among male and female participants. Furthermore, the association between ≥2 income drops was slightly lower among those who aged over 50 (HR 1.34; 95% CI 0.87 to 2.09) compared with their younger counterparts (HR 1.55; 95% CI 1.00 to 2.39), but

Table 2 Incidence and risk of all-cause mortality by income groups

	n (%)	No. of events/ person-years	IR* (95% CI)	Model 1 HR (95% CI)	Model 2 HR (95% CI)	Model 3 HR (95% CI)
Overall	4757	535/60 232	8.88 (8.16 to 9.66)	–	–	–
Income drops, n (%)						
0	2214 (46.54)	236/27 857	8.47 (7.46 to 9.62)	1 (Ref)	1 (Ref)	1 (Ref)
1	2066 (43.43)	237/26 430	8.97 (7.90 to 10.18)	1.07 (0.89 to 1.28)	1.09 (0.88 to 1.34)	1.06 (0.86 to 1.32)
≥2	477 (10.03)	62/5945	10.43 (8.14 to 13.36)	1.23 (0.93 to 1.63)	1.43† (1.05 to 1.94)	1.42† (1.04 to 1.93)

Model 1 is unadjusted. Model 2 is adjusted for 1989 age, gender, ethnicity, *hukou* status, completion of middle school education, health insurance status, occupation and logarithm of 1997 income. Model 3 is additionally adjusted for smoking status, alcohol consumption, physical activity, overweight status, reported history of myocardial infarction, stroke, diabetes and hypertension.
*Per 1000 person-years.
†Statistically significant, p<0.05.
IR, incidence rate.

Table 3 Incidence and risk of all-cause mortality by income trajectory classes

	n (%)	No. of events/ person-years	IR* (95% CI)	Model 1 HR (95% CI)	Model 2 HR (95% CI)	Model 3 HR (95% CI)
Overall	4757	535/60 232	8.88 (8.16 to 9.66)	–	–	–
Income trajectory classes, n (%)						
Always high	271 (5.70)	9/3337	2.70 (1.40 to 5.18)	1 (Ref)	1 (Ref)	1 (Ref)
Increasing	730 (15.35)	53/8628	6.14 (4.70 to 8.03)	2.29† (1.13 to 4.64)	2.97† (1.16 to 7.61)	2.92† (1.14 to 7.51)
Decreasing	1042 (21.90)	110/12 941	8.50 (7.06 to 10.24)	3.12† (1.58 to 6.16)	3.32† (1.34 to 8.19)	3.36† (1.36 to 8.32)
Always low	2714 (57.05)	363/35 326	10.28 (9.28 to 11.38)	3.67† (1.90 to 7.12)	3.58† (1.45 to 8.87)	3.61† (1.45 to 8.96)

Model 1 is unadjusted. Model 2 is adjusted for 1989 age, gender, ethnicity, *hukou* status, completion of middle school education, health insurance status, occupation and logarithm of 1997 income. Model 3 is additionally adjusted for smoking status, alcohol consumption, physical activity, overweight status, reported history of myocardial infarction, stroke, diabetes and hypertension.
*Per 1000 person-years.
†Statistically significant, p<0.05.
IR, incidence rate.

the difference was statistically insignificant (p for interaction=0.15).

Sensitivity analyses

When using 25% and 75% as cut-offs for income drops, the patterns of mortality and different numbers of income drops remained consistent (online supplemental table 4). In fully adjusted models, the association between ≥2 income drops and mortality was stronger when using 75% as cut-off (HR 1.47; 95% CI 0.90 to 2.41) compared with 50% cut-off and 25% cut-off (HR 1.37; 95% CI 1.00 to 1.88).

After adjusting for time-dependent income between 2000 and 2015, the association between income drops and mortality remained materially unchanged (online supplemental table 5). Similar to the main results, both serial absolute household per capita income drops and a low relative household per capita income trajectory were associated with significantly higher risks of mortality (online supplemental figure 3, online supplemental tables 6 and 7).

Compared with participants with no income drops, those with ≥2 income drops had lower healthy lifestyle scores during the follow-up period (online supplemental table 8, mean 1.56; 95% CI 1.49 to 1.63 for ≥2 drops vs 1.66; 95% CI 1.62 to 1.69 for 0 drops). Although we found no differences in the probability of illness during

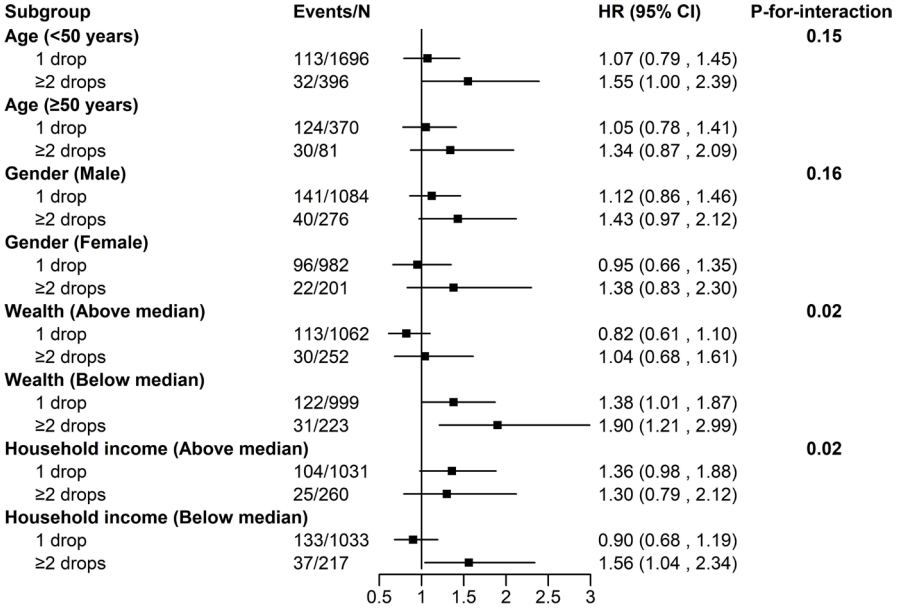

Figure 2 Subgroup analysis of income drops and all-cause mortality. Model adjusted for 1989 age, gender, ethnicity, *hukou* status, completion of middle school education, health insurance status, occupation, logarithm of 1997 income, smoking status, alcohol consumption, physical activity, overweight status, reported history of myocardial infarction, stroke, diabetes and hypertension.

the follow-up period among different income drop groups (0.16; 95% CI 0.11 to 0.21 for ≥2 drops vs 0.18; 95% CI 0.16 to 0.20 for 0 drops, p>0.1), individuals with ≥2 income drops had significantly lower medical expenditure compared with those with no income drops (RMB436; 95% CI RMB26 to RMB846 for ≥2 drops vs RMB793; 95% CI RMB467 to RMB1118 for 0 drops, p=0.03).

DISCUSSION

In a large sample of the Chinese population with repeated income measurement and over 14 years of follow-up, we found that independent of baseline income, both serial absolute income drops and a low relative income trajectory during early to mid-adulthood were associated with a higher risk of mortality. Notably, these associations were observed only among individuals with lower wealth and household income, and potentially more impactful among younger people. These findings underscore the enduring significance of experiencing negative income shock as a predictor of mortality.

As a developing country, China has experienced rapid growth in income with massive structural shifts in economy. In the 1980–1990s, China introduced economic reforms and started to transform from a planned economy to market-oriented economy. Together with other significant policy changes, such as reforms to the pension system and the hardening of budget constraints on state enterprises, these changes have increased uncertainty and income volatility.[21] In our study, we found that farmers and people with lower socioeconomic status were more likely to experience income drops, which is consistent with previous studies.[6 31] The higher-income volatility among farmers could be potentially attributed to several reasons. For example, farmers may have unstable product outlets due to a market-oriented economy. Additionally, their income was vulnerable to natural disaster such as a series of severe floods along the Yangzte River and Pearl River in China during the 1990s.[32 33]

The associations found in our study were consistent with previous studies conducted in high-income countries.[2 3 34] For instance, a study using Norwegian register data found that males aged 50–69 who experienced at least two substantial falls in income had a 17% excess mortality rate.[34] Similarly, an analysis based on a cohort of young adults in the USA showed that experiencing more than two income drops over a 15-year period was associated with a 1.92-fold increase in the risk of death.[3] Another study using a US sample from the Panel Study of Income Dynamics found that income level was a strong predictor of mortality, especially for persons under the age of 65 years.[35] In the current study, we found that ≥2 income drops over 14 years were associated with 1.42-fold increased risk of all-cause mortality. Sensitivity analyses showed that income drop using 75% cut-off had stronger association with mortality when compared with analyses using 25% or 50% cut-off. However, the association was not statistically significant when using 75% cut-off, likely due to the smaller sample size and a smaller number of events among those with two income drops using 75% cut-off.

Until now, most studies examining the association between income changes and all-cause mortality have been conducted in high-income, developed countries. Despite the weaker social welfare systems and increased vulnerability of populations in developing countries, there has been a notable absence of research addressing the association between serial income shocks and mortality within these contexts. A study using the China Kadoorie Biobank found that individuals experiencing sharp socioeconomic status downshift between baseline and resurvey had a significant 30% reduction in survival time before cardiovascular deaths.[36] However, like other studies on income and health outcomes,[10 37–39] it was unable to capture serial income changes across multiple time points. Our study examined longer-term income volatility and showed that independent of baseline income, serial drops in absolute income and low relative income were associated with higher risks of mortality. In addition, we found a dose–response association between income drops and mortality, with more income drops associated with greater mortality risk.

Our study revealed that the association between negative income shock and all-cause mortality was observed only among individuals with low-wealth and low-household income. Specifically, among participants with high baseline wealth and household income, ≥2 income drops were not associated with risks of mortality compared with no income drop. The results suggested that higher wealth and household income may mitigate some impacts of income drops on these mechanisms and weaken the association with mortality. In sensitivity analyses, we found that lifestyle and healthcare accessibility are potential mechanisms underlying the association between income drop and mortality. This is consistent with previous studies suggesting that income drops may induce stress-coping behaviours such as increased cigarette smoking[40] and alcohol consumption,[41] longer working hours at the expense of physical activities,[42 43] as well as delayed medical care and incomplete adherence to prescription medications.[44]

Interestingly, we found that increasing relative income was associated with a slightly lower risk of mortality compared with individuals with always low income and decreasing income, though the association was not statistically significant. This may suggest that upward relative income change could to some extent modify the greater risk of mortality among individuals with low baseline income. An upshift in socioeconomic status has been associated with a lower risk of cardiovascular mortality in a Korean study.[45] Potential mechanisms could be that rising socioeconomic status results in healthier lifestyle,[46] better affordability of healthcare services[47] and better support from members in the same socioeconomic class.[48]

With a precarious economic outlook and increasing income volatility in current times, our study underscores the importance of prioritising policies aimed at enhancing resilience against serial income shocks. In the USA, unemployment and wage insurance have been implemented as short-term strategies to offset the burdens of transitory income shocks such as job loss.[49] Unemployment insurance might reduce the adverse health consequences of job loss by shielding workers from financial stress,[50] improving access to care[51] and also diminishing the psychosocial impact of unemployment.[52] Studies have shown that countries with more generous unemployment insurance systems exhibit better health outcomes and narrower health inequalities.[53–55] In China, some local governments have launched vocational skills subsidy programmes to equip recently unemployed individuals with the necessary skills to find jobs.[56] By addressing the root causes of income instability and providing targeted support to vulnerable populations, policy-makers can help mitigate the detrimental effects of income volatility on health and well-being.

Our study had several strengths. First, previous studies were predominantly conducted in developed countries, while our study focused on a large developing country. We confirmed that in developing countries with weaker social welfare systems, independent of baseline income, long-term drops in income were associated with increased mortality risk. Moreover, we highlighted the independent impact of relative income changes on survival risk. Second, the repeated income data in the CHNS allowed us to capture detailed income change and the long follow-up time allowed us to assess the mortality risk over nearly two decades. Third, rather than relying solely on theoretical frameworks, we explored potential mechanisms underlying negative income shock and mortality using population data. Our findings underscore the pivotal roles of health behaviours and healthcare access in mediating these associations.

However, we acknowledge several limitations in our study. First, there was no standard definition of substantial income change. Prior studies have used 25% and 75% as the cut-off for drop.[3 57] Nevertheless, the associations in our study remained consistent across various thresholds (50%, 25% and 75%). Similar to Elfassy *et al*,[3] our analysis noted that more than two 25% drops in income were substantial enough to significantly impact mortality risk. Second, studies on income change and health are subject to reverse causation, where individuals who become ill may be more prone to job loss and subsequent negative income shock. We controlled for baseline comorbidities and were able to preserve temporal order by using income change information between 1989 and 1997 to assess mortality in the subsequent follow-up. Third, self-reported income data might be susceptible to recall bias. Fourth, participants included in our study were likely more socioeconomically advantaged compared with those lost to follow-up, which may bias our estimates of the associations.

Conclusions

Using data from a developing country, we found that independent of baseline income, both serial absolute income drops and a low relative income trajectory during early to mid-adulthood were associated with a higher risk of mortality. We also found that wealth and household income could mitigate some of the adverse effects. These findings underscore the enduring significance of experiencing negative income shock as a predictor of mortality. In current times with increasing economic uncertainty and income volatility, these evidences call for policies to mitigate the health consequences of income shocks.

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Ethics approval This study involves human participants and the CHNS was approved by the institutional review boards at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Health of the Chinese Center for Disease Control and Prevention (ethical approval number: 2015-024). Each CHNS participant has provided a written informed consent. Participants gave informed consent to participate in the study before taking part.

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