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ORIGINAL ARTICLE

Associations of relative income deprivation with perceived happiness and self-rated health among the Hong Kong Chinese population

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Abstract
Objectives To investigate the association of relative income deprivation (RID) with perceived happiness and self-rated health in Hong Kong.
Methods We measured RID on Yitzhaki indices constructed using multiple reference groups and used multilevel ordinal logistic regression models to assess its linkages with the two outcomes, using data from 6272 respondents from a large-scale representative household survey.
Results Among the overall population, increased RID was found to be consistently associated with reduced perceived happiness, even after adjusting for respondents' level of absolute income and other socio-demographic covariates; however, there were no consistent associations between RID and self-rated health. In subgroup analysis, we observed significant linkages between RID and self-rated health only among men, the middle and older age ranges, and among those with less education and those not engaged in economic activities.
Conclusions Our findings suggest that RID is adversely associated with perceived happiness. However, its negative linkage with self-rated health is less clear. The weak tie between RID and self-rated health may relate to the Hong Kong context, where the public health system is relatively equitable and has multiple pro-poor health policies.

Keywords Relative income deprivation · Happiness · Self-rated health · Social inequalities · Chinese

Introduction

According to the relative income hypothesis (Elstad 1998; Kawachi and Kennedy 1999; Wilkinson and Pickett 2006), individuals have expectations of a standard of living set by the rest of their society. A person may feel deprived if she perceives herself to be failing to meet the expected living standard: this inability to fulfill expectations may lead to elevated social stress and frustration that could contribute to deteriorating subjective well-being.

Ecological investigations that support this line of thinking have mostly shown that areas with greater income inequality are more likely to present reduced happiness and worse health outcomes for low-income groups (Alesina et al. 2004; Kondo et al. 2009). However, this evidence has been challenged as "biased", as it fails to take account of individual variability (Smith et al. 2012). Recently, increasing numbers of studies at the individual level have addressed the association between relative income deprivation (RID) and well-being. One approach is to measure RID using the Yitzhaki index, an income-based measure reflecting relative "distance" from the most desirable socioeconomic position (Yitzhaki 1983). Multiple studies have investigated the association between Yitzhaki-based measures of RID and outcomes related to individual well-being. Among the common outcomes tested are happiness and self-rated health (Adjaye-Gbewonyo and Kawachi 2012; Kuo and Chiang 2013; Oshio et al. 2011).

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Happiness and self-rated health can be considered as two different dimensions of well-being. The former is a multidimensional measure that covers physical, mental, socioeconomic, and many other aspects of subjective welfare; the latter is an indicator of health found to predict mortality (DeSalvo et al. 2006; Jylhä 2009). Although these two constructs are mostly examined separately, more and more studies are showing that they are interrelated and that some socioeconomic determinants influence both happiness and self-rated health (Oshio and Kobayashi 2010; Subramanian et al. 2005).

Reports of the associations between RID and happiness and self-rated health show heterogeneity. While studies have more consistently reported a link between increased RID and reduced happiness (Oshio et al. 2011), the association between RID and health outcomes is inconclusive. In a review of research published between 2000 and 2010, Adjaye-Gbewonyo and Kawachi (Adjaye-Gbewonyo and Kawachi 2012) found four studies reporting an inverse relationship between RID and self-rated health, and another four reporting that the linkage is weak or non-existent. Also, with some exceptions (Ling 2009; Salti 2010; Wildman 2003), few researchers have explored the linkage across demographic compositions.

Studies examining the linkage between RID and well-being have mostly been conducted in Western countries. Few attempts have been made in Southeast Asian societies. To date, only a handful of studies have examined the association between RID and health outcomes among Chinese populations (Kuo and Chiang 2013; Li and Zhu 2006; Ling 2009) and attempts to detect the differential effect of RID across socioeconomic subgroups are even rarer. In recent decades, China and a number of Southeast Asian countries have experienced swift economic development. Despite substantial improvements in living standards, these societies face widening socioeconomic inequality. For instance, Hong Kong is one of the most affluent cities in the world but approximately 1 million of its inhabitants are living in relatively deprived circumstances (C&SD 2015).

Given the high degree of income inequality in Hong Kong, we expected to observe a negative linkage between RID and individual well-being among this population. In this study, we investigated the associations between RID and perceived happiness and self-rated health in Hong Kong, and explored whether the associations differ across socio-demographic subgroups.

Method

Sample

Data were taken from the first wave of the Hong Kong Panel Study of Social Dynamics (HKPSSD), a large-scale representative survey conducted through interviews with over 3000 Chinese households in 2011. The HKPSSD employed a random sampling strategy stratified by constituency areas and their socioeconomic status, and collected information from 7208 respondents aged 15 and over. Details of the study design and survey administration are reported elsewhere (Wu 2014).

Measures

Relative income deprivation (RID)

We measured respondents' RID using the Yitzhaki index. Its mathematical representation can be written as follows:

$$Y(x_i) = \sum_{y}^{\max(y)} (y - x_i) \cdot p(y),$$

where x_i denotes individual i with income x, and y is the income of individuals at levels above x_i, the reference groups. The individual's score on the Yitzhaki index is weighted by the proportion of the population with income y, denoted $p(y)$. The range of the Yitzhaki index runs from zero to the mean of the population's income (based on reference groups); a higher score on the index indicates that an individual is relatively more deprived. The HKPSSD asked respondents for their 12-month averaged monthly household income from all possible sources. Respondents who refused to answer this question directly were more inclined to indicate the level of their household income on a 14-point scale.

Identifying reference groups for the Yitzhaki index is a widely recognized issue and there is still no consensus on the most appropriate approach. The general guideline is to select by geographic locality and demographic proximity (Adjaye-Gbewonyo and Kawachi 2012; Eibner and Evans 2005) due to the contention of social evaluation theory that individuals are more likely to make comparisons with others who share demographic similarities (Singer 1981). In this analysis, we follow the common practices of previous studies, using multiple geographic and demographic variables as "reference groups". We selected six variables: all (whole territory), district (18 district council districts), age, sex, education, and employment status. These six "reference groups" are commonly used in previous studies and thus facilitate comparison.

Subjective happiness and self-rated health

The outcomes were respondents' perceived happiness and self-rated health. Happiness was assessed by a single question extracted from the Subjective Happiness Scale (Lyubomirsky and Lepper 1999). Respondents were asked to rate themselves on a 7-point scale between (1) "not a very happy person" and (7) "a very happy person". On self-rated health, respondents were asked, "Overall, how would you describe your health?" They were offered a choice of five responses, from (1) "excellent", "very good", "good", "fair" to (5) "poor". Our measure of self-rated health is identical to few previous studies on social comparison (Hounkpatin et al. 2016; Kondo et al. 2008; Mishra and Carleton 2015; Subramanyam et al. 2009).

Respondents' characteristics

We used variables of respondents' socio-demographic profile (age, sex, marital status, educational attainment, employment status, equalized absolute monthly household income). Equalized monthly household income was calculated by dividing household income by the square root of the number of members in the household (Buhmann et al. 1988). Our analysis also included respondents' health-related variables (chronic conditions, smoking status, and frequency of alcohol consumption). Chronic conditions were screened by whether respondents had received a diagnosis of any of the following conditions from a Western medical doctor: cancer, diabetes mellitus, cardiovascular heart disease, hypertension, stroke, and dementia.

Statistical analysis

Taking into account the hierarchical structure of the data, we performed multilevel regression models, which involve three levels (individual, household, and district). Since the outcomes are in ordinal scale, we employed the proportional odds models for analysis, whose general form is:

$$\begin{cases} \left[\ln\frac{\Pr(Y\le m)}{\Pr(Y<m)}\right]_{ijk} = \beta_{0jk,m} + \beta' X & \ldots\ldots\ldots \text{individual level} \\ \beta_{0jk,m} = \alpha_{00k,m} + u_{0jk,m} & \ldots\ldots\ldots \text{household level,} \quad m = 1,\ldots,l-1 \\ \alpha_{00k,m} = \gamma_{000,m} + v_{00k,m} & \ldots\ldots\ldots\ldots \text{district level} \end{cases}$$

where i, j, and k denote the individual, household, and district levels of interest, respectively; l denotes the maximum level of Y; β denotes the coefficients of the independent variables. The error terms at the household and district levels are denoted by u and v, respectively. Proportional odds model is an extension of binary logistic regression (Armstrong and Sloan 1989; Scott et al. 1997). Estimate of the model is a summary of the binary logistic odds ratios representing each of the cut-points and can be viewed as an odds ratio that is independent of the dichotomy chosen to classify the outcome. The proportionality assumption were tested by the score test (Liu 2009). It is a more sensitive analysis for ordinal outcomes as it considers ordinality and avoids arbitrarily dichotomizing the outcome variables (Scott et al. 1997).

Our analysis first explored the characteristics of the respondents and their scores on the outcomes (perceived happiness and self-rated health). Associations between respondents' characteristics and the outcomes were examined. Then we investigated the associations between RID (Yitzhaki indices) and the outcomes. Three models were fitted. In Model 1, we tested the associations between RID and the outcomes without adjusting for respondents' characteristics. In Model 2, we tested the associations adjusting for respondents' demographic and socioeconomic characteristics (age, sex, marital status, education, employment status, equalized household income). These covariates were commonly used in previous studies addressing the association between RID and health outcomes (Adjaye-Gbewonyo and Kawachi 2012) and are consistently found to correlate with perceived happiness or self-rated health (Oshio and Kobayashi 2010; Subramanian et al. 2005). Few studies have included health-related variables as part of the controls (Kondo et al. 2008; Subramanyam et al. 2009) and so, in Model 3, we extended Model 2 to adjust for respondents' health-related variables (chronic conditions, smoking status, frequency of alcohol consumption).

Third, due to previous findings showing heterogeneity in the association between RID and health across demographic subgroups, we investigated whether a similar situation existed in our sample. We tested the associations between Yitzhaki indices and the outcomes by age group (15–34, 35–64, 65 or above), sex, education (primary or below, secondary, post-secondary), and employment status (employed, unemployed, economically inactive).

In our model testing, we first used the six Yitzhaki indices described above as measures of RID. They reflected respondents' RID in terms of absolute distance. In addition, since it has been suggested that social comparison may be more relevant when conducted by rank than by absolute distance (Eibner and Evans 2005; Subramanyam et al.

2009), we also examined RID based on decile rank. We classified respondents into ten decile groups based on their scores on the Yitzhaki indices; respondents in the bottom group indicated that they were the least deprived and those in the top group are the most deprived. We tested both sets of measures for the purpose of consistency checking. Uses of multiple Yitzhaki indices as measures of RID could be considered sensitivity tests for alternative hypothesis. The more significant associations yielded between the indices and outcomes were interpreted as stronger evidence of the linkage between RID and the outcomes (Subramanyam et al. 2009). We reversed the order of respondents' happiness for ease of interpretation. A higher score in both happiness and self-rated health indicates a poorer outcome (less happy and worse health).

Results

Of the 7208 respondents who completed the first wave of the HKPSSD survey, 13% ($n=936$) had missing data for their monthly household income and thus excluded from our analysis. Therefore, this analysis was based on 6272 respondents from 2802 households. Respondents' mean scores on happiness and self-rated health were 3.10 (SD = 1.20) and 3.33 (SD = 0.89), respectively. We observed that respondents' happiness is positively associated with self-rated health but the two are only moderately correlated ($r=0.21$, $p<.001$).

Table 1 summarizes the respondents' scores on happiness and self-rated health stratified by their characteristics. Estimates from the multilevel proportional odds models of the associations between respondents' characteristics and the outcomes are presented. There are a number of noteworthy observations. First, increasing age appeared to be linked to reduced happiness and poorer self-rated health. However, we observed that those in the oldest age group were not necessarily less happy than their younger counterparts. Another noteworthy observation is that respondents with higher equalized household income were significantly more likely to report being happier and having better health. Interestingly, when we treated respondents' equalized household income as a continuous variable in regression models, it was significantly associated with happiness (OR 1.16; 95% CI 1.10, 1.23) but not related to self-rated health (OR 0.97; 95% CI 0.93, 1.03). Of the respondents' health-related characteristics, only smoking was associated with both reduced happiness and poorer self-rated health.

We examined the associations between RID (measured on Yitzhaki indices by absolute distance) and respondents' perceived happiness. Estimates from the regression models are reported in Table 2. In Model 1, where respondents' socio-demographic variables were not adjusted, we found significant positive associations between all Yitzhaki indices and respondents' degree of happiness, except the index using education as a reference. In Model 2, where respondents' socio-demographic factors were adjusted, we found all six indices to be positively associated with happiness. For the majority of the indices, the strength of the associations was attenuated, which indicates that some effects of the linkage is accounted by the adjusted variables. For the Yitzhaki index constructed using education as reference, the positive association became significant after the adjustment of the covariates. In Model 3, we found that the positive associations between the Yitzhaki indices and happiness remain robust even after further adjustment of respondents' health status. To check consistency, we repeated the analysis with the six Yitzhaki indices by decile rank; all Yitzhaki indices were found to be positively associated with happiness.

When we examined the associations between the RID (measured on Yitzhaki indices by absolute distance) and respondents' self-rated health, the results were different (Table 3). While in Model 1 we still observed that a majority of the Yitzhaki indices were positively associated with self-rated health, almost all Yitzhaki indices were found not to be significantly related to respondents' self-rated health after the adjustment of their socio-demographic variables (Model 2), with the exception of age, which remained significant. In models where respondents' health status was also adjusted (Model 3), we observed that only one Yitzhaki index (reference group defined by age) was positively linked with respondents' self-rated health. We checked the findings with Yitzhaki indices by decile rank, and overall we noted that the results were very similar but one additional Yitzhaki index (reference group defined by sex) was found to be positively associated with self-rated health.

We investigated whether the relationship between RID and outcomes differed across demographic subgroups. Figure 1a–d show the associations between the six Yitzhaki indices and respondents' self-rated health, stratified by the four demographic characteristics. Subgroup analysis stratified by age showed that positive associations were more consistently observed among the middle and older age groups, and within these two groups, and that some indices resulted in significant positive associations. Similarly, we detected more consistent positive associations among respondents with less education (primary and secondary educated) and those not engaged in economic activities (economically inactive or unemployed). Although all the tested associations among men and women were consistently positive, we only observed significant associations among the former group.

Table 1 Respondents' characteristics and its associations (in odd ratios) with perceived happiness (1 Happiest–7 Least Happy) and self-rated health (1 Excellent–5 Poor) among 6272 Hong Kong Chinese population (Hong Kong, China, 2011)

	N (%)	Perceived happiness (1) Happiest–(7) least happy		Self-rated health (1) Excellent–(5) poor	
		mean (SD)	OR (95% CI)[a]	Mean (SD)	OR (95% CI)[a]
Age					
15–34	1903 (30.3%)	3.01 (1.13)	1.00	3.07 (0.85)	1.00
35–64	3230 (51.5%)	3.11 (1.22)	**1.22 (1.05, 1.42)**	3.37 (0.85)	**1.42 (1.24, 1.69)**
65 or above	1139 (18.2%)	3.25 (1.29)	1.12 (0.90, 1.40)	3.69 (0.90)	**1.45 (1.14, 1.77)**
Sex					
Male	2992 (47.7%)	3.17 (1.20)	1.00	3.27 (0.89)	1.00
Female	3280 (52.3%)	3.04 (1.21)	0.93 (0.83, 1.03)	3.40 (0.87)	**1.40 (1.26, 1.60)**
Marital status					
Married	3743 (59.7%)	3.06 (1.19)	1.00	3.38 (0.87)	1.00
Widowed	449 (7.1%)	3.31 (1.30)	**1.26 (1.02, 1.55)**	3.74 (0.94)	0.99 (0.81, 1.22)
Divorced/separated	198 (3.2%)	3.58 (1.46)	**1.95 (1.48, 2.58)**	3.47 (0.87)	1.07 (0.81, 1.40)
Never married	1878 (30.0%)	3.10 (1.16)	**1.28 (1.11, 1.47)**	3.13 (0.87)	1.03 (0.89, 1.19)
Education					
Primary or below	1852 (29.7%)	3.23 (1.28)	1.00	3.62 (0.90)	1.00
Secondary	2982 (47.7%)	3.08 (1.19)	0.91 (0.80, 1.03)	3.25 (0.86)	**0.74 (0.65, 0.84)**
Post-secondary	1412 (22.6%)	3.01 (1.12)	0.89 (0.76, 1.04)	3.16 (0.84)	**0.76 (0.64, 0.88)**
Employment status					
Employed	3128 (50.1%)	3.10 (1.23)	1.00	3.22 (0.83)	1.00
Unemployed	196 (3.1%)	3.48 (1.28)	**1.46 (1.12, 1.91)**	3.30 (0.90)	1.04 (0.93, 1.16)
Economically inactive	2923 (46.8%)	3.09 (1.17)	**0.84 (0.75, 0.93)**	3.46 (0.92)	1.11 (0.85, 1.49)
Equalized household income					
<4000	1004 (16.0%)	3.40 (1.35)	1.00	3.65 (0.91)	1.00
4000–10,000	2468 (39.4%)	3.18 (1.21)	**0.79 (0.68, 0.92)**	3.32 (0.86)	**0.77 (0.66, 0.90)**
10,000 and above	2800 (44.6%)	2.94 (1.11)	**0.56 (0.48, 0.66)**	3.24 (0.83)	**0.76 (0.66, 0.89)**
Chronic conditions					
No	4764 (76.0%)	3.07 (1.17)	1.00	3.18 (0.83)	1.00
Yes	1508 (24.0%)	3.22 (1.29)	1.05 (0.92, 1.20)	3.84 (0.86)	**3.32 (2.89, 3.81)**
Smoking status					
Never smoked	4839 (77.2%)	3.03 (1.18)	1.00	3.30 (0.88)	1.00
Ex-smoker	538 (8.6%)	3.32 (1.28)	**1.48 (1.24, 1.78)**	3.56 (0.90)	**1.53 (1.32, 1.78)**
Current smoker	894 (14.3%)	3.36 (1.21)	**1.56 (1.35, 1.81)**	3.38 (0.88)	**1.32 (1.10, 1.59)**
Alcohol consumption					
Less than 3 times a week	5792 (92.4%)	3.20 (1.20)	1.00	3.34 (0.90)	1.00
At least 3 times a week	477 (7.6%)	3.10 (1.26)	0.96 (0.81, 1.16)	3.25 (0.88)	0.84 (0.68, 1.05)

Estimates in bold are statistically significant at the 5% level

SD standard deviation, *OR* odds ratio, *CI* confidence interval

[a]Odd ratios were estimated by simultaneously entering all respondents' characteristics into the multinomial logistic regression model, including household composition and household district as the two random effects

Discussion

Based on a large-scale survey among the Hong Kong Chinese population, we investigated the association between RID and perceived happiness and self-rated health. Based on the six Yitzhaki indices constructed, we observed consistent evidence indicating that increased RID is related to reduced happiness. In multilevel models in which respondents' socio-demographic characteristics and their health status were adjusted, the linkages between the two remained significant. On the other hand, although increased RID also appeared to be linked to poorer self-rated health, among our sample we observed that only two of the six Yitzhaki indices were significantly associated with self-rated health

Table 2 Odd ratios (with 95% confidence intervals) estimated from multilevel proportional odds models for associations between respondents' relative income deprivation and perceived happiness (1 Happiest–7 Least Happy) among 6272 Hong Kong Chinese population (Hong Kong, China, 2011)

	Reference group defined by					
	All	District	Age	Sex	Education	Employment
Model 1[a, d]						
Yitzhaki indices by absolute distance	**1.277 (1.219, 1.339)**	**1.324 (1.238, 1.416)**	**1.254 (1.197, 1.315)**	**1.287 (1.227, 1.349)**	1.016 (0.971, 1.064)	**1.214 (1.158, 1.272)**
Yitzhaki indices by decile rank	**1.092 (1.074, 1.111)**	**1.105 (1.083, 1.128)**	**1.079 (1.062, 1.097)**	**1.096 (1.078, 1.114)**	**1.023 (1.007, 1.040)**	**1.071 (1.054, 1.089)**
Model 2[b, d]						
Yitzhaki indices by absolute distance	**1.262 (1.175, 1.355)**	**1.195 (1.090, 1.310)**	**1.279 (1.204, 1.358)**	**1.262 (1.175, 1.355)**	**1.128 (1.046, 1.216)**	**1.259 (1.165, 1.361)**
Yitzhaki indices by decile rank	**1.082 (1.053, 1.111)**	**1.079 (1.045, 1.115)**	**1.080 (1.055, 1.104)**	**1.083 (1.055, 1.112)**	**1.054 (1.025, 1.083)**	**1.075 (1.042, 1.110)**
Model 3[c, d]						
Yitzhaki indices by absolute distance	**1.260 (1.173, 1.353)**	**1.194 (1.090, 1.309)**	**1.270 (1.195, 1.349)**	**1.260 (1.173, 1.353)**	**1.136 (1.053, 1.224)**	**1.257 (1.163, 1.359)**
Yitzhaki indices by decile rank	**1.082 (1.054, 1.112)**	**1.081 (1.046, 1.117)**	**1.078 (1.053, 1.102)**	**1.083 (1.055, 1.112)**	**1.058 (1.029, 1.087)**	**1.077 (1.044, 1.111)**

Results are presented in: "odd ratio (95% confidence interval)"; estimates in bold are statistically significant at the 5% level

[a]Estimates are adjusted for household composition (random effect) and district of the household (random effect)

[b]Estimates are adjusted for variables in Model 1 plus age, sex, marital status, education, employment status, and equalized household income

[c]Estimates are adjusted for variables in Model 2 plus chronic conditions, smoking status, and alcohol consumption

[d]Estimates are based on one standard deviation increase in the Yitzhaki indices

after respondents' socio-demographic characteristics were adjusted. Our results suggest that the linkage between RID and self-rated health is weak among our sample.

We observed a positive association between happiness and self-rated health. However, these two measures of well-being are only weakly correlated, which is in line with previous reports that they do not have a close correspondence (Subramanian et al. 2005). Our findings are also similar with previous studies indicating that a common set of factors influence both happiness and self-rated health (Oshio and Kobayashi 2010; Subramanian et al. 2005). While in our sample individuals with lower household income were more likely to have poorer self-rated health, we noted that the association between income and self-rated health was not significant when income was considered as continuous data. Our findings indicate that the relationship between income and self-rated health may not be linear (Lynch et al. 2000).

There is a wealth of research showing that increased RID is linked to reduced happiness in the Western context (Smith et al. 2012). Studies have increasingly noted this linkage in Asian societies (Asadullah et al. 2015; Kye and Park 2014; Oshio and Kobayashi 2010). Our study among a sample of the Hong Kong Chinese population found that RID is associated with reduced happiness even after adjusting for the sample's socio-demographic and health status. Our observations add support to the relative income hypothesis highlighting the negative linkage between RID and individuals' subjective well-being.

A number of investigations have addressed the association between RID and self-rated health, many of which measured RID with the Yitzhaki index. Although some studies reported a significant linkage between the two, others found weak or even no support for the linkage (Gravelle and Sutton 2009; Jones and Wildman 2008; Li and Zhu 2006; Lorgelly and Lindley 2008). In Taiwan, a recent study examined the linkage of RID and self-rated health among the middle age group and reported that increased RID was linked to worse self-rated health (Kuo and Chiang 2013). Analyses in our study drawing from the overall sample indicated that after adjusting covariates, only one or two of six RID measures yielded significant association with self-rated health. Our study, unlike Kuo's work, provides rather weak support for the linkage.

We measured respondents' self-rated health using a 5-point scale on which three responses corresponded to

Table 3 Odd ratios (with 95% confidence intervals) estimated from multilevel proportional odds models for associations between respondents' relative income deprivation and self-rated health (1 Excellent–5 Poor) among 6272 Hong Kong Chinese population (Hong Kong, China, 2011)

	Reference group defined by					
	All	District	Age	Sex	Education	Employment
Model 1[a, d]						
Yitzhaki indices by absolute distance	**1.206 (1.150, 1.265)**	**1.260 (1.180, 1.345)**	**1.058 (1.009, 1.109)**	**1.194 (1.139, 1.253)**	**0.858 (0.820, 0.899)**	**0.949 (0.906, 0.995)**
Yitzhaki indices by decile rank	**1.068 (1.050, 1.086)**	**1.076 (1.054, 1.099)**	**1.019 (1.002, 1.036)**	**1.065 (1.048, 1.083)**	**0.962 (0.946, 0.978)**	0.989 (0.973, 1.005)
Model 2[b, d]						
Yitzhaki indices by absolute distance	1.022 (0.951, 1.098)	1.000 (0.913, 1.096)	**1.074 (1.011, 1.142)**	1.022 (0.951, 1.099)	0.950 (0.880, 1.025)	0.967 (0.893, 1.047)
Yitzhaki indices by decile rank	1.015 (0.988, 1.043)	1.018 (0.984, 1.052)	**1.028 (1.005, 1.052)**	1.022 (0.995, 1.049)	1.023 (0.995, 1.052)	1.016 (0.984, 1.050)
Model 3[c, d]						
Yitzhaki indices by absolute distance	1.046 (0.971, 1.126)	1.025 (0.935, 1.124)	**1.116 (1.050, 1.188)**	1.046 (0.971, 1.126)	0.970 (0.898, 1.048)	0.999 (0.921, 1.083)
Yitzhaki indices by decile rank	1.021 (0.993, 1.118)	1.027 (0.994, 1.062)	**1.042 (1.019, 1.067)**	**1.028 (1.000, 1.056)**	1.026 (0.997, 1.055)	1.016 (0.984, 1.049)

Results are presented in: "odd ratio (95% confidence interval)"; estimates in bold are statistically significant at the 5% level

[a]Estimates are adjusted for household composition (random effect) and district of the household (random effect)

[b]Estimates are adjusted for variables in Model 1 plus age, sex, marital status, education, employment status, and equalized household income

[c]Estimates are adjusted for variables in Model 2 plus chronic conditions, smoking status, and alcohol consumption

[d]Estimates are based on one standard deviation increase in the Yitzhaki indices

good health, one to neutral, and one to bad health. This measure has been widely used in previous studies (Hounkpatin et al. 2016; Kondo et al. 2008; Mishra and Carleton 2015). Although it may differ from other self-rated health measures having two choices on bad health ("poor" and "very poor health"), one essential commonality is that they reflect the "relative position" of one's health across a range of consecutive choices, rather than focusing on the absolute responses of "good" or "bad" health. While some might speculate that the differences between our results and those of previous studies may be the result of our self-rated health measure, we do not believe that this is the case. Previous studies using the same measures as ours have identified significant linkage between RID and self-rated health (Kondo et al. 2008; Subramanyam et al. 2009); on the other hand, null observations were also detected in studies using alternative self-rated health measures (Gravelle and Sutton 2009; Li and Zhu 2006).

Existing research used various approaches to analyze the associations between RID and self-rated health. Some of which categorized the sample into two groups but the dichotomization was often based on arbitrary cut-offs (Kondo et al. 2008; Subramanyam et al. 2009). Our approach made full use of the information from the ordinal scale. While some studies ignoring the clustering nature of the sample (Kuo and Chiang 2013), others addressing the issue by examining the associations using either multilevel approach (such as ours) or generalized estimating equations approach (Kondo et al. 2008). The inconsistency of the findings may be partially related to these modeling approaches. A review comparing the results estimated from various methodological approaches is warranted.

We believe the weak tie between RID and self-rated health is related to the context of Hong Kong, which has an equal access public health system. Unlike the US and some European countries, research has shown that our public health system is "pro-poor" and the financing mechanism has served to redistribute health resources from the rich to the poor (Johnston et al. 2006; Leung et al. 2009). The health care system in Hong Kong is considered to be one of the most equitable among 13 Asian economies (O'donnell et al. 2008). We argue that a highly equitable health infrastructure may to some extent weaken the negative linkage between RID and health.

Some studies have shown that the linkage of RID and health varies across demographic strata (Ling 2009; Salti 2010; Wildman 2003). Our study has extended research in this direction and found that the linkage between RID

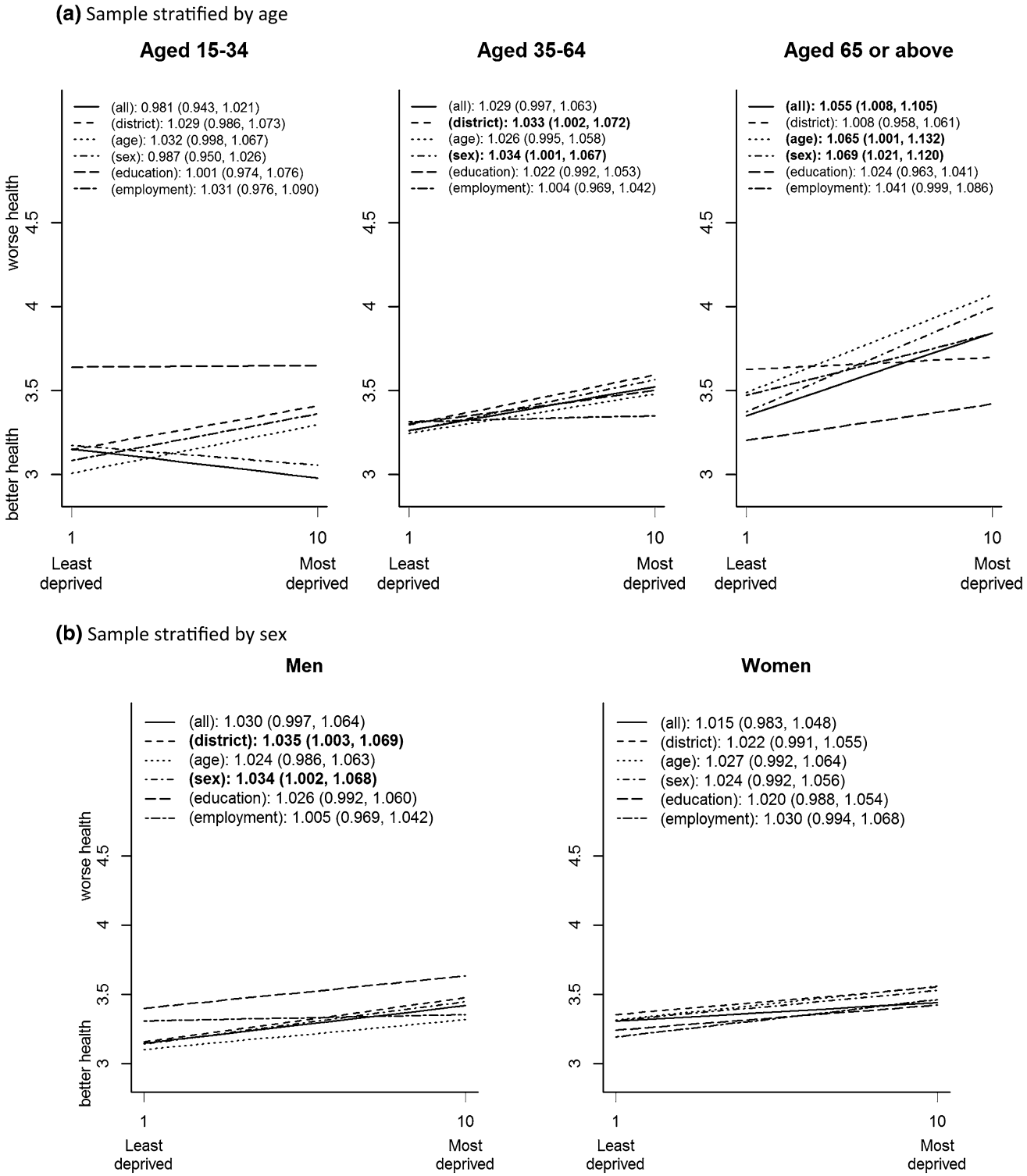
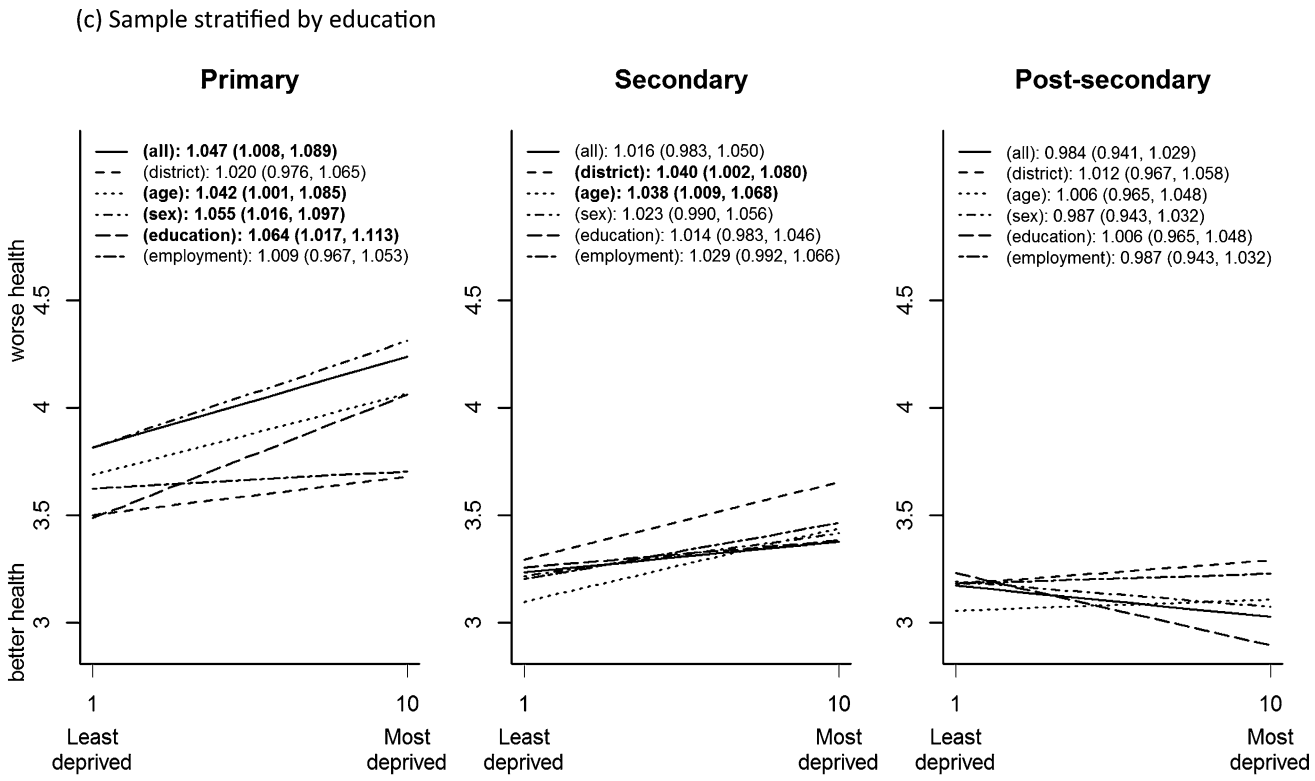


Fig. 1 **a**–**d** Odd ratios (with 95% confidence intervals) estimated from multilevel proportional odds models for associations between respondents' relative income deprivation (decile-rank based measures) and self-rated health (1 Excellent–5 Poor) by demographic or socioeconomic subgroups among 6272 Hong Kong Chinese population. **a** Sample stratified by age. **b** Sample stratified by sex. **c** Sample stratified by education. **d** Sample stratified by employment status. Results are presented in: "(Reference group): Odd ratio (95% confidence interval)". Estimates in bold are statistically significant at the 5% level. All models were adjusted for age, sex, equalized household income, education, marital status, employment status, household composition (random effect), and the district of the household (random effect). HKSAR, China, 2011



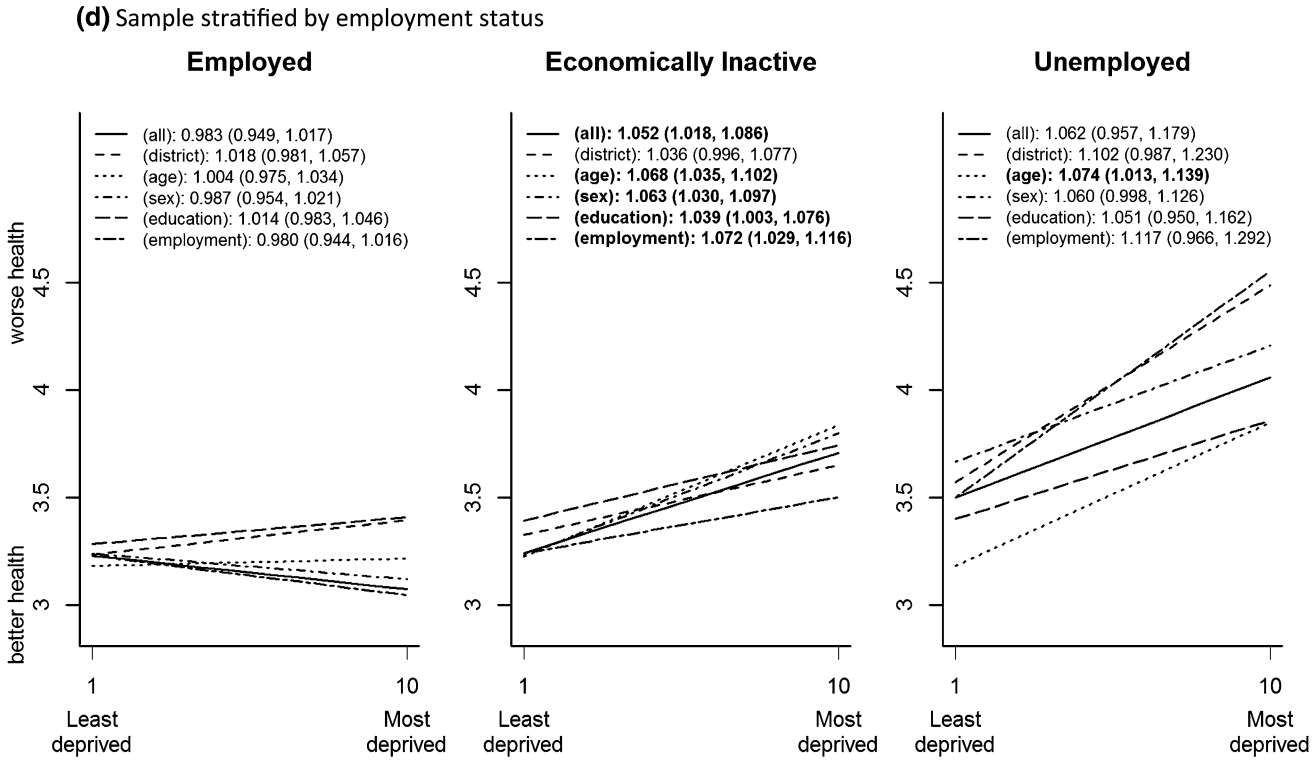


Fig. 1 (continued)

and self-rated health appears to be more notable among men, older individuals, and those lower down the economic ladder (i.e., the less educated and unemployed). The observed gender difference may be related to that fact that men are more likely to make economic comparisons; among women, comparison may have a greater focus on other culturally specific tasks, such as child-rearing or maintaining family welfare (Demakakos et al. 2008). Having more cumulative life experience, older individuals may be at a life stage where they more readily assess themselves with respect to others, which may account for the more pronounced effect of RID among them (Demakakos et al. 2008). The stronger linkage between RID and health among the most socioeconomically deprived may be related to the fact that this group is likely to have at least perceived opportunities to escape their disadvantaged circumstances and present greater perceived social injustice and stress (Franzini and Fernandez-Esquer 2006).

Our study addresses the linkage between RID and happiness and health in Hong Kong, and is one of the few to have addressed this topic in Chinese communities. In addition, we made use of multilevel analysis that takes the household and neighborhood influence into account. Our analysis also controlled multiple potential confounding factors that may bias the relationship between RID and outcomes. Nevertheless, our work has limitations. The use of a cross-sectional design limited the possibilities for drawing causal inferences. Second, we cannot verify whether the missing data would introduce bias into the results. However, an exploration among respondents' with missing data on income showed that their socio-demographic characteristics and happiness and health do not substantially deviate from the main sample (Online Appendix).

In conclusion, our study supports the relative income hypothesis in the Hong Kong Chinese community, according to which increased RID is significantly associated with reduced happiness. On the other hand, our study has yielded weak support for the linkage between RID and self-rated health, although there are sizeable subgroup differences. We believe that this weak tie may be partially related to counterbalancing influences from our highly equitable health care system and a number of pro-poor health care strategies. Further research is needed to confirm the ameliorating role of the public health system and to explore whether this effect is manifest in other sociocultural contexts. Last but not least, our study has shown that the linkage between RID and health appears to be more pronounced among men, older individuals, and those at a lower economic position.

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Compliance with ethical standards

Research ethics Ethical approval was obtained from the Hong Kong University of Science and Technology, Hong Kong (Ref No. HKUST-6001-SPPR-08).

Conflict of interest The authors declare no conflict of interest.

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