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Household income and adolescent blood pressure in a Chinese birth cohort: "Children of 1997"

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ABSTRACT

The inconsistent relation of national income with population blood pressure raises questions as to whether social comparisons of relative income at individual or neighbourhood level may be more relevant than absolute income. We examined the associations of absolute household income (income *per se*), absolute neighbourhood median income (average income among geographically-proximate households), relative household income [deprivation using Yitzhaki index, or rank by position] (differences in income or rank compared with others) and relative neighbourhood income inequality [Gini coefficient] (income gap within a neighbourhood) with blood pressure z-score, prehypertension or hypertension at ~13 years using a fixed effects multilevel linear or logistic model in a Chinese birth cohort (n = 5063, 61% of follow-up). Absolute household or neighbourhood income was not associated with adolescent blood pressure. Greater relative household income deprivation was associated with higher diastolic blood pressure (0.01 z-score per USD 128 difference in Yitzhaki index, 95% confidence interval (CI) 0.005 to 0.02), so was lower relative household income rank (−0.10, 95% CI −0.15 to −0.04), but relative neighbourhood income inequality was not, when considering each income measure separately. Such associations remained when considering all income measures together. Income measures were not associated with prehypertension or hypertension. Relative household income (greater deprivation or lower rank) were positively associated with adolescent blood pressure independent of absolute household income while absolute or relative neighbourhood income had little contribution, suggesting social comparisons at a key developmental stage could be relevant. Clarifying specific effects of socioeconomic position across the life-course could inform interventions.

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1. Introduction

The relation of national income with population mean blood pressure (BP) is inconsistent: a declining trend of varying extent in high-income regions, whereas a rising trend in low-to middle-income regions since the 1980s (Danaei et al., 2011). Concomitantly, income inequality indexed by Gini coefficient rose more in rapidly developing than economically developed regions (Central Intelligence Agency, 2014). Considering treated hypertensive adults still have excess mortality compared to normotensives (Andersson et al., 1998), adolescence may be a key intervention window because BP rises during adolescence (National High Blood Pressure Education Program, 2004), adolescent BP tracks into adulthood (Chen and Wang, 2008) and predicts early-onset hypertension (Bao et al., 1995), vascular abnormalities (Drukteinis et al., 2007) and cardiovascular disease (Lurbe et al., 2009). Specifically, systolic and diastolic BP in late adolescent men were associated with coronary heart disease and/or stroke incidence (Falkstedt et al., 2008) and cardiovascular disease mortality (Sundstrom et al., 2011). Understanding what income at household and neighbourhood levels represents to adolescent BP within specific social contexts may inform corresponding prevention.

Income confers not only the ability to purchase material necessities (e.g. food and shelter), but also the ability to participate in social networking (e.g. smartphone and internet) and possess symbolic resources (e.g. status and prestige) (Lynch et al., 2000). As such, income has been broadly conceptualized as absolute income (income *per se*) or relative income (social comparisons of income) and measured at the household or neighbourhood level. These four

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related yet distinct income measures could disproportionately affect the health of poor households in society (Harling et al., 2014).

The absolute income hypothesis posits that a child's health status depends only on his/her household income via expenditure to obtain goods (e.g. food, housing and transport) and services (e.g. health care, education and recreational facilities) that may affect health (Galobardes et al., 2006). With the concave relationship between resources and health suggesting a positive but diminishing marginal health return from additional income, children from poor households would be expected to have poorer health disproportionately (Leigh et al., 2009). As such, *absolute household income* reflects the living conditions and resources of a household and may affect poor households in any neighbourhood due to lack of resources. Younger adults from lower income households in economically developed settings have been shown to have greater adiposity, higher smoking rates and higher alcohol intake that may partly contribute to their higher BP (Brummett et al., 2011). Hong Kong is an ideal setting in which to assess this pathway as smoking rates and alcohol use are both very low. *Absolute neighbourhood median income* describes the average income among geographically-proximate households. It could reflect the average living conditions of households who make up the neighbourhood, or imply public resources availability in the neighbourhood. Lower availability of affordable healthy foods, limited accessibility to recreational areas, low walkability and greater availability of tobacco could all contrbute to higher BP (Diez Roux, 2003). Similarly, poor households in any neighbourhood may be affected because poor households still have limited resources in any neighbourhood (with similar or a wide income distribution).

The relative income hypothesis posits a child's health status depends not just on his/her household income but also on incomes of other households in terms of relative rank or differences in income compared with others (Kawachi et al., 2002). This suggests inability to attain the normative standards of consumption beyond meeting basic necessities could affect health. *Relative household income* indicates a lack of resources in comparison with others (Runciman, 1966) or reduced access to socially desirable resources (Kawachi et al., 2002). It may induce a sense of relative deprivation or lower rank and thus increased stress and frustration that may impose a physiological burden or encourage stress-coping behaviour resulting in poor health (Wood et al., 2012). Psychological stress could up-regulate the hypothalamic-pituitary-adrenal system (Hamer and Steptoe, 2012), which would be expected to increase BP (Prodam et al., 2013). Poor households who live in a higher than average income neighbourhood may have more psychological stress, although they may benefit from better access to public goods and safer neighbourhoods. Alternatively, *relative neighbourhood income inequality* could affect all households in neighbourhoods with a wide income distribution because the greater income gap within a neighbourhood may reflect weaker social cohesion and underinvestment in social and public infrastructure, comprising education, health services, housing, transport, and recreational facilities, thus affecting everyone in the neighbourhood (Lynch et al., 2000). Adolescents residing in neighbourhoods with a wide income distribution might experience chronic stress from traffic and noise pollution, vandalism, disturbance by others (Steptoe and Feldman, 2001), persistent struggle to control others or perceived subordination (Ewart et al., 2014) and thereby tend to have higher BP (McGrath et al., 2006).

To date, most observational studies suggest an inverse association of absolute household income with adult, but not adolescent BP (Ali et al., 2011; Batty and Leon, 2002; Colhoun et al., 1998; Loucks et al., 2007) and cardiovascular disease-specific mortality (Galobardes et al., 2004). Limited cross-sectional studies using relative income deprivation suggest a positive association with adult BP (Ling, 2009) and cardiovascular disease-specific mortality (Eibner and Evans, 2005; Modrek et al., 2012), though not always consistently so (Li and Zhu, 2006). Little is known about how income inequality (indexed by Gini coefficient) across regions within a country relates to adolescent BP, although a cross-sectional study in Germany found no association with adult BP (Breckenkamp et al., 2007). Moreover, possible confounding by other socioeconomic attributes such as parental education which predicts household income and child health, over-adjustment for mediating risk factors, reverse causation, inherent issue in defining the social comparison group and inconsistencies across strata makes previous findings conservative (Razak and Subramanian, 2014). Given the lack of information about a key developmental stage, with potentially lifelong implications for BP, we examined prospectively the associations of absolute household income, absolute neighbourhood median income, relative household income (deprivation or rank) and relative neighbourhood income inequality with adolescent BP using a Chinese birth cohort in Hong Kong where the income gap has been widening since mid-1980s and the Gini coefficient (0.54) is wide (Economic Analysis Division, 2012).

2. Methods

2.1. Data source

Hong Kong's "Children of 1997" birth cohort is a population representative Chinese birth cohort ($n = 8327$) that covered 88.0% of all births in Hong Kong from April 1, 1997 to May 31, 1997, described in detail elsewhere (Schooling et al., 2012). The study was initially established to investigate the effect of second-hand smoke exposure on infant health. Families were recruited at the first postnatal visit to any of the 49 Maternal and Child Health Centers in Hong Kong, which parents of all newborns are strongly encouraged to attend for free vaccinations and well-baby checks. Characteristics obtained using a self-administered questionnaire in Chinese at recruitment and subsequent routine visits include maternal and birth characteristics and parental education. Monthly household income and household size was also reported. Passive follow-up via record linkage was instituted in 2005 to obtain routinely collected information including: (i) weight and height from birth to 5 years and anonymous addresses from the Maternal and Child Health Centers ($n = 7999$, 96% successful matching); (ii) annual measurements of weight and height (grade 1 (age 6–7 years) onwards) and bi-annual assessments of BP (grade 5 (age 10–11 years) onwards) from the Student Health Service, Department of Health, which provides free annual check-ups for all school students ($n = 7809$, 94% successful matching). At the Student Health Service, height without shoes was measured by stadiometer to the nearest 0.1 cm and weight without shoes and outer clothing was measured by digital scale to the nearest 0.1 kg. BP was measured by nurses on the right arm in a seated position after more than 10 min of rest with an age and size appropriate cuff size using an automated oscillometric device. Initial systolic or diastolic BP more than the 90th percentile for sex, age and height was double checked by physicians with a sphygmomanometer after 15 min of rest and this second measurement was recorded. Parental birthplace was based on a postal survey (Survey I) in 2008–2009, a postal survey (Survey III) with telephone follow-up in 2011–2012, supplemented with parental residency status in Hong Kong from the baseline questionnaire in 1997.

2.2. Exposures

2.2.1. Absolute income

Absolute income was considered at the household and

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