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Original Article

## The Association of Intergenerational Mismatch With Adiposity and Blood Pressure in Childhood and Adolescence

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### ABSTRACT

**Purpose:** An intergenerational “mismatch,” a transition from limited to plentiful living conditions over generations, may increase cardiovascular disease risks. In a migrant population within a homogenous culture, we tested the hypothesis that an intergenerational mismatch in childhood living condition is associated with higher body mass index (BMI) and blood pressure in childhood and adolescence.

**Methods:** We used data from 6,965 native born Chinese in Hong Kong (participated in “Children of 1997” birth cohort) and migrant Chinese born elsewhere in China in 1997 (N = 9,845). We classified children into those with intergenerational mismatch (child migrants or first-generation migrants) or those without (second+generation migrants). Generalized estimating equations were used to examine the associations of migration status (child migrants, first-generation migrants or second+generation migrants) with age- and sex-specific BMI z-score at 8–15 years and age-, sex-, and height-specific blood pressure z-score at 11–13 years, adjusted for sex, month of birth, and age.

**Results:** Compared with second+generation migrants, first-generation migrants had higher diastolic blood pressure z-score (.04, 95% confidence interval (CI) .02, .06) and BMI z-score (.12, 95% CI .06, .18), whereas child migrants had higher diastolic blood pressure z-score (.03, 95% CI .01, .05) regardless of age at migration and higher BMI z-score if they had migrated in infancy (.17, 95% CI .11, .23).

**Conclusion:** Different relations for blood pressure and BMI suggest that intergenerational mismatch and proximal exposures may have different impacts on adiposity and blood pressure.

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### IMPLICATION AND CONTRIBUTION

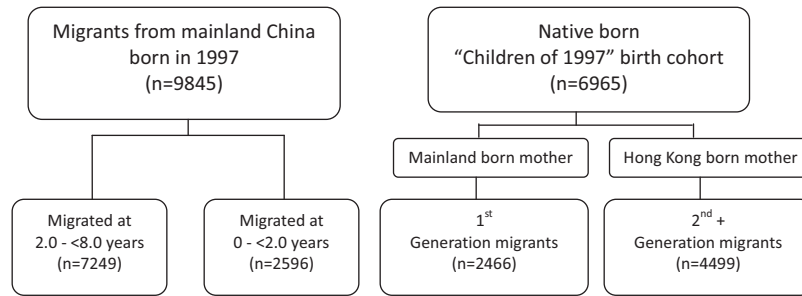
In Hong Kong, with a unique migration history, first-generation migrants had higher diastolic blood pressure and body mass index (BMI) in childhood and adolescence. Child migrants had higher diastolic blood pressure, but only had higher BMI if they had migrated in infancy. An intergenerational mismatch in early living condition may influence blood pressure more compared to BMI.

**Conflicts of Interest:** The authors have no conflicts of interest relevant to this article to disclose.

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High-income countries experienced an increase in the prevalence of cardiovascular diseases (CVD) with economic growth [1], but after a peak in about the 1970s, most of these countries have seen a downward trend in CVD mortality [2]. Since the 1990s low income countries have experienced an epidemic of CVD [3]. Such differences in secular trends cannot be attributed solely to



**Figure 1.** Study participants and classification of migration status.

lifestyle or behavioral factors, such as unhealthy diet, physical inactivity, and smoking [4]. Increasing evidence suggests that influences on adult health not only operate during an individual's life span but also across generations [5]. Specifically a "mismatch" of living condition or a transition from limited living conditions to plentiful conditions over generations or over the life course, which is more commonly seen in countries undergoing recent and rapid economic development, has been hypothesized as contributing to the development of chronic diseases [6,7], through adaptive responses of the fetus to cues from the mother [7].

Few studies were able to investigate the impact of intergenerational mismatch on CVD and its risk factors and reported mixed findings. Maternal illiteracy, a proxy for limited maternal living conditions, was associated with central adiposity in women but not in men in an older Chinese population [8]. A small study from Mexico in a population undergoing nutrition transition showed that women with childhood malnutrition were shorter and gave birth to smaller babies, who in turn were more obese at 4–6 years of age [9]. In contrast, a study from Sweden, where economic development has been more gradual than that currently taking place in Asia, reported that less food availability before puberty in fathers was associated with lower cardiovascular disease mortality [10].

Migrant studies may be useful in unraveling intergenerational influences on CVD and its risk factors as migrants to high-income countries often experience a rapid transition in living conditions. Migration from less to more economically developed countries is associated with central obesity and/or higher risks of type II diabetes [11], although not always with a higher risk of CVD [12]. However, most migrant studies have either compared migrants with the host population from a different culture and ethnicity, or with nonmigrants from their own communities who may be different from migrants in many ways. With such comparisons it is not possible to separate out intergenerational influences. Few migrant studies have been able to clarify whether there are critical periods of vulnerability when changes in living conditions are more likely to impact health [13] and whether any impact is greater in men than women, given the higher prevalence of CVD in men.

Hong Kong is an ethnically Chinese city whose population has undergone a recent and rapid economic development from a pre-to postindustrial economy [14,15] at different rates [16]. The Hong Kong population was largely formed by young migrant workers from the neighboring province of China in the late 1940s to early 1950s, with some additional migration subsequently. After the return of sovereignty to China in 1997, migration of children born in China to Hong Kong increased. In the 1970s, the gross domestic product per capita in China was about 12% of that in Hong

Kong [17]. As such, Chinese children growing up in Hong Kong had different degrees of intergenerational mismatch depending on their place of birth and their mothers' place of birth. This population history provides an opportunity to assess intergenerational influences and timing of mismatch within an ethnically homogeneous but economically heterogeneous population.

In this unique setting, we have previously observed a different social gradient in childhood and early adolescent body mass index (BMI) by migration status and that lower parental education was associated with greater BMI z-score in second generation of migrants (native born children with native born mothers), but not first-generation migrants (native born children with mothers who had migrated from China) [18,19]. In this study we augmented Hong Kong's "Children of 1997" birth cohort with child migrants to test the hypothesis that children with greater intergenerational mismatch have greater BMI and higher blood pressure, allowing for any differences by sex and socioeconomic position (SEP). We also tested whether any difference in BMI and blood pressure in child migrants related to timing of intergenerational mismatch proxied by age at migration (0–<2.0 years or 2.0–<8.0 years).

## Methods

### Study participants

The study participants were from two sources. We used information from Hong Kong's "Children of 1997" birth cohort, as well as migrants from the rest of China born in 1997 who migrated to Hong Kong before 8 years (Figure 1).

**"Children of 1997" birth cohort.** The Hong Kong "Children of 1997" birth cohort is a population representative of a Chinese birth cohort ( $n = 8,327$ ) that covered 88% of all births in Hong Kong from April 1, 1997 to May 31, 1997 [20]. Families were recruited at their first postnatal visit to the 49 Maternal and Child Health Centres in Hong Kong. Baseline characteristics were obtained at recruitment using a self-administered questionnaire in Chinese. Passive follow-up via record linkage was instituted in 2005 to obtain routinely collected data from various health sections.

**Migrants from the rest of China.** Staff from the Student Health Service (SHS) identified students who ever attended the SHS and were born in 1997 in the rest of China and migrated to Hong Kong before the age of 8 years.

In Hong Kong the SHS provides annual health checkups for students from all (public/private) primary and secondary schools.

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