

DISCUSSION PAPER SERIES

IZA DP No. 15305

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Subjective Well-Being in China**

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## ABSTRACT

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# Housing Unaffordability and Adolescent Subjective Well-Being in China

Using the 2010-2018 waves of the China Family Panel Studies, we investigate the impact of housing unaffordability on subjective well-being (SWB) among Chinese adolescents aged 10-15. Using a combined methodology of propensity score matching and fixed effects and instrumental variable estimations, we show that housing unaffordability leads to higher levels of depression, with more pronounced impacts among older adolescents (aged 13-15), those from migrant and urban families, and those living in regions with high housing prices and expensive living costs. These results are robust not only to alternative housing unaffordability and SWB measures but to a series of estimation approaches that control for endogeneity. An additional structural equation modelling analysis of underlying pathways further reveals that this housing unaffordability-SWB relation is mediated by paternal depression and (lower) adolescent trust in parents.

**JEL Classification:** D10, I10, I31, J13, R21

**Keywords:** housing unaffordability, depression, adolescents, China

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## 1. Introduction

Given housing's importance as a determinant of child health and well-being (Dunn, 2020), inadequate housing and homelessness represent significant barriers not only to family stability and child development (Fowler & Farrell, 2017) but to achieving WHO's (2021) third sustainable goal of ensuring healthy lives and well-being across the globe. In this context, the rising price of housing with its corresponding unaffordability is of mounting concern in many countries. In Beijing, for example, the average real house price rose by about 41.8% between 2012 and 2015, while low-priced homes experienced deteriorating conditions (Zhang & Yi, 2018). Such housing unaffordability – the inability for households to meet housing expenditures without excessively limiting nonhousing consumption (Hulchanski, 1995) – not only causes stress and impaired functioning among adults (Wang et al., 2021) but appears anecdotally to affect child subjective well-being (SWB). Yet despite such serious outcomes, the topic has as yet been subjected to little rigorous research.

The case of China is particularly apt for assessing the impact of housing unaffordability on child SWB for several reasons: First, since the market-oriented reform of its welfare housing system in 1998, China has made remarkable progress over a reasonably short time in improving housing conditions (Shi et al., 2016), including almost tripling the average floor area per capita of urban households from 13 square meters in 1992 to 40 square meters in 2018 (Huang et al., 2021). Nonetheless, unaffordable housing remains one of urban China's greatest challenges (Shi et al., 2016), with several studies confirming serious and worsening housing affordability, especially in urban areas (Shen, 2012; Shi et al., 2016; Wang et al., 2021; Wu et al., 2012, 2016). Faced with this pressing housing unaffordability crisis, China's central and local governments have implemented a large set of affordability enhancing policies. On the supply side, for instance, during the 12<sup>th</sup> Five-Year Plan period of 2011-2015, they built over 40 million public and quasi-public housing units across the country (Li et al., 2020). After 2016 in particular, the central government committed to advancing rental housing market development as another potential supply-side tool to tackle the mounting housing unaffordability in first- and second-tier cities. Yet unaffordable housing has proven difficult to address under current policy settings and remains embedded in the operation of market-oriented housing reforms (Shi et al., 2016). China thus has an urgent need to combine affordable housing policies with urban policies and planning, particularly as cities increase in size because of continued urbanization (Cai & Lu, 2015). This urgency is heightened by the rise in average national house prices, which, because of an average 14.4% annual increase in

land values ((Wu et al., 2016), is now at least double the rise in household income (Chen et al., 2020), especially in megacities such as Beijing (Zhang & Yi, 2018). Such rocketing growth not only increases concerns about housing unaffordability (Li et al., 2020) but negatively affects the well-being of Chinese residents (Nie et al., 2022).

Policy interventions to improve this well-being, however – particularly during the psychologically challenging time of adolescence – is difficult given the current lack of comprehensive research on the relation between housing unaffordability and adolescent SWB in developing and transitional economies like China. Rather, the relatively small body of extant research focuses exclusively on Western countries, particularly the US (Clair, 2019; Coley et al., 2013; Fertig & Reingold, 2007; Harkness & Newman, 2005; Marçal & Maguire-Jack, 2021; Newman & Holupka, 2021; Newman & Holupka, 2015). This current study aims to narrow this knowledge gap by leveraging longitudinal representative data from the 2010-2018 China Family Panel Studies (CFPS) to assess how housing unaffordability in China affects the SWB of adolescents aged 10-15. In doing so, it makes four valuable contributions to the existing literature on the housing-SWB nexus: First, by expanding empirical investigation beyond the West, it examines this relation in a context of rapid urbanization in which unique housing market reforms have led to soaring home prices. Second, by focusing on adolescents rather than adults, it recognizes housing as an important dimension of child well-being (Clair, 2019). That is, given the significant physical and cognitive changes that accompany adolescence, impairing adolescent SWB may have critical consequences (Lu et al., 2021), including low self-esteem (Lin & Yi, 2017) and even economic loss from mental disorders (Bursztyn et al., 2018). Third, by combining the three different methodological approaches of fixed effects (FE) estimation, propensity score matching (PSM), and instrumental variable (IV) estimation, it enables clear differentiation of the housing unaffordability impact on adolescent SWB from other factors that jointly determine household housing unaffordability and child SWB. Finally, by using a structural equation model (SEM) that tests the intervening variables of adolescent-parent squabbling, adolescent trust in parents, and paternal depression as potential mediators of the housing unaffordability–SWB relation, it sheds light on underlying pathways not yet considered in the more narrowly focused prior research.

The remainder of the paper is organized as follows: Section 2 summarizes the relevant literature on housing unaffordability and its impact on child and adolescent SWB, whose possible mechanisms are explored in Section 3. Section 4 then describes the data and outlines

identification strategies, after which Section 5 presents the main results. Section 6 concludes the paper with a summary of major findings and their practical implications for policy.

## **2. Literature review**

### *2.1 Housing unaffordability measure*

The housing unaffordability concept dates back to 19th century household budget studies that posited “one week’s pay for one month’s rent” (Hulchanski, 1995). Such unaffordability is generally assessed by either the housing expenditure-to-income ratio (HEIR) method, which compares housing costs to household income (Cai & Lu, 2015), or the less popular residual income method, which posits that when housing unaffordability is absent (present), household income minus housing expenditures is sufficient (insufficient) to cover nonhousing needs like food and clothing (Bourassa, 1996). Among the various HEIR methods used to address housing affordability, the US Department of Housing and Urban Development designates a cost burden of 30-50% as moderate and over 50% as severe housing unaffordability (Newman & Holupka, 2015). Most Australian research, in contrast, adopts a 30/40 rule (Baker et al., 2020; Milligan et al., 2016; Yates & Milligan, 2007) by which the household is in the lowest 40% of the equivalized disposable income distribution and pays over 30% of its gross income in rent or mortgage costs (Baker et al., 2020). The somewhat similar criterion in Canada is that the household pays over 30% of its income on housing and earns income insufficient to rent an adequate dwelling (Cooper, 2004). One weakness of this standard ratio method, however, is that given the variations in household size and income to which housing unaffordability is subject (Borrowman et al., 2017; Kutty, 2005; Stone, 2006a), larger households with lower income are worse off than the standard would indicate, primarily because nonhousing costs make up a higher fraction of household income (Kutty, 2005; Stone, 2006b). Hence, some studies instead employ a ratio of housing price to income (HPIR) (Cai & Lu, 2015; Li et al., 2020), which the World Bank deems acceptable when in the 3 to 6 range (Lau & Li, 2006).

In China, the most common measure of housing unaffordability is the HEIR method, whose application to 1999 and 2000 China Real Estate Statistical Yearbook data shows a decline in HPIR in Beijing from 11.65 in 1992 to 6.74 in 2002 (Lau and Li (2006). Alternative HPIR analyses using the same indicators demonstrate a decrease from 8 in 1995 to 6.7 in 2000, followed by a rise to 7.4 in 2008 (Chen et al. (2010), but with an overall increasing trend among eight major Chinese markets from 1999 to 2010 (Wu et al. (2012)<sup>1</sup>, which when extended to

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<sup>1</sup> The eight markets include Beijing, Chengdu, Hangzhou, Shanghai, Shenzhen, Tianjin, Wuhan and Xi’an.

12 Chinese markets shows overall HPIRs to be extraordinarily high (Wu et al. (2016)).<sup>2</sup> Other such research, in addition to positively linking HPIR to income inequality, documents around a 6% increase in urban China from 2002 to 2009 (Zhang et al. (2016)). Likewise, more recent prefectural level calculations of annual average house prices in 2014–2018 for 275 cities, which use HEIR to quantify city-level housing unaffordability, underscore that China’s substantial housing unaffordability is in fact concentrated in a few megacities, including Beijing, Shanghai, and Shenzhen (Li et al., 2020).

Whether based on HPIR or HEIR, the ratio method is straightforward and technically simple, and is thus widely used in different geographic regions and international comparisons (Chen et al., 2010). As previously commented, however, it cannot accurately identify housing unaffordability in households of different size and income nor take into consideration nonhousing costs (Cai & Lu, 2015). The residual income approach, in contrast, not only combines individual housing decisions with adequate consumption levels, but can also identify adequate levels of maximum affordable housing spending, enabling policy makers to set the proper level of housing assistance for impoverished households (Chen et al., 2010). Nonetheless, using the method to accurately define necessary nonhousing expenditures remains a challenge (Stone, 2006b).

## *2.2 Housing unaffordability and adolescent SWB*

Despite broad analytic evidence of the links between housing characteristics and adult health and well-being (Cattaneo et al., 2009; Clair & Hughes, 2019; Diepstraten et al., 2020; Gibson et al., 2011; Katz et al., 2001; Kling et al., 2007; Ludwig et al., 2013; Nie, Li, Ding, et al., 2021; Palacios et al., 2021; Pollack et al., 2004), the effect of housing unaffordability on child SWB or mental disorder has received far less attention (Clair, 2019). More important, little consensus exists on how negative this effect might be. For example, in Canada, the most extreme consequence of the shortage of reasonably priced housing is homelessness, with homeless children experiencing more anxiety and depression than their housed counterparts (Cooper, 2004). In the US, however, based on cross-sectional data from the 1997 National Survey of America’s Families, housing unaffordability is associated with poor self-reported health (SRH)<sup>3</sup> among children aged 6-11, with such effects operating primarily through material

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<sup>2</sup> These 12 Chinese markets encompass Beijing, Tianjin, Shanghai, Chongqing, Changsha, Guangzhou, Chengdu, Xi’an, Dalian, Nanjing, Hangzhou and Wuhan.

<sup>3</sup> Child health is measured by parental rating on a 5-point scale from 1 = poor to 5 = excellent.

hardship in early childhood (Harkness & Newman, 2005). According to a more recent analysis of the Fragile Families and Child Well-Being Study (FFCWS), among children born 1998–2000 in 20 large American cities, housing insecurity at age 5 (measured by mothers reporting missed rent or mortgage payments due to inability to pay, or having moved in with others because of housing costs) is associated with adolescent depression at age 15 and even adolescent delinquency (Marçal & Maguire-Jack, 2021).

Other studies, in contrast, find no evidence of unaffordable housing’s negative impact on well-being. For instance, analyses of data from the Panel Study of Income Dynamics (PSID) and its 1997 and 2002 Child Development Supplements find neither support for unaffordable housing being detrimental to child SRH (Harkness et al., 2009)<sup>4</sup> nor even any association between housing unaffordability and SRH among US children aged 5-17 (Newman & Holupka, 2015). They do, however, link unaffordable housing to a reduction in child cognitive achievement (Newman & Holupka, 2015). A more detailed examination of longitudinal data from the 1997-2005 Three-City Study (Boston, Chicago, and San Antonio) also finds no correlation between housing unaffordability and such adolescent psychological problems as anxiety, depression, withdrawal, or somatic complaints (Coley et al., 2013).

Studies of subsidized housing, however, do provide indirect evidence of housing unaffordability’s role in child well-being, with 1992 and 1993 data from the Survey of Income and Program Participation and Current Population Survey suggesting that US children in subsidized housing programs enjoy better academic achievement than children in other rental accommodation (Currie & Yelowitz, 2000). Although this positive effect is reinforced by other research using assisted housing data from the PSID (Newman & Harkness, 2002), attributing beneficial effects to housing affordability alone is difficult given its being only one of several characteristics in the subsidized housing package. In fact, not only does the FFCWS analysis confirm the absence of any significant effect of public-housing residence on child health as measured by maternal reporting (Fertig & Reingold, 2007), but data from the 2000-2004 Welfare to Work Voucher program indicate no effects of housing vouchers either (Wood et al., 2008), a finding confirmed for Chicago children aged 0-18 (Jacob et al., 2015).

Surprisingly, in the case of China, no research as yet explores the consequences of unaffordable housing on either child or adolescent SWB, and we identify only three studies that address this link in Chinese adults (Li & Liu, 2018; Wang et al., 2019; Wang et al., 2021). Whereas the first, using large-scale 2009 survey data for 12 Chinese cities, shows that informal

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<sup>4</sup> Child SRH is based on primary caregiver assessment using a 5-point scale from 1 = excellent to 5 = poor.

housing tenants have worse mental health than dormitory tenants and formal housing residents (Li & Liu, 2018);<sup>5</sup> the second, based on 2014 CFPS data, finds no significant association between housing unaffordability and mental health ((Wang et al., 2019).<sup>6</sup> A later analysis of a similar CFPS dataset, however, does pinpoint an association between unaffordable housing and worsening depression, with stronger impacts among males and residents of China's western regions ((Wang et al., 2021).

Overall, then, not only is the empirical evidence on the housing unaffordability-child SWB relation confined mostly to the US and other Western countries, but conclusions are mixed, and no such research exists for China; only a handful of studies for adults. Moreover, not only do most such studies, including those from China, suffer the major drawback that their cross-sectional design precludes any causal analysis, but the research overall pays little attention to the possible mechanisms through which housing unaffordability may affect child or adolescent SWB. To address these shortcomings, we conduct a longitudinal analysis of 2010-2018 CFPS data to identify the impact of housing unaffordability on SWB among Chinese adolescents aged 10-15. In doing so, we first use PSM of individuals with a similar constellation of individual and household characteristics but different housing unaffordability to identify the separate effects of housing unaffordability on SWB. We then employ an IV approach to shed more light on the causal relations between these two variables. Lastly, using a SEM approach, we perform a comprehensive exploration of underlying pathways through which housing unaffordability may operate on SWB.

### **3. Potential mechanisms for the housing unaffordability impact on adolescent depression**

The relation between housing unaffordability and adolescent SWB is partially explainable by the widely applied Family Stress Model (FSM)<sup>7</sup> (Conger, Ge, Elder, et al., 1994), which assumes that because economic hardship from low income or job loss contributes to parental stress and depression, it leads to lower quality parenting that affects children's physical, behavioral, cognitive, and emotional well-being. Also pertinent is emotional contagion theory (ECT), which posits that negative emotions are transmitted through families because of a shared environment (Larson & Almeida, 1999). Given that negative emotions are more readily

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<sup>5</sup> Mental health in this study is evaluated using the 6-item Kessler Psychological Distress Scale (K6, ranging from 0 to 24) and perceived stress ranging from 0 to 16 (Li & Liu, 2018).

<sup>6</sup> Mental health here is measured based on the question: "How often during the past month did you feel depressed, nervous, restless or fidgety, hopeless, that everything was an effort, and that life was meaningless?"

<sup>7</sup> The FSM is commonly used in various cultures and countries, including the US (Conger et al., 1994; 2002), Mexico (White et al., 2015), Finland (Solantaus et al., 2004), and China (Zhang et al., 2020).

transmitted from parents to children than positive ones (see, for instance, Larson & Almeida, 1999; Larson & Gillman, 1999), children of depressed parents show a higher risk of clinical depression than their peers (Downey & Coyne, 1990; Powdthavee & Vignoles, 2008).

For households living in unaffordable housing, the need to spend a large portion of income on rent and mortgage increases the likelihood of economic hardship, whose well-documented link to parental distress or depression results in low quality parenting (Conger, Ge, Elder Jr, et al., 1994; McLoyd et al., 1994; Mistry et al., 2008). In addition to its potential negative affect on child emotional development (Coley et al., 2014), such parental stress is responsible for housing unaffordability's indirect effect on child abuse or neglect (Warren & Font, 2015). It is thus not surprising that housing insecurity, including subjective housing cost burden, is associated with higher adolescent depression (Marçal & Maguire-Jack, 2021). Drawing on all these observations, we formulate the following hypotheses:

**Hypothesis 1:** *Housing unaffordability positively affects adolescent depression through low-quality parenting.*

**Hypothesis 2:** *Housing unaffordability positively affects adolescent depression through parental depression.*

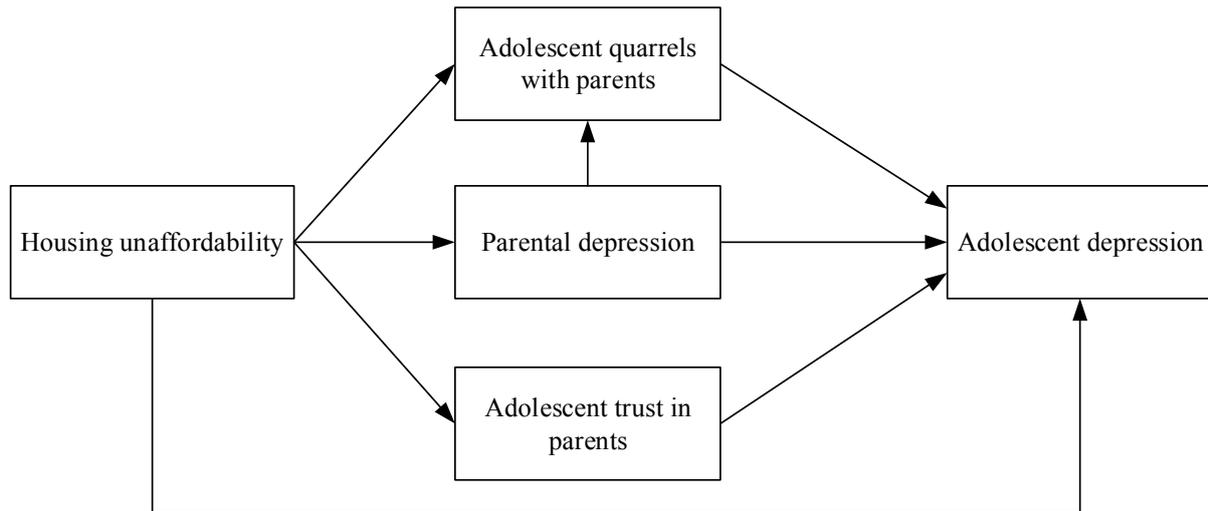
Another common theoretical framework for explaining the housing effect on adolescent well-being is Bronfenbrenner's (1979) ecological systems model (ESM) of human development, which postulates that child outcomes are influenced by the characteristics of both family and the dwelling units and neighborhoods in which the children live and interact (Bronfenbrenner & Morris, 1998). This model thus highlights the impacts on child development of multiple social contexts – including the family unit, area of residence, and social networks (Leventhal & Newman, 2010) – which it views as a collection of nested settings (Clair, 2019). Although housing, as a microsystem within this context, is a key element for child development (Clair, 2019), it is likely to affect children and adolescents indirectly via their family (Leventhal & Newman, 2010), making the family environment central to such development, especially as regards socioemotional well-being (Bradley & Corwyn, 2002; Coley et al., 2013; Zhou et al., 2021). When the economic hardship induced by housing unaffordability is detrimental to the parent–adolescent bond of affection (Delgado et al., 2013), the relationship may become one of anxious attachment<sup>8</sup> (Rawatlal et al., 2015). On the other

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<sup>8</sup> Attachment patterns are generally classified as secure, insecure avoidant, or insecure-anxious, with the latter indicating poor primary caregiver-child interaction and the child's possible predisposition to negative psychological and behavioral outcomes in adolescence (Rawatlal et al., 2015).

hand, a higher level of adolescent trust in parents may augment the quality of this parent-adolescent relation (Shek, 2010) thereby increasing adolescent well-being in the manner documented for Chinese youth (Prakash & Smyth, 2019). We thus formulate our third hypothesis as follows:

**Hypothesis 3:** *Housing unaffordability positively affects adolescent depression through adolescent trust in parents.*



**Figure 1** Heuristic of potential pathways of housing unaffordability on adolescent depression

## 4. Data and methods

### 4.1 Study design and population

We draw our data from the China Family Panel Studies (CFPS), administered by Peking University’s Institute of Social Science Survey, using all five waves available to date: 2010, 2012, 2014, 2016, and 2018. Because the survey covers 25 provinces or administrative equivalents representing 94.5% of China’s total population (excluding Hong Kong, Macao, and Taiwan), this database constitutes a nationally representative sample that captures both the socioeconomic development and the economic and noneconomic well-being of Chinese households (Xie & Lu, 2015). Given the research focus, however, we restrict our analytic sample to adolescents aged 10-15 for which detailed information about depression, household income, housing expenditure, and demographic and socioeconomic characteristics is available. To identify households experiencing housing unaffordability, we also exclude those with zero

household income, resulting in an unbalanced panel of 5,110 adolescents and 8,072 observations.

#### **4.2 Depression measures**

The CFPS depression assessment is based on a 20-question version of the Center for Epidemiologic Studies Depression (CES-D) questionnaire (Radloff, 1977), which encompasses three negative and one positive aspect; namely, somatic-retarded activity, interpersonal relations, depressed affect, and positive affect (Hsieh & Qin, 2018). Respondents indicate on a scale from 1 to 4 how often in the preceding week they experienced the specified emotion. For our sample, we recode these scores as 0 = never (<1 day), 1 = sometimes (1-2 days), 2 = often (3-4 days), and 3 = most of the time (5-7 days) and then calculate the CES-D score as follows:

$$CES - D = \sum_i score_{i,somatic} + \sum_j score_{j,interpersonal} + \sum_k score_{k,depressed} + \sum_m (3 - score_{m,positive}) \quad (1)$$

where  $score_{i,somatic}$ ,  $score_{j,interpersonal}$ ,  $score_{k,depressed}$ , and  $score_{m,positive}$  denotes the score for the  $i$ th question on somatic-retarded activity, the  $j$ th question on interpersonal relations, the  $k$ th question on depressed affect, and the  $m$ th question on positive affect, respectively. The overall CES-D score ranges from 0 to 60, with higher scores indicating a higher probability of depression.

Because the CES-D questionnaire is not uniformly administered across the different CFPS waves, with only the 2010 and 2014 questionnaires incorporating the Kessler Psychological Distress Scale (K6), we enable comparability by calculating z-scores for the K6 and CES-D 20 scales in each wave, with a higher value indicating a higher level of depression (Zou et al., 2020). Although this depression z-score is the primary measure for the empirical analysis, our various robustness checks employ the original CES-D 20 and K6 depression scores, as well as unhappiness as a proxy for depression (Zhang et al., 2017). We base this latter on the question: “How often in the past month did you feel so depressed that nothing could cheer you up?” measured on a 5-point scale from 0 to 4, with a higher value indicating a higher likelihood of unhappiness.

#### **4.3 Housing unaffordability**

Following Wang et al. (2019) and Wang et al. (2021), we define unaffordable housing based on the commonly used 30% threshold; that is, households spending 30% of their income on

housing, including rent and mortgage (Newman & Holupka, 2014). As a robustness check, we also use the alternative threshold of 50% (HUD, 2007).

#### ***4.4 Control variables***

Our model controls for the adolescent characteristics of age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); the household characteristics of size and logged income; and the parental demographics of education (measured in years of schooling) and employment status (1 = yes, 0 = no). Given possible geographic heterogeneity, we also control for location type of current residence (1 = urban, 0 = rural), migration status (1 = migrant, 0 = nonmigrant), and region (east, central, west, or northeast). Because we employ a fixed effects estimation, only our heterogeneity analysis controls for gender (1 = boy, 0 = girl).

#### ***4.5 Empirical strategy***

##### *4.5.1 Two-way fixed effects (TWFE) model*

Given the potential for bias from individual time-invariant unobservables, we estimate the effects of housing unaffordability on adolescent depression using the following TWFE model:

$$Depression_{it} = \beta_0 HA_{it} + \beta_1 X_{it} + \beta_2 P_{it} + \beta_3 W_t + \mu_i + \delta_{it} \quad (2)$$

where  $Depression_{it}$  represents the depression z-score of individual  $i$  at wave  $t$ ,  $HA_{it}$  denotes individual  $i$ 's household housing unaffordability status at wave  $t$ ,  $X_{it}$  is a set of time-variant controls,  $P_{it}$  and  $W_t$  denote provincial and wave dummies, respectively, and  $\delta_{it}$  is an error term. The unobservable time-invariant individual effect is captured by  $\mu_i$ .

##### *4.5.2 Propensity score matching (PSM)*

One major limitation of the FE estimate is that it fails to consider time-variant unobserved factors that may simultaneously affect housing expenditure and adolescent depression, which could lead to biased estimates of the housing unaffordability effect. To rule out such endogeneity, we apply a propensity score matching (PSM) approach (Abadie & Cattaneo, 2018; Rosenbaum & Rubin, 1983) to address the self-selection problem of pre-existing differences causing individuals to select into a group, thereby biasing the results. This method approximates an experimental design in which individual, household, and community characteristics are fixed but housing unaffordability differs (Newman & Holupka, 2014). To

overcome the PSM weakness of excluding unobservable factors and ensure results consistent with an experimental design, we also incorporate a broad array of covariates (Cook et al., 2008; Stuart, 2010); namely, the adolescent, household, and parental sociodemographic characteristics used in our baseline FE model. To test the robustness of the PSM results, we adopt the various matching methods used by Prakash and Smyth (2019), including nearest neighbor matching ( $k = 6$ ), radius matching ( $r = 0.05$ ), and kernel matching (bandwidth = 0.01). Lastly, we perform FE estimations based on the matched sample.

#### *4.5.3 Instrumental variable estimation*

To identify a causal relation between housing unaffordability and adolescent depression, we also run two-stage least squares (2SLS) estimations using province-level housing prices as the instrumental variable (IV). Based on prior work (Cai & Lu, 2015; Li et al., 2020; Tsai, 2013; Winke, 2020), we assume that rising housing prices lead to an increase in housing expenditures, resulting in a higher probability of housing unaffordability and thus an ultimate deterioration in adolescent mental health. One concern with our IV, however, is that the required exclusion restriction may not hold. For instance, despite some evidence that children raised in higher priced housing markets fare no worse psychologically than those reared in lower priced markets (see, for instance, Harkness et al., 2009), higher housing prices might influence adult SWB and thereby that of adolescents (Clark et al., 2019). Alternatively, rising housing prices might increase homeowners' potential wealth prompting a higher level of consumption (Carroll, 2004) and a decreased probability of female homeowner participation in the labor force, leading to greater time investment in family (Fu et al., 2016). By positively affecting the family environment, such developments might decrease the risk of adolescent depression, especially given that children who report higher levels of family wealth are more likely to report higher levels of SWB (Becchetti & Pisani, 2014).

To test these conjectures, we adopt the 2SLS approach developed by Lewbel (2012), which first employs only an internally constructed IV that it then combines with an external IV; in our case, province-level housing prices. Although widely used in the absence of an external or valid IV (Mishra & Smyth, 2015; Nie, Li, & Sousa-Poza, 2021), this method has as a precondition for identification the presence of heteroskedasticity, which is testable using the Pagan-Hall and Breusch-Pagan tests (Breusch & Pagan, 1979).

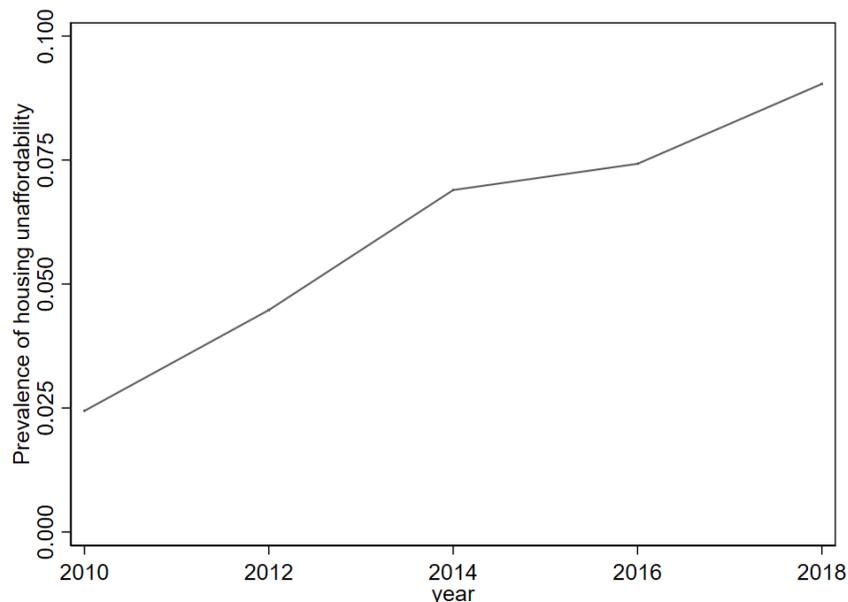
#### *4.5.4 Structural equation modeling*

To explore the potential pathways through which housing unaffordability impacts adolescent depression, we use structural equation modeling (SEM) to examine three potential mediators: paternal depression score, adolescent quarrels with parents, and adolescent trust in parents (see Section 3). We also control for adolescent age, gender, SRH, and Chinese and math performance; household size and logged income; and parental years of schooling and employment status. To evaluate the goodness-of-fit of our SEM estimations, we employ the comparative fit index (CFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA), with rules of thumb for acceptable fit of  $CFI \geq 0.95$ ,  $SRMR \leq 0.1$ , and  $RMSEA \leq 0.08$ , respectively (Schermelleh-Engel et al., 2003).

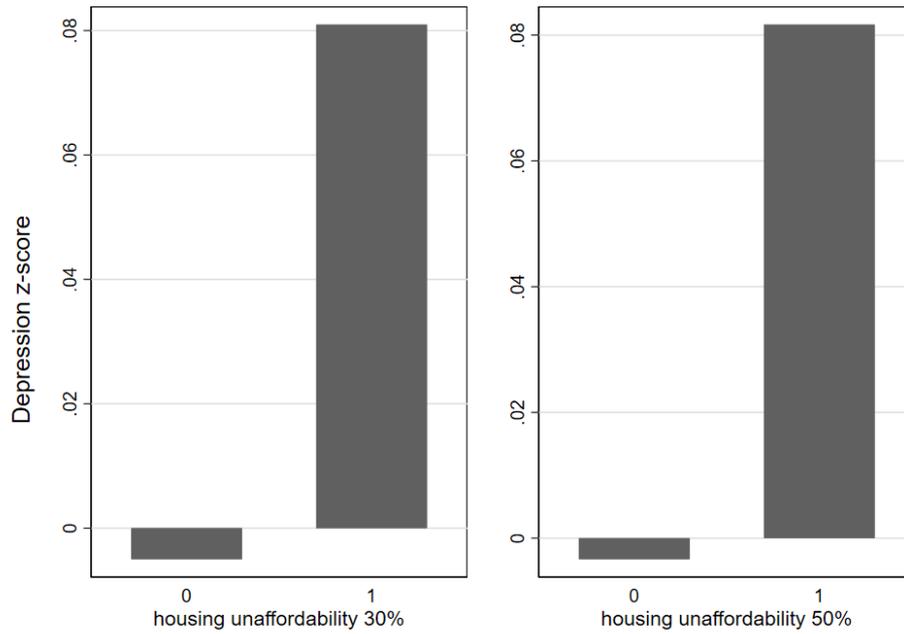
## 5. Results

### 5.1 Descriptive statistics

As Table A1 shows, consistent with other studies for China (Cai & Lu, 2015; Wang et al., 2021), the average values of CES-D20, K6, and unhappiness in our sample are 11.4, 2.9, and 0.7, respectively, with about 5.8 percent of respondents experiencing housing unaffordability, 4 percent of the households to a severe degree. The fraction of households experiencing unaffordable housing also trends upward over 2010-2018 (see Figure 2), with these households also more likely to have higher depression z-scores (see Figure 3).



**Figure 2** Prevalence of housing unaffordability over time: CFPS 2010-2018



**Figure 3** Different measures of housing unaffordability and depression z-score, with the latter calculated using the CES-D score or K6 score in each wave and a higher value indicating a higher probability of depression. Housing unaffordability is a dummy variable (1 = yes, 0 = no).

### 5.2 Impact of housing unaffordability on adolescent depression

Based on TWFE estimates, we find that housing unaffordability significantly increases the affected adolescents' depression z-scores (Table 1) even when we control for wave, provincial, and individual fixed effects together with multiple covariates. These findings not only confirm the association documented by Wang et al. (2021) between unaffordable housing and deteriorating mental health but are well in accordance with the evidence for the US (Harkness & Newman, 2005; Marçal & Maguire-Jack, 2021; Newman & Holupka, 2015).

**Table 1** FE estimates of the housing unaffordability effect on depression among Chinese adolescents aged 10-15: CFPS 2010-2018

	(1)	(2)	(3)	(4)
Housing unaffordability 30%	0.192** (0.088)	0.171** (0.087)	0.189** (0.087)	0.175** (0.087)
Age		-0.004 (0.009)		-0.007 (0.010)
Health		-0.104*** (0.021)		-0.117*** (0.022)
Chinese performance		-0.022 (0.025)		-0.020 (0.025)
Math performance		-0.052** (0.026)		-0.052** (0.026)
Household size		0.043 (0.031)		0.046 (0.031)
Log (household income)		-0.003 (0.017)		-0.005 (0.017)
Maternal education in years		-0.016		-0.018

		(0.022)		(0.023)
Paternal education in years		0.017		0.012
		(0.028)		(0.028)
Maternal employment		-0.003		0.014
		(0.058)		(0.060)
Paternal employment		0.023		0.045
		(0.062)		(0.063)
Observations	8072	8072	8072	8072
Number of individuals	5110	5110	5110	5110
Wave FE	No	No	Yes	Yes
Provincial FE	No	No	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes

Notes: The dependent variable is depression z-score; the controls are adolescent age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

To address possible problems of sample self-selection and rerun FE estimations, we next apply a PSM-based FE approach, whose results again link unaffordable housing with higher adolescent depression, although the association is admittedly insignificant in the nearest neighbor matching analysis (see Table 2). These results do affirm, however, that our sample is free of self-selection problems.

**Table 2** FE estimates of the housing unaffordability effect on depression among Chinese adolescents aged 10-15: CFPS 2010-2018

	(1)	(2)	(3)	(4)	(5)	(6)
	Nearest neighbor		Kernel		Radius	
Housing unaffordability 30%	0.104	0.073	0.190**	0.176**	0.192**	0.175**
	(0.136)	(0.133)	(0.089)	(0.088)	(0.088)	(0.087)
Age		0.020		-0.008		-0.008
		(0.024)		(0.010)		(0.010)
Health		-0.106*		-0.118***		-0.119***
		(0.063)		(0.023)		(0.022)
Chinese performance		0.019		-0.020		-0.021
		(0.068)		(0.025)		(0.025)
Math performance		-0.122*		-0.061**		-0.059**
		(0.073)		(0.025)		(0.025)
Household size		0.125		0.043		0.044
		(0.085)		(0.031)		(0.031)
Log (household income)		-0.024		0.005		-0.004
		(0.038)		(0.018)		(0.017)
Maternal education in years		-0.105**		-0.022		-0.018
		(0.042)		(0.022)		(0.023)
Paternal education in years		0.106*		0.015		0.014
		(0.059)		(0.030)		(0.030)
Maternal employment		0.035		0.000		-0.001
		(0.152)		(0.060)		(0.060)
Paternal employment		0.023		0.042		0.038
		(0.200)		(0.063)		(0.063)
Observations	2661	2661	7958	7958	7980	7980
Number of individuals	2246	2246	5044	5044	5053	5053
Wave FE	No	Yes	No	Yes	No	Yes
Provincial FE	No	Yes	No	Yes	No	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the depression z-score; the controls are adolescent age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

To address other potential endogeneity issues of housing unaffordability, we employ the Lewbel (2012) 2SLS technique, which reveals a consistently significant and positive housing unaffordability effect on adolescent depression (see Table 3, columns 1 & 2). Whereas the Pagan-Hall and Bresuch-Pagan tests affirm the presence of heteroskedasticity, an important prerequisite of this method; the first-stage F-statistics exceeding 10 indicate no weakness in the IV and a Hanson  $J$  test confirms its exogeneity. As regards effect size, the magnitude from the 2SLS estimation is somewhat larger than those from the FE estimates, possibly because the latter address only the potential bias from individual time-invariant unobservables. This observation underscores that failure to rule out the housing unaffordability endogeneity issue would result in underestimation.

**Table 3** Lewbel 2SLS estimates of the housing unaffordability effect on depression among Chinese adolescents aged 10-15: CFPS 2010-2018

	(1) Lewbel internal IV	(2) Lewbel internal & external IV
Housing unaffordability 30%	0.255** (0.111)	0.256** (0.111)
Controls	Yes	Yes
Observations	8072	8072
First-stage F-statistic	14.81	13.99
Hanson $J$ P-value	0.714	0.790
Pagan-Hall test	161.503	162.090
Bresuch-Pagan test	332.355	333.638

Notes: The dependent variable is the depression z-score; the controls are adolescent age, gender (1 = boys, 0 = girls), SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

#### 5.4 Robustness checks

As a robustness check, we rerun the estimates substituting the 50% for the 30% threshold as an indicator of severe housing unaffordability (HUD, 2007). With this raised threshold, the housing unaffordability effect on adolescent depression not only remains significant and positive but increases in magnitude from the baseline value of 0.171 (Table 1) to 0.204 (Table 4, columns 1 & 2), implying that the heavier the housing cost burden, the greater the adolescent

depression. This assumption is reinforced by the inclusion of housing cost ratio, which links a higher housing expenditure ratio to a higher adolescent depression score (columns 3 & 4).

**Table 4** FE estimates of the housing unaffordability effect on depression among Chinese adolescents 10-15: CFPS 2010-2018 panel

	(1)	(2)	(3)	(4)
Housing unaffordability 50%	0.218** (0.106)	0.204* (0.104)		
Housing cost ratio			0.003** (0.001)	0.003** (0.001)
Age		-0.007 (0.010)		-0.008 (0.010)
Health		-0.118*** (0.022)		-0.117*** (0.022)
Chinese performance		-0.021 (0.025)		-0.020 (0.025)
Math performance		-0.052** (0.026)		-0.053** (0.026)
Household size		0.046 (0.031)		0.046 (0.031)
Log (household income)		-0.005 (0.017)		-0.005 (0.017)
Maternal education in years		-0.017 (0.023)		-0.017 (0.023)
Paternal education in years		0.013 (0.029)		0.012 (0.029)
Maternal employment		0.014 (0.060)		0.014 (0.060)
Paternal employment		0.044 (0.063)		0.044 (0.063)
Observations	8072	8072	8072	8072
Number of individuals	5110	5110	5110	5110
Wave FE	No	Yes	No	Yes
Provincial FE	No	Yes	No	Yes
Individual FE	Yes	Yes	Yes	Yes

Notes: The dependent variable is the depression z-score; the controls are adolescent age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

When we then introduce three alternative proxies of mental health – namely, the original scores for CES-D 20, K6, and unhappiness – adolescents living in families confronting housing unaffordability again show higher measures of negative mental health, especially unhappiness (see Table 5). These results are in line with both the baseline results from Table 1 and the Wang et al. (2021) evidence for Chinese adults.

**Table 5** FE estimates of the housing unaffordability effect on depression among Chinese adolescents aged 10-15: CFPS 2010-2018

	(1)	(2)	(3)	(4)	(5)	(6)
	CES-D 20		K6		Unhappiness	
Housing unaffordability 30%	1.208 (0.861)	1.313 (0.835)	2.059** (1.042)	1.501 (1.054)	0.588** (0.243)	0.476* (0.263)

Age		0.043 (0.100)		0.091 (0.083)		0.013 (0.025)
Health		-0.770*** (0.254)		-0.166 (0.288)		-0.084 (0.083)
Chinese performance		-0.103 (0.267)		0.286 (0.240)		0.003 (0.078)
Math performance		-0.303 (0.278)		-0.251 (0.280)		-0.068 (0.074)
Household size		-0.070 (0.323)		0.487** (0.243)		0.082 (0.080)
Log (household income)		0.075 (0.192)		-0.146 (0.192)		0.021 (0.055)
Maternal education in years		-0.328* (0.171)		-0.048 (0.235)		-0.002 (0.059)
Paternal education in years		-0.198 (0.293)		0.068 (0.293)		-0.044 (0.073)
Maternal employment		2.180*** (0.760)		-0.354 (0.471)		-0.203 (0.130)
Paternal employment		1.107 (1.203)		1.031** (0.462)		0.312** (0.139)
Observations	4628	4628	3444	3444	3439	3439
Number of individuals	3635	3635	3107	3107	3104	3104
Wave FE	No	Yes	No	Yes	No	Yes
Provincial FE	No	Yes	No	Yes	No	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The controls are adolescent age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no), as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

#### 5.4 Heterogeneity analysis

To deepen our understanding of housing unaffordability's impact on adolescent depression, we perform additional analyses based on sociodemographic characteristics; specifically, adolescent gender and age group, household migration status, rural versus urban residence, and geographic region. As regards gender, housing unaffordability has a larger negative impact on depression in boys than in girls, although neither effect is significant (see Table 6, Panel A). This finding is consistent with Wang et al. (2021) evidence that males are more likely than females to suffer from depressive symptoms because of unaffordable housing. In addition, like Harkness and Newman (2005) for the US, we observe a stronger effect in older than in younger adolescents (in our case, aged 13-15 vs. 10-12; Panel B), which may suggest that such detrimental effects are cumulative (Harkness & Newman, 2005). It is also possible that the consequences of material deprivation experienced in early childhood because of housing unaffordability may manifest in adolescence (Harkness & Newman, 2005). An even greater dichotomy exists based on residential location: the housing unaffordability effect on depression

is over four times greater for urbanites than for their rural counterparts (Panel C), possibly because of the much higher urban housing prices.

In terms of the housing unaffordability effect by migration status (Panel D), after defining migrants as urban residents whose government designation (*hukou*) is “agricultural,” we confirm that for the around 22.7 percent of adolescents in our sample from migrant households, the housing unaffordability effect, although statistically insignificant, is twice as large as that for nonmigrants. One possible explanation is that those with a “local” designation have greater opportunities for accessing such services as public housing, child education, medical care, and other benefits (Chan, 2009), while migrants are more often vulnerable to housing problems such as housing unaffordability (Li & Liu, 2018). Lastly, for different housing unaffordability effects by region, we find a seemingly larger negative impact on adolescent depression in more economically developed regions – particularly, the east and central areas of the country (with estimated coefficients of 0.265 and 0.389, respectively; Panel E) – but no significant impact for adolescents in the west and northeast. This variation is possibly attributable to the dual pressure of high housing prices and expensive living costs in these more developed regions, especially in metropolitan areas such as Beijing and Shanghai (Cai & Lu, 2015; Chen et al., 2010; Li et al., 2020).

**Table 6** FE estimates of the housing unaffordability effect on depression among Chinese adolescents aged 10-15 by sociodemographic characteristic: CFPS 2010-2018

	(1)	(2)
<b>Panel A: By gender</b>	<b>Girls</b>	<b>Boys</b>
Housing unaffordability 30%	0.147 (0.118)	0.196 (0.127)
Observations	3807	4265
Number of individuals	2411	2699
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes
<b>Panel B: By age group</b>	<b>Aged 10-12</b>	<b>Aged 13-15</b>
Housing unaffordability 30%	-0.110 (0.129)	0.448* (0.252)
Observations	4112	3960
Number of individuals	3388	3362
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes
<b>Panel C: Rural versus urban</b>	<b>Rural</b>	<b>Urban</b>
Housing unaffordability 30%	0.068 (0.133)	0.293** (0.120)
Observations	4735	3316
Number of individuals	3073	2159
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes

<b>Panel D: By migration status</b>	<b>Non-migrants</b>	<b>Migrants</b>
Housing unaffordability 30%	0.136 (0.106)	0.301* (0.178)
Observations	6205	1823
Number of individuals	4012	1230
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes
<b>Panel E: By region</b>	<b>East</b>	<b>Central</b>
Housing unaffordability 30%	0.265** (0.133)	0.389* (0.208)
Observations	2309	2169
Number of individuals	1448	1372
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes
	<b>West</b>	<b>Northeast</b>
Housing unaffordability 30%	0.088 (0.141)	-0.128 (0.158)
Observations	2762	832
Number of individuals	1792	505
Wave FE	Yes	Yes
Provincial FE	Yes	Yes
Individual FE	Yes	Yes

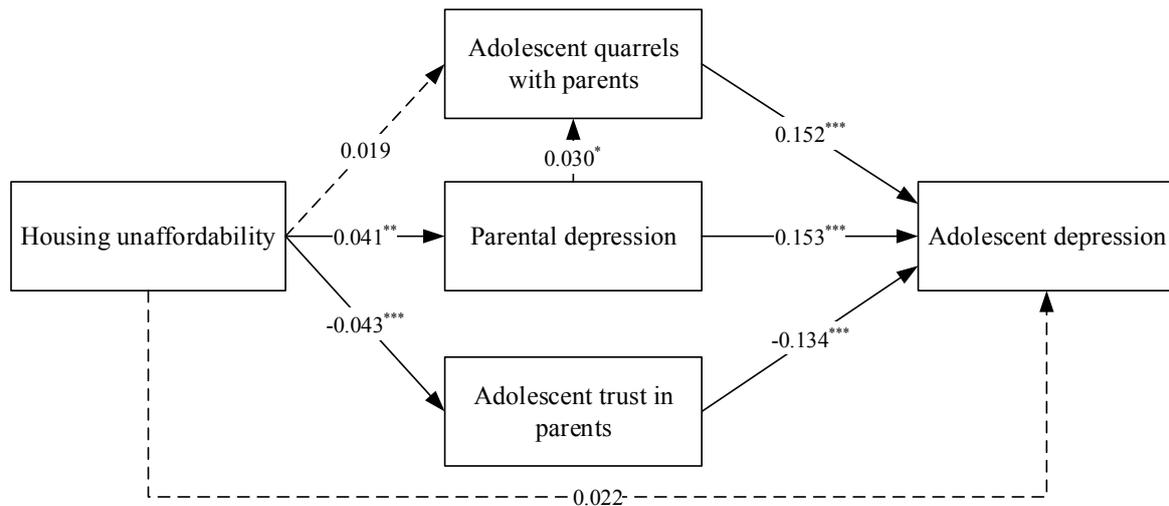
Notes: The dependent variable is the depression z-score; the controls are adolescent age, SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

### 5.5 Underlying mechanisms

To test our three hypotheses that housing unaffordability positively affects adolescent depression through low-quality parenting (H1), parental depression (H2), and/or adolescent trust in parents (H3), we adopt an SEM model whose appropriateness is confirmed by a goodness-of-fit test: RMSEA = 0.061 ( $< 0.08$ ), SRMR = 0.008 ( $< 0.1$ ), and CFI = 0.968 ( $> 0.95$ ). The SEM results both validate our three hypotheses and confirm our baseline estimation that living in unaffordable housing increases adolescent depression scores (see Figure 4 and Table 7). More specifically, not only are adolescents in families experiencing housing unaffordability more likely to have a lower level of trust in their parents (standardized coefficient = 0.041,  $p < 0.05$ ), but their fathers have higher depression scores (standardized coefficient = 0.041,  $p < 0.05$ ) associated with an increased number of adolescent quarrels with parents (standardized coefficient = 0.03,  $p < 0.1$ ). Such quarrels, the paternal depression, and the lower adolescent trust in parents are also all significantly correlated with adolescent depression (standardized coefficient = 0.152, 0.153, and -0.134, respectively).

Overall, about 22 percent of the total housing unaffordability effect on depression z-scores is mediated by paternal depression, with 3 percent of it also mediated by adolescent-parent

quarrels, with approximately 21% mediated by (lower) adolescent trust in parents (see Table 8). The insignificance of housing unaffordability's direct effect on depression, however, may imply relatively large indirect effects (e.g., via paternal depression and adolescent trust in parents),<sup>9</sup> thereby supporting mediation hypotheses H2 and H3. On the other hand, although around 11% of the total housing unaffordability effect on depression is mediated by adolescent-parent quarrels, housing unaffordability's effect on these quarrels is insignificant, meaning that H1 is not validated in our case.



**Figure 4** Underlying mechanisms through which housing unaffordability impacts adolescent depression based on SEM estimates with all coefficients standardized: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

**Table 7** Path analysis: SEM with controls

Dependent variable	Independent variable	Total effect	Direct effect	Indirect effect
Quarrels with parents	Housing unaffordability 30%	0.020	0.019	0.001
	Paternal depression	0.030*	0.030*	
Paternal depression	Housing unaffordability 30%	0.041**	0.041**	
Trust in parents	Housing unaffordability 30%	-0.043***	-0.043***	
Depression z-score	Housing unaffordability 30%	0.037**	0.022	0.015***
	Quarrels with parents	0.152***	0.152***	
	Paternal depression	0.158***	0.153***	0.005*
	Trust in parents	-0.134***	-0.134***	

Notes: The dependent variable is the depression z-score; the controls are adolescent age, gender (1 = boy, 0 = girl), SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

<sup>9</sup> Here, although the direct effects are admittedly insignificant, it is worth noting that we place no emphasis on *complete* mediation because of both its rarity in the context of multiple mediators and its connotation of amplitude or importance (Preacher and Kelly, 2011).

**Table 8** Indirect effects of housing unaffordability on depression z-score and their proportion to total effects: SEM with controls

Mediators	Indirect effect	Standard error	Z-value	Indirect effect/total effect
Paternal depression	0.006**	0.003	2.392	0.220
Trust on parents	0.006**	0.002	2.467	0.205
Quarrel with parents	0.003	0.003	1.108	0.113

Notes: The dependent variable is the depression z-score; the controls are adolescent age, gender (1 = boy, 0 = girl), SRH (from 1 = poor to 5 = excellent, with poor as reference), and academic performance on Chinese and math (from 1 = poor to 4 = excellent); household size and logged income; and parental years of schooling and employment status (1 = yes, 0 = no); as well as wave dummies (with 2012 as the reference) and provincial dummies (with Beijing as the reference). Individual-level adjusted standard errors are in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

## 6. Conclusions

Despite a small body of literature documenting housing unaffordability's detrimental effect on adult SWB, including depression (Wang et al., 2021), no research to date thoroughly examines the relation between housing unaffordability and adolescent SWB in developing economies like China. Nor is there any comprehensive exploration of possible pathways through which this housing unaffordability effect operates. Hence, using nationally representative CFPS data for 2010-2018, this study conducts one of the first assessments of housing unaffordability's impact on depression among 10- to 15-year-olds in China while also using SEM to explore the pathways underlying this relation.

According to our results, housing unaffordability does indeed raise depression scores among these Chinese youth, a finding that remains robust to both alternative measures of housing unaffordability and SWB, and different approaches to addressing endogeneity issues (i.e., PSM and Lewbel's 2SLS). Our heterogeneity analysis further demonstrates that housing unaffordability's negative impact on depression is much stronger for those from migrant and urban families, as well as those residing in eastern and central regions. Lastly, our SEM modeling shows this housing unaffordability and depression linkage to be mediated by paternal depression and (lower) adolescent trust in parents, which account for 22% and 21% of the total housing unaffordability effect, respectively.

These findings have important policy implications, especially given China's urgent need to alleviate housing unaffordability's detrimental effects on adolescent SWB as soaring land values and housing prices propel the HPIR into multiples. In particular, the results underscore the need to increase the availability of affordable housing through provision of public, low-rent, and subsidized housing, especially for families in mega-cities with large rural-to-urban migrant populations and an abundance of shanty town and low-income communities. At the same time, the incidence of mental health problems among Chinese children and adolescents has continued to rise, prompting government implementation of various targeted plans,

guidelines, and interventions, including the National Health Commission's 2019–2022 *Healthy China Action: Action Plan for Mental Health of Children and Adolescents*, the *Healthy China Initiative (2019-2030)*, and *Healthy China 2030*. Whereas the action plan is aimed at building a social environment conducive to both child and adolescent mental health, the two initiatives propose the strengthening of interventions for common mental health problems such as depression and anxiety disorders. Given this increased importance of mental well-being as a national development-related public health issue, mitigating the housing cost burden on Chinese families may be an effective way to improve adolescent mental health and boost the success of *Healthy China 2030*.

### **Conflicts of interest**

None.

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## Appendix:

**Table A1** Descriptive statistics for the Chinese adolescents aged 10-15: CFPS 2010–2018

Variables	Obs.	Mean/percentage	S.D.	Min	Max
<b>Dependent variables</b>					
Depression score: CES-D20	4628	11.425	6.415	0	40
Depression score: K6	3444	2.937	3.597	0	24
Unhappiness <sup>a</sup> (0-4)	3439	0.728	0.985	0	4
<b>Independent variables</b>					
Housing unaffordability 30% <sup>b</sup>	8072	0.058	0.234	0	1
Housing unaffordability 50% <sup>b</sup>	8072	0.039	0.194	0	1
<b>Individual characteristics</b>					
Age	8072	12.455	1.696	10	15
Gender	8072	0.528	0.499	0	1
Self-reported health (SRH)					
Poor	8072	0.008	0.087	0	1
Fair	8072	0.040	0.195	0	1
Good	8072	0.209	0.406	0	1
Very good	8072	0.319	0.466	0	1
Excellent	8072	0.426	0.494	0	1
Academic performance <sup>c</sup>					
Chinese	8072	2.708	0.947	1	4
Math	8072	2.664	1.030	1	4
Urban	8051	0.412	0.492	0	1
Region					
East	8072	0.286	0.452	0	1
Central	8072	0.269	0.443	0	1
West	8072	0.342	0.474	0	1
Northeast	8072	0.103	0.304	0	1
<b>Parental characteristics</b>					
Maternal education					
Illiterate	8072	0.293	0.455	0	1
Primary school	8072	0.267	0.442	0	1
Middle school	8072	0.293	0.455	0	1
High school	8072	0.092	0.289	0	1
Vocational school	8072	0.035	0.185	0	1
University or higher	8072	0.019	0.138	0	1
Maternal employment status	8072	0.798	0.402	0	1
Paternal education					
Illiterate	8072	0.164	0.370	0	1
Primary school	8072	0.272	0.445	0	1
Middle school	8072	0.362	0.481	0	1
High school	8072	0.132	0.338	0	1
Vocational school	8072	0.046	0.209	0	1

University or higher	8072	0.024	0.152	0	1
Paternal employment status	8072	0.886	0.318	0	1
<b>Household characteristics</b>					
Household size	8072	4.861	1.640	2	17
Log (household income)	8072	10.213	1.252	0	14
<b>Mediating variables</b>					
Paternal depression score <sup>d</sup>	4314	12.736	7.299	0	50
Adolescent quarrels with parents <sup>e</sup>	8024	1.008	2.638	0	50
Adolescent trust in parents <sup>f</sup>	4881	9.404	1.234	0	10

Notes: The sample is an unbalanced panel.

<sup>a</sup> Unhappy is measured based on the question “How often in the past month did you feel so depressed that nothing could cheer you up?” ranked on a 0-4 scale, with higher scores indicating more unhappiness.

<sup>b</sup> Housing unaffordability 30% (50%) is a dummy equal to 1 if the ratio of income to housing costs (including rent and mortgage) is >30% (>50%); 0 = otherwise.

<sup>c</sup> Academic performance is measured by parent/guardian ratings of the child's average grade in Chinese and math the previous semester (on a scale from 1 = poor to 4 = excellent).

<sup>d</sup> Paternal depression is measured by the CES-D 20 score, with higher values signaling higher depression risk.

<sup>e</sup> Adolescent quarreling with parents is measured based on the question “How many times did you quarrel with your parents in the past month?”

<sup>f</sup> Adolescent trust in parents, measured from 2012 to 2018, is based on the question “How much do you trust your parent?” from 0 = very distrustful to 10 = very trusting. In the 2012 wave, only adolescents aged 11, 13, and 15 answered the question; in the 2014 wave, only adolescents with no previous records did.