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The impact of parental migration on left-behind children's tooth health in China

Yunyun Zhang¹ and Kang Du^{1*}

Abstract

Background Parental migration plays a significant role in shaping the health outcomes of left-behind children. However, limited research has been conducted on how parental migration impacts the dental health of these children in China. To address this gap, this study aims to investigate the effects of parental migration on the dental health of left-behind children and explore the underlying mechanisms that contribute to these outcomes.

Methods This study utilized data from the first wave of the China Education Panel Survey (CEPS), which included a representative sample of 9,175 junior high school students. Dental caries, the most common dental issue among school-aged children, were employed as the primary indicator of oral health, focusing on both the presence of caries and their treatment. The analysis incorporated multiple methodologies, including the Ordinary Least Squares (OLS) model, instrumental variables approach, and the Propensity Score Matching (PSM) method, to assess the impact of parental migration on the dental health of left-behind children.

Results The findings indicated that parental migration did not increase the likelihood of left-behind children developing dental caries. However, it significantly reduced the probability of these children receiving treatment for dental caries. These results were consistent across various robustness tests. Mechanism analysis revealed no significant differences in the consumption of carbonated or sugary drinks between left-behind and non-left-behind children. However, left-behind children were less likely to identify their parents as their primary source of support and experienced lower levels of proactive communication from parents about their challenges compared to their peers.

Conclusions The study highlights that although parental migration does not increase the prevalence of dental caries among left-behind children, it contributes to inequities in their access to treatment. Given the serious implications of untreated dental caries, targeted efforts are needed to improve treatment rates among left-behind children.

Keywords Dental caries prevalence, Dental caries treatment, Left-behind children, Parental migration, Public health

Introduction

People often migrate both internationally and domestically in search of better employment opportunities to improve their families' financial circumstances [1]. This migration trend often results in children being left under

the care of extended family members or other caregivers [2, 3]. Noteworthy statistics reveal that approximately 27% of children in the Philippines, 36% in Ecuador, and over of 40% in South Africa experience this "left-behind" phenomenon [4]. China, one of the most substantial middle-income countries, harbors a notable and potentially vulnerable group of left-behind children (LBC). Over the past four decades, many Chinese parents have moved to urban areas seeking higher-paying jobs to enhance their families' economic prospects [5]. However, China's strict internal migration policies, known as hukou, often prevent migrant parents from bringing their children with

*Correspondence:

Kang Du
dk1@xaufe.edu.cn

¹ College of Economics, Xi'an University of Finance and Economics,
Xi'an 710100, Shaanxi, China



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them [6]. As a result, more than one-third of Chinese children—an estimated 61 million—are classified as "left-behind," with one or both parents migrating for work [7].

The impact of parental migration on the well-being of left-behind children (LBC), particularly the disparities in health outcomes and health-seeking behaviors when compared to non-LBC, is a matter of profound concern. However, the evidence in this regard presents a complex picture. On one hand, extensive research underscores the inequities in health outcomes between LBC and non-LBC. Due to the physical separation from their parents, health issues of a non-urgent nature or those with less conspicuous symptoms among LBC might be more prone to being overlooked [8, 9]. For instance, numerous studies suggest that LBC face an elevated risk of mental health challenges, diminished non-cognitive abilities, and even contemplate suicidal thoughts [10–13].

In contrast, the tangible benefits of remittances and improved financial security may positively influence the health outcomes of left-behind children (LBC) by enhancing their families' ability to afford healthcare services. For instance, research on migration in Pakistan indicates a positive impact on the physical growth of LBC. [14]. Similarly, studies conducted in China report that LBC have lower prevalence rates of soil-transmitted helminth infections and refractive errors compared to non-LBC counterparts [15, 16]. These findings underscore the complexity of parental migration's impact on LBC's health, highlighting that its effects can vary significantly depending on the specific health domains under consideration.

Dental caries, a condition characterized by the localized destruction of dental hard tissues, is caused by acidic by-products resulting from the bacterial fermentation of carbohydrates [17, 18]. The World Health Organization (WHO) identifies early childhood caries as a global health concern, with a prevalence ranging from 30 to 60% [19, 20]. This condition can negatively impact appetite, hinder food digestion and nutrient absorption, and, if left untreated, progress to more severe complications such as pulpitis, alveolar abscesses, and other related diseases [21]. Despite the availability of evidence-based, simple, and cost-effective preventive measures, untreated dental caries in permanent teeth affected approximately 2.3 billion individuals globally in 2017, making it the most prevalent health condition worldwide [22, 23].

Research on dental caries in children predominantly focuses on its incidence and associated risk factors [24, 25], with limited empirical studies examining the treatment of dental caries [26]. Moreover, studies investigating the influence of parental migration on children have largely concentrated on its effects on academic performance [27, 28] and mental well-being [29, 30], and only

a small number of studies have explored the impact of parents going out on students' organ health, such as Du (2023) examined the effects of parental migration on students' visual health, finding that the increased income associated with parental migration reduced the risk of myopia in children. However, the absence of parents limited the timely detection of health issues, leading to a lower rate of myopia correction in affected children [31].

The present study aims to fill these gaps in the literature by examining the effect of parental migration on left-behind children's tooth health in China based on data from the China Education Panel Survey (CEPS). Specifically, we pursue three objectives. First, we describe the prevalence of dental caries and the current state of dental caries treatment among children in China. Additionally, we aim to investigate the disparities in dental health and treatment seeking behavior among subgroups differentiated by the migration status of their parents. To achieve this, we utilize the T-test to statistically analyze and compare these subgroups. Second, building upon the descriptive analysis, we estimate the impact of parental migration on children's dental caries and dental caries treatment. This objective is addressed through an OLS regression analysis, which allows us to control for various confounding factors and provide a detailed assessment of how parental migration influences children's dental health outcomes. At last, we explore possible channels through which parental migration influences children's dental caries and dental caries treatment. The remaining paper is structured as follows: We introduce the data and describe the variables. We then provide the econometric models and indemnification strategies, followed by the estimation results and discussion. Finally, we summarize the findings and suggest policy implications.

Method

Data

The data for this study were obtained from the China Education Panel Survey (CEPS), a comprehensive national survey targeting Chinese students enrolled in the 7th grade (ages 12–13) and 9th grade (ages 14–15) in 2013. The CEPS was conducted with ethical approval from the ethics committee of Renmin University of China, ensuring adherence to ethical research standards. Written informed consent was obtained from all participating students and their legal guardians or immediate family members.

In the initial survey year (2013–2014 academic year), a systematic multi-stage probability-proportional-to-size sampling method was employed. This approach began by selecting 28 counties or districts across China, using average educational levels and the proportion of migrant populations as stratification criteria. Next, four schools

were randomly chosen from each selected county or district, with enrollment size and school type serving as additional stratification factors. Ultimately, 438 classes were randomly selected within these schools, resulting in a sample of approximately 20,000 students.

The CEPS survey administered tailored questionnaires to students, parents, teachers, and school administrators. This extensive dataset provided rich information, enabling an in-depth analysis of the impact of parental migration on dental health.

Although follow-up surveys were conducted, our analysis primarily focuses on data from the initial baseline survey due to its significantly larger sample size. The follow-up surveys tracked only 7th-grade students and lacked key data on variables such as migration status and dental health. Consequently, the final analyzable sample consists of 9,175 individuals, including 2,479 left-behind children (LBC) and 6,696 non-LBC participants.

Variable

In this study, dental caries and dental caries treatment were used as key indicators of dental health. Two dummy variables were constructed to measure these outcomes: one indicating whether a student had dental caries and another indicating whether the student had received treatment for dental caries (coded as 1 for "yes" and 0 for "no"). To determine the presence of dental caries, students were asked if they had experienced the condition. A response of "Yes" classified the student as having dental caries, while a response of "No" indicated the absence of the condition. For students who reported having dental caries, a follow-up question assessed whether they had received treatment, such as fillings. A response of "Yes" classified the student as having received treatment, while a response of "No" indicated untreated dental caries.

The primary independent variable in this analysis is parental migration. This variable is coded as 1 if either or both parents have migrated and 0 if both parents are residing at home. This definition aligns with the study's categorization of "left-behind children" (LBC): any child with at least one migrant parent is considered left behind.

In addition to parental migration, various other factors that may influence the dental health of LBC were considered, including both the incidence of dental caries and the likelihood of treatment. To mitigate potential biases from omitted variables, the empirical models incorporated a range of control variables reflecting demographic and familial characteristics. These control variables encapsulate demographic and familial attributes of the students under examination, encompassing characteristics such as gender, age, number of siblings, ethnicity, enrollment in boarding school, educational levels attained by both parents, the economic status of the family, and household

registration. Data for these variables were reported by both students and parents. Table 1 provides a detailed summary of these key variables.

To further investigate the mechanisms through which parental migration affects dental health, this study also examined its influence on students' consumption of carbonated and sugary drinks. The variable Drinking carbonated and sugary drinks was derived from the survey question: "Do you frequently drink sugary beverages (e.g., milk tea) or carbonated drinks (e.g., cola)?" A response of "Yes" was coded as 1, while "No" was coded as 0. Additionally, the study explored how parental migration influences communication about health issues. Since the survey did not directly inquire whether students informed their parents about dental problems, two proxy variables were constructed: Parents are children's first choice for help and Parents and children take the initiative to communicate about troubles. The first variable was coded as 1 if students reported that they would seek help from their parents first when in need, and 0 otherwise. Similarly, the second variable was coded as 1 if students indicated that they and their parents proactively communicated about their difficulties, and 0 otherwise.

Statistics analysis

Initially, this study compiled descriptive statistics pertaining to individual and familial background attributes. Additionally, a comparison between the characteristics of left-behind children (LBC) and non-LBC was conducted using sample t-tests. These tests aimed to discern any potential disparities in means between the two student groups.

To address the primary research question, the study employed an Ordinary Least Squares (OLS) regression model to estimate the effects of parental migration on students' dental caries and dental caries treatment.

$$Y_i = \alpha + \beta_1 \text{Parental migration}_i + \beta_2 X_i + \varepsilon_i \quad (1)$$

where Y_i is a binary indicator for the dental caries status or dental caries treatment status of student i . Where $\text{Parental migration}_i$ is a dummy variable indicating whether there is a migratory parent for student i or not. Where X_i represents a vector of baseline variables that would be correlated with student's tooth health. These baseline variables include demographic factors (gender, age, number of siblings, ethnicity, enrollment in boarding school), family factors (educational levels attained by both parents, the economic status of the family, and household registration). ε_i is a random error term.

In the regression models, we adjust standard errors for clustering at the school level using the cluster-corrected Huber-White estimator. All analyses were performed using Stata 15.0 (Stata Corp., Texas, USA). All tests

Table 1 Summary statistics of background characteristics

Variable, mean (SD)	Full Sample	Left-behind	Non-Left-behind	t-test Difference
	(1)	(2)	(3)	(2)-(3)
Panel A: outcome variables				
1.Dental caries (1 = yes, 0 = no)	0.270(0.444)	0.281(0.450)	0.267(0.443)	0.014
2. Dental caries treatment (1 = yes, 0 = no)	0.455(0.498)	0.386(0.487)	0.474(0.499)	-0.088***
Panel B: personal characters				
3.Gender (1 = male, 0 = female)	0.521(0.500)	0.529(0.499)	0.518(0.499)	0.011
4.Age(years)	14.111(0.718)	14.177(0.813)	14.094(0.690)	0.083***
5.Only child (1 = yes, 0 = no)	0.798(0.402)	0.852(0.355)	0.784(0.412)	0.068***
6.Ethic (1 = Han, 0 = other)	0.916(0.278)	0.893(0.310)	0.922(0.269)	-0.029***
7.Board (1 = yes, 0 = no)	0.301(0.459)	0.393(0.488)	0.277(0.448)	0.116***
8.Father has education level above high school(1 = Yes 0 = No)	0.369(0.483)	0.310(0.463)	0.385(0.487)	-0.075***
9.Mother has education level above high school(1 = Yes 0 = No)	0.302(0.459)	0.265(0.442)	0.311(0.463)	-0.046***
10.Household Wealth				
Poor	0.160(0.366)	0.248(0.430)	0.138(0.345)	0.110***
Average	0.707(0.455)	0.664(0.472)	0.718(0.450)	-0.054***
Rich	0.133(0.340)	0.091(0.288)	0.144(0.351)	-0.053***
11.Household registration (1 = rural, 0 = city)	0.523(0.500)	0.571(0.495)	0.510(0.500)	0.060***
N	9175	2479	6696	

Note: a 2479 dental caries individuals answered whether they treat dental caries, including 531 LBC and 1498 non-LBC. Columns (1), (2), and (3) represent the mean values for each variable, with standard deviations in parentheses. Column (4) displays the differences in mean values between the LBC and non-LBC groups

*** $p < 0.01$

were two-sided, and $P < 0.1$ was considered statistically significant.

Result

Tooth health and background characteristics

Table 1 presents summary statistics of these variables for all samples and separately by whether they were the LBC and non-LBC. Overall, 27% of students (2,479 out of 9,175) self-reported having dental caries, and among those with dental caries, the treatment rate was 45.5% (1,128 out of 2,479). This indicates that more than half of the students with dental caries had not received treatment.

In all samples, 52.1% of students were male, with a mean age of 14.11 years. Among them, 71.8% were only children, 91.6% identified as Han Chinese, and 30.1% boarded at school. In terms of parental education, 36.9% of students fathers had at least a high school diploma, compared to 30.2% for their mothers. Furthermore, 52.3% of the students were registered as living in rural areas.

When comparing the groups, the prevalence of dental caries was 28.1% among LBC and 26.7% among non-LBC, with no statistically significant difference between the two groups. However, there was a significant difference in

treatment rates: 38.6% of LBC with dental caries received treatment, compared to 47.4% of non-LBC ($p < 0.01$).

Additionally, significant differences ($p < 0.01$) were observed between LBC and non-LBC in terms of age, number of siblings, ethnicity, enrollment in boarding school, parental education levels, family economic status, and household registration. These variations underscore the diverse characteristics of the two groups and highlight potential factors influencing disparities in dental health and treatment.

Effects of the parental migration on children's tooth health

Table 2 presents the findings on the impact of parental migration on dental health. The dependent variables analyzed are the prevalence of dental caries (Column 1) and the rate of dental caries treatment (Column 2). The key parameter of interest is the coefficient for the parental migration variable.

First, the results indicate that parental migration does not significantly affect the likelihood of left-behind children (LBC) developing dental caries. In the Ordinary Least Squares (OLS) model, the coefficient for parental migration (0.012) is positive but not statistically significant (Column 1). However, when dental caries do occur, LBC are less likely to receive treatment (e.g. fillings) compared to their non-LBC peers. Specifically, the results

Table 2 Effect of parent migrated on rates of dental caries and dental caries treatment (OLS)

Variables	Dental caries	Dental caries treatment
1. Any parent migrated (1 = yes 0 = no)	0.010 (0.012)	-0.058** (0.024)
2. Gender (1 = male, 0 = female)	-0.086*** (0.009)	-0.025 (0.020)
3. Age(years)	-0.001 (0.007)	-0.027* (0.014)
4. Onlychild (1 = yes, 0 = no)	-0.002 (0.012)	0.028 (0.025)
5.Ethic (1 = Han, 0 = other)	0.045** (0.017)	0.052 (0.038)
6.Board (1 = yes, 0 = no)	0.031*** (0.011)	-0.045** (0.023)
7.Father has education level above high school(1 = Yes 0 = No)	-0.013 (0.012)	0.037 (0.025)
8.Mother has education level above high school(1 = Yes 0 = No)	-0.018 (0.012)	0.118*** (0.027)
9. Household Wealth		
Average	0.007 (0.013)	0.068** (0.028)
Rich	-0.019 (0.018)	0.141*** (0.039)
10.Household registration (1 = rural, 0 = city)	-0.006 (0.011)	-0.095*** (0.022)
10. Constant	0.291*** (0.106)	0.748*** (0.219)
11. Observations	9175	2479
12. R-squared	0.013	0.065
13. Mean without Community_support population	0.267	0.474

The numbers outside the parentheses are the OLS estimation coefficients; Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$

show that parental migration reduces the likelihood of caries treatment by 5.8%, a statistically significant finding ($p < 0.05$).

Other factors also play a significant role in dental caries and dental caries treatment. Girls, Han Chinese students, and those enrolled in boarding schools are more likely to experience dental caries ($p < 0.05$), a trend consistent with prior research [32, 33].

On the other hand, younger students and those not attending boarding schools are more likely to receive treatment for dental caries ($p < 0.1$). Family characteristics also significantly influence dental caries treatment. Higher maternal education levels are associated with a greater likelihood of children receiving dental treatment; the coefficient for maternal education is 0.118 ($p < 0.01$). Additionally, children from wealthier families are more likely to access treatment compared to those from economically disadvantaged backgrounds ($p < 0.05$). In

contrast, students living in rural areas are less likely to receive dental treatment than their urban counterparts, further highlighting disparities in healthcare access.

Robustness test

Thus far, the results show that parental migration has no significant effect on the prevalence of dental caries in LBC, but has a significant negative effect on the dental caries treatment behavior of LBC. To assess the robustness of these findings, we conducted several robustness checks to determine whether the results from our primary model remain consistent. The outcomes of these checks are presented in Table 3.

First, we replaced our definition of LBC by replacing our independent variable with both parents migrated (compared to no parents migrated, or only one parent migrated) (row 1), and the results were similar.

Table 3 Effect of parent migrated on rates of dental caries and dental caries treatment (Robustness test)

Variables	Dental caries	Dental caries treatment
1. Panel A: Change explanatory variable		
Both Parents Migrated (1 = yes; 0 = no)	-0.026 (0.017)	-0.126*** (0.037)
2. Panel B: IV-probit		
Any Parent Migrated (1 = yes; 0 = no)	-0.078 (0.051)	-0.303*** (0.098)
3. Panel C: PSM		
Any Parent Migrated (1 = yes; 0 = no)	0.008 (0.014)	-0.049** (0.020)

The numbers outside the parentheses are the OLS estimation coefficients; Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$

Second, our empirical task is to isolate the effects of parental migration on dental caries and dental caries treatment in students. This is challenging because unobservable variables may influence parental migration, student caries, and caries treatment, leading to endogenous problems. To infer causation between parental migration and children's tooth health, we apply the instrumental variable (IV) estimation to address this problem.

It is important to discuss how we choose the IVs. The IVs should be significantly correlated with parental migration, but do not correlate with ε_i . Inspired by Zhao et al. (2014) and Ao et al. (2017), one possible IV is migration probability at the class level [34, 35]. We construct a variable that measures the proportion of parental migrants in the class level as our main IV. The rationale for our choice is as follows. On the one hand, current studies show that social networks are closely related to the migration behavior of individual's members. Therefore, for individuals in a class with a richer migration experience, their members will have a higher probability of migration [36, 37]. On the other hand, the migration probability at the class level is presumed to not directly affect dental caries and dental caries treatment of a child at the individual level. To further verify the validity of the IV, in the latter section, we not only test whether our IV is weak; but also construct a new IV of migration probability at the school level for robustness check.

Before we use the instrumental variables to assess the effect of parental migration on children's tooth health, it is necessary to test whether our instrumental variable is weak. If the instrument is weak, the normal distribution provides a poor approximation of the sampling distribution of the instrument estimator, even when it contains a large sample size [38]. Table A1 reports the estimation results for the first stage of the instrumental estimation.

Overall, our IV had a significant positive effect on the migrant decision in both the full sample (column 1) and dental caries sample (column 2). The estimated coefficients were stable and statistically significant at the 1% level. Moreover, the F test values of the first stage regression were 507.78 and 156.02, which were larger than the usual critical value of 10. Thus, weak IV is not a threat to this study. In Table 3, row (2) reports the IV estimates. the results were similar.

Third, to ensure the robustness of our model's results, we conduct rigorous validation using the propensity score matching method. Due to the fact that parent migration is not a random event and can be influenced by a variety of factors, there is the possibility of bias in the estimates. This issue, if left unaddressed, could result in significant deviations in the distribution of relevant eigenvalues. Therefore, implementing the propensity score matching method becomes essential for accurately estimating the impact of parent migration. Table A2 showed that there was no significant difference in the characteristics of the LBC and Non-LBC groups after matching, and a twin group was constructed, and the effect of parental migration on the dental health of LBC children could be derived by regression on the matched samples.

The results from this matching procedure, presented in Row (3) of Table 3, show an average treatment effect on the treated (ATT) of 0.008 for dental caries, though this difference is not statistically significant. In contrast, the ATT for dental caries treatment is -0.049, which is significant at the 5% level. This indicates that LBC children are 4.9% less likely to receive treatment for dental caries compared to their Non-LBC peers. These results further support the robustness of our initial regression findings.

Mechanisms

In this subsection, we explore potential mechanisms to better understand how parental migration influences students' dental health. The first two columns of Table 4 examine the mechanisms through which parental migration affects the likelihood of dental caries, while the second and third columns focus on the factors influencing dental caries treatment.

According to existing literature, the consumption of sugary or carbonated drinks is a major factor contributing to the development of dental caries [17, 21]. To explore this, we first assessed the impact of parental migration on children's consumption of sugary and carbonated drinks. Our findings revealed that Left-Behind Children (LBC) consume sugary and carbonated drinks at similar rates to Non-LBC, which helps explain why LBC exhibit similar rates of dental caries as their peers (see Column (1) in Table 4).

Table 4 Mechanism analysis

Variables	Dental caries	Dental caries treatment	
	Drinking carbonated and sugary drinks	Parents are children's first choice for help	Parents and children take the initiative to communicate with children about their troubles
Any Parent Migrated	0.012 (0.010)	-0.078*** (0.024)	-0.068*** (0.024)
Control variable	YES	YES	YES
Mean in without community_sup- port population	0.211	0.371	0.425
N	8963	2423	2423

The numbers outside the parentheses are the OLS estimation coefficients; Standard errors in parentheses; *** $p < 0.01$

Regarding the lower rate of dental caries treatment among LBC, one possible explanation is that their dental issues are overlooked due to parental migration. The first step in treating dental caries is its identification. Previous research has shown that whether children inform their parents about their dental problems can influence the likelihood of seeking treatment [39].

Considering that the questionnaire did not directly ask students whether they informed parents about their tooth problems, we made a tentative test on whether parents were the first to ask for help when they needed help and whether parents and children took the initiative to communicate with children about their troubles. The results showed that compared to non-LBC, the proportion of LBC choosing their parents as the first help provider was lower. And compared to non-LBC, the proportion of LBC parents are less likely take the initiative to communicate with children about their troubles. In other words, LBC were less likely to inform their parents when they had tooth problem on time than non-LBC, which led to the failure of LBC to treat their tooth problems on time.

Heterogeneous analysis

We further examined the heterogeneous effects of parental migration by introducing interaction terms into our OLS model. As shown in Table 5, we found no significant evidence of heterogeneous effects across most student demographic and family characteristics, including gender, age, number of siblings, ethnicity, parental education levels, family economic status, and household registration (see Table 5, rows 1–4 and rows 6–9).

We found that parental migration made children who not board in school more likely to be dental caries (Table 5, rows 5, column 1). This may be because LBC who do not board in school can drink more sugary drinks or carbonated drinks. We also found that parental migration made children who not board in school more likely

to treat dental caries (Table 5, rows 5, column 2). This may be because LBC who board in school can't inform parents about their tooth problems.

Discussion

Few quantitative studies have examined the impact of parental migration on the tooth health of Left-Behind Children (LBC). Using a nationally representative dataset from China, our empirical analysis not only provides new evidence on this topic but also contributes to a more comprehensive understanding of how parental migration affects the health of LBC. By utilizing dental caries and dental caries treatment as indicators of oral health, our findings suggest that parental migration negatively impacts the dental health of LBC.

Our study shows that while parental migration does not significantly affect the incidence of dental caries in LBC, it does significantly reduce the likelihood of dental caries treatment for these children. This implies that parental migration has led to disparities in access to dental care for LBC, a finding consistent with previous studies exploring the broader impact of parental migration on health outcomes. Although limited research has focused specifically on the treatment of dental caries among students, existing studies have shown that parental migration can reduce the utilization of health services among left-behind children [40, 41]. A meta-analysis further found that the healthcare needs of children separated from their parents are more likely to be overlooked [42].

Additionally, we explored the underlying mechanisms to better understand how parental migration affects LBC's dental health. One key factor associated with the development of dental caries is the consumption of sugary and carbonated drinks [17, 21]. Our results indicate that parental migration does not increase the frequency with which LBC consume sugary or carbonated drinks, which helps explain why there is no significant effect on the prevalence of dental caries in this group.

Table 5 Heterogeneous effect

Variables	Dental caries	Dental caries treatment
1. Any parent migrated*Gender	0.010 (0.023)	-0.018 (0.048)
2. Any parent migrated*Age	0.010 (0.015)	0.013 (0.031)
3. Any parent migrated*Onlychild	0.007 (0.034)	0.059 (0.070)
4. Any parent migrated*Ethnic	0.000 (0.039)	0.078 (0.086)
5. Any parent migrated*Board	-0.060** (0.024)	0.098** (0.050)
6. Any parent migrated*Father has education level above high school	-0.013 (0.025)	-0.021 (0.053)
7. Any parent migrated*Mother has education level above high school	-0.017 (0.026)	-0.025 (0.056)
8. Household Wealth		
Any parent migrated*Average	-0.022 (0.025)	0.062 (0.053)
Any parent migrated*Rich	0.018 (0.039)	0.067 (0.084)
9. Any parent migrated*Household registration	-0.013 (0.023)	0.015 (0.048)

The numbers outside the parentheses are the OLS estimation coefficients; Standard errors in parentheses; ** $p < 0.05$

It is important to note that the absence of a significant effect on sugary drink consumption does not suggest that LBC manage their health better in the absence of parental oversight. In the Chinese context, where LBC are often cared for by their grandparents during their parents' absence [43], both parents and grandparents recognize the health risks of sugary drinks [44]. There is no significant difference in how children's sugary drink consumption is managed by grandparents versus parents; both groups actively work to regulate this behavior.

Furthermore, we explored why children of migrant parents have lower rates of dental caries treatment. Our findings suggest that parental migration significantly hinders the ability of LBC with dental caries to receive timely treatment. Specifically, parental migration reduces the likelihood of LBC receiving dental caries treatment by approximately 6%. This result is robust, as confirmed by a series of sensitivity tests. Drawing from existing literature, the primary explanation for this outcome is the lack of parental attention and supervision in the absence of parents [31].

To better understand the mechanisms behind this, we examined how parental migration affects LBC's ability to communicate with their parents, particularly in terms of whether parents are the first individuals children seek

help from and whether children inform their parents about dental issues in a timely manner. Our findings indicate that parental migration leads to reduced communication between LBC and their parents, making it more difficult for parents to detect dental caries in their children. As a result, LBC are less likely to inform their parents about their dental problems, contributing to the low rate of treatment.

Additionally, grandparents, who often care for LBC in the absence of parents, may face economic constraints and transportation challenges that further delay access to timely healthcare. This is especially true for health conditions that are not immediately urgent or are less symptomatic, such as dental caries [9].

Given that parental migration has contributed to inequality in dental caries treatment for LBC, it is crucial for LBC parents to pay more attention to their children's oral health and encourage timely communication about dental issues. Additionally, social support networks for LBC, involving teachers and other caregivers, are necessary to mitigate the negative effects of parental migration on access to dental care. Research has shown that when teachers inform parents about their child's health, it can positively influence treatment outcomes [39]. Furthermore, studies indicate that health service subsidies can be

effective in improving the health behaviors of LBC [43]. Therefore, policymakers should consider increasing the availability of dental care subsidies for LBC families to improve treatment rates.

This research adds some important value to the discipline in a number of ways. First, based on representative data, our study enriches the impact of parental migration on students' health and healthy behaviors. In contrast to many descriptive analytic studies, we assessed causality, which deepened our understanding of the relationship between parental migration and LBC dental health. Second, this study has practical significance for the prevention and treatment of dental caries in China and even the world. In the context of the high incidence of dental caries, the findings of this study will help to develop dental caries control interventions in LBC populations, particularly in terms of treatment. Third, our study discusses how parental migration affects dental health in LBC, which contributes to a better understanding of the impact of parental migration.

The study is subject to several limitations. Firstly, due to data constraints, we were unable to explore the effects of varying durations of parental migration on the tooth health of Left-Behind Children in both the short and long term. It is imperative for future research to address this aspect comprehensively. Secondly, the potential for self-report bias may have influenced our findings, as dental caries and dental caries treatment relied on self-reported information. Dental caries is painless and undetectable in the early stages, therefore the incidence of dental caries in this study is lower than in other studies. Additionally, it's important to note that the data utilized in this study was gathered in 2013. Subsequent research employing updated datasets with more comprehensive data could enhance the accuracy of our estimations.

Conclusion

This study utilized a comprehensive, nationally representative dataset from China. Using both an instrumental variable approach and the Propensity Score Matching method, our findings reveal that parental migration does not directly affect the likelihood of dental caries among LBC. However, it does contribute to disparities in access to dental treatment. Since untreated dental caries can have significant negative effects on mental health and overall well-being, it is crucial to prioritize the oral health of LBC. Therefore, the implementation of public health initiatives or interventions aimed at reducing disparities in dental care access for LBC could be highly beneficial.

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Authors' contributions

Y.Z. and K.D. conceived the study. Y.Z. and K.D. performed the analysis and interpreted the results. Y.Z. and K.D. drafted the manuscript. Two authors critically revised the manuscript and approved the final manuscript as submitted.

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Data Availability

Database available from the China Education Panel Survey (CEPS) repository, <http://ceps.ruc.edu.cn/English/Home.htm>.

Declarations

Ethics approval and consent to participate

Research ethics approval for data collection in the China Educational Panel Survey (CEPS) dataset was granted by the Institutional Review Board of Renmin University, PR China. The survey was conducted in accordance with the ethical guidelines laid down in the Declaration of Helsinki. All participants provided written informed consent before taking part in the survey.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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