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Residential Area vs. Home Environment: Analysis of Surrounding Factors on Children's Health Using Longitudinal Survey of Newborns in Japan

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This study examines the factors that influence the incidence of influenza infections in children, specifically how residential area and home environment impact the health of children. Using the Longitudinal Survey of Newborns in the 21st Century in Japan, data from the third survey in 2004 and eighth survey in 2009 are analyzed by using logistic regression with maximum likelihood estimation and panel analysis that control for individual effects. The results suggest that residential areas have a significant influence on the health of children. High land prices also have a positive effect on infection, thus suggesting that the probability of influenza infection is higher in densely populated areas.

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The results also show that influenza infections are suppressed in big cities as a result of better access to medical institutions and strong municipality support for raising children, which are necessary from a preventive medicine perspective. Additionally, increased opportunities of human contact may initiate the onset of influenza. This study uses two dummies, the employment status of mothers and school attendance status of children, to show that it is crucial to avoid going outdoors or interacting with people during an epidemic. Particularly, measures such as allowing mothers to work online may be effective in reducing influenza incidence during an epidemic.

Keywords

Residential area, Home environment, Children's health, Influenza, Longitudinal survey of newborns

1. Introduction

A number of studies have analyzed the effects of residential area and home environment on the health of children, genetics, and physical problems. The early years are a critical stage of development for children, and if they are not adequately supported and nurtured, there could be significant ramifications later in life (Christian et al., 2017). As improving the surrounding environment of children is essential for their healthy development, extensive research is being conducted internationally in this area. Among the studies, there are those that focus on the different health issues of children, such as colds, infectious diseases, and asthma, and their relationship with residential area, housing, and the home environment (e.g., Dong et al., (2008); Schmeer and Yoon (2016); Solari and Mare (2012)).

In Japan, long-term mortgages that exceed 25 years are common, so purchasing a new house before the first child reaches school-going age is also common.[1] However, changes in the place of residence may affect the health of children. Gambaro and Joshi (2016) focus on moving residence and examine the effect of frequent moves on early childhood health in the United Kingdom (UK). They find that there are adverse outcomes to moving. Similarly, Morris et al. (2017) use data from the UK to confirm the exacerbation of mental illness in children after moving.

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[1] Ministry of Land, Infrastructure, Transport and Tourism, https://www.e-stat.go.jp/statsearch/files?page=1&layout=datalist&toukei=00600630&tstat=000001017729&cycle=8&year=20211&month=0&result_back=1&tclass1val=0 (Accessed 21 October 2022)

However, very few studies in Japan focus on the effect of moving into a new house on the health of children before or after they begin to attend school. Therefore, to address this research gap in the literature, this paper analyzes the impact of residential area and home environment on the health of children in their early years through a panel analysis of the data on families who have undertaken such a housing move.

For this purpose, we use data from the Longitudinal Survey of Newborns in the 21st Century (hereinafter "newborns' data") conducted by the Ministry of Health, Labor, and Welfare (MHLW) in Japan.[2] This is panel data that the MHLW collects annually from the parents of children born in January and July of 2001. The first survey was conducted in August 2001 and February 2002 with a sample size of 47,015. Despite the loss of some samples in the process, the survey maintained a sample size of 36,136 in its eighth year. Although the newborns' data include the yearly data of the same children, it is an unbalanced panel that does not contain continuous data on housing. We therefore use data from the third and eighth surveys to focus on the residential areas and housing environment information within the newborns' data in this study. This is due to the introduction of questions regarding residence in these two surveys.

The newborns' data survey children born in January and July, but the months during which the data are collected vary. Specifically, in the third survey, those born in January were surveyed in August, and those born in July were surveyed in February. Since this seasonality may distort the estimated results, we limit our sample to the children born in July. This allows for analysis using data immediately after seasonal infectious diseases had passed their peak to avoid response bias, which are influenced by memory ambiguity. Furthermore, to avoid the duplication of household and surrounding environment data, household data with twins and triplets are excluded from the sample.

This study is unique in that it considers the impact of both residential area and home environment on the health of children, as opposed to previous studies that only examine individual relationships between the health of children and residential area, housing, or home environment. Furthermore, this is the first empirical analysis in Japan that uses longitudinal survey data and random effects model to address individual heterogeneity.

This study is organized as follows. Section 2 provides an overview of the literature and the originality of this study. Section 3 describes the analysis method and data. Section 4 presents the results of the analyses, and Section 5 discusses them. Section 6 concludes and presents the policy implications.

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[2] MHLW, https://www.mhlw.go.jp/english/database/db-hw/newborns6th/2-4.html (Accessed 21 October 2022)

2. Literature Review

Previous studies have analyzed factors that affect the health of children. These can be broadly classified into five categories: Residential Area, Outdoor Play, Houses, Home Environment, and Attributes and Customs of the Child.
Employing cross-section data for the Residential Area category in Zurich, Switzerland, Hüttenmoser (1995) shows that living in the city center and areas with heavy traffic worsens health and motor development in early childhood. Edwards and Bromfield (2009) use cross-section data obtained in Australia and affirm that the perception of parents of neighborhood safety mediates the relationship between neighborhood socioeconomic status and behavioral problems in young children. Alvarado (2016) focuses on socio-economic class and shows that living in disadvantaged neighborhoods worsens childhood obesity in the United States (US). Jia et al. (2019) use panel data of children from kindergarten to the eighth grade in the US to show that higher walkability in residential neighborhoods promotes physical activity and might lead to lower obesity in children. With cross-section data from Germany, Poulain et al. (2020) find that higher road ratios in residential areas are associated with increased obesity in children who are between 3 and 19 years old.

Several studies have focused on the effects of Outdoor Play. Most measure the relationship between outdoor play and the health of children and residential environment (for e.g., Fjørtoft (2004)). Fan and Chen (2012) use neighborhood cross-section data from the US on outdoor play and health of children to show that enriching recreational resources, such as parks in a neighborhood, improves the health of children who are between 6 and 17 years old. Feng and Astell-Burt (2017) focus on surrounding green spaces and confirm their positive influence on the health of Austrian children who range from 0 to 13 years old with the use of panel data.

For Houses, previous studies have focused on factors such as housing type, yard, ownership, and housing density. Moore et al. (2020) use cross-section data to show that Canadian children who are 5–17 years old and living in detached houses spend more time walking and cycling, with more physical activity outside. Miller et al. (2020) use panel data on young children in low-income households in the US, and find that they engage in more physical activity when the yard is larger. These findings can be interpreted as an indication of the superiority of detached housing. Schüle et al. (2016) use cross-section data from Germany, and reveal that living in a housing complex leads to obesity in early childhood because of limited access to private gardens and restricted outdoor activity. Some studies analyze the impact of the number of residential floors in apartment buildings on the health of children. Oda et al. (1989) use data from Japanese questionnaires to show that living on higher floors delays physical and mental development in young children because of restricted outings. Evans et al. (2002) point out that high housing density worsens the health of children and causes behavioral problems and infections.

Various previous studies present similar results on housing density (for e.g., Ertem et al. (2003); Liddell and Kruger (1989); Malaty and Graham (1994); Solari and Mare (2012); and Widmayer et al. (1990). Dong et al. (2008) show that large living areas and many rooms inhibit the prevalence of respiratory illness in children. Green and White (1997), Boyle (2002), and Haurin et al. (2002) find that children from high-income homeowner families are less likely to develop behavioral problems.

The home environment also affects the health of children. Wang et al. (2017) use cross-section data from Hong Kong and reveal that low-income level households and parents with low educational backgrounds increase the probability of obesity in children who are 9–12 years old. Ertem et al. (2003) and Malaty and Graham (1994) indicate that households with a high-income level households and mothers with a high educational background are negatively correlated with incidence of infectious diseases in children. Quihui et al. (2006) use data on intestinal parasitism in two Mexican states and find that unemployed mothers and low education level are related to high risks of infection in children. Conversely, Nozaki and Matsuura (2020) find that the employment status of mothers does not affect the development of school-aged children with the use of the same data analyzed in this study. The reason that there are so many previous multifaceted studies in the literature is because there is much academic interest in the impact of the home environment on children. Generally, the home environment has a significant influence on children and has been shown to affect not only health but also socio-emotional development and learning (Gerde et al., 2021; Hagekull and Bohlin, 1995; Pinto et al., 2013).

The attributes of children, which include constitution and lifestyle, also affect their health. Ball et al. (2002) use panel data from the US to identify a common cold constitution among children. Baker et al. (1998) also verify that there is a negative relationship between the duration of breastfeeding and the onset of infectious diseases in infants. Ertem et al. (2003) use cross-section data from Turkey, and aver that short breastfeeding sessions are more likely to cause Helicobacter pylori infection in kindergarten and elementary school children. In addition, Sinha et al. (2003) who use cross-section data from the US, find that breastfeeding affects the immunity of infant girls. Nakamuro et al. (2015) find that excessive time spent watching television or playing video games increases obesity in school-aged children. Moreover, Hinkley et al. (2018) indicate that the social skills of preschool children might be adversely affected by television watching but favorably affected by outdoor play.

In this study, we merge five factors in previous studies into three: the residential area, home environment, and attributes of children. We assume that the outdoor play of children is related to residential area, and residential area includes the housing environment. Therefore, this study analyzes the relationship between the residential area, home environment and health of children based on their attributes as the control variable. Specifically, we focus on influenza, which is an infectious disease that causes concerns due to its complications, and clarify the impact of both residential area and home environment.

3. Material and Methods

This study employs logistic regressions with maximum likelihood estimation to analyze the data. The dependent variable Y of our model is a binomial variable that takes the value "0" when the child is not infected with influenza, and "1" when infected. The estimation equation is as follows:

$$log(\frac{P(Y_i = 1)}{1 - P\,(Y_i = 1)}) = \alpha + \sum_{k=1}^{m} \beta_k X_{ki} \qquad (1)$$

$$(i \;=\; 1, 2, \dots, \mathrm{n})$$

Here, $P(Y = 1)$ *is* the probability of getting influenza, α is the constant term, β is the regression coefficient, k is the number of explanatory variables, X is the explanatory variable, and i is each subject.

Next, the panel analysis allows for unobserved individual effects, including effects in error terms, to be observed (Boyle, 2002; Haurin et al., 2002; Morris et al., 2017). The model formula for such individual effects (Ai) is as follows:

$$\log\left(\frac{P\,(Y_{it} = 1)}{1 - P\,(Y_{it} = 1)}\right) = \alpha + \sum_{k=1}^{m} \beta_k X_{kit} + A_i \qquad (2)$$

$$(i \;=\; 1, 2, \dots, \mathrm{n})$$

Here, t represents the survey year (2004 and 2009).

$$\log(\frac{p_t}{1 - p_t}) \qquad (3)$$

Table 1 presents the sources of the data for the residential area variables. Some of the data are obtained through hearings from municipalities and confirmed.

The residential area factor has five variables: ratio of residential ground, ratio of park area, regional average rent, big city dummy, and detached house dummy. The first four are used to indicate the quality of the surrounding environment based on Midouhas and Platt (2014). The newborns' data include their municipality code, which allows us to determine their location. The data provide complementary information about the surrounding environment, thus making it possible for us to assess the impact of housing location on children. The ratio of residential ground is calculated by dividing the area of the residential ground by the total area of the relevant municipality. It is used as a variable to express the residential housing density of the area. Similarly, the ratio of park area is calculated by dividing the area of the park grounds by the total area of the relevant municipality. This is used to measure the relationship between the natural surroundings and developmental problems of children (Feng and Astell-Burt, 2017). Moreover, the regional average rent (unit price converted per square meter) is used to understand city facilities and area density, along with other factors in the region, following Harkness and Newman (2005). The big city dummy is coded as "1" if the child lives in a big city, which means either an ordinance designated city or one of the 23 wards of Tokyo, and "0" otherwise. The detached house dummy is coded as "1" if the child lives in a detached house and "0" otherwise.

The variables under the home environment factor are number of siblings, household income, mother's employment dummy, and mother's age at birth. The number of siblings is the total number of all brothers and sisters. Household income is the sum of the annual income of both parents and other annual income received by the household. Mother's employment dummy is a dummy variable that corresponds to the employment status of the mother, which is coded as "1" if the mother is: looking for a job, employed full-time, employed part-time, self-employed, or otherwise working. Since fathers work full-time in over 90% of the cases, their employment status is not considered a variable. The mother's age at birth is a numerical variable that represents the age of the mother when the child was born. This variable is also a proxy for the education level of the mothers because there is a correlation between educational background and childbearing age in Japan.[3] Moreover, we also include squared mother's age at birth in the estimation model to take into account a nonlinear relationship.

The attributes of the children factor have four variables: boys dummy, breastfeeding dummy, school-aged children dummy, and watching TV time. The boys dummy is coded as "1" if the child is a boy. The duration of breastfeeding refers to the number of months that the child was breastfed. The boys and breastfeeding dummies are time-invariant. The school-aged children dummy is used to distinguish between the data from the third and eighth surveys. By the eighth survey, the children had entered elementary school. Watching TV time is surveyed by time zone and its actual value is attained by converting the obtained value to the central value or central tendency. Concretely, if the child does not watch TV, the value is converted into 0 hours, and less than one hour is converted into 0.5 hour, and the maximum value is five hours.

The variables of the home environment and attribute factors are adopted based on the estimated results of Nakamuro et al. (2015) and Nozaki and Matsuura (2020), who use the same survey as this study. Table 2 shows the descriptive statistics of the dependent and independent variables (see Appendix 1 for correlations between each variable).

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[3] Osaka City, https://www.city.osaka.lg.jp/kodomo/cmsfiles/contents/0000459/459136/P391-416zentaiban_Part11.pdf (Accessed 21 October 2022)

Table 1 Source of Variables

Variable	Investigation body	Source
Ratio of residential ground	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Residential ground: "City planning annual report."
	MLIT Geographical Survey Institute	Total area of the relevant municipality: "Statistical reports on the land area by prefectures and municipalities"
Ratio of park area	MLIT	Park area: "City park improvement level report."
	MLIT Geographical Survey Institute	Habitable land area of the relevant municipality: "Statistical reports on the land area by prefectures and municipalities"
Regional average rent	Ministry of Internal Affairs and Communications (MIC)	"Housing and land survey"
Big city dummy	MIC	https://www.soumu.go.jp/main_sosiki/jichi_gyousei/bunken/shitei_toshi-ichiran.html
Detached house dummy	Ministry of Health, Labour and Welfare (MHLW)	"Longitudinal Survey of Newborns in the 21st Century"
Number of siblings		
Household income		
Mother's employment dummy		
Mother's age at birth		
Boys dummy		
Duration of breastfeeding		
School-aged children dummy		
Watching TV time		

Table 2 Descriptive Statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Influenza (binomial variable)	0.188	0.391	0.000	1.000
Residential area				
Ratio of residential ground [%]	0.277	0.241	0.000	0.979
Ratio of park area [%]	0.019	0.019	0.161	3.099
Regional average rent [thousand yen*/㎡]	1.081	0.416	0.161	3.099
Big city dummy [0,1]	0.241	0.428	0.000	1.000
Detached house dummy [0,1]	0.581	0.493	0.000	1.000
Home environment				
Number of siblings [persons]	1.027	0.780	0.000	10.000
Household income [million yen*]	5.985	3.228	1.000	49.000
Mother's employment dummy [0,1]	0.443	0.497	0.000	1.000
Mother's age at birth [years old]	30.196	4.299	16.000	49.000
Squared mother's age at birth	930.252	263.174	256.000	2401.000
Attribute of children				
Boys dummy [0,1]	0.526	0.499	0.000	1.000
Duration of breastfeeding [months]	4.800	2.241	0.000	7.000
School-aged children dummy [0,1]	0.474	0.499	0.000	1.000
Watching TV time [hours per day]	2.226	1.189	0.000	5.000

Notes: 1 USD = 160.27 Yen (as of June 27, 2024).

4. Results

Table 3 shows the results of the analysis for influenza. Following the analysis, a log-likelihood ratio-test was performed to verify whether individual effects could be significantly detected. The null hypotheses without individual effects are rejected; the chi-square statistic of the models is 968.894 (Prob>chi2 = 0.000). As a result, the random effects model is adopted. Hence, the following results focus primarily on those of the random effects model.

Variables that do not contribute to the infection of children are big city dummy and squared mother's age at birth. Conversely, variables that contribute to infections in children are regional average rent, mother's employment dummy, school-aged children dummy, and mother's age at birth.

Our results show that children in big cities with proper access to medical facilities are protected against influenza, while those who are living in densely populated areas with high rent are more likely to catch influenza. Children who are school age tend to be in continuous contact with people, and hence are more likely to be infected with influenza. Similarly, working mothers bring the virus into the home, thus increasing the susceptibility of their children. The mother's age at childbirth is related to the incidence of influenza and it is found that there is no linear relationship, as the mother's age at birth and squared mother's age at birth are adopted as statistically significant variables. Our results suggest that the an older mother at birth means that she has more experience and knowledge to protect her child against disease.

We sample and analyze only first-birth children, as the parents could show cautious response bias due to lack of experience in raising children. Table 4 shows the results of the analysis for influenza with only first children. Following the analysis, a log-likelihood ratio-test is performed to verify whether individual effects can be significantly detected. The null hypotheses without individual effects are rejected; the chi-square statistic of the models is 675.195 (Prob>chi2 = 0.000). As a result, a random effects model is adopted. Hence, the following focuses primarily on the results of the random effects model.

This result of the only first-birth children shows that the same variables are adopted as statistically significant and have exactly the same sign as in the analysis for all of the children. This makes it possible to determine that these analyses have robust results.

Table 3 Estimated Results for Influenza: All Children

Model	Pooled		Random effects	
	Coefficient (Standard error)	Marginal effect (Standard error)	Coefficient (Standard error)	Marginal effect (Standard error)
Ratio of residential ground	-0.003	0.000	-0.003	0.000
	(0.100)	(0.015)	(0.101)	(0.011)
Ratio of park area	1.452	0.211	1.465	0.159
	(1.007)	(0.147)	(1.022)	(0.110)
Regional average rent	0.152***	0.022***	0.154***	0.017***
	(0.055)	(0.008)	(0.056)	(0.006)
Big city dummy	-0.120***	-0.018***	-0.121***	-0.013***
	(0.043)	(0.006)	(0.043)	(0.005)
Detached house dummy	0.003	0.000	0.003	0.000
	(0.032)	(0.005)	(0.033)	(0.004)
Number of siblings	-0.003	0.000	-0.002	0.000
	(0.020)	(0.003)	(0.020)	(0.002)
Household income	-0.004	-0.001	-0.004	0.000
	(0.005)	(0.001)	(0.005)	(0.001)
Mother's employment dummy	0.056*	0.008*	0.057*	0.006*
	(0.031)	(0.004)	(0.031)	(0.003)
Mother's age at birth	0.073**	0.011**	0.074**	0.008**
	(0.035)	(0.005)	(0.036)	(0.004)
Squared mother's age at birth	-0.001**	-0.000**	-0.001**	-0.000**
	(0.001)	(0.000)	(0.001)	(0.000)
Boys dummy	0.038	0.006	0.039	0.004
	(0.029)	(0.004)	(0.030)	(0.003)
Duration of breastfeeding	-0.001	0.000	-0.001	0.000
	(0.007)	(0.001)	(0.007)	(0.001)
School-aged children dummy	0.940***	0.137***	0.949***	0.103***
	(0.034)	(0.005)	(0.035)	(0.003)
Watching TV time	-0.02	-0.003	-0.021	-0.002
	(0.014)	(0.002)	(0.014)	(0.002)
Constant term	-3.152***		-3.187***	
	(0.538)		(0.547)	
Obs.	31,723		31,723	
Groups	-		18,914	
psedo-R^2	0.036		-	
chi2_c	1,113.115		968.894	
p	0.000		0.000	

Notes: ***, **, * denote significance at 1%, 5%, and 10%, respectively. The marginal effect is calculated by using the averaged data of each variable.

Table 4 Estimated Results for Influenza: Only First-birth Children

Model	Pooled		Random effects	
	Coefficient (Standard error)	Marginal effect (Standard error)	Coefficient (Standard error)	Marginal effect (Standard error)
Ratio of residential ground	-0.04	-0.006	-0.041	-0.004
	(0.140)	(0.020)	(0.143)	(0.014)
Ratio of park area	1.88	0.271	1.90	0.182
	(1.424)	(0.205)	(1.452)	(0.138)
Regional average rent	0.144*	0.021*	0.146*	0.014*
	(0.076)	(0.011)	(0.078)	(0.008)
Big city dummy	-0.108*	-0.016*	-0.109*	-0.010*
	(0.060)	(0.009)	(0.061)	(0.006)
Detached house dummy	-0.039	-0.006	-0.039	-0.004
	(0.046)	(0.007)	(0.046)	(0.004)
Number of siblings	-0.009	-0.001	-0.009	-0.001
	(0.036)	(0.005)	(0.037)	(0.003)
Household income	-0.004	-0.001	-0.004	0.000
	(0.007)	(0.001)	(0.007)	(0.001)
Mother's employment dummy	0.091**	0.013**	0.092**	0.009**
	(0.044)	(0.006)	(0.045)	(0.004)
Mother's age at birth	0.084*	0.012*	0.085*	0.008*
	(0.049)	(0.007)	(0.050)	(0.005)
Squared mother's age at birth	-0.001*	-0.000*	-0.001*	-0.000*
	(0.001)	(0.000)	(0.001)	(0.000)
Boys dummy	0.022	0.003	0.023	0.002
	(0.042)	(0.006)	(0.043)	(0.004)
Duration of breastfeeding	0.004	0.001	0.004	0.000
	(0.010)	(0.001)	(0.010)	(0.001)
School-aged children dummy	1.176***	0.169***	1.192***	0.114***
	(0.054)	(0.007)	(0.057)	(0.004)
Watching TV time	-0.024	-0.003	-0.025	-0.002
	(0.020)	(0.003)	(0.020)	(0.002)
Constant term	-3.474***		-3.518***	
	(0.728)		(0.743)	
Obs.	15,648		15,648	
Groups	-		9,331	
psedo-R^2	0.055		-	
chi2_c	834.946		675.195	
p	0.000		0.000	

Notes: ***, **, * denote significance at 1%, 5%, and 10%, respectively. The marginal effect is calculated by using the averaged data of each variable.

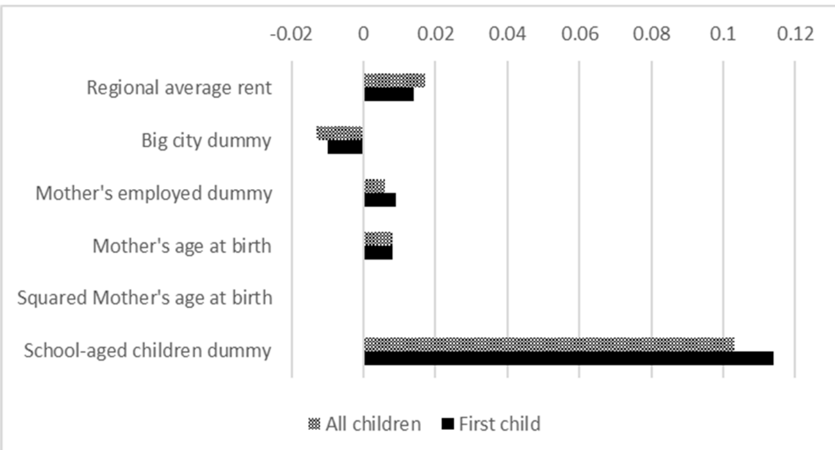
5. Discussion

The data on children who become infected with influenza show a positive relationship with the school-aged children dummy, which confirms that the probability of getting infected increases with age. This is a novel contribution of this study as it is only possible to confirm this finding through a panel analysis.

There are no differences in the analysis results between all of the children and first child data. Figure 1 shows the variables that are statistically significant for all of the children and first child, respectively. Although the same variables are statistically adopted for each, there are slightly different marginal effects. The school-aged children dummy has the most infection effect among the statistically significant variables, followed by regional average rent, which reflects a high population density, and mother's employment dummy, as mothers may bring the virus from outside.

The results indicate that more opportunities of contact with people result in higher risk of infection. Therefore, there are increased chances that influenza is likely to be transmitted when living in a high population density area, having a working mother or going to school because there is more contact with people. These results suggest that both the factors of residential area and home environment have an effect on children being infected with influenza.

Figure 1 Marginal Effects



In terms of the residential area factors, a higher regional average rent means denser residential area, which is considered similar to the findings in Evans et al. (2002), who find that highly dense housing worsens the health of children. This also echoes Hüttenmoser (1995) who shows that living in the city center worsens the health of children. Moreover, this also resonates with Alvarado (2016), who reveals that the environment that surrounds children influences their health. Unlike previous studies such as Moore et al. (2020), our results do not reveal a significantly positive effect of detached houses on influenza infection. This suggests that type of housing has nothing to do with infectious diseases due to its development from contact with the virus.

In terms of home environment factors, besides mother's employment dummy, there is a positive relationship between the mother's age at birth and the likelihood of a child catching influenza. As squared mother's age at birth is statistically adopted, this means a non-linear relationship for the age of the mother, and it is confirmed that the likelihood of infection diminishes with her age. Older mothers could prevent infection due to their experience and knowledge. This is also supported by the fact that the same analysis results are obtained with the data for only the first child. However, more data would be required to confirm this finding. The duration of breastfeeding is found to have no effect. Although the effect of breast milk is generally recognized, previous studies have confirmed that this holds true only for girls (Sinha et al., 2003) or specific diseases (Ertem et al., 2003), so it is not universal. This result suggests that further validation regarding the effect of breast milk is needed. The boy dummy is also confirmed to have no significance for influenza. Unlike the findings in Quihui et al. (2006) which indicate that it is less likely that children of households with a higher income will be infected, the results of this study are not statistically significant. This could be because there is little variation by social class in this regard in Japan because of the high level of hygiene awareness, regardless of income.

6. Conclusion

This study investigates whether residential area or home environment has a more significant effect on the health of children through a panel analysis of data that include housing moves.

The results indicate that there are some influencing factors for influenza through both residential area and home environment. We find notably two effects from the residential area factors. The analysis results show that high land prices have a positive effect on infection, thus suggesting that the probability of influenza infection is higher in densely populated areas. Influenza infections are less likely in big cities, which reflects better access to medical institutions and strong municipality support for raising children which are necessary from a preventive medicine perspective.

Even after controlling for unobservable individual heterogeneous effects, the influence of attributes of children still exists. The study reveals that children become more susceptible to infectious diseases when they go to school, thus emphasizing the importance of preventing infectious diseases in school-aged children. Additionally, increased opportunities for human contact may contribute to the onset of influenza since both the mother’s employment and school-aged children dummies are statistically adopted. Therefore, it is crucial to avoid going outdoors or interacting with people during an epidemic. Particularly, measures such as allowing mothers to work online may be effective for preventing spread of disease in the event of an outbreak.

We find that mother’s age at childbirth is related to the incidence of influenza; however, further detailed research is needed for findings that can lead to specific policies, because it is not a linear relationship.

In comparing the marginal effects of residential area and the home environment by using the results from our analysis, it is considered that the influence of residential area is greater than that of home environment (Figure 1). Therefore, with respect to policy development and review, it is important to focus on the residential area factors: regional average rent and big city dummy.

The study involves a two-point panel analysis rather than a cross-section analysis, which allows for more robust results. However, the limitations of this study is also the two-point panel used, and future research should re-verify the results by using the data in a multiple-point panel analysis with newborns' data to address the research gaps between this study and previous research work.

In summary, this study provides valuable insights into the impact of residential area and home environment on the health of children and highlights the need to prioritize preventive measures for infectious diseases, particularly in school-aged children.

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Appendix 1

Correlation Coefficient

		v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13	v14
v1	Ratio of residential ground	1													
v2	Ratio of park area	0.727	1												
v3	Regional average rent	0.645	0.516	1											
v4	Big city dummy	0.451	0.542	0.462	1										
v5	Detached house dummy	-0.258	-0.234	-0.246	-0.218	1									
v6	Number of siblings	-0.082	-0.078	-0.064	-0.057	0.173	1								
v7	Household income	0.143	0.220	0.108	0.123	0.044	0.076	1							
v8	Mother's employment dummy	-0.143	-0.104	-0.097	-0.072	0.150	0.049	0.065	1						
v9	Mother's age at birth	0.095	0.103	0.060	0.072	0.058	0.127	0.259	0.000	1					
v10	Squared mother's age at birth	0.092	0.100	0.057	0.071	0.058	0.126	0.252	0.002	0.995	1				
v11	Boys dummy	0.006	0.007	0.003	-0.005	0.015	0.013	0.004	0.003	0.005	0.006	1			
v12	Duration of breastfeeding	0.026	0.031	0.021	0.030	-0.007	0.035	0.094	-0.011	0.078	0.070	0.002	1		
v13	School-aged children dummy	-0.065	0.033	-0.012	0.001	0.183	0.242	0.144	0.255	0.009	0.008	0.003	0.010	1	
v14	Watching TV time	0.005	-0.033	-0.008	-0.006	-0.076	-0.095	-0.144	-0.169	-0.082	-0.079	0.003	-0.059	-0.291	1