Relationship between the presence of inter-municipal cooperation to provide daycare services for children with mild illness and geographic, financial, and demographic factors of municipalities depending on such cooperation – Multivariate analysis of inter-municipal cooperation to provide daycare for mildly ill children –

病児保育提供のための自治体間連携の有無と連携に依存する自治体の地理的・財政的・人口統計的要因の解析

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Abstract：In Japan, more than 30% of infants attend nursery schools during the day. However, these facilities do not accept children who are unwell, even those with mild symptoms such as low-grade fever. Although specialized nurseries for children with mild illness are being developed, these facilities have mainly been established in urban areas and few are located in small municipalities. Some small municipalities work with neighboring municipalities that possess these facilities to secure access to daycare for children with mild illness for their residents. However, the factors that determine the presence of this inter-municipal cooperation remain unclear. This study analyzed associations between the presence of inter-municipal cooperation and the geographical, financial, and demographic factors of municipalities depending on such cooperation. Proximity to the nearest municipality with specialized nurseries for children with mild illness and adjacency between municipalities with and without these nurseries was strongly associated with the presence of inter-municipal cooperation, albeit with regional differences. However, financial indicators were not related to the presence of cooperation.

Keywords：childcare; financial indicators; geographical information systems; Japan; nurseries for children with mild illness; social environment

1. Introduction

In Japan, more than 30% of infants and toddlers attend nursery schools [1, 2]. Children of this age are susceptible to colds and gastroenteritis. A national patient survey reported that children aged 0–4 years visited medical institutions because of illness or injury twice a month on average [3]. However, most nursery schools do not accept unwell children, even those with mild symptoms such as low-grade fever [4].

Although specialized nurseries for children with mild illness are being developed in Japan with financial support from municipalities, most of these facilities are located in urban areas and few are based in small municipalities [5, 6]. However, some small municipalities cooperate with neighboring municipalities that possess these facilities to secure access to daycare services for children with mild illness [7, 8]; this form of inter-municipal cooperation also occurs in other spheres, such as waste management and public hospital administration [9].

A previous study [10] showed that the distance to the nearest municipality with nurseries for children with mild illness was shorter when there was inter-municipal cooperation compared with distances in the absence of such cooperation. However, geographic factors may not be the only factors affecting the provision of daycare services for children with mild illness. The existence of nurseries for children with mild illness in municipalities is associated with several factors, such as the numbers of infants and toddlers enrolled in nursery schools that care for healthy children, number of practicing pediatricians, population size, and the financial situation of local governments [11]. Therefore, in addition to geographical factors, factors such as the demographic and financial status of municipalities that do not have nurseries for children with mild illness may affect cooperation between municipalities.

This study analyzed associations between the presence of inter-municipal cooperation and the geographical, financial, and demographic factors of municipalities that depended on such cooperation.

2. Materials and Methods

A list of municipalities that had nurseries for children with mild illness in the 2016 fiscal year was provided by the Ministry of Health, Labour and Welfare on November 13, 2018. Municipalities that had newly installed these facilities, as reported in surveys conducted in 2020 [7, 8], were added to this list. The presence or absence of inter-municipal cooperation to provide such services in municipalities without these nurseries was also confirmed by the lists used in those surveys [7, 8]. The population of each municipality was obtained from the 2015 census [1], and the capacity of nursery schools (for healthy children) in each municipality was obtained from the Report on Social Welfare Administration and Services for the 2018 fiscal year [2]. The number of nursery school attendees in each municipality was not disclosed in this report. However, as this exceeded 90% of the capacity nationwide [2], the number of infants and toddlers enrolled in nursery schools (for healthy children) in each municipality as of the 2018 fiscal year was substituted by the capacity of each municipality in this study. Information on the financial situation of each municipality for the 2019 fiscal year was obtained from the Ministry of Internal Affairs and Communications [12, 13]. Because wealthy municipalities do not receive central government subsidies (in the form of local allocation taxes), data on the amount of the subsidy received, which are published by the Ministry of Internal Affairs and Communications (MIC), were converted into a dummy for the presence of the subsidy in the analysis. The MIC publishes indicators related to the fiscal balance of local governments nationwide (the financial capability index and ordinary balance ratio), local government debt (the real debt service ratio), and public employee salaries (the Laspeyres index) for local governments nationwide. As the literature has shown that the financial capability index and ordinary balance ratio are positively correlated with the presence of nurseries for mildly ill children in the municipality [11], these two indicators were used in this analysis (Table 1). However, medical resource indicators were not considered because municipalities without nurseries for children with mild illness did not require medical resources in their territory for inter-municipal cooperation.

Table 1. Information on the financial situation of each municipality (2019 fiscal year)[12, 13]

Type	Method of calculation
Subsidy (local allocation tax) dummy from the central government	
Financial capability index	Basic financial income / Basic financial needs (3-year average)
Ordinary balance ratio	(D) / ((A) + (B) + (C)) ×100 (%) (A) Ordinary general revenue sources (B) Special cases of revenue decrease compensation loan (C) Extraordinary financial measures loan (D) General revenue sources appropriated for ordinary expenditure

The geographical factors used in this study were the affiliated regions of municipalities, the logarithm with base 10 of the distance from each municipality without nurseries for children with mild illness (point 1) to the nearest municipality with such facilities (point 2), the geographic adjacency of municipalities with and without nurseries for children with mild illness, and the distinction between cities and towns or villages.

The distance calculation was performed using Python 3.7.1 with the following formula [14].

$$\mathrm{hav}(d/r) = \mathrm{hav}(\varphi 2 - \varphi 1) + \cos(\varphi 1)\cos(\varphi 2)\,\mathrm{hav}(\lambda 2 - \lambda 1)$$

- $\mathrm{hav}(\theta) = \sin^2(\theta/2)$
- d: Distance between two points (km).
- r: Radius of the Earth (6,378.14 km) [15].
- φ1, φ2: Latitude of point 1 and point 2 (radians).
- λ1, λ2: Longitude of point 1 and point 2 (radians).

In practice, distances to all municipalities with nurseries for children with mild illness from each municipality without such nurseries were calculated using the differences in latitude and longitude for the population centers in municipalities (average latitude and longitude of inhabitants' residences) [16]. The shortest distance from each municipality without such nurseries was then identified. Geographic data from the Geospatial Information Authority of Japan [17] were used to analyze the adjacency between municipalities with Arc GIS version 10.8.1. The distinction between cities and towns or villages was based on the population census [1]. The median population of cities without nurseries for children with mild illness was 48,100, whereas the median population of towns and villages was 4,310.

As used in the analysis for inter-municipal cooperation in Italy [18], a logistic model was used to investigate associations between the presence of inter-municipal cooperation to provide daycare for children with mild illness and the geographical, financial, and demographic factors of municipalities without nurseries for children with mild illness as follows.

$$ln\left(\frac{p}{1-p}\right) = a1 \times x1 + a2 \times x2 + a3 \times x3 + a4 \times x4 + a5 \times x5 + a6 \times x6 + a7 \times x7 + a8 \times x8 + a9 \times x9 + a10 \times x10 + a11 \times x11 + a12 \times x12 + a13 \times x13 + a14 \times x14 + b$$

- a1: Logarithm with base 10 of the distance from each municipality without nurseries for children with mild illness to the nearest municipality with such nurseries.
- a2: Adjacency dummy to a municipality with nurseries for children with mild illness.
- a3: City dummy of a municipality.

- a4: Subsidy (local allocation tax) dummy from the central government.
- a5 and a6: Financial capability index and ordinary balance ratio, respectively, as financial indicators.
- a7: Capacity of nursery schools (for healthy children) or the municipality population as demographic indicators.
- a8–a14: Regional dummy of 01 for Hokkaido, 02 for Tohoku, 04 for Chubu, 05 for Kinki, 06 for Chugoku, 07 for Shikoku, and 08 for Kyushu and Okinawa, with reference to 03 for Kanto (Fig. 1).
- b: Constant.

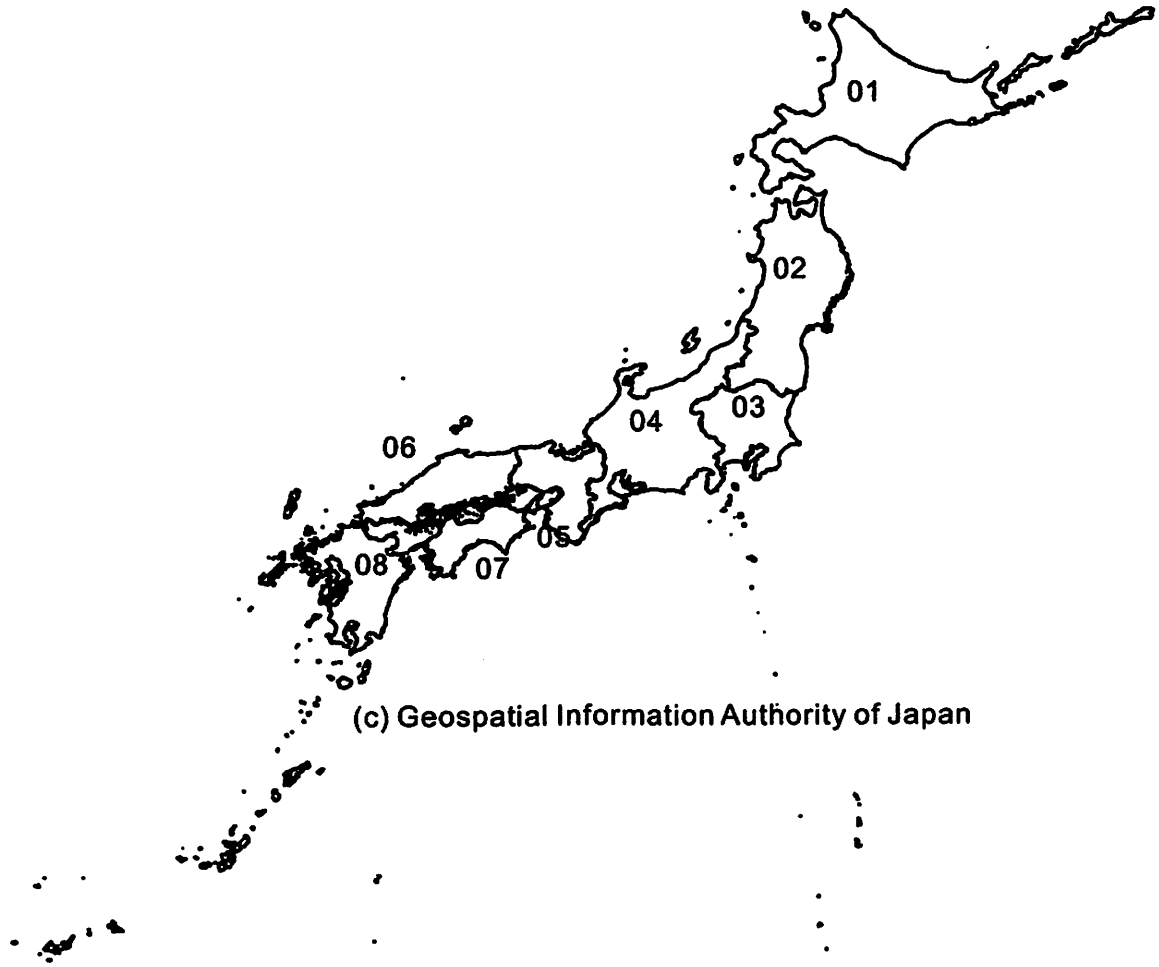

Fig 1. Eight regions of Japan. The eight regions are: 01, Hokkaido; 02, Tohoku; 03, Kanto; 04, Chubu; 05, Kinki; 06, Chugoku; 07, Shikoku; and 08, Kyushu and Okinawa. Map of Japan reprinted from Global Map Japan (public domain, open-access resources) under a Creative Commons Attribution (CC BY) license, with permission from the Geospatial Information Authority of Japan. Available from: http://www1.gsi.go.jp/geowww/globalmap-gsi/download/data/gm-japan/gm-jpn-trans_u_2_1.zip.

If there were multiple variables with a variance inflation factor (VIF) greater than 10, one factor was selected as the independent variable and the other factors were excluded to avoid multicollinearity. SPSS version 23.0.0.3 was used for the analyses, and the threshold (*P*-value) for statistical significance was set at 0.05.

After consultation with the Hiroshima International University Medical Research Ethics Committee, it was determined that this study did not require ethical review (approval number: Rin 21-001, April 20, 2021).

3. Results

Assuming that each special ward in Tokyo is a city, there were 1,741 municipalities (cities, towns, and villages) in Japan. Of these, 664 municipalities had nurseries for children with mild illness and 827 did not, although 250 municipalities were uncertain about the presence of such nurseries. Overall, 225 municipalities without nurseries for children with mild illness cooperated with neighboring municipalities

with these nurseries to secure access to daycare services for mildly ill children for residents (Table 2). The proportion of municipalities with inter-municipal cooperation varied across regions, from 3% in Hokkaido to 71% in Chugoku (Table 3).

Table 2. Inter-municipal cooperation to provide daycare for children with mild illness

Nursery*	Cooperation	Municipality		Children	
		Number	Proportion	Population	Proportion
NO	YES	225	13%	264,772	4%
	NO	602	35%	936,739	13%
YES	N/A	664	38%	5,555,064	78%
Subtotal		1,491	86%	6,756,575	95%
Japan		1,741	100%	7,086,411	100%

Children: aged 0–6 years.
*Nursery: nursery for children with mild illness.

Table 3. Percentage of inter-municipal cooperation in municipalities in eight regions of Japan without nurseries for children with mild illness

Region	Inter-municipal cooperation		
	(A) YES	(B) NO	A/(A+B)
01 Hokkaido	4	123	3%
02 Tohoku	23	114	17%
03 Kanto	26	108	19%
04 Chubu	62	79	44%
05 Kinki	24	51	32%
06 Chugoku	30	12	71%
07 Shikoku	12	34	26%
08 Kyushu and Okinawa	44	81	35%
Total	225	602	27%

Table 4 shows the results of a logistic regression analysis for the presence of inter-municipal cooperation based on the geographic, financial, and demographic factors of municipalities without nurseries for children with mild illness. The P-value in the Hosmer-Lemeshow test was above 0.7, indicating a good fit to the logistic regression model. The populations of the municipalities were excluded from the analysis because the capacity of nursery schools (for healthy children) and the population of municipalities were highly correlated and their VIF exceeded 10.

Table 4. Geographic, financial, and demographic factors and the presence of inter-municipal cooperation (Part 1)

	Parameter	B (Estimate)	SD	*P*	Exp (B) (Odds ratio)	95% CI for Exp (B) Lower	Upper
Logarithm with base 10 of d	a1	−3.284	0.449	<0.001	0.037	0.016	0.09
Adjacency to a municipality	a2	1.13	0.39	0.004	3.097	1.442	6.652
City	a3	−1.180	0.318	<0.001	0.307	0.165	0.573
Central government subsidy	a4	1.15	0.603	0.057	3.157	0.968	10.296
Financial capability index	a5	−0.060	0.522	0.908	0.942	0.338	2.621
Ordinary balance ratio (%)	a6	−0.008	0.019	0.68	0.992	0.957	1.029
Capacity of nursery schools	a7	−0.001	0.016	0.949	0.999	0.968	1.031
Region							
01 Hokkaido	a8	−0.683	0.608	0.261	0.505	0.153	1.663
02 Tohoku	a9	0.463	0.375	0.217	1.589	0.761	3.317
03 Kanto	Reference						
04 Chubu	a10	1.5	0.333	<0.001	4.481	2.335	8.597
05 Kinki	a11	0.675	0.392	0.085	1.964	0.912	4.231
06 Chugoku	a12	2.871	0.482	<0.001	17.655	6.866	45.398
07 Shikoku	a13	0.907	0.482	0.06	2.477	0.964	6.367
08 Kyushu & Okinawa	a14	1.142	0.349	0.001	3.134	1.582	6.209
Constant	b	0.531	1.893	0.779	1.7		

- Hosmer–Lemeshow test, P = 0.764. SD denotes standard deviation, CI, confidence interval, and P, probability.
- Logarithm with base 10 of distance showing odds ratios comparing distances that differed by a factor of 10.
- Adjacency dummy: equals 1 if adjacent to a municipality with nurseries for children with mild illness; and 0 otherwise.
- City dummy: equals 1 for a city; and 0 otherwise (i.e., for towns and villages).
- Subsidy (local allocation tax) dummy: equals 1 for municipalities subsidized by the central government; and 0 otherwise.

The logarithm with base 10 of the distance to the nearest municipality where nurseries for children with mild illness were located was negatively correlated with the presence of inter-municipal cooperation (P < 0.001). However, the adjacency between municipalities with and without nurseries for children with mild illness was positively correlated with the presence of inter-municipal cooperation (P = 0.004). Among municipalities without nurseries for children with mild illness, cities had a lower rate of inter-municipal cooperation than towns or villages (P < 0.001). The proportion of cooperating municipalities varied from region to region. With the Kanto region as the reference, cooperation tended to be statistically significantly higher in Chubu, Chugoku, and Kyushu and Okinawa. However, no significant differences were found in Hokkaido, Tohoku, Kinki, and Shikoku compared to Kanto.

The capacity of nursery schools that cared for healthy children had no association (P = 0.949) with the presence of inter-municipal cooperation. Furthermore, the presence of a subsidy (local allocation tax) from the central government in these municipalities and the financial indicators of municipalities

without nurseries for children with mild illness did not show a significant association with the presence of inter-municipal cooperation.

A logistic regression analysis in which the capacity of nursery schools (for healthy children) was replaced by the population of municipalities showed almost the same results as in Table 4 (see Table 5). The population was not associated with the presence of inter-municipal cooperation ($P = 0.812$). Furthermore, this analysis showed that the presence of a subsidy from the central government in these municipalities and the financial indicators of municipalities without nurseries for children with mild illness were not statistically significantly associated with inter-municipal cooperation.

Table 5. Geographic, financial, and demographic factors and the presence of inter-municipal cooperation (Part 2)

	Parameter	B (Estimate)	SD	*P*	Exp (B) (Odds ratio)	95% CI of Exp (B) Lower	Upper
Logarithm with base 10 of d	a1	−3.291	0.45	< 0.001	0.037	0.015	0.09
Adjacency to a municipality	a2	1.13	0.39	0.004	3.096	1.442	6.649
City	a3	−1.148	0.316	< 0.001	0.317	0.171	0.59
Central government subsidy	a4	1.138	0.605	0.06	3.122	0.954	10.214
Financial capability index	a5	−0.050	0.526	0.924	0.951	0.339	2.667
Ordinary balance ratio (%)	a6	−0.008	0.019	0.68	0.992	0.957	1.029
Population (× 10,000)	a7	−0.009	0.038	0.812	0.991	0.919	1.068
Region							
01 Hokkaido	a8	−0.692	0.609	0.256	0.5	0.152	1.651
02 Tohoku	a9	0.456	0.377	0.227	1.577	0.753	3.301
03 Kanto	Reference						
04 Chubu	a10	1.487	0.336	<0.001	4.426	2.289	8.558
05 Kinki	a11	0.665	0.394	0.091	1.945	0.899	4.206
06 Chugoku	a12	2.859	0.485	<0.001	17.437	6.746	45.069
07 Shikoku	a13	0.896	0.484	0.064	2.449	0.949	6.322
08 Kyushu & Okinawa	a14	1.13	0.352	0.001	3.096	1.553	6.172
Constant	b	0.563	1.898	0.767	1.755		

- Hosmer–Lemeshow test, P = 0.767. SD denotes standard deviation, CI, confidence interval, and P, probability.
- Logarithm with base 10 of distance showing odds ratios comparing distances that differed by a factor of 10.
- Adjacency dummy: equals 1 if adjacent to a municipality with nurseries for children with mild illness; and 0 otherwise.
- City dummy: equals 1 for a city; and 0 otherwise (i.e., for towns and villages).
- Subsidy (local allocation tax) dummy: equals 1 for municipalities subsidized by the central government; and 0 otherwise.

4. Discussion

Infants and toddlers are vulnerable to acute illnesses (e.g., infectious diseases) and visit medical institutions because of injuries or illnesses twice per month on average [3]. Nursery schools that care for healthy children do not accept unwell children, even those with minor symptoms [4], meaning working parents must find alternative care for children with sudden onset mild illness. In such cases, it is desirable for children to remain with a guardian, but in reality, it is difficult for Japanese workers to take paid leave [19]. Many working parents ask relatives and friends to provide urgent daycare services, but this support is not always available. Therefore, it is imperative that public daycare services that specialize in caring for children with mild illnesses are available as part of childcare support.

Similar situations occur overseas as all children are susceptible to acute illness. However, a search of databases (e.g., PubMed) did not yield any literature on systems of daycare services for children with mild illness in other countries. In addition, a survey by the National Diet Library indicated there were

no data on daycare services for children with mild illness in other countries as of 2005 [20]. That report stated that when a child becomes ill, home care is standard in other countries, and efforts to enhance long-term care leave for caregivers have been introduced. Changes to the Japanese labor culture take a long time, meaning it is imperative to develop daycare facilities for children with mild illness until Japanese labor practices change to be consistent with those in other countries.

Many nurseries for children with mild illness are run at a loss and cannot be maintained without financial support; however, the financial support system for these facilities is implemented on a municipal basis [21]. Nurseries for children with mild illness are unevenly distributed in Japan, and most small municipalities do not have these facilities [5, 6]. In small municipalities, low budgets and low child populations make it difficult to provide financial support to these facilities without external support [7]. Therefore, small municipalities should provide daycare services for children with mild illness through cooperation with other municipalities. However, it is difficult to promote such cooperation unless factors that enable such cooperation are identified.

This study found that important factors enabling inter-municipal cooperation were proximity to the nearest municipality with nurseries for children with mild illness and adjacency between municipalities with and without these nurseries, regardless of the capacity of nursery schools (for healthy children), the population, or the financial situation of the municipality without nurseries for children with mild illness. This is not surprising because it is practically impossible to use nurseries for children with mild illness in other municipalities unless they are in close proximity to the place of residence of parents and children. In a previous report [10], the median distances between municipalities with and without inter-municipal cooperation were 8.4 km and 16.2 km, respectively ($p < 0.001$). The financial situation of these small municipalities may not be related to the presence of inter-municipal cooperation because the financial burden in most cases of inter-municipal cooperation is proportional to the number of users of nurseries for children with mild illness, and the expenditure of small municipalities without these nurseries is relatively small [8].

There was no significant difference in the presence or absence of inter-municipal cooperation in Hokkaido, Tohoku, Kinki and Shikoku compared to Kanto. The reason for this is unclear, however, it may be that the confidence intervals for the standard deviations are longer due to the small number of municipalities that have inter-municipal cooperation.

Among municipalities without nurseries for children with mild illness, cities had a lower rate of inter-municipal collaboration than towns and villages. The reasons for this finding are unknown, but one explanation may be that small towns and villages are likely to rely heavily on large neighboring cities for administrative and other services. In addition, the proportion of municipalities that worked with neighboring municipalities varied across regions. Cooperation between municipalities was more common in regions with a high proportion of municipalities with nurseries for children with mild illness [7,8]. In those regions, the distance between municipalities with and without nurseries for mildly ill children was shorter than in other regions, which may facilitate inter-municipal cooperation.

Proximity to the nearest municipality with nurseries for children with mild illness and adjacency between municipalities with and without these nurseries had a major impact on the presence of inter-municipal cooperation. Therefore, it is necessary to create areas comprising neighboring municipalities and establish at least one nursery for such services in that area to ensure access to daycare services for children with mild illness nationwide.

Limitations

The following research limitations exist in this study.

1. This study was conducted as a cross-sectional analysis of the presence or absence of inter-municipal cooperation in the provision of care for mildly ill children. It did not analyze changes over time using

a hazard model, as in the study of inter-municipal cooperation in tourism marketing in West German municipalities [22]. Therefore, the association was found, but the causal relationship is unknown in this study.

2. Of the municipalities that did not have nurseries for children with mild illness, those that had inter-municipal cooperation and those that did not were included in this study. Therefore, municipalities that have these nurseries but do not have inter-municipal cooperation were excluded from the scope of this study.
3. This study concluded that the financial situation of the small municipalities may not be related to the presence of inter-municipal cooperation. However, factors related to how the cost of childcare for mildly ill children is borne in the case of inter-municipal cooperation were not included in this study.
4. The enthusiasm of physicians, other professionals, and local government leaders is likely to have a significant impact on inter-municipal cooperation, but this is difficult to quantify. Although this factor is excluded from this analysis, it will be essential to incorporate such hard-to-quantify factors in a mathematical model of inter-municipal cooperation in future studies.
5. A literature search did not reveal any facility-based care for mildly ill children overseas. Therefore, it is difficult to make comparisons between these nurseries in Japan and other countries. However, this study has introduced the concept of facility-based care for children with mild illness to foreign countries and noted its availability in Japan and the inter-municipal cooperation involved in its provision.

Conclusions

This study found that important factors enabling inter-municipal cooperation to provide care for children with mild illness were proximity to the nearest municipality with nurseries providing such specialized care and adjacency between municipalities with and without these nurseries, regardless of the capacity of nursery schools (for healthy children), the population, or the financial situation of the municipality without nurseries for children with mild illness.

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和文抄録

日本では乳幼児の 3 割以上が日中保育園に通っている。しかし、これらの施設は、微熱などの軽微な症状がある子どもの登園を認めていない。こうした子どもたちを受け入れる病児保育施設が全国で整備されつつあるが、主に都市部に限られている。一方、小規模な市町村の中には、病児保育施設を持つ近隣の市町村と連携し、住民に病児保育を提供しているところもある。しかし、このような自治体間連携の有無を決定する要因が何であるかは不明である。本研究では、市町村間連携の有無と、病児保育の住民への提供を自治体間連携によって確保している自治体の地理的、財政的、人口学的要因との関連を分析した。この結果、地域差はあるものの、病児保育施設がある最寄りの自治体への近さや自治体同士の隣接性が自治体間連携の有無に強い相関を示すことが明らかになった。一方、こうした自治体における財政状況は連携の有無に有意な相関を認めなかった。