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Inter-Regional Differences in Travel Time to the Nearest Nursery for Children with Mild Acute Illness in Japan

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Access to day-care services for children with mild acute illness is important for working parents, because infants and toddlers often suddenly become ill, and most Japanese nursery schools do not accept children with even mild illnesses. Actual travel time to nurseries providing such day-care services is one of the indicators for measuring accessibility. However, this variable has not been well analyzed in previous work. To clarify practical access to such nurseries, this study used a car navigation algorithm to calculate the percentage of the population of children in Japan who can access nurseries providing services for children with mild acute illnesses within 15 to 30 minutes and compared this with the proportion of children living within a linear distance of 10 km of such nurseries. Of the 4,987,706 children younger than 5 years in 2015, 51.7% lived in areas from which the nearest nursery for children with mild acute illness was accessible within 0-15 minutes by automobile. In addition, 81.5% lived within 0-30 minutes of such nurseries, and the same percentage (81.5%) lived within a linear distance of 10 km of such nurseries. Both calculation methods (travel time and linear distance) showed inter-regional differences in accessibility, and the proportion of children with access to these nurseries was higher in heavily populated regions (e.g., Kanto and Kinki) than in less populated regions (e.g., Hokkaido and Tohoku). Children and caregivers throughout Japan should have equal access to these nurseries, because the national government subsidizes such services.

Keywords: child care; geographical information systems; Japan; nurseries for children with mild acute illness; social environment

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Introduction

In Japan, 90.0% of men and 72.1% of women aged 25-34 years were permanently or temporarily employed in 2015 (Statistics Bureau, Ministry of Inner Affairs and Communication of Japan 2016a). In addition, 62.4% of babies born in 2015 were to women in this age group (Ministry of Health, Labour and Welfare 2016a).

Infectious diseases can cause sudden illness in infants and toddlers. The 2014 Patient Survey (Ministry of Health, Labour and Welfare 2015) indicated that children in Japan averaged two visits per month to medical facilities because of diseases and injuries. The Infection Control Guideline for Nurseries (Ministry of Health, Labour and Welfare 2012, 2018) instructs general nursery schools to refrain from accepting infants and toddlers with mild fevers (37.5-38.0 centigrade) who are not doing well. However, it is difficult for nursery schools to judge precisely whether or not these children are in good condition, and it is probable that most nursery schools simply do not accept children with temperatures above 37.5 centigrade. Therefore, working parents who have children with even mild illnesses must seek alternative day-care service providers. Alternative providers may include relatives and friends, but these options are not always available. In such cases, one of the working parents—usually the mother in Japan (Cabinet Office, Government of Japan 2017)—must be absent from their workplace to care for the child.

The Japanese Government has attempted to increase the capacity of day-care services for children in an unhealthy condition (Council for Gender Equality of Cabinet Office, Government of Japan 2013). A previous report (Ehara 2017) analyzed the straight distance to nurseries for children with mild acute illness (787 nurseries) from each residential block in Japan (median size of 0.18 km^2). That study showed that 47.0% of children in Japan lived within 3 km of the nearest nursery, 64.8% within 5 km, and 82.1% within 10 km. However, most roads do not follow straight lines because of geographical features such as rivers and mountains. This means the actual travel time is likely to affect practical access to nurseries that accept children with mild acute illness.

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A recent survey conducted in the Kanto region (Yamazaki et al. 2017) indicated that 60.6% of parents sometimes used their automobile or public transport (e.g., a taxi) to transport children to childcare facilities. In most prefectures in Japan, the average number of automobiles exceeds one per household (excluding the five over-populated areas: Tokyo, Kanagawa, Kyoto, Osaka, and Hyogo) (Automobile Inspection & Registration Information Association 2015). Therefore, to clarify practical access to nurseries for children with mild acute illnesses, this study used geographic information systems (GIS) to calculate the driving time necessary for parents to transport their children from each residential area to the nearest nursery for children with mild acute illness. Calculations were based on the algorithm widely used in car navigation systems.

Methods

The list of 787 subsidized nurseries that accept children with mild acute illness in Japan provided by the Ministry of Health, Labour and Welfare (as of March 31, 2016) was used for this study. This list was also used in the previous study (Ehara 2017). The present author divided Japan into 219,100 residential blocks (median area: 0.17 km^2) and the child population into three groups (aged 0-4, 5-9, and 10-14 years), consistent with the 2015 Population Census (Statistics Bureau, Ministry of Internal Affairs and Communications of Japan 2017). As 82.7% of children who used nurseries for children with acute illness in the 2012 fiscal year were aged under 5 years (Council for Gender Equality of Cabinet Office, Government of Japan 2013), this analysis focused on driving time to the nearest qualifying nursery from each residential block in which children aged 0-4 years lived.

A GIS using ArcGIS version 10.5.1 software (Esri, Redlands, CA, USA) was used to determine the latitude and longitude of all residential blocks in Japan (Statistics Bureau, Ministry of Internal Affairs and Communications of Japan 2017). The geocoding service for CSV-formatted files on the Internet, provided by the Center for Spatial Information Science of The University of Tokyo (Center for Spatial Information Science, The University of Tokyo 2015) was used to determine the coordinates for each nursery for children with mild acute illness. GIS using ArcOnline (January 24-26, 2017) was used to identify residential blocks that could reach the nearest nursery for children with mild acute illness within 15 or 30 minutes by automobile. This system estimates travel time using Dijkstra's algorithm (Dijkstra 1959), which is widely used in car navigation systems. The mean automobile velocity as a function of the type and width of roads according to road density was pre-fixed in ArcOnline, based on the 2010 Road Traffic Census (Ministry of Land, Infrastructure, Transport and Tourism 2011) (Table 1). In addition, GIS using ArcGIS version 10.5.1 was used to identify residential blocks within a straight distance of 10 km of such nurseries by spherical trigonometry (Todhunter 2013).

In 2015, Japan's population density was 341 persons/km^2 (Table 2; Statistics Bureau, Ministry of Internal Affairs and Communications of Japan 2016b). Population density was high in Kanto (1,333 persons/km^2), Chubu (353 persons/km^2), Kinki (765 persons/km^2), and Kyushu and Okinawa (345 persons/km^2). Population density was low in Hokkaido (69 persons/km^2), Tohoku (141 persons/km^2), Chugoku (234 persons/km^2), and Shikoku (205 persons/km^2). The mean number of household members in 2015 ranged from 2.24 in Hokkaido to 2.67 in Tohoku (Table 2). The employment rate for women aged 25-34 years in 2015 (Statistics Bureau, Ministry of Internal Affairs and Communications of Japan 2016a) ranged from 69.0% in Kinki to 75.9% in Tohoku (Table 3). The proportion of healthy nursery users, which was approximated by dividing nursery users by the child population aged 0-5 years, ranged from 28.5% in Hokkaido to 43.8% in

Table 1. Mean velocity of an automobile according to the type and width of roads (km/h).

Location (Road density)	Road type		Width (m) ≥ 13	5.5-13	3-5.5	< 3	Unknown
Urban (≥ 15,000 m/km^2)	Highway						
		Inter-city	80	80	50	10	2
		Intra-city	60	60	50	10	2
	Main road						
		National	30	20	17	7	2
		Prefectural and municipal	30	17	17	7	2
	Other roads and unknown		30	12	8	4	2
Rural I (5,000-15,000 m/km^2)	Highway						
		Inter-city	80	80	60	15	10
		Intra-city	60	60	60	15	10
	Main road						
		National	50	40	25	10	10
		Prefectural and municipal	50	35	25	10	10
	Other road and unknown		50	20	15	10	10
Rural II (< 5,000 m/km^2)	Highway						
		Inter-city	80	80	60	15	10
		Intra-city	60	60	60	15	10
	Main road						
		National	55	50	30	10	10
		Prefectural and municipal	55	45	30	10	10
	Other road and unknown		55	30	15	10	10

Mean automobile velocity, as a function of the type and width of roads according to road density, was based on the 2010 road traffic census (Ministry of Land, Infrastructure, Transport and Tourism 2011).

Geographical information systems using ArcOnline was used to estimate travel time using Dijkstra's (1959) algorithm, which is widely used in car navigation systems.

Table 2. Social indicators for eight Japanese regions (2015).

Region	(a) Total population (person)	(%)	Total land area[a] (km^2)	(%)	Population density ($persons/km^2$)	(b) Total households	(a)/(b) Household members (persons)
A Hokkaido	5,384,000	4.2	78,421	21.0	69	2,404,800	2.24
B Tohoku	8,983,000	7.1	63,852	17.1	141	3,362,000	2.67
C Kanto	42,992,000	33.8	32,240	8.6	1,333	18,514,600	2.32
D Chubu	23,282,000	18.3	66,048	17.7	353	8,757,600	2.66
E Kinki	20,728,000	16.3	27,101	7.3	765	8,599,600	2.41
F Chugoku	7,440,000	5.9	31,818	8.5	234	2,965,000	2.51
G Shikoku	3,847,000	3.0	18,789	5.0	205	1,567,500	2.45
H Kyushu and Okinawa	14,455,000	11.4	41,918	11.2	345	5,844,400	2.47
Total[a]	127,111,000	100.0	372,969	100.0	341	52,015,500	2.44

[a]Total land area excludes the northern territories and Takeshima island.

Table 3. Social indicators for workforce and nursery use.

Region	Employment rate (%) 25-34 years (2015) Male	Female	(c) Population 0-5 years (2015)	(d) No. nursery users[b] (2015)	(d)/(c) Proportion of nursery users (%)
A Hokkaido	88.9	70.6	225,760	64,365	28.5
B Tohoku	90.4	75.9	381,346	142,531	37.4
C Kanto	90.1	73.0	2,012,941	627,259	31.2
D Chubu[a]	92.9	70.9	1,134,050	462,099	40.7
E Kinki	87.8	69.0	977,070	312,825	32.0
F Chugoku	90.9	71.9	362,217	155,838	43.0
G Shikoku	88.1	75.4	170,922	74,797	43.8
H Kyushu and Okinawa	90.4	72.4	767,369	325,889	42.5
Total	90.0	72.1	6,031,675	2,165,603	35.9

[a]Employment rates of Nagano and Yamanashi in Chubu were analyzed as in Kanto region.
[b]Users of general nursery schools.

Shikoku (Table 3; Ministry of Health, Labour and Welfare 2016b; Statistics Bureau, Ministry of Internal Affairs and Communications of Japan 2017).

This study did not require ethical approval from the Medical Research Ethics Committee of Hiroshima International University because only previously published Japanese government data were used.

Results

Of the 4,987,706 children aged younger than 5 years as of 2015, 51.7% lived in areas from which the nearest nursery that accepted children with mild acute illness was accessible by automobile within 0-15 minutes (Table 4). These areas represented 4.2% of Japan's total land area (Table 4 and Fig. 1). The proportion of children who could access such nurseries was high in over-populated regions such as Kanto (56.9%) and Kinki (63.7%), but low in under-populated regions such as Hokkaido (9.1%) and Tohoku (29.3%).

Areas from which qualifying nurseries were accessible within 0-30 minutes represented 14.6% of Japan's total land area, with 81.5% of Japan's children living in these areas. The same percentage of children (81.5%) lived within 10 km of such nurseries (Table 4 and Fig. 1). The percentage of children with mild acute illness who could access a nursery within 0-30 minutes by automobile was highest in Kinki (89.8%) and lowest in Hokkaido (35.9%). The percentages of children living within a straight distance of 10 km of such nurseries showed similar results (Kinki: 91.1%, Hokkaido: 20.7%).

Discussion

In a potential over-adaptation of Japan's Infection Control Guideline for Nursery (Ministry of Health, Labour and Welfare 2012, 2018), most nursery schools in Japan do not accept children with even mild illnesses. This is intended to prevent the spread of infectious diseases. If alternative day-care services are not readily available for children with sudden-onset acute illness, one parent—usually the mother (Cabinet Office, Government of Japan 2017)—may have to take leave from work to care for the child. For working parents in other countries, day-care arrangements for a child with mild acute illness may present a similar problem. An earlier study reported that a primary cause of worker absence in Europe was sudden-onset infectious diseases of children (Peetoom et al. 2018).

Many parents sometimes use their automobile or public transport (e.g., a taxi) to transport children to childcare facilities (Yamazaki et al. 2017). In addition, the average number of automobiles across Japan generally exceeds one per household (excluding over-populated areas) (Automobile Inspection & Registration Information Association 2015). Therefore, to investigate practical access to the nearest nurseries for children with acute illness, I calculated the actual driving time from each residential block. These calculations were based on the car navigation algorithm

Table 4. Percentages of child population and land area accessible to nurseries for children with acute mild illness calculated using driving time and straight distance.

	Region		Automobile 0-15 min (%)	Automobile 0-30 min (%)	Linear distance < 10 km (%)
A	Hokkaido	Child population	9.1	35.9	20.7
		Area	0.2	1.6	1.5
B	Tohoku	Child population	29.3	59.6	56.5
		Area	1.8	8.1	8.9
C	Kanto	Child population	56.9	89.6	89.0
		Area	11.0	37.2	34.7
D	Chubu	Child population	44.2	79.8	79.1
		Area	5.6	17.6	22.2
E	Kinki	Child population	63.7	89.8	91.1
		Area	7.7	22.7	27.5
F	Chugoku	Child population	53.2	81.9	85.5
		Area	4.0	18.5	23.7
G	Shikoku	Child population	51.7	72.5	80.7
		Area	4.3	12.3	19.0
H	Kyushu and Okinawa	Child population	56.6	78.6	81.8
		Area	6.0	20.6	26.8
	Total	Child population	51.7	81.5	81.5
		Area	4.2	14.6	17.2
	Highest	Child population	63.7 (Kinki)	89.8 (Kinki)	91.1 (Kinki)
		Area	11.0 (Kanto)	37.2 (Kanto)	34.7 (Kanto)
	Lowest	Child population	9.1 (Hokkaido)	35.9 (Hokkaido)	20.7 (Hokkaido)
		Area	0.2 (Hokkaido)	1.6 (Hokkaido)	1.5 (Hokkaido)

Travel time was calculated using Dijkstra's (1959) algorithm, which is widely used in car navigation systems, and linear distance was calculated by spherical trigonometry (Todhunter 2013).

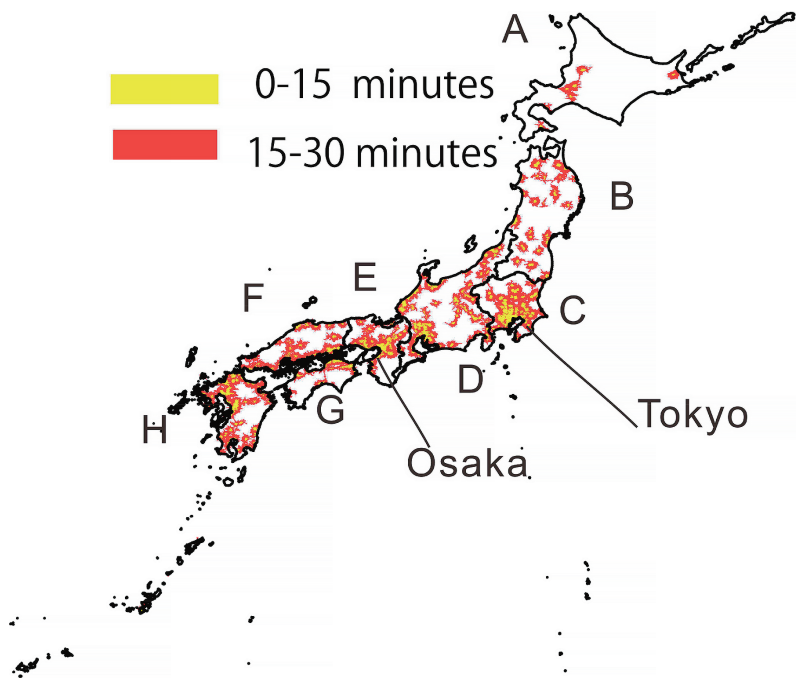

Fig. 1. Travel time to the nearest nursery for children with mild acute illness.
Areas accessible by automobile are shown in yellow (0-15 minutes) and red (15-30 minutes). The territory of Japan is divided into eight regions: A, Hokkaido; B, Tohoku; C, Kanto; D, Chubu; E, Kinki; F, Chugoku; G, Shikoku; H, Kyushu and Okinawa. Kanto (C), Kinki (E), Chubu (D), and Kyushu and Okinawa (H) have high population densities. Other regions have lower population densities. Map of Japan reprinted from Global Map Japan (public domain, open-access resources) under a CC BY license, with permission from the Geospatial Information Authority of Japan.

using data for the mean velocity of an automobile by type and width of roads in urban and rural areas. This showed that 51.7% of children in Japan could access the nearest nursery for children with acute illness by automobile within 0-15 minutes, and 81.5% within 0-30 minutes. This study also calculated the linear distance from each residential

block to the nearest nursery for children with mild acute illness, using data from the 2015 Population Census, finding that 81.5% of Japanese children aged 0-4 years lived within 10 km of these nurseries. This percentage (81.5%) was comparable to the result (82.1%) calculated using data from the 2010 Population Census (Ehara 2017). Both calculation methods (travel time and linear distance) showed inter-regional differences in accessibility, and a higher proportion of children had access to these nurseries in heavily populated regions (e.g., Kanto and Kinki), compared with less populated regions (e.g., Hokkaido and Tohoku).

Japan faces a problem of the combined effects of aging and a decreasing birth rate, which predicts a decrease in the labor force in the near future. Increasing the workforce requires supporting working parents, especially mothers, who are raising children. Since 1994, the Japanese government has subsidized nurseries for children in an unhealthy condition (Ministry of Health, Labour and Welfare 2009). However, a higher proportion of parents who live in northern parts of Japan (e.g., Hokkaido and Tohoku) cannot transport their children to nurseries for children with mild acute illness within 15 or 30 minutes compared with those in other regions because there are few such nurseries nearby.

The employment rates of women aged 25-34 years in Hokkaido (70.6%) and Tohoku (75.9%) were comparable with those in Kanto (73.0%) and Kinki (69.0%) (Table 3). In addition, nursery users per population aged 0-5 years in Hokkaido (28.5%) and Tohoku (37.4%) did not differ markedly from those in Kanto (31.2%) and Kinki (32.0%) (Table 3). There were no significant differences in average numbers of household members between under-populated regions such as Hokkaido (2.24) and Tohoku (2.67), and over-populated areas such as Kanto (2.32) and Kinki (2.41) (Table 2). Given the provision of national subsidies and lack of major differences in official indicators concerning the childcare environment, children and parents throughout Japan should have equal access to these services.

The 2014 Patient Survey (Ministry of Health, Labour and Welfare 2015) reported that children in Japan visited medical facilities because of diseases and injuries an average of twice a month. This highlights that support for working parents requires provision of nursery services for children with mild acute illness, as well as for healthy children. Quantitative data analysis based on GIS is indispensable for promoting discussion regarding the distribution and accessibility of such nurseries.

There are limitations in the present study, as listed below.

1) Other potential providers of childcare (e.g., relatives) were not considered in this study, although child-rearing families may live close to such relatives, particularly in rural areas.

2) Operating hours of nurseries were not considered.

3) Only pre-fixed data for average automobile velocity were used, and the effects of factors such as traffic congestion and poor weather were not considered.

4) It was unknown whether every nursery claiming to accept children aged 0-4 years was able to care for babies aged 3 months or younger that might need a greater level of care.

5) It was unknown whether every nursery could manage all types of illnesses.

6) The socioeconomic status of parents in each residential block was unknown.

7) Only nurseries for children with mild acute illness subsidized by the Japanese government were analyzed. Non-subsidized facilities were not included.

In conclusion, 51.7% of children younger than 5 years lived in areas from which the nearest nursery for children with mild acute illness was accessible within 0-15 minutes by automobile. Furthermore, 81.5% lived within 0-30 minutes of such nurseries, and the same percentage (81.5%) lived within a linear distance of 10 km of such nurseries. Both calculation methods (travel time and linear distance) showed inter-regional differences in accessibility, and a higher proportion of children in heavily populated regions (e.g., Kanto and Kinki) could access these nurseries, compared with less populated regions (e.g., Hokkaido and Tohoku). Children and caregivers throughout Japan should have equal access to these nurseries, because the national government subsidizes such services.

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Conflict of Interest

The author declares no conflict of interest.

References

Automobile Inspection & Registration Information Association (2015) Car Ownership Rate in Each Prefecture. https://www.airia.or.jp/publish/statistics/trend.html [*Accessed*: June 10, 2018] (in Japanese).

Cabinet Office, Government of Japan (2017) Declining Birthrate White Paper, FY2016. http://www8.cao.go.jp/shoushi/shoushika/whitepaper/measures/w-2017/29webhonpen/index.html [*Accessed:* June 10, 2018] (in Japanese).

Center for Spatial Information Science, The University of Tokyo (2015) Geocoding service for CSV formatted file on WWW. http://newspat.csis.u-tokyo.ac.jp/geocode-cgi/geocode.cgi?action=start [*Accessed*: October 31, 2017] (in Japanese).

Council for Gender Equality of Cabinet Office, Government of Japan (2013) About day-care for sick children, the 8th conference of child and child-feeding support, November 25. http://www8.cao.go.jp/shoushi/shinseido/meeting/kodomo_kosodate/b_8/pdf/s2-2.pdf

[*Accessed*: June 10, 2018] (in Japanese).
Dijkstra, E.W. (1959) A note on two problems in connexion with graphs. *Numerische Mathematik*, **1**, 269-271.
Ehara, A. (2017) Unequal accessibility of nurseries for sick children in over- and under-populated areas of Japan. *Tohoku J. Exp. Med.*, **241**, 97-102.
Ministry of Health, Labour and Welfare (2009) The 27th Falling Birthrate Special Committee of Social Security Council, September 30.
http://www.mhlw.go.jp/shingi/2009/09/dl/s0930-9d.pdf
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Health, Labour and Welfare (2012) Infection Control Guideline for Nursery, 2012.
http://www.mhlw.go.jp/bunya/kodomo/pdf/hoiku02.pdf
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Health, Labour and Welfare (2015) Patient Survey, 2014.
http://www.e-stat.go.jp/SG1/estat/NewList.do?tid=000001031167
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Health, Labour and Welfare (2016a) Vital Statistics, 2015.
http://www.e-stat.go.jp/SG1/estat/NewList.do?tid=000001028897
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Health, Labour and Welfare (2016b) Report on Social Welfare Administration and Services, 2015.
https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&tstat=000001034573&cycle=8&tclass1=000001091575&tclass2=000001091616&second2=1
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Health, Labour and Welfare (2018) Infection Control Guideline for Nursery, 2018.
http://www.mhlw.go.jp/file/06-Seisakujouhou-11900000-Koyoukintoujidoukateikyoku/0000201596.pdf
[*Accessed*: June 10, 2018] (in Japanese).
Ministry of Land, Infrastructure, Transport and Tourism (2011) Road Traffic Census, 2010.
http://www.mlit.go.jp/road/census/h22-1/
[*Accessed*: June 10, 2018] (in Japanese).
Peetoom, K.K.B., Crutzen, R., Bohnen, J.M.H.A., Verhoeven, R., Nelissen-Vrancken, H.J.M.G., Winkens, B., Dinant, G.J. & Cals, J.W.L. (2018) Optimising decision making on illness absenteeism due to fever and common infections within child-care centres: development of a multicomponent intervention and study protocol of a cluster randomised controlled trial. *BMC Public Health*, **18**, 61.
Statistics Bureau, Ministry of Internal Affairs and Communications of Japan (2016a) 2015 Yearly Average Results of Labour Force Survey.
http://www.stat.go.jp/english/data/roudou/results/annual/ft/index.html
[*Accessed*: June 10, 2018].
Statistics Bureau, Ministry of Internal Affairs and Communications of Japan (2016b) Japan Statistical Yearbook 2017, Ministry of Internal Affairs and Communications of Japan, Tokyo.
http://www.stat.go.jp/data/nenkan/66nenkan/index.html
[*Accessed*: June 10, 2018] (in Japanese).
Statistics Bureau, Ministry of Internal Affairs and Communications of Japan (2017) 2015 Population Census.
https://www.e-stat.go.jp/stat-search/database?page=1&layout=normal&toukei=00200521&tstat=000001080615&survey=%E5%9B%BD%E5%8B%A2%E8%AA%BF%E6%9F%BB&result_page=1&second=1
[*Accessed*: June 10, 2018] (in Japanese).
Todhunter, I. (2013) *Spherical Trigonometry, For the Use of Colleges and Schools, With Numerous Examples*, 3rd ed., Kindle version, Research Press, Champaign, IL.
Yamazaki, S., Kaneko, T., Mizuno, M. & Nakayama, H. (2017) An examination of the relationships between the method of going to a childcare facility and children awareness in that setting. *Bulletin of Tokyo University and Graduate School of Social Welfare*, **8**, 43-54 (in Japanese).