

HOKKAIDO UNIVERSITY

Title	Relationship between out of facility deliveries and distance and travel time to delivery facilities in Hokkaido, Japan : An ecological study
Author(s)	Saito, Yoshihiro; Asakura, Toshiaki; Kimura, Takashi; Umazume, Takeshi; Watari, Hidemichi; Tamakoshi, Akiko
Citation	Journal of Obstetrics and Gynaecology Research, 49(3), 930-937 https://doi.org/10.1111/jog.15543
Issue Date	2023-03
Doc URL	http://hdl.handle.net/2115/91335
Rights	This is the peer reviewed version of the following article: Saito, Y, Asakura, T, Takashi, K, Umazume, T, Watari, H, Tamakoshi, A. Relationship between out-of-facility deliveries and distance and travel time to delivery facilities in Hokkaido, Japan: An ecological study. J Obstet Gynaecol Res. 2023; 49(3): 930– 937. which has been published in final form at [Link to final article using the DOI]. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions. This article may not be enhanced, enriched or otherwise transformed into a derivative work, without express permission from Wiley or by statutory rights under applicable legislation. Copyright notices must not be removed, obscured or modified. The article must be linked to Wiley 's version of record on Wiley Online Library and any embedding, framing or otherwise making available the article or pages thereof by third parties from platforms, services and websites other than Wiley Online Library must be prohibited.
Туре	article (author version)
File Information	JOGR 49(3) 930-937.pdf



1 Original article

2	Relationship be	etween out-of-facility	deliveries and	distance and t	ravel time to	delivery fac	ilities
---	------------------------	------------------------	----------------	----------------	---------------	--------------	---------

- 3 in Hokkaido, Japan: an ecological study
- 4

5 Author

- 6 Yoshihiro Saito^a, Toshiaki Asakura^b, Takashi Kimura^b, Takeshi Umazume^a, Hidemichi Watari^a, Akiko
- 7 Tamakoshi^b
- 8

9 Author's affiliations

10 ^aDepartment of Obstetrics and Gynecology, Hokkaido University Graduate School of Medicine,

11 Sapporo, Japan

- 12 ^bDepartment of Public Health, Hokkaido University Faculty of Medicine, Sapporo, Japan
- 13

14 Corresponding author

- 15 Akiko Tamakoshi, M.D.,
- 16 Department of Public Health, Hokkaido University Faculty of Medicine, Sapporo, Japan,
- 17 N15W7, Kita-ku, Sapporo 060-8638, Japan
- 18 Email Address: tamaa@med.hokudai.ac.jp

19	Telephone No.: +81-11-706-5068
20	Fax No: +81-11-706-7805
21	
22	Running title: Out-of-facility delivery
23	
24	Word count: manuscript 3,922 words, abstract 248 words
25	

26 Abstract

27 Aim: This study aimed to investigate the relationship between the distance and travel time from each 28 municipality to the nearest delivery facilities in the other municipalities and the frequency of out-of-29 facility deliveries in Hokkaido. 30 Methods: Vital Statistics from 2016 to 2020 were used. For municipalities without delivery facilities, 31 the distance and travel time from the town office of each municipality to the nearest delivery facility 32 was measured using Google maps. Negative binomial regression with an offset term was used to 33 calculate the relative risks (RRs) and 95% confidence intervals (CIs) of out-of-facility delivery for 34 distance (<30, 30–59, \geq 60 km), and travel time by car (<30, 30–59, and \geq 60 min) from the town 35 office to the nearest delivery facility compared with the presence of delivery facilities. 36 **Results:** The overall rate of out-of-facility deliveries in Hokkaido was 2.1‰; in municipalities with 37 delivery facilities, 1.8‰, and in municipalities without delivery facilities, 3.1‰. The adjusted RRs 38 (95% CIs) for out-of-facility deliveries were significantly higher in municipalities with less than 30 39 km and travel time of less than 30 min to delivery facilities, 2.63 (1.34-5.17) and 2.76 (1.36-5.58), 40 respectively, compared to municipalities with delivery facilities. However, the adjusted RR of out-of-41 facility delivery for municipalities \geq 30 km was higher, although the difference was not significant. 42 Conclusions: Even in municipalities with a distance to delivery facilities of less than 30 km or travel

43 time of less than 30 min, we should keep in mind the occurrence of out-of-facility deliveries.

- 44 Keywords: Hokkaido, out-of-facility delivery, out-of-hospital delivery, unplanned home birth, Vital
- 45 Statistics in Japan

47 Introduction

48 An out-of-facility delivery is a delivery that occurs outside of a hospital or midwifery center, which 49 should be avoided because it can cause hypothermia of the newborn in those born at low environmental 50 temperatures and hyperbilirubinemia due to delayed umbilical cord ligation.^{1,2} In Japan, Miyazono et 51 al.³ reported a mortality rate of 4.7% in 2015 for prehospital births, which is a risk that is more than 52 ten times higher than the 3.7‰ perinatal mortality rate in Japan in the same year. 53 The incidence of out-of-facility deliveries has been reported in different countries, with 54 Australia reporting 4.6⁴, France 3.0⁵, and Israel 15⁶. In recent years, most Japanese have given 55 birth in hospitals or midwifery centers, and those who deliver at home or in other facilities are rare. In 56 a Japanese report, Yoshii et al.¹ in Osaka and Hanaki et al.⁷ in Tsukuba reported that the percentages 57 of out-of-facility deliveries in their limited areas were 5.9‰ and 5.5‰, respectively. However, there 58 is currently no report on the number of out-of-facility deliveries in Hokkaido, which is the largest 59 prefecture in Japan with relatively low population density, and where the long distances to delivery 60 facilities are problematic for pregnant women. 61 In Japan, the number of delivery facilities has been slowly decreasing along with the number 62 of births. In 2021, the number of facilities for delivery was 985, a decrease of 23.1% from 14 years 63 earlier.⁸ It is clear that the decrease in the number of delivery facilities increased the distance and travel 64 time to hospitals for pregnant women, especially when the only delivery facility in a municipality had

65	closed. Similar change have also occurred in Hokkaido; thus, it is significant to investigate the
66	relationship between out-of-facility delivery and distance or travel time from municipalities to delivery
67	facilities in Hokkaido, which has many rural areas. This study aimed to determine the number of out-
68	of-facility deliveries in Hokkaido using Vital Statistics in Japan ⁹ and to investigate the relationship
69	between the distance and travel time from each municipality without a delivery facility to the nearest
70	delivery facilities in the other municipalities and the proportion of out-of-facility deliveries.
71	
72	Materials and methods
73	Data collection
74	We used Vital Statistics in Japan ⁹ from 2016–2020. Japanese Vital Statistics are publicly available on
75	the Internet and can be used free of charge by anyone. Vital Statistics on births are published annually
76	and created by collecting and reorganizing birth certificates, which must be submitted within two
77	weeks of the births in question. These statistics do not offer individual-level data but are published as
78	data grouped at the municipality level. There is also a stratified version of birthplace at the municipality
79	level, and the categories of birthplace are hospitals, clinics, midwifery centers, homes, and others. In
80	this paper, out-of-facility deliveries were defined as births that occurred at home and at other places
81	(excluding hospitals and midwifery centers) in each municipality and were picked from Vital Statics.
82	It should be notified that the number of out-of-facility deliveries might include a small number of

83	planned home deliveries with midwives and the number of hospital deliveries might include a non-
84	negligible number of planned hospital deliveries due to non-medical indications such as the distance
85	between home and the delivery facility in Hokkaido.
86	In Hokkaido, pregnant women who live far from delivery facilities are sometimes either
87	instructed to stay at hotels near delivery facilities after 36 weeks of gestation or induced to deliver. ¹⁰
88	The number of births in each municipality is determined based on the place of residence; so, even if a
89	person who lived in a municipality without delivery facilities delivers in another municipality, it will
90	be counted as a birth that occurred in the municipality of her own residence.
91	The total number of records from 179 municipalities was 162,372 births from 2016 to 2020.
92	Four remote island municipalities, in which pregnant women cannot be transported by car to delivery
93	facilities, were excluded from the analysis. A total of 162,114 births were included in this analysis
94	after excluding 258 births that occurred in the four remote island municipalities (Figure 1).
95	
96	Definition of the distance and travel time from municipalities to delivery facilities
97	Although we did not have individual-level of birthplace data and residence data, we tried to assess the
98	impacts of distance or travel time to delivery facilities on out-of-facility deliveries. We defined them
99	by municipality as follows. We divided the municipalities into those with or without delivery facilities
100	inside their areas (Figure 2). As for municipalities without delivery facilities inside their areas, the

101	distance from delivery facilities was defined as the distance from the town offices of each municipality
102	to the nearest delivery facility, and this distance was measured using Google maps. Similarly, the travel
103	time by car was defined and calculated using Google maps. For municipalities with their own delivery
104	facilities, the distance and travel time were not defined. The date and time using Google maps and
105	calculated necessary values were March 10, 2022, between 16:00 and 18:00. If there were multiple
106	delivery facilities in the most neighboring municipality, the delivery facility providing the highest level
107	of perinatal care was selected as the nearest delivery facility.
108	
109	Confounding variables

We obtained our data from the 2020 population census data¹¹ and 2020 specific health examination 110 111 data¹². Since nuclear family households have limited help in transporting pregnant women to delivery 112 facilities, the percentage of nuclear families was obtained by dividing the number of nuclear families¹¹ by the number of private households¹¹ for each municipality. To evaluate whether municipalities are 113 114 urban or rural, the population density and the rate of population change from 2015 to 2020 were used as they are expressed in the data¹¹. As an economic indicator for each municipality, we also calculated 115 116 the unemployment rate with the workforce population¹¹ and the employment population¹¹ of those aged at least 15 years. From the 2020 specific health examination data¹², the receiving rate of specific 117 118 health examinations covered by national health insurance exists for the municipality level, and we

119 used this rate as a substitute for the degree of activities of public health nurses.

120

121 Statistical analysis

122 First, we summarized the basic descriptive information on births, out-of-facility deliveries, and other 123 confounding variables by municipalities. Second, we performed univariate analyses with negative 124 binomial regression with an offset term¹³. Counts of out-of-facility deliveries were used for the 125 outcome, and the number of total births was used for the offset term to account for the variability 126 between municipalities. We calculated relative risks (RRs) and 95% confidence intervals (95% CIs) 127 of out-of-facility deliveries for delivery facility existence and the distance or travel time by car from 128 the town office to the nearest delivery facility. We divided the distance into three categories; <30, 30-129 59, and ≥ 60 km. The threshold of 30 km was determined with reference to previous studies¹⁴ that the 130 rate of unplanned out-of-facility deliveries increases when the distance from the delivery facility is more than 30 km. In Hokkaido, the Hokkaido Medical Plan¹⁵ states that the distance from all 131 132 residences to delivery facilities should be within 100 km, and the allocation of delivery facilities was designed in such a policy. The setting of 60 km was arbitrarily determined between 30 km and 100 133 134 km. We also used a travel time index to help readers visualize the travel time for distances in Hokkaido, 135 as different regions have different travel times by car for the same distance. Since the second stage of delivery takes approximately 60 min for primiparous women¹⁶ and less than 30 min for parous 136

women¹⁶, the categories of travel time were <30, 30-59, and ≥ 60 min. To clarify the degree of effects of distance, the predicted number of out-of-facility deliveries against total births was visualized with the univariate model.

- 140 Third, a multivariate analysis was performed to assess the relationship between the distance or 141 travel time to delivery facilities and out-of-facility delivery, adjusting for confounding variables. The 142 population density was transformed by the logarithm of 10 to ensure normality. There were no missing 143 values for outcomes and explanatory variables. To validate categorical results, the restricted cubic 144 spline was performed for the distance with the multivariate model. For knot positions, we used one or 145 two knots and all patterns of knots from 5 km to 95 km. Those with 5 km bins were tested, and the 146 best model, based on the Akaike Information Criteria value, was selected for the main result. The 95% 147 CI of the cubic spline curve was obtained using the basic percentile bootstrap method¹⁷. We estimated 148 the valid patterns of sampling 2000 times for the bootstrap method. All analyses were performed using 149 Python 3.9, and Statsmodels v0.13.2 was used for regression analyses.
- 150
- 151 *Ethical approval*
- 152 Ethical approval was waived by the local ethics committee member.

154 **Results**

155 Table 1 shows the characteristics of the municipalities that were surveyed. Among the 175 156 municipalities surveyed in Hokkaido, 28 (16.0%) had their own delivery facilities while 62 (35.4%) 157 municipalities without such facilities of their own had the nearest delivery facilities less than 30 km 158 away from their town offices; 67 (38.3%) of them had ones between 30 and 59 km away, and 18 159 (10.3%) had ones at a distance of 60 km or more. The total number of births in Hokkaido, Japan, from 160 2016 to 2020, was 162,114, and the number of out-of-facility deliveries was 339 (2.1‰). In 161 municipalities with delivery facilities, the total number of deliveries during the five-year period was 162 129,932, of which 240 (1.8‰) were out-of-facility deliveries. However, in municipalities without 163 delivery facilities, the total number of deliveries was 32,182, of which 99 (3.1‰) were out-of-facility 164 deliveries, a higher proportion than that in municipalities with delivery facilities. 165 Compared to municipalities with delivery facilities, the highest percentage of out-of-facility 166 deliveries was found in municipalities that were ≤ 30 km away from delivery facilities (3.4‰, 167 66/19,542), and the percentage of out-of-facility deliveries was slightly higher in municipalities that 168 were 30–59 km away (2.6‰, 27/10,449), and \geq 60 km away (2.7‰, 6/2,191) (Table 1). Figure 3 is a 169 plot of the total number of deliveries against the number of out-of-facility deliveries for each 170 municipality. Each dashed line represents the predicted number of out-of-facility deliveries against the 171 total number of births, obtained from the results of the univariate analysis, for the categories of distance

172	from town offices of each municipality to the delivery facilities, within 30 km, between 30 km and 59
173	km, and more than 60 km. The relationship between the total number of deliveries and the proportion
174	of out-of-facility deliveries and the distance to delivery facilities is presented in Supplementary Figure
175	1. Compared to municipalities with delivery facilities, a higher percentage of out-of-facility deliveries
176	occurred in municipalities without delivery facilities; however, the category of municipalities with the
177	highest percentage of out-of-facility deliveries was municipalities in which the delivery facilities were
178	<30 km away. However, the further away the delivery facilities were, the lower the total numbers of
179	deliveries and of out-of-facility deliveries tended to be. The distance from each municipality to its
180	nearest delivery facility was approximately proportional to the travel time by car and the Pearson's
181	correlation coefficient between the distance and time was 0.96.
182	Table 2 shows the DDs (050/ CIs) of out of facility delivery with reference to the
	Table 2 shows the KRS (95% CIS) of out-of-facility derivery with reference to the
183	municipalities with delivery facilities stratified by distance and travel time categories. Univariate
183 184	municipalities with delivery facilities stratified by distance and travel time categories. Univariate analyses revealed that the risk of out-of-facility delivery was significantly higher for municipalities
183 184 185	municipalities with delivery facilities stratified by distance and travel time categories. Univariate analyses revealed that the risk of out-of-facility delivery was significantly higher for municipalities that did not have their own delivery facilities than for ones that had their own delivery facilities. Also,
183 184 185 186	municipalities with delivery facilities stratified by distance and travel time categories. Univariate analyses revealed that the risk of out-of-facility delivery was significantly higher for municipalities that did not have their own delivery facilities than for ones that had their own delivery facilities. Also, after the categorization of distance or travel time, the tendency of higher risk of out-of-facility delivery
183 184 185 186 187	municipalities with delivery facilities stratified by distance and travel time categories. Univariate analyses revealed that the risk of out-of-facility delivery was significantly higher for municipalities that did not have their own delivery facilities than for ones that had their own delivery facilities. Also, after the categorization of distance or travel time, the tendency of higher risk of out-of-facility delivery was maintained for the point estimates although the 95% CIs were wide. The adjusted RR (95% CI)
183 184 185 186 187 188	nunicipalities with delivery facilities stratified by distance and travel time categories. Univariate analyses revealed that the risk of out-of-facility delivery was significantly higher for municipalities that did not have their own delivery facilities than for ones that had their own delivery facilities. Also, after the categorization of distance or travel time, the tendency of higher risk of out-of-facility delivery was maintained for the point estimates although the 95% CIs were wide. The adjusted RR (95% CI) for out-of-facility delivery was higher, 2.28 (1.15–4.52), in municipalities where there were no

190	municipality office to the delivery facility was divided into categories, municipalities whose delivery
191	facilities were less than 30 km away had significantly higher RR [2.63 (1.34–5.17)]. Conversely, even
192	municipalities whose delivery facilities were 30-59 km or >60 km away did not show an increase in
193	the adjusted RRs [1.31 (0.57-2.99), 1.44 (0.43-4.83)] for out-of-facility delivery. Relationship
194	between the distance and travel time to delivery facilities were strongly correlated. Therefore, the RRs
195	for out-of-facility delivery were higher in municipalities with a shorter travel time to delivery facilities
196	than in those with a longer travel time.
197	The best model per the restricted cubic spline was the model with one knot at 75 km (Figure
198	4). The adjusted RR had a bi-modal shape where peaks were at approximately 15 km and 80 km, and
199	the adjusted RR was below one from 40 km to 65 km. The 95% CI did not contain one for the left
200	peak; however, overall, the confidence interval was relatively wide. It is noted that only six out-of-
201	facility deliveries occurred in municipalities that were at least 60 km away from the nearest delivery
202	facility.

204 **Discussion**

205 Main findings

First, the rate of out-of-facility deliveries in Hokkaido was 2.1‰. When municipalities with no

- 207 delivery facilities were categorized by distance, the adjusted RR (95% CI) for out-of-facility delivery
- 208 was significantly high, at 2.63 (1.34–5.17) in municipalities where the town office was less than 30
- 209 km away from the nearest delivery facility compared to municipalities with nearby delivery facilities.
- 210 On the other hand, the adjusted RR for out-of-facility delivery in municipalities where the town office
- was ≥30 km away from the nearest delivery facility was higher, although the difference was not
 statistically significant.
- 213

214 Frequency of out-of-facility deliveries

This is the first study in Japan to use Vital Statistics⁹ to deduce the relationship between the number of out-of-facility deliveries and the distance and travel time to delivery facilities. This study examined the relationship between the distance from delivery facilities and out-of-facility delivery; however, it did not distinguish between planned and unplanned out-of-facility deliveries. A key piece of information, the number of unplanned out-of-facility deliveries, is required to more accurately evaluate the relationship between the distance from delivery facilities and high-risk out-of-facility deliveries. In Japan, the number of planned home births attended by midwives, which are reported to be safe¹⁸⁻²¹

222	and unsafe ^{6,22} , is not known. According to the Vital Statistics ⁹ , midwifery center deliveries in 2016-
223	2020 accounted for 2.1‰ of all deliveries in Hokkaido, of which it is estimated that only about 10%
224	were planned home births attended by a midwife. ²³ Therefore, the proportion of planned home births
225	attended by midwives in Hokkaido over the 5-year period of this study was expected to be roughly
226	0.2‰, and the proportion of unplanned out-of-facility deliveries was expected to be 1.9‰, which did
227	not differ significantly from the present results.
228	In previous Japanese studies conducted in Osaka ¹ and Tsukuba ⁷ , the rate of out-of-facility
229	deliveries was 5.5–5.9‰, estimated from the number of out-of-facility deliveries subsequently brought
230	to hospitals and the total number of deliveries in the region, and the present results were lower at 2.1‰.
231	However, the rate of out-of-facility deliveries in Japan, estimated using similar methods to those used
232	in this study, was 1.5‰, indicating that Hokkaido is a region with a relatively high percentage of out-
233	of-facility deliveries. The rates of out-of-facility deliveries in Osaka prefecture and Ibaraki prefecture,
234	where Tsukuba City is located, were 1.0‰ and 1.8‰, respectively, using the same method as was
235	employed in the present study; therefore, it is necessary to interpret the proportion of out-of-facility
236	delivery while paying attention to the study design, data collection method, and period covered.
237	Several national population-based studies similar to this one have been conducted abroad.
238	It was similar to the unplanned out-of-facility delivery rate of 1.4‰ for Finland with 1,052,559
239	deliveries ²³ and 3.0‰ for France with 1,999,453 deliveries ⁵ . Delivery facilities are becoming

240	centralized in Finland and France, with 9.9% and 25.3% ^{5,24} , respectively, living in locations more than
241	30 km and 35 km away from the delivery facility. In the present study, 7.8% of the deliveries in
242	Hokkaido were performed at a minimum distance of approximately 30 km away from delivery
243	facilities, which might be a shorter travel distance than that in France and Finland. In Finland, the
244	government is involved in discussions about the centralization of the delivery facilities and uses an
245	accessibility survey ²⁵ to ensure the safety of centralizing delivery facilities. A study ²⁶ noted the
246	importance of education and protocol development for emergency medical services (EMS), which
247	contributes to decreasing the hospitalization rate at birth for out-of-facility delivery facilities. ²⁷ A
248	survey of Japanese EMS in 2017 described a prehospital perinatal emergency as one existing in the
249	border region between the perinatal and general emergency systems, which highlights the need to
250	improve the prehospital perinatal system of medical care and education. ³ In Japan, research on
251	centralization and out-of-facility delivery facilities should be conducted, and when centralization is
252	carried out, the education of EMS and the establishment of a prehospital perinatal care system should
253	be offered in collaboration with the government at the same time. In Hokkaido, we are now working
254	with local governments to focus on perinatal education for EMS.
255	

facility deliveries

Relationship between the distance from the nearest delivery facility and the proportion of out-of-

258	It is fascinating to note that the rate of out-of-facility delivery was significantly higher in municipalities
259	that were less than 30 km and 30 min away from delivery facilities than in municipalities with delivery
260	facilities. There are three possible reasons for this observation. First, both pregnant women living near
261	(less than 30 km) delivery facilities and perinatal staff may not have paid as much attention to
262	unplanned out-of-facility delivery, which is not safe, as pregnant women living farther away did.
263	Second, it is possible that there were more planned home births, which may be safe, were attended by
264	midwives in municipalities relatively close to delivery facilities than in other areas. Finally, it is
265	possible that planned home deliveries without the presence of medical providers, which is not safe,
266	were clustered in municipalities around large cities where delivery facilities were located.
267	There are no reports in Japan that clarify the relationship between distance or travel time to
268	delivery facilities and the proportion of out-of-facility deliveries; however, there are several reports
269	from other countries. In a study of 1,517,599 births using French Vital Statistics, ¹⁴ the odds of out-of-
270	hospital delivery were doubled for pregnant women who lived more than 30 km away from delivery
271	facilities than for those who lived less than 5 km away from them. The same French nationwide
272	population-based-study reported that the RR (95% CI) was 1.5 (1.4-1.5) for 16-30 km, 2.6 (2.4-2.9)
273	for 31–45 km, and 3.9 (3.2–4.8) for 46–90 km with a reference of 0–15 km distance from the closest
274	maternity unit. ⁵ However, contrary to those reports, the present results revealed that there was no
275	significant increase in the rate of out-of-facility delivery in municipalities that were more than 30 km

away from delivery facilities. In our study, the total number of deliveries was lower in municipalities
that were farther away from delivery facilities, which may have made it difficult to find statistically
significant differences.

279 However, an urban-only report in Finland indicated that the increase in the rate of unplanned out-of-hospital delivery could not be explained by long-distance travel.²⁸ Similarly, a report of 324 280 prehospital births in Victoria, Australia²⁹, found little evidence that prehospital births were more 281 282 common in rural areas, suggesting that there may be differences depending on medical delivery 283 systems. Our study covered a five-year period during which there was almost no centralization of 284 delivery facilities; so, it is possible that the empirical systems of delivery for pregnant women living 285 far away from their homes were sufficiently prepared. Namely, the risk of out-of-facility delivery 286 increases as the distance from the delivery facility increases; however, the system might be able to 287 prevent it. In this study, the number of out-of-facility deliveries did not increase in Hokkaido when the 288 distance from the delivery facility ranged from more than 30 km to within approximately 100 km and 289 the time required to travel to the delivery facility was more than 30 min to within 2 hours; however, 290 we should keep in mind that this is the result of various efforts made by medical institutions, pregnant 291 women, and local governments to prevent out-of-facility deliveries. 292

293

294 Strengths and limitations of this study

295 This study has two main strengths. Firstly, it used Japanese Vital Statistics,⁹ which has extensive data 296 on the total number of deliveries (162,372) from 2016 to 2020 in Hokkaido. During this period, there 297 was little centralization of delivery facilities in Hokkaido. Secondly, the study used data available on 298 the Internet, making it possible to reproduce the study in other regions of Japan. However, this study 299 had several limitations. Firstly, the accuracy of the demographic statistics used in this study should be 300 carefully interpreted. For example, in the case of unplanned out-of-facility deliveries, both mother and 301 infant are often transported to the hospital for emergency care. In such cases, birth certificates are often 302 recorded in hospitals, there is a small possibility that the number of out-of-facility deliveries may be 303 underestimated due to the incorrect recording of the place of birth as a hospital. In the same way, there 304 are variations in rules among municipalities and hospitals in the way the person attending the delivery 305 is written, and accuracy is problematic; thus, this item was not used in this study. Secondly, however, 306 treating live births and stillbirths combined after 22 weeks of gestation is inherently appropriate when 307 treating the number of deliveries as an outcome, this study did not include stillbirths that occurred 308 outside the delivery facilities after 22 weeks gestation as there was no such data available. For 309 reference, according to Japanese Vital Statistics, the only published data available is the number of 310 stillbirths after 12 weeks gestation, and there were 31 out-of-facilities stillbirths in Hokkaido in the 311 same period. Thirdly, although the purpose of this study was to investigate the relationship between

312	distance and time to delivery facilities and the number of out-of-facility deliveries, what is truly
313	essential is the impact of distance and time to delivery facilities on maternal and infant outcomes.
314	Since only 4 maternal deaths occurred in Hokkaido during this period, and the number of infant deaths
315	(perinatal mortality: stillbirths after 22 weeks gestation and neonatal deaths within 7 days of birth) was
316	not available at the municipalities level, neither could be examined. Further research is needed to
317	clarify the relationship between the distance and time to delivery facilities and perinatal mortality.
318	Fourthly, the findings of this study can hardly be generalized to regions outside of Hokkaido in Japan.
319	A wide variety of factors influence out-of-facility delivery, including the local perinatal care system,
320	national healthcare resources, distance and travel time to delivery facilities, the background of the
321	pregnant woman, and the centralization of delivery facilities. The findings of the present study may
322	be useful in areas similar to Hokkaido. Finally, this is an ecological study based on municipalities, and
323	the backgrounds of the individual patients who experienced out-of-facility delivery are not known.
324	Further research on risk factors for out-of-facility delivery targeting individual cases of out-of-facility
325	delivery is expected to be conducted in the future.
326	In conclusion, we found no evidence of a linear positive relationship between the distance to a
327	delivery facility and the rate of out-of-facility delivery, although the proportions of out-of-facility
328	deliveries are higher in municipalities without delivery facilities than in municipalities with delivery
329	facilities. Perinatal staff should beware of the occurrence of out-of-facility deliveries, even for

- 330 pregnant women who live in municipalities that are less than 30 km or 30 min away from delivery
- 331 facilities.

333	Acknowledgments
-----	-----------------

334	The authors thank the members of the Hokkaido Organization for the advancement of Pregnancy,
335	Perinatal, and Infant care and Emergency treatment (HOPPIE), who together founded HOPPIE and
336	are providing perinatal education.
337	
338	Author contributions
339	Yoshihiro Saito, Takeshi Umazume, and Hidemichi Watari substantially contributed to the study
340	conceptualization. Toshiaki Asakura, Takashi Kimura, and Akiko Tamakoshi significantly contributed
341	to the data analysis and interpretation. Yoshihiro Saito and Toshiaki Asakura substantially contributed
342	to the manuscript drafting. All authors critically reviewed and revised the manuscript draft and
343	approved the final version for submission.
344	
345	Data availability statement
346	All the original data used in this paper are publicly available. Data and code used in this paper can be
347	accessed via https://doi.org/10.5281/zenodo.7068218.
348	
349	Disclosure
350	The authors declare no conflict of interest.

- 351 Approval of the research protocol: N/A
- 352 Informed consent: N/A
- 353 Registry and the registration no. of the study/trial: N/A
- 354 Animal studies: N/A
- 355

356 References

- 357 Yoshii M, Takegawa M, Sakamoto H et al. A study of infants with out-of-hospital delivery who 1. 358 were managed in our hospital. Journal of Japan Society for Premature and Newborn Medicine 359 2011;23(1):135-140 (Japanese) 360 2. Pasternak Y, Wintner EM, Shechter-Maor G, Pasternak Y, Miller N, Biron-Shental T. Perinatal 361 outcomes of unplanned out-of-hospital deliveries: a case-control study. Arch Gynecol Obstet 362 2018 Apr;297(4):871-875 363 Miyazono Y, Arai J, Murai F et al. A national survey on the actual situation and education of 3. 364 prehospital perinatal emergency in Japan. Foundation for ambulance Service Development. 2016. 365 Available from: https://fasd.jp/files/libs/701/201706090910578607.pdf. Accessed 4 Jan 2023 366 (Japanese) 367 4. Thornton CE, Dahlen HG. Born before arrival in NSW, Australia (2000-2011): a linked 368 population data study of incidence, location, associated factors and maternal and neonatal 369 outcomes. BMJ Open 2018;8(3):e019328 370 Combier E, Roussot A, Chabernaud JL, Cottenet J, Rozenberg P, Quantin C. Out-of-maternity 5. 371 deliveries in France: A nationwide population-based study. PLOS ONE 2020;15(2):e0228785
- 372 6. Gutvirtz G, Wainstock T, Landau D, Sheiner E. Unplanned out-of-hospital birth-short and long-
- term consequences for the offspring. J Clin Med 2020;9(2):339

374	7.	Hanaki M, Miyazono Y, Nagafuji M et al. Neonatal characteristics and outcomes of unplanned
375		out-of-hospital births over a period of 11 years at our hospital. Journal of Japan Society of
376		Perinatal and Neonatal Medicine 2021;57(1):43-48 (Japanese)
377	8.	Japan Association of Obstetricians and Gynecologists. Questionnaire survey report on improving
378		treatment of obstetricians and gynecologists and working environment of female doctors,
379		available at: https://www.jaog.or.jp/wp/wp-content/uploads/2022/02/20220112_1.pdf (accessed
380		13 Jun 2022). (Japanese)
381	9.	Vital statistics in Japan, available at: https://www.mhlw.go.jp/english/database/db-hw/vs01.html
382		(accessed 20 Jun 2022) (Japanese)
383	10.	Yonehara T. Current status of perinatal care in a large area. Japan Society of maternal Health
384		2011;52(1):28-30. (Japanese)
385	11.	Population census, statistics Breau of Japan, available at:
386		https://www.stat.go.jp/english/data/kokusei/index.html (accessed 20 Jul 2020) (Japanese)
387	12.	Specific health checkups and specific health guidance, available at:
388		https://www.mhlw.go.jp/english/wp/wp-hw3/dl/2-007.pdf (accessed 20 Jul 2020) (Japanese)
389	13.	Lindén A, Mäntyniemi S. Using the negative binomial distribution to model overdispersion in
390		ecological count data. Ecology 2011;92(7):1414-1421

- 391 14. Blondel B, Drewniak N, Pilkington H, Zeitlin J. Out-of-hospital births and the supply of maternity
- 392 units in France. Health Place, Elsevier 2011;17(5):1170-1173
- 393 15. The Hokkaido Government. Japan. Hokkaido health care plan, available at:
- 394 https://www.pref.hokkaido.lg.jp/hf/cis/iryokeikaku/aratanairyoukeikaku.html (accessed 6 Jul
- 395 2022). (Japanese)
- 396 16. Abalos E, Oladapo OT, Chamillard M et al. Duration of spontaneous labour in 'low-risk' women
- 397 with 'normal' perinatal outcomes: A systematic review. Eur J Obstet Gynecol Reprod Biol 2018
- 398 Apr;223:123-132
- 399 17. Wehrens R, Putter H, Buydens LMC. The bootstrap: a tutorial. Chemom Intell Lab Syst
 400 2000;54(1):35-52
- 401 18. Kataoka Y, Eto H, Iida M. Outcomes of independent midwifery attended births in birth centres
- 402 and home births: a retrospective cohort study in Japan. Midwifery 2013 Aug;29(8):965-972
- 403 19. Suzuki S. Recent clinical characteristics of labors using three Japanese systems of midwife-led
- 404 primary delivery care. Nurs Res Pract 2016;2016:9101479
- 405 20. Olsen O, Clausen JA. Planned hospital birth versus planned home birth. Cochrane Database Syst
- 406 Rev 2012 Sep 12;9(9):CD000352
- 407 21. de Jonge A, Geerts CC, van der Goes BY, Mol BW, Buitendijk SE, Nijhuis JG. Perinatal mortality
- 408 and morbidity up to 28 days after birth among 743070 low-risk planned home and hospital births:

a cohort study based on three merged national perinatal databases. BJOG 2015 Apr;122(5):720-

410 728

- 411 22. Snowden JM, Tilden EL, Snyder J, Quigley B, Caughey AB, Cheng YW. Planned out-of-hospital
- 412 birth and birth outcomes. N Engl J Med 2015 Dec 31;373(27):2642-2653
- 413 23. Adachi K. National midwifery delivery basic data collection system 2019 report of summary
- 414 results. Midwife 2021 75(2);75. (Japanese)
- 415 24. Ovaskainen K, Ojala R, Tihtonen K, Gissler M, Luukkaala T, Tammela O. Unplanned out-of-
- 416 hospital deliveries in Finland: A national register study on incidence, characteristics and maternal
- 417 and infant outcomes. Acta Obstet Gynecol Scand 2020;99(12):1691-1699
- 418 25. Huotari T, Rusanen J, Keistinen T, Lähderanta T, Ruha L, Sillanpää MJ, Antikainen H. Effect of
- 419 centralization on geographic accessibility of maternity hospitals in Finland. BMC Health Serv
- 420 Res. 2020 Apr 21;20(1):337.
- 421 26. McLelland GE, Morgans AE, McKenna LG. Involvement of emergency medical services at
- 422 unplanned births before arrival to hospital: a structured review. Emerg Med J. 2014
- 423 Apr;31(4):345-50.
- 424 27. Rodie VA, Thomson AJ, Norman JE. Accidental out-of-hospital deliveries: an obstetric and
- 425 neonatal case control study. Acta Obstet Gynecol Scand 2002;81(1):50-54

- 426 28. Pirneskoski J, Peräjoki K, Nuutila M, Kuisma M. Urgent EMS managed out-of-hospital delivery
- 427 dispatches in Helsinki. Scand J Trauma Resusc Emerg Med 2016 Jul 25;24:94
- 428 29. McLelland G, McKenna L, Morgans A, Smith K. Epidemiology of unplanned out-of-hospital
- 429 births attended by paramedics. BMC Preg Childbirth 2018 Jan 8;18(1):15

431 Figure legends

432 Figure 1. Flowchart of the participant selection process.

433

- 434 Figure 2. Map of municipalities with or without delivery facilities.
- 435 Green represents municipalities with one or more delivery facilities, light cyan for those without
- delivery facilities <30 km from delivery facilities, blue for 30-59 km, navy for ≥ 60 km, and gray for
- 437 remote island municipalities not included in the analysis.

438

439 Figure 3. Scatter plot and the predicted number of out-of-facility deliveries in 2016–2020 against total

440 deliveries.

- 441 Each point represents a municipality. Dashed straight lines show the predicted number of out-of-
- 442 facility deliveries against total births, which were obtained from univariate analysis results. Blue,
- 443 orange, green, and purple correspond to the existence of delivery facilities, distance from town offices
- to delivery facilities within 30 km, between 30 km and 59 km, and at least 60 km, respectively. Sapporo
- 445 City, in which the number of births was 66,090 and that of out-of-facility deliveries was 140, is not

shown here.

447

448 Figure 4. The adjusted relative risk of out-of-facility deliveries over distances.

449	References are municipalities with at least one delivery facility. A solid curved line represents adjusted
450	relative risk over distance, which is obtained by the restricted cubic spline. The shaded area shows the
451	95% confidence interval calculated via the bootstrap method. The green bar chart with 10-km bins
452	represents the number of municipalities without delivery facilities while the number of municipalities
453	with delivery facilities used for reference is not shown in the bar chart.
454	
455	Supplemental Figure 1. The relationship between the distance to delivery facilities and the total
456	number of births and the rate of out-of-facility deliveries in municipalities without delivery facilities.
457	The bars in the 10-km bins represent the total number of deliveries in municipalities without delivery
458	facilities, and the line represents the rate of out-of-facility deliveries per 1,000 births.

Table 1. Demographic survey of the municipalities[†]

		Total All	Delivery facility existence in municipalities				
		-	Exist	Non-Exist			
				Total Non-Exist	<30 km‡	30–59 km‡	≥60 km‡
Number of municipalities, n (%)		175	28 (16.0)	147 (84.0)	62 (35.4)	67 (38.3)	18 (10.3)
Birth/2016–2020, n (%)		162,114	129,932 (80.0)	32,182 (19.9)	19,542 (12.1)	10,449 (6.4)	2,191 (1.4)
Out-of-facility delivery/2016–2020, n (‰)		339 (2.1)	240 (1.8)	99 (3.1)	66 (3.4)	27 (2.6)	6 (2.7)
Distance (km), mean (SD) ‡		35.5 (20.7)	-	35.5 (20.7)	17.1 (6.0)	41.4 (7.9)	76.9 (10.2)
Travel time, n (%) ‡	Exist	28 (16.0)	-	-	-	-	-
	<30 min.§	75 (42.9)	-	46 (31.3)	45 (72.6)	1 (1.5)	-
	30–59 min. §	46 (26.3)	-	75 (51.0)	17 (27.4)	56 (83.6)	2 (11.1)
	≥60 min. §	26 (14.9)	-	26 (17.7)	-	10 (14.9)	16 (88.9)
Primiparous, n (%)		75,714 (46.7)	-	-	-	-	-
Percentage of nuclear families, 2020 (%), mean		53.8 (5.4)	53.6 (4.1)	53.8 (5.7)	56.2 (5.8)	52.2 (5.4)	51.7 (2.5)
Population density, 2020 (/km ²), mean (SD)		65.4 (174.9)	238.1 (376.3)	32.5 (58.9)	51.1 (62.0)	20.6 (59.1)	13.0 (15.5)
Rate of population change, 2020 (%), mean (SD)		-7.9 (4.4)	-5.1 (3.5)	-8.4 (4.4)	-7.9 (4.5)	-8.3 (4.6)	-10.5 (2.3)
Unemployment rate, 2020 (%), mean (SD)		3.0 (1.5)	3.8 (1.0)	2.9 (1.5)	3.3 (1.7)	2.6 (1.2)	2.6 (1.5)
Consultation rate, 2020 (%), mean (SD)		36.5 (12.8)	28.4 (9.2)	38.0 (12.9)	38.4 (11.9)	37.9 (13.9)	37.0 (12.9)

 \ddagger Data are presented as the mean \pm standard deviation (SD) or as frequencies and percentages (%)

3 ‡As for municipalities without delivery facilities, the distance to the delivery facility was defined as the distance from the town offices of each municipality

4 to the nearest delivery facility, and these distances were measured using Google Maps. Similarly, travel time by car was defined and calculated using Google

5 Maps. The date and time using Google Maps and calculated necessary values were March 10, 2022, between 16:00 and 18:00, respectively.

6 §min. represents minute(s).

		Total delivery, N	Out-of-facility Delivery, N	Crude RR (95% CI) †	Adjusted RR (95% CI) †‡
Delivery facility	Exist	129,932	240	Ref.	Ref.
	Non-Exist	32,182	99	2.36 (1.40–3.98)	2.28 (1.15-4.52)
Distance	Exist	129,932	240	Ref.	Ref.
	<30 km	19,542	66	3.16 (1.76–5.67)	2.63 (1.34–5.17)
	30–59 km	10,449	27	1.65 (0.86–3.16)	1.31 (0.57–2.99)
	≥60 km	2,191	6	1.72 (0.60-4.89)	1.44 (0.43–4.83)
Travel time	Exist	129,932	240	Ref.	Ref.
	<30 min.	16,894	57	3.31 (1.79–6.12)	2.76 (1.36–5.58)
	30–59 min.	12,537	36	1.96 (1.06–3.62)	1.63 (0.75–3.58)
	≥60 min.	2,751	6	1.29 (0.47–3.52)	1.11 (0.34–3.61)

7 **Table 2.** Crude and adjusted relative risks of out-of-facility deliveries for distance and time

8 † RR (95% CI) represents the relative risk (95% Confidence Interval).

9 ‡ The adjusted RR was adjusted by the percentage of nuclear families, population reduction rates from

10 2015 to 2020, unemployment rates, and special checkup consultant rate.

All live births in Hokkaido, Japan (2016-2020) N=162,372 (179 municipalities)









