Relationship between road traffic noise and adverse birth outcomes: Analysis of the birth cohort of the Hokkaido Study

Junta Tagusari[1*], Farah Elida Selamat[2], Ryosuke Sato[3], Toshihito Matsui[1], Naomi Tamura[4], Chihiro Miyashita[4], Reiko Kishi[4], Atsuko Araki[4,5]

[1] Faculty of Engineering, Hokkaido University, Hokkaido, Japan

[2] College of Engineering, Universiti Tenaga Nasional (The Energy University), Selangor, Malaysia

[3] School of Engineering, Hokkaido University, Hokkaido, Japan

[4] Center for Environmental and Health Sciences, Hokkaido University, Hokkaido, Japan

[5] Faculty of Health Sciences, Hokkaido University, Hokkaido, Japan

* Corresponding author's e-mail address: j.tagusari@eng.hokudai.ac.jp

ABSTRACT

Traffic noise may affect fetal growth and lead to adverse birth outcomes. However, the risks of noise exposure remain unclear. The objective of the present study is to investigate the exposure-response relationship between road traffic noise and adverse birth outcomes. We analysed the birth cohort of the Hokkaido Study of Environment and Children's Health, which is the first large-scale prospective birth cohort study in Japan. Low birth-weight, preterm birth, and small-for-gestational-age were employed as the outcomes. To examine the effect of road traffic noise, multivariate logistic regression analysis was applied and adjusted for physiological differences (e.g., sex, age, parity), lifestyles (e.g., smoking and drinking habits), and socioeconomic status (e.g., household income, educational level). The adjusted risks were not significantly increased by road traffic noise exposure indexed by equivalent sound level during nighttime (L_{night}). However, this is a preliminary result and other noise sources such as railway and potential confounding factors may affect the result. Moreover, appropriate noise indices are desired, as L_{night} does not sufficiently account for the effects of sound-level fluctuations.

INTRODUCTION

Traffic noise may cause a variety of health effects [1]. For pregnant women, exposure to traffic noise may affect fetal growth and lead to adverse birth outcomes such as low birth weight [2,3]. However, the risks are still unclear. In a recent meta-analysis, no significant relationship with noise exposure was identified [3]. Extensive research on the effects on birth is desirable.

In Japan, there have been no studies on the birth effects of road traffic noise, which is a major source of noise for many residents. For road traffic noise, we created the first significant-sized noise maps in Japan for Sapporo city [4], where a large-scale prospective birth cohort study, the Hokkaido Study of Environment and Children's Health, is being conducted [5]. Information has been obtained on factors associated with adverse birth effects [6].

The objective of the present study was to investigate the relationship between road traffic noise and adverse birth outcomes. To elucidate the risk of noise, we analysed the birth cohort of the Hokkaido Study. It should be noted that this was a preliminary study and that there may be potential unadjusted confounders.

METHOD

We analysed the Hokkaido birth cohort of the Hokkaido Study [5]. Thirty-seven hospitals in Hokkaido prefecture, Japan, cooperated in the study and approximately 20 thousand pregnant women were enrolled as participants between 2003 and 2012. Information on the physiological characteristics (e.g., sex, age, parity), lifestyles (e.g., smoking and drinking habits, occupation), and socioeconomic status (e.g., household income, educational level) of the parents and children were obtained through questionnaires, medical records, and the collection of blood and other samples. Follow-up studies have been conducted to investigate development disorders in children, details of which are described in the previous paper [5].

The present study used information obtained from questionnaires at enrolment (<13 weeks of gestational age), maternal plasma samples collected in the third trimester of pregnancy, and birth records. The study area was Sapporo city, which is located in the northern part of Japan and the capital of Hokkaido prefecture (see Figure 1), and for which noise maps were available [6]. We selected participants who were living in the city at the time they enrolled in the Hokkaido Study.

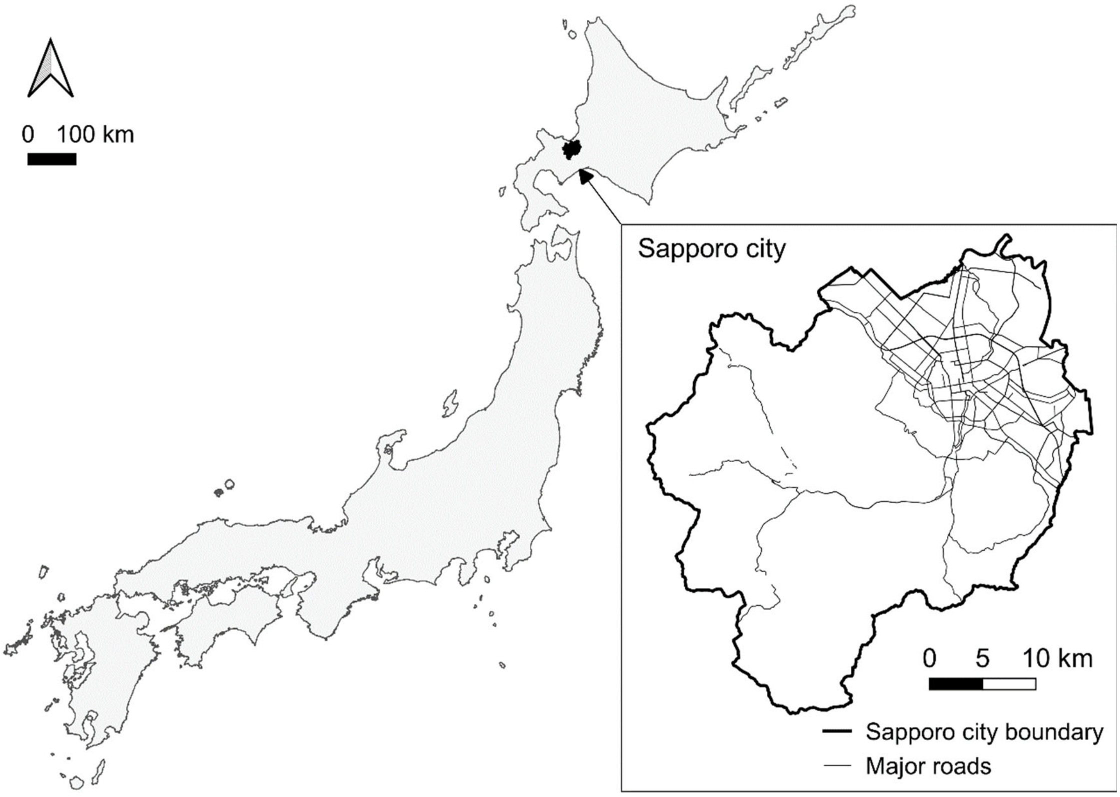

Figure 1: Study area of the present study: Sapporo city. The enlarged view of Sapporo city also illustrates major roads considered in the calculation of road traffic noise.

In the evaluation of road traffic noise, exposure from trunk roads was taken into account. Equivalent sound levels during daytime and nighttime at the façade of the buildings were calculated using the common noise assessment methods in Europe [7]. The place of residence was detected from the address of each participant and the sound level at most exposed façade was adopted as the exposure level of the participant. The details of the calculation are described in a previous study [6].

As the adverse birth outcomes, we selected low birth weight (birth weight < 2500 g), preterm birth (gestational age < 37 weeks), and small for gestational age (birth weight < 10th percentile of the normative reference birth weight shown for each gestational age, sex, and parity [8]).

We applied multivariate logistic regression analysis to examine the effects of road traffic noise. Equivalent sound level during nighttime (L_{night}) was used as a noise index because sleep disturbance due to night-time noise would be the main reason causing adverse birth outcomes. Physiological differences (e.g., infant sex, maternal age at birth, prepregnant body mass index (BMI)), lifestyles (e.g., drinking and smoking habits), and socioeconomic status (e.g., household income, educational level) were included in the statistical model.

The present study was approved by the ethics review board of the Hokkaido University Center for Environmental and Health Sciences.

RESULTS

Of the total samples of the Hokkaido cohort (sample size: 20 778), 5935 samples from Sapporo city were selected. We excluded samples that were lost to follow-up, that presented with multifetal pregnancy, stillbirth, miscarriage, pregnancy-induced hypertension, and/or gestational diabetes, and that showed missing values. Finally, a total of 4639 samples were obtained.

Table 1 exhibits the characteristics of the study population. The rates of adverse birth outcomes and noise exposure were also displayed. The risks of the outcomes were suggested to be associated with infant sex, maternal age, BMI, cotinine level, drinking habit, and the application of the artificial reproductive technique. Plasma cotinine levels were used to assess the effects of smoking, using the cut-off value shown in a previous study (>11.48 ng ml^{-1}) [9]. No strong associations were found between L_{night} and these variables.

Table 1: Characteristics of the population with adverse birth outcomes and noise exposure

		Low birth weight	Preterm birth	Small for gestational age	L_{night} > 40 dB	L_{night} > 50 dB
Variable / Category	N	Rate	Rate	Rate	Rate	Rate
Infant sex						
Male	2314	7.2%	5.1%	6.4%	46.4%	17.6%
Female	2325	10.5%	5.9%	7.0%	48.0%	18.1%
Maternal age (year)						
< 20	37	5.4%	2.7%	2.7%	62.2%	24.3%
20–24	451	7.5%	4.4%	6.9%	48.6%	17.1%
25–29	1301	7.3%	3.8%	6.2%	52.2%	21.2%
30–34	1735	9.1%	6.1%	6.7%	46.2%	18.3%
≥ 35	1115	11.0%	7.2%	7.3%	46.1%	16.5%

Parity						
Nulliparity	2266	9.0%	4.9%	6.9%	49.8%	19.8%
Primiparity, Multiparity	2373	8.8%	6.1%	6.7%	46.7%	17.5%
Pre-pregnant BMI ($Kg \cdot m^{-2}$)						
< 18.5	849	13.4%	7.5%	9.9%	46.3%	19.2%
18.5–19.9	1220	9.4%	5.7%	7.0%	49.2%	19.0%
20.0–24.9	2123	7.0%	4.1%	5.5%	48.5%	18.1%
25.0–29.9	340	6.2%	6.5%	4.4%	47.4%	19.4%
≥ 30.0	107	13.1%	12.1%	8.4%	48.6%	15.9%
Plasma cotinine level ($ng\ ml^{-1}$)						
Not detected (< 0.12)	1080	6.8%	4.4%	5.8%	46.1%	17.8%
< 1.00	1792	6.4%	3.5%	6.8%	49.7%	18.6%
1.00–11.48	463	8.0%	3.5%	4.8%	48.3%	18.4%
> 11.48	539	10.2%	4.6%	9.6%	52.3%	21.5%
Missing	765	17.4%	13.9%	7.3%	44.8%	17.9%
Drinking at 1st trimester						
No	4018	8.5%	5.4%	6.5%	47.9%	18.8%
Yes	621	11.1%	6.1%	8.2%	50.2%	17.2%
Assisted reproductive technology						
No	4327	8.6%	5.3%	6.7%	48.3%	18.5%
Yes	312	12.8%	8.0%	6.7%	47.4%	19.9%
Maternal educational level (year)						
< 12	277	9.0%	5.4%	6.9%	52.7%	20.6%
12–13	1634	8.8%	5.5%	6.3%	47.2%	17.9%
14–15	2026	9.1%	5.5%	7.4%	49.4%	19.0%
≥ 16	702	8.4%	5.7%	5.6%	45.6%	18.7%
Household income (million yen)						
< 3.00	831	8.5%	4.9%	7.8%	46.8%	18.7%
3.00–4.99	1806	8.9%	5.7%	6.2%	49.0%	18.3%
5.00–7.99	1088	9.8%	5.7%	7.5%	46.4%	18.9%
≥ 8.00	321	10.9%	6.9%	5.6%	52.0%	16.5%
Missing	593	6.6%	4.7%	5.7%	49.0%	20.2%
L_{night} (dB)						
< 40.0	2385	8.6%	5.4%	6.5%	–	–
40.0–49.9	1379	9.4%	5.2%	6.7%	–	–
50.0–59.9	540	8.5%	5.9%	6.3%	–	–
≥ 60.0	335	9.9%	7.2%	7.8%	–	–

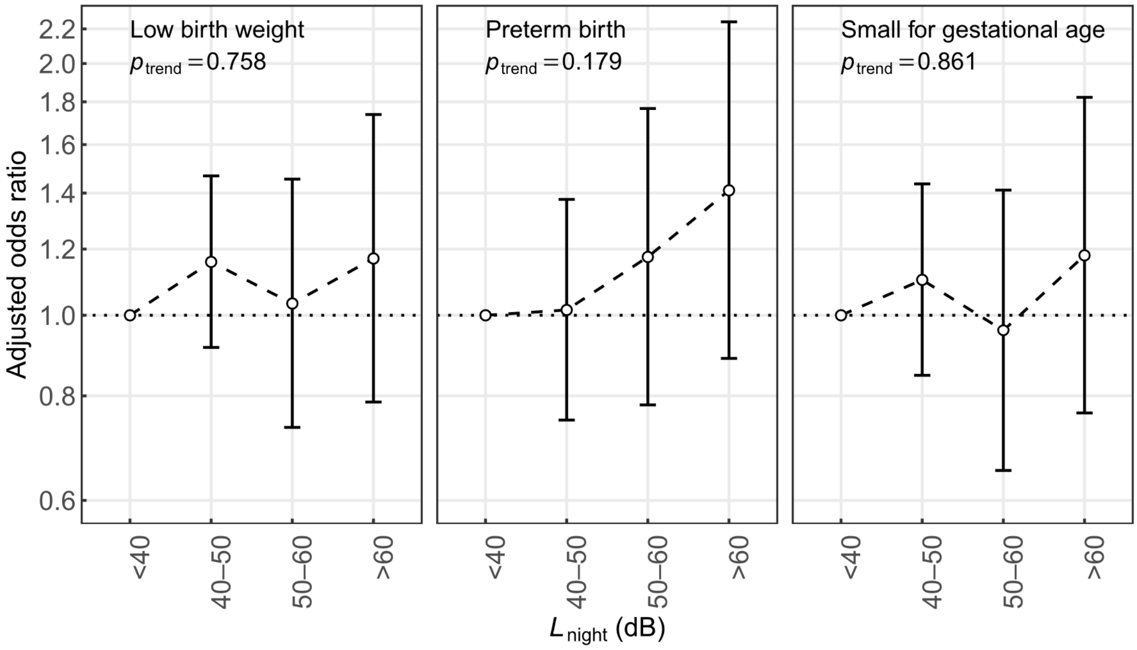

Figure 2: Adjusted odds of low birth-weight, preterm birth, and small-for-gestational-age associated with L_{night}. White circles and error bars indicate most likelihood estimates and 95% confidence intervals, respectively. *P* values of the trend test are also shown.

Figure 2 illustrates the results of the multivariate logistic regression analysis. The odds ratios were adjusted with all the variables displayed in Table 1. Although the risks tended to increase with noise exposure, they were not statistically significant.

DISCUSSION

In the present study, we investigated the effects of road traffic noise on birth by analysing the Hokkaido Study birth cohort. To the best of our knowledge, this is the first study investigating the effects of road traffic noise in Japan.

We did not identify a significant association between noise exposure and adverse birth effects; however, it should be noted that this was a preliminary study and had several limitations. First, it did not take into account other noise sources such as railways. The city's railways operate even at night to transport freight, and their noise may pose health risks. Second, confounding factors may not be adequately considered. Statistical adjustment of the risk by appropriate confounding factors is needed. Other risk factors caused by road traffic, such as air pollution, may also influence the results. Third, we did not take into account changes in noise exposure due to the movement of the participant's place of residence. We assumed that they resided in the same place during pregnancy. The effects of these constraints need to be considered in future investigations.

Furthermore, consideration of how to assess the effects of noise is desirable. Equivalent sound levels were adopted for practical reasons; however, they are insufficient to evaluate the intermittency of noise and may inaccurately assess the effects of noise. The evaluation of the sound levels using noise indices based on how intermittent night-time noise can cause sleep disturbance is necessary to elucidate the effects on birth.

In a previous study [10], we examined the neurophysiological mechanisms of the effects of noise and theoretically identified that the arithmetic mean of the sound level above 60 dB is applicable as an alternative noise index. This index can be applied to arbitrary noise exposure from arbitrary sources including short-term intermittent noise and long-term continuous noise. This index is not currently available on noise maps; however, it could provide an accurate assessment of the impact of noise in future analysis.

Acknowledgements

This study was funded by a Grant-in-Aid for Scientific Research from the Japanese Ministry of Health, Labor and Welfare (JPMH14427175), the Japan Agency for Medical Research and Development (AMED) (JPMH18950314), and the Ministry of Education, Culture, Sports, Science, and Technology; and the Japan Society for the Promotion of Science (JP19H01071).

REFERENCES

[1] World Health Organization Regional Office for Europe. (2018). Environmental Noise Guidelines for the European Region. Copenhagen: WHO Regional Office for Europe.

[2] Nieuwenhuijsen, M. J., Ristovska, G., & Dadvand, P. (2017). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Adverse Birth Outcomes. International journal of environmental research and public health, 14(10), 1252. https://doi.org/10.3390/ijerph14101252

[3] Dzhambov, A. M., & Lercher, P. (2019). Road Traffic Noise Exposure and Birth Outcomes: An Updated Systematic Review and Meta-Analysis. International journal of environmental research and public health, 16(14), 2522. https://doi.org/10.3390/ijerph16142522

[4] Selamat, F. E., Tagusari, J., & Matsui, T. (2021). Mapping of transportation noise-induced health risks as an alternative tool for risk communication with local residents. Applied Acoustics, 178, 107987. https://doi.org/10.1016/j.apacoust.2021.107987

[5] Kishi, R., Araki, A., Minatoya, M., Hanaoka, T., Miyashita, C., Itoh, S., Kobayashi, S., Ait Bamai, Y., Yamazaki, K., Miura, R., Tamura, N., Ito, K., Goudarzi, H., & members of The Hokkaido Study on Environment and Children's Health (2017). The Hokkaido Birth Cohort Study on Environment and Children's Health: cohort profile-updated 2017. Environmental health and preventive medicine, 22(1), 46. https://doi.org/10.1186/s12199-017-0654-3

[6] Tamura, N., Hanaoka, T., Ito, K., Araki, A., Miyashita, C., Ito, S., Minakami, H., Cho, K., Endo, T., Sengoku, K., Ogasawara, K., & Kishi, R. (2018). Different Risk Factors for Very Low Birth Weight, Term-Small-for-Gestational-Age, or Preterm Birth in Japan. International journal of environmental research and public health, 15(2), 369. https://doi.org/10.3390/ijerph15020369

[7] Kephalopoulos, S., Paviotti, M., & Anfosso-Lédée, F. (2012). Common noise assessment methods in Europe (CNOSSOS-EU) Report EUR 25379 EN. Luxembourg: Publications Office of the European Union.

[8] Itabashi, K., Miura, F., Uehara, R., & Nakamura, Y. (2014). New Japanese neonatal anthropometric charts for gestational age at birth. Pediatrics international: official journal of the Japan Pediatric Society, 56(5), 702–708. https://doi.org/10.1111/ped.12331

[9] Sasaki, S., Braimoh, T. S., Yila, T. A., Yoshioka, E., & Kishi, R. (2011). Self-reported tobacco smoke exposure and plasma cotinine levels during pregnancy--a validation study in Northern Japan. The Science of the total environment, 412-413, 114–118. https://doi.org/10.1016/j.scitotenv.2011.10.019

[10] Tagusari, J., Takakusaki, M., & Matsui, T. (2020). Development of a new night-time noise index: Integration of neurophysiological theory and epidemiological findings. Noise & health, 22(104), 1–9. https://doi.org/10.4103/nah.NAH_27_20