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Title	Health risks due to road traffic noise : Mapping health effects for risk communication and mitigation of the risks by shifting to electric vehicles [an abstract of dissertation and a summary of dissertation review]
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Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第14309号
Issue Date	2020-12-25
Doc URL	https://hdl.handle.net/2115/80252
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	doctoral thesis
File Information	Farah_Elida_Binti_Selamat_abstract.pdf, 論文内容の要旨

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学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　Farah Elida Binti Selamat

学　位　論　文　題　名

Health risks due to road traffic noise: Mapping health effects for risk communication and mitigation of the risks by shifting to electric vehicles

(道路交通騒音による健康リスク: リスクコミュニケーションのための健康リスクマップ作成および電気自動車への移行による健康リスクの低減)

Environmental noise is a threat to public health. It may cause a myriad of health effects, varying from sleep disturbance to severe outcomes, such as hypertension, ischaemic heart disease, stroke, and diabetes. A health impact estimation of 32 European countries showed that more than 12,000 premature deaths per year are caused by environmental noise exposure.

In an attempt to mitigate environmental noise, the European Union requires the member states to produce noise maps for estimating noise exposure and developing noise mitigation measures (Directive 2002/49/EC). Thus far, the noise maps, which are geospatial visualisations of sound levels, have been created in cities and around major noise sources in Europe.

Nevertheless, estimations of sound level are not useful in communicating risks with the public because a noise map shows acoustic intensity instead of health effects. Moreover, recent social changes in achieving a low carbon society would transform the acoustic environment, i.e. the transition to electric vehicles (EVs). However, the health risk reduction impact of the transition remains unclear.

Thereby, the objectives of the present study were (1) to develop health risk maps from a noise map as an alternative tool for public risk communication; and (2) to analyse the reduction of health risks in a future noise-exposure setting by the transition to EVs.

In both studies, I investigated the health risks due to road traffic noise, which is the major source of environmental noise. As health outcomes, high annoyance, high sleep disturbance, and ischaemic heart disease were selected because their exposure-response functions with the sound levels are shown in the Environmental Noise Guidelines for the European Region issued by the World Health Organization Regional Office for Europe.

In the first study, I created health risk maps as an alternative tool for enhancing risk communication. The health risk maps were derived from the sound levels and exposure-response relationships with health outcomes. To demonstrate it, I calculated the sound levels using geospatial data of Sapporo City and the standard framework for noise mapping in the European Union, i.e. CNOSSOS-EU. In addition, the number of population exposed to road traffic noise and health risks in Sapporo City was estimated by employing the exposure-response functions and the national health statistics and surveys.

The health risk maps visualise the distribution of health risks instead of acoustic intensity. For instance, a percentage of people highly sleep-disturbed of 6.0 % was estimated instead of 55 dB of night equivalent sound level. By using the health risk maps, the public will be able to realise the significance of the health impacts of noise exposure. The estimated number of people highly annoyed

and highly sleep-disturbed in Sapporo City was 100,773 and 44,674, respectively, in 1.91 million population. In respect to ischaemic heart disease, the estimated number of patients and yearly deaths were 257 and 49, respectively.

To summarise, in the first study, I demonstrated the feasibility of health risk mapping to identify health risks for effective public health risk communication. The methods are also applicable to other types of traffic noise and health risks; provided that the dose-response relationships are available. The health risk maps would contribute to the knowledge sharing and raising public awareness; thus, effective for public health risk communication.

In the second study, I investigated the health risk reduction by the transition to EVs from the internal combustion engine vehicles (ICEVs). Firstly, I examined the relationship between the reduction of the health effects and traffic conditions, i.e. the percentage of heavy vehicles and traffic speed, based on CNOSSOS-EU and the exposure-response functions. Given that EVs have no engine, the driveline noise was assumed as negligible. To validate the calculation results, I selected two urban areas in Sapporo City with different traffic conditions and estimate the reduction of health risks due to the transition to EVs. The methods used are identical to the methods in the first study. The total mitigation in Sapporo City was also carried out.

The calculation results showed that the higher the percentages of heavy vehicles, and the lower the traffic speeds, the more effective the health risks reduction would be. For example, the health risk reduction for highly annoyed at 70 dB of day-evening-night equivalent sound level is 55.0 % when traffic speed of 30 km/h and 30 % of heavy vehicles in the fleet were assumed; and 66.3 % when traffic speed of 20 km/h and 50 % of heavy vehicles were assumed.

The results in the two areas are consistent with the calculations, which show that health risks reduction has more impact with higher percentages of heavy vehicles and low traffic speeds. The area with higher percentages of heavy vehicles and lower traffic speeds contributed to higher risk reductions (30–40 %) compared to the area with the opposite traffic conditions (10–20 %). Meanwhile, the estimated health risk reduction in the total agglomeration of Sapporo City was approximately 20 %.

To conclude, in the second study, I analysed the reduction of health risks by the transition to EVs and reveal the effective traffic conditions. The results showed that health risk reduction largely depends on the proportion of heavy vehicles and traffic speeds. Higher percentages of heavy vehicles and lower traffic speeds would contribute to an effective health risk reduction.

This thesis presents approaches that would contribute to managing health risks due to road traffic noise. Health risk maps directly show the risks and are effective as an alternative tool for risk communication. Several ten percent of health risk reductions were estimated with the shift to EVs; thus, the wide spreading of EVs would be a transformative means in the health effects mitigation of road traffic noise. Hopefully, these contributions will serve a role in our eventual transition towards achieving zero noise pollution in the future. Further research is needed to assess the effectiveness of the health risk maps and to identify additional factors that could enhance the health risk reduction by the shift to EVs.