Int. J. Hum. Capital Urban Manage., 7(2): 283-296, Spring 2022

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

REVIEW PAPER

Policy and societal relevance of traffic noise models in urban zones

S.S. Ahmadi Dehrashid[1],*, H.R. Jafari[2], A. Amjadi[3]

[1] Department of Environmental Engineering, the Air Pollution Group, Faculty of Engineering, Kish International Campus, University of Tehran, Iran

[2] Department of Environment, Faculty of Environment, University of Tehran, Iran

[3] Department of Acoustics, Faculty of Physics, Sharif University of Technology, Tehran, Iran

ARTICLE INFO

Article History:
Received 07 July 2021
Revised 18 October 2021
Accepted 25 November 2021

Keywords:
Conceptual model
Noise abatement policies
Traffic noise factors
Transport

DOI: 10.22034/IJHCUM.2022.02.10

ABSTRACT

BACKGROUND AND OBJECTIVES: Road traffic noise is a matter of challenge for both people and policymakers. For instance, the price of lands/houses which are close to road traffic noise is reduced. The key objective of this study is to propose a conceptual model to illustrate details of a road traffic noise model along with its policy and societal relevance. The second objective is to consider the honking of horns in such a conceptual model, as honking is a remarkable traffic noise factor, however, it has been neglected in some noise abatement policies.
METHODS: By the use of previously proposed traffic noise models, some attempts were made to figure out how the models were applicable in minimizing road noise and how they would be helpful for environmentalists in conducting Environmental Impact Assessment. The proposed models were used to design a conceptual model explaining how policy makers and people in the urban areas may implement the traffic noise models.
FINDINGS: 5 groups of policy makers including roadway engineers, acoustical engineers, acoustic specialists, expert witnesses, and traffic engineers; and 5 groups in the society comprising drivers, people, health practitioners, property owners, and ecosystem may benefit from the traffic noise models. Finally, a conceptual model entailing 3 actors of a traffic noise model (meteorological, traffic, and infrastructure factors) and its 2 outputs i.e. equivalent and maximum noise levels were obtained.
CONCLUSION: Given the conceptual model derived from the road traffic noise models, one is capable of understanding their policy and societal relevance. It is recommended dynamic road noise maps of urban areas be obtained using the models during various times of day and night so that number of inhabitants in different noise spectrums of the map to be specified. Such a noise map is beneficial for both people and policymakers.

NUMBER OF REFERENCES
106

NUMBER OF FIGURES
3

NUMBER OF TABLES
2

*Corresponding Author:
Email: *seyedshaho.ahmadi@ut.ac.ir*
Phone: +98 918 970 1195
ORCID: 0000-0001-5287-8032

Note: Discussion period for this manuscript open until July 1, 2022 on IJHCUM website at the “Show Article.

INTRODUCTION

Approximately 70 percent of total noise pollution in urban regions is caused by road traffic noise (Calixto *et al.*, 2003; European Environment Agency (EEA), 2019; Manea *et al.*, 2017; Younes *et al.*, 2017). It has always been a motivation to carry out diverse research on road traffic noise models which are performed in the urban areas (Abo-Qudais and Alhiary, 2007; Avşar *et al.*, 2004; Barry and Reagan, 1978; Cammarata *et al.*, 1995; Der Bundesminister für Verkehr, 1990; Galloway *et al.*, 1969; Gilani and Mir, 2021; Givargis and Karimi, 2010; Golmohammadi *et al.*, 2009; Gundogdu *et al.*, 2005; Rahmani *et al.*, 2011; Welsh Office, 1988). In the research, normally three individual models for day time, evening time, and night time are designed by which traffic noise pollution is predicted at any location of the urban zones based on a decibel scale (dB). Using the three models traffic noise levels are calculated in any time period during the day, evening, and night which is relatively a common approach. Obviously, the designer of the model needs to clarify in what time of year, the noise model is calculated. For example, if the traffic and noise data are collected during summer and autumn, and, based on the collected data a noise model is obtained, then the model designer should mention the two seasons in the related report. Another point is that each road traffic noise model for day, evening, and night may include either traffic factors or infrastructure factors or meteorological factors or a combination of the aforementioned factors which are representing various predictor/independent variables. In most cases, each model entails one traffic noise descriptor (dependent variable) i.e. equivalent sound level, LA_{eq}. Although honking is a remarkable traffic noise factor, it has been ignored in the noise pollution control policies in urban regions. Therefore, the transport department of the municipalities in the urban zones and its policy makers should find a solution to control/minimize the honking. It is noteworthy to mention that in the recent 30 years some models have been designed to predict and assess the road traffic noise such as Federal Highway Administration, FHWA (Barry and Reagan, 1978), Calculation of Road Traffic Noise, CoRTN (Welsh Office, 1988), and Richtlinien für den Lärmschutz an Straßen, RLS-90 (Der Bundesminister für Verkehr, 1990). However, the latest versions of the models do not entail honking for the prediction of traffic noise (Sharma *et al.*, 2014). Some studies revealed that "honking increased the equivalent noise level (L_{eq}) from 2 to 13 dB(A) in urban highway (Aditya and Chowdary, 2020)." Also, Nassiri *et al.* (2013) showed that vehicles' horn noise levels range between 78.6 and 102.4 dBA. Hence, new variables including 'traffic load/speed of motorcycles', 'vehicle honking', 'number of traffic lanes on the road segments', 'level of service, LOS (Systems Implementation Office, 2020)', and 'altitude of each traffic noise metering station' should be a trial for extending the traffic noise models in the urban areas. Besides a model for prediction of 'equivalent traffic noise level (L_{eq})', a model could be formulated for the estimation of 'maximum traffic noise level (L_{max})'. Therefore, an appropriate traffic noise prediction model may calculate the two indices i.e. L_{eq} and L_{max}. The main aim of the current study is to present a conceptual model which indicates how traffic noise model components interact with political and social decision makings in urban areas. The second aim is to take into account the honking of horns in such a conceptual model, as honking is a significant traffic noise actor, nonetheless, it has been ignored in some noise abatement policies. This review study has been conducted in Sanandaj, Iran from September 2020 to July 2021.

MATERIALS AND METHODS

In 2018, the first author of this paper carried out a research project to design noise maps for two routes in the Netherlands by the use of three different traffic noise models (Ahmadi Dehrashid, 2018). The research was the basis of the idea for the author to do a literature review for discovering the role of traffic noise models in association with policymakers and society stakeholders. Therefore, the related literature was reviewed since September 2020 till July 2021. In preparing the current review paper the following materials were applied: journals' articles, books, published results of conferences, and websites in relation to environmental issues focusing on the published works since 1970s till 2021. As for the methodology, a desk research method (Polak, 2021) was used to write this review article. In doing so, the required information was gathered through investigating the existing resources. Then, traffic noise model stakeholders that have been categorized based on policy relevance and societal relevance, were shown in two tables. Finally, the attempt was made to design a conceptual model as a method to indicate how policymakers and society stakeholders are involved in utilizing a traffic noise model.

RESULTS AND DISCUSSION

Noise models and decision making

As a statistical tool, path analysis technique (Crossman, 2019; Douma and Shipley, 2021; Hoyle, 2012; Population Health Methods, 2021; Rastegar, 2006; Salkind, 2010; ScienceDirect, 2021; Strohmaier *et al.*, 2015; Thom, 1983; Walker *et al.*, 2008; Wu, 2019) could be used by decision makers to calculate the influence of all independent and dependent variables of a noise model as an integrated system. This technique reveals that how independent variables interact with each other and how they affect dependent variables both directly and indirectly. Fig. 1 illustrates an example which includes external independent variable (i.e. temperature), internal independent variables (i.e. traffic load of heavy, medium-weight, and light vehicles as well as total traffic flow), and dependent variable (i.e. L_{eq}):

Traffic noise assessment and management is a challenging task for urban planners. The traffic noise models are applicable in minimizing road noise by transport engineers in the urban areas and can be helpful for environmentalists in conducting Environmental Impact Assessment, EIA (Convention on Biological Diversity, 2021; Drishti, 2020; Rantakallio, 2021; Sharafi *et al.*, 2008; IISD, 2021) and more specifically, Noise Impact Assessment, NIA (Brown, 2006; ENL-Acoustic Consultants, 2013; Noise Solutions, 2020; NOVA Acoustics, 2021) in the cities. Furthermore, the traffic noise models can be applied by traffic engineers in intelligent transportation systems, ITS (Aindra Labs, 2019; Alrawi, 2017; Choudhary, 2019; Chowdhury and Sadek, 2021; Gordon, 2016; Monshaw, 2021; Pagano, 2016; Pina, 2021; Shaheen and Finson, 2004; WSP, 2021) in the urban zones all over the globe in future. Normally, a software package derived from the traffic noise prediction models, is developed by which all stakeholders in the urban zones may obtain a noise contour plot of the zone that they live or work in (Alam *et al.*, 2020; Aumond *et al.*, 2018; Bocher *et al.*, 2019; Golmohammadi *et al.*, 2009; Gulliver *et al.*, 2015). Therefore, people learn whether or not the noise levels in their region are low, medium, or high. If the noise levels were higher than World Health Organization (WHO) standards then municipality, environmental protection agency, and other related organizations present applicable policies to minimize and control road traffic noise. In major studies, Sound Level Meters placed in different locations along the routes measure the traffic noise levels directly by which designing noise maps is performed (Alam *et al.*, 2021; Altaweel, 2017; Cai *et al.*, 2017; Cho *et al.*, 2007; Golmohammadi *et al.*, 2009; McAlexander *et al.*, 2015; Oyedepo *et al.*, 2019). In doing so, much time and money should be spent. Therefore, traffic noise models make it feasible to compute noise levels from infrastructure and traffic data (for instance speed and flow) at less expense. Afterwards, the noise maps for the urban environments are designed. In such a situation, there is no need to establish Sound

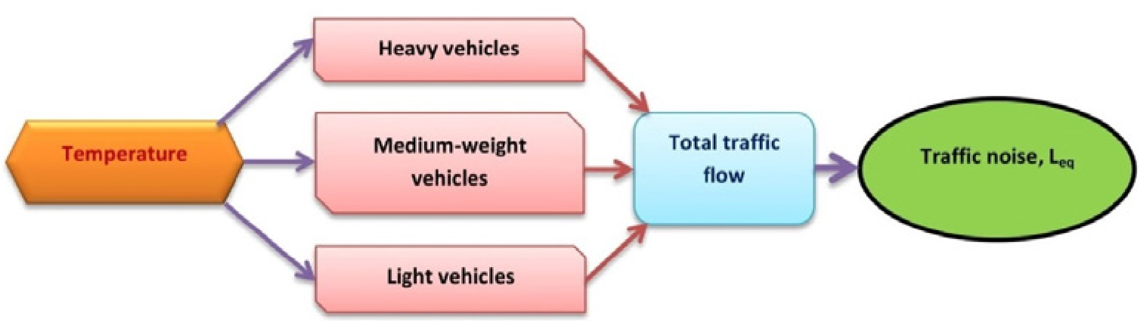

Fig. 1: Example of applying path analysis technique in a noise model by decision makers

Level Meters over the routes, so that much money and time could be saved (Ahmadi Dehrashid, 2018; Anachkova *et al.*, 2020; Kim *et al.*, 2021; Jeong *et al.*, 2010). Chen and Wang (2020) have compared noise maps derived from field measurements with those estimated by the traffic noise models and showed how the noise maps could be used by the landscape planners and designers to abate traffic noise in the environment of a city. All the noise maps of the urban areas should compare traffic noise levels in the cities with the WHO noise guidelines. Results of such research may be interesting for both academicians and non-academicians since its social and policy relevance is directly apparent. Ambühl (2015) states: "research provides the basis for decision-making and possible solutions. Decision-making, implementation, and negotiation are a matter of policy." The aforementioned statement is also valid for traffic noise-related research. Hence, policy relevance and societal relevance of the noise-related research especially the research on the road traffic noise models, are discussed more comprehensively as follows:

Policy relevance

In general two main organizations in urban zones play the role of policy makers in the field of road traffic noise comprising Municipality and Environmental Protection Agency, which may utilize the three traffic noise models (day, evening, and night models) derived from the traffic noise research in decision-making and traffic noise abatement policies. The following experts who are involved (directly or indirectly) in the policies of the two above-mentioned organizations may benefit from the three traffic noise models:

Roadway engineers may implement the models to investigate whether or not infrastructure dimensions meet noise standards. The roadway engineers can also use the models to design screens and required spacing between structures and routes (FHWA, 2021; Steele, 2001). As an example, X Street in Y city with a surface of asphalt is adjacent to two hospitals. The three traffic noise models estimate that average road noise is 69 dB at the location of hospitals, which is higher than WHO noise standards. If the models estimate that using diamond ground on the surface of X street, road noise will be 54 dB, then the asphalt will be replaced with the diamond ground (Cox, 2013; Gharabegian and Tuttle, 2002; Parsons Brinckerhoff Quade and Douglas Inc., 2000; Rawool and Stubstad, 2007; Skarabis and Stöckert, 2015).

Acoustical engineers (Steele, 2001) along with architects may use the models to calculate traffic noise levels close to the building's walls so that they can design appropriate noise-absorbent panels for the building facade and special windows to minimize the traffic noise levels indoors in the cities (Pallett *et al.*, 1978; Precision, 2021). They may also design noise barriers along the roads which are in critical noise conditions (Ekici and Bougdah, 2003; Halim *et al.*, 2015; Kesten *et al.*, 2019). For example, if the traffic noise models show that the average noise level in Z highway in Y city is 81 dB, construction of noise barriers along the highway will be necessary to protect inhabitants affected by noise who live or work around the highway.

Acoustic specialists who write the acoustic-related report of Environmental Impact Statements (EIS) may benefit from the traffic noise models (Steele, 2001). "The environmental impact statement (EIS) is a government document that outlines the impact of a proposed project on its surrounding environment" (Middleton, 2021). As an example, if a new motorway is going to be built in Y city, using the traffic noise models the amounts of noise levels are estimated and assessed along the proposed motorway and will be reported in the EIS. In reality, EIS is applied to elaborate potential adverse effects of a project on the human environment (BOEM, 2021; USEPA, 2020).

Expert witnesses who need to provide a report for the civil courts aside from any noise regulations assessment, may apply the traffic noise models (Steele, 2001). For instance, by the use of the models, the experts can calculate unpleasant traffic noise in residential zones of the cities, which are adjacent to highways or other roads (Babic and Wheeler, 2015; eNoise Control, 2021).

Traffic engineers may utilize the three traffic noise models as a section of Intelligent

Table 1. Noise model stakeholders categorized based on policy relevance.

Policy relevance				
Roadway engineers	Acoustical engineers	Acoustic specialists	Expert witnesses	Traffic engineers
Municipality		Environmental protection agency		Municipality

Transportation Systems (ITS) of the cities in future. As an example, noise monitoring stations using the models, could be set up in different locations along the city roads. Thus, dynamic noise maps of the roads are provided on the determined stations' screens. In doing so, the IT'S encompasses the noise models (Ahmadi Dehrashid, 2018; Wilmink and Vonk, 2015; Garrido Salcedo *et al.*, 2019). On the whole, it could be said that the three traffic noise models are helpful for Environmental Impact Assessment (EIA) of traffic noise pollution and also its management in the cities which is a challenging task for urban planners and other related policy makers. For the high amount of time and cost that should be spent for the measurement of road traffic noise and its complexity, and lack of its possibility at the design step of road, the traffic noise models are essential tools in designing new routes or recalculating traffic volume in current roads to provide convenient noise levels situation (Bendtsen, 1999; Gundogdu *et al.*, 2005). A noise contour plot (noise map) could be derived from a traffic noise model along the roads. In addition, "it should be noted that the main focus of noise maps is for the strategic management of environmental noise, based upon a notional annual average day. They should not be seen as representing what may be measured directly at any location within the map" (Ireland Environmental Protection Agency, 2021). A noise contour plot could also be advantageous for noise-related environmentalists (i.e. acoustical engineers, acoustic specialists, and expert witnesses), and transport-related policy makers (i.e. roadway engineers and traffic engineers) that have been indicated in Table 1. As for the official organizations, environmental protection agency and municipalities can implement the noise maps for considering suitable decisions to mitigate traffic-related noise pollution in the areas exceeding the WHO noise guidelines (Ahmadi Dehrashid, 2018; Breemen, 2008; Cueto *et al.*, 2010; Erwin and van Banda, 2015; Vogiatzis and Remy, 2019). In reality, Table 1 briefly indicates traffic noise model stakeholders categorized based on policy relevance.

Societal relevance

Even in developed countries such as Germany and the Netherlands, people encounter noise pollution which disturbs everyone's life. Southern European countries such as Serbia (Jakovljevic *et al.*, 2009) and Bulgaria (Dzhambov and Dimitrova, 2015) are also involved in traffic noise pollution issue. Road traffic could be considered the most troublesome source of noise pollution in the Netherlands. Research revealed that 29% of the Dutch people whose age was 16 and over were exposed to traffic noise pollution in 2003. Moreover, in developed and developing European countries it was reckoned that up to 30% of European individuals in 2003 were bothered enormously by the traffic noise and regarding the fast urbanization, traffic noise nuisance may rise in urban areas (Wismans, 2012). Moreover, a study in 2013 in Kermanshah, Iran showed that the average traffic noise level in residential-commercial areas was 76.01 dB, higher than the Iranian noise standard in residential-commercial zones i.e. 60 dB (Noori and Zand, 2013). Therefore, all individuals of society are involved in traffic noise pollution as an environmental issue. Traffic noise lowers the property value for people living in the vicinity of urban roads. The price of lands/houses which are close to road traffic noise is reduced (Blanco and Flindell, 2011; Guijarro, 2019; Morano *et al.*, 2021; Wilhelmsson, 2000). Thus, using the three traffic noise models in urban zones it is possible to locate places of the cities in which traffic noise levels are higher than standards (or will be greater than standards in the future) for finding a solution to mitigate the traffic noise to prevent reducing properties values which belong to the people. As mentioned earlier, a remarkable application of the three models in the cities is to predict noise levels and then evaluate the impact of traffic noise on people in the urban areas. In reality, using the

Table 2. Noise model stakeholders are categorized based on societal relevance.

Societal relevance				
Drivers and traffic officers	Normal people	Health practitioners and patients	Property owners	Ecosystem

software package derived from the three models, first, a noise map for a specified zone is obtained. Thus, residents will learn whether or not the noise levels in their region are low, medium, or high. Then a number of inhabitants affected by various levels of traffic noise is calculated so that people can protect themselves against harmful noise levels using applicable solutions which can be given by public health experts. For instance, experts may advise people to wear earplugs during the day in critical noise zones. Drivers and traffic officers are another group who are persistently exposed to the highest amount of road traffic noise. Furthermore, animals, birds, plants, and trees are significantly affected by the road noise. So that, some species of animals move to other habitats which have low noise.

It should be stated that the newer models reveal that honking is one of the significant factors in producing road traffic noise in the cities (Abo-Qudais and Alhiary, 2007; Aditya and Chowdary, 2020; Guarnaccia *et al.*, 2018; Kalaiselvi and Ramachandraiah, 2016; Nassiri *et al.*, 2013; Singh *et al.*, 2021). Therefore, all drivers should be informed of this issue to reduce the amount of honking in urban areas. For instance, side effects of noise pollution caused by honking can be clarified for the drivers through media so that they will be encouraged not to use vehicle horn for unnecessary affairs. Table 2 briefly indicates traffic noise model stakeholders categorized based on societal relevance.

Conceptual model for noise models

In Fig. 2, a conceptual model has been included which illustrates details of a road traffic noise model with its policy and societal relevance as a flowchart. At the top of the flowchart two inputs of a transport model entailing travel demand and supply of infrastructure could be observed. The transport model has two outputs i.e. traffic volume and traffic speed, which along with honking will play the role of inputs for the road traffic noise model. Other inputs of the traffic noise model including meteorological factors (e.g. temperature and relative humidity), traffic safety (e.g. number of road accidents), traffic congestion (e.g. level of service, LOS), and infrastructure factors (e.g. distance between traffic noise source and receiver) are shown in the flowchart. LA_{eq} and LAF_{max} are two outputs of the traffic noise model, which will be transferred to the Intelligent Transportation System (ITS). About the flowchart, LA_{eq} values are also entered into the Geographic Information System (GIS) to acquire a related noise map. Using the noise map, a number of inhabitants affected by traffic noise are calculated and transferred to the ITS. At the same time, prescriptions of public health experts like wearing earplugs are given to the people. It is noteworthy to mention that LA_{eq} and LAF_{max} are two sound indices. L_{eq} is in fact equivalent to continuous sound level namely logarithmic average of sound pressure levels over a specified time. If L_{eq} values are implemented with 'A' Frequency weighting, they are reported as LA_{eq}. "LAF_{max} is the maximum sound level with 'A' Frequency weighting and Fast Time weighting during the measurement period" (Cirrus Research plc., 2020). According to the aforementioned flowchart in Fig. 2, after obtaining LA_{eq} values using the traffic noise model, they are compared with WHO noise standards. If the values were less than the standards, no actions are required to be taken. If the LA_{eq} values were higher than WHO standards, traffic noise abatement policies should be taken comprising A) Technical solutions for vehicles such as designing more efficient mufflers, silencers, etc. B) Transportation and infrastructure management solutions such as limiting noisy vehicles, building noise barriers alongside the roads, planting noise absorber vegetation along the roadsides, etc.

With respect to this conceptual model, the first author of the present paper i.e. Ahmadi Dehrashid (2018) used the volume and speed of vehicles in three different traffic noise models, computed the noise levels, and in the end designed the related

Fig. 2: Conceptual model illustrating traffic noise model with its policy and societal relevance

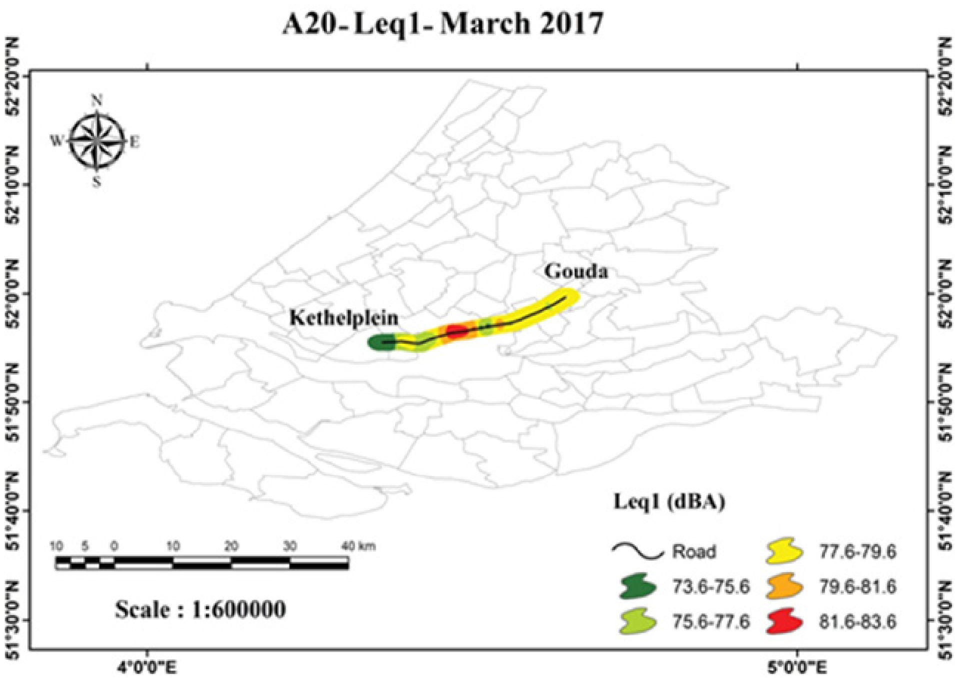

Fig. 3: Noise map (Leq1) in March 2017 for route A20 in the Netherlands (Ahmadi Dehrashid, 2018)

noise maps along two highways in the Netherlands. Nonetheless, it should be noted that the traffic volume and traffic speed were not computed using any transport model but through special instruments that were implemented to count traffic volume and measure its average speed. For instance, Fig. 3 depicts a so-called 'linear noise map' obtained by the noise model Leq1 for route A20 in March 2017 in the Netherlands.

Comparison

In contrast to other studies, Gilani and Mir (2021), introduced a traffic noise system by the use of Graph-theoretic approach (GTA) which takes a traffic noise as a single system that includes various subsystems. Their proposed traffic noise system comprises 4 subsystems with their related parameters: road traffic subsystem (traffic volume, traffic speed, honking, classified traffic volume, acceleration and deceleration, volume of heavy vehicles, and road gradient), human subsystem (driver's skill, driver's age, experience, driver's reaction time, and personality), environmental subsystem (ground effects, temperature, humidity, atmospheric attenuation, rainfall, and greenery), and traffic network subsystem (highways, city roads, traffic signals, grade separators, commercial areas, and type of housing). Whereas the authors of the present paper considered their traffic noise model comprising 3 groups of factors: traffic factors (honking, traffic volume, traffic speed, traffic safety, and traffic congestion), infrastructure factors (road width, buildings' heights, etc.), and meteorological factors (relative humidity, temperature, etc.). Therefore, the authors did not take into account the human factors (driver's skill, driver's age, etc.) that have been used by Gilani and Mir (2021). Another point is that the authors of the current paper have mentioned the traffic network factors as supply of infrastructure (infrastructure factors) which is an input of a transport model. Nonetheless, Gilani and Mir (2021) did not use any transport model nor its input i.e. travel demand, that generates traffic volume and traffic speed (traffic factors). It is noteworthy to mention that traffic factors and meteorological factors in the traffic noise model presented in the current paper are the same as road traffic subsystem and environmental subsystem in the traffic noise system proposed by Gilani and Mir (2021). In this paper the output of traffic noise model i.e. LA_{eq} could be used to design a noise map whereas in the proposed traffic noise system by Gilani and Mir (2021) nothing special said on how to apply its output i.e. LA_{eq} in the engineering works. Bravo *et al.* (2019) utilized the traffic noise model RLS-90 (Der Bundesminister für Verkehr, 1990) to develop a noise map which its algorithm is similar to that of the present paper, since the RLS-90 model applies a transport model to give the inputs of traffic noise model i.e. traffic volume and speed. However, the RLS-90 model does not cover some traffic factors (such as honking, classified vehicle groups, etc.) and lacks the meteorological factors especially temperature and relative humidity. Quiñones-Bolaños *et al.* (2016) changed the CoRTN model (Welsh Office, 1988) so that traffic factors (total traffic volume and classified vehicle counts comprising automobiles, motorcycles, and heavy vehicles), traffic volume adjustment, and meteorological conditions were considered. Nevertheless, Quiñones-Bolaños *et al.* (2016) did not include infrastructure factors and certain traffic factors (such as honking, traffic speed, etc.) in their noise model which were taken into account by the authors of the present paper. Another point is that conceptual model of traffic noise in the current article has implemented a transport model to give traffic volume and speed but Quiñones-Bolaños *et al.* (2016) did not utilize any transport model in designing their noise model. In this paper the output of traffic noise model i.e. LA_{eq} can be used to design a noise map but in the suggested traffic noise model by Quiñones-Bolaños *et al.* (2016) nothing stated on how to apply its output i.e. LA_{eq} in the engineering studies. Nassiri *et al.* (2013) proposed a traffic noise model entailing traffic factors (honking and traffic volume of trucks) and infrastructure factors. Thus, they did not utilize meteorological factors as used by the authors of the current paper. Furthermore, Nassiri *et al.* (2013) did not use transport model in the structure of their traffic noise model which was implemented by the authors of the current paper. In this article the output of traffic noise model i.e. LA_{eq} could be used to design a noise map whereas in the proposed traffic noise model by Nassiri *et al.* (2013) nothing mentioned on how to apply its output i.e. LA_{eq} in the engineering affairs.

CONCLUSION

Road traffic noise is the main source of environmental noise pollution. Therefore, road noise is a matter of challenge for both people and policy makers in urban zones. Road traffic noise models are implemented as a tool to deal with such challenges in decision-making and traffic noise abatement policies. Roadway engineers, acoustical engineers, acoustic specialists, expert witnesses, and traffic engineers who are involved in policies of Municipality and Environmental Protection Agency may benefit from the traffic noise models (policy relevance). Using the models one may determine locations of the roads in which noise levels are higher than standards to mitigate the traffic noise to prevent reducing properties values belonging to the people. Hence, the noise models are helpful for 5 sectors of society comprising: drivers and traffic officers, normal people, health practitioners and patients, property owners, and ecosystem (societal relevance). Given the conceptual model in this study that entails all the actors of a traffic noise model (meteorological, traffic, and infrastructure factors) and its outputs (equivalent sound level and maximum sound level), one is capable of understanding its policy and societal relevance. The added value of this conceptual model is that it implements a transport model to compute traffic volume and speed (traffic factors) as the inputs of a traffic noise model. Such a noise model could be called hybrid model. Another added value of the conceptual model is that it covers new traffic factors comprising honking, traffic safety, and traffic congestion. Based on the previous research gaps, it is recommended dynamic road noise maps of urban areas be obtained using the noise models during various times of day and night so that number of inhabitants in different noise spectrums of the map to be specified. Such a noise map is beneficial for both people and policy makers. Thus, the noise researchers need to facilitate generating noise contour plots (noise maps) along the roads using the traffic noise models. In reality, the researchers should extend the existing research on noise mapping in two aspects. Firstly, they need to make attempt to produce noise maps indirectly by the use of traffic noise models, which is relatively a new approach. Secondly, they need to focus on not only a specified area for noise mapping but also to focus on producing noise maps along the roads so that more detailed noise variations along the roads could easily be observed. Also, it is recommended to design some models for statistical noise levels (L_n values) and put them as set of the traffic noise models, resulting in having more ideal conceptual model.

AUTHOR CONTRIBUTIONS

S.S. Ahmadi Dehrashid worked on the literature review, interpreted the results of literature, designed the conceptual model, wrote the manuscript context, and revised the manuscript. H.R. Jafari studied the literature review, details of the conceptual model, and checked the manuscript to have it prepared. A. Amjadi aided in the literature review and manuscript revisions.

ACKNOWLEDGMENTS

Special thanks to Prof. M.R. Monazzam from Tehran University of Medical Sciences for providing insightful comments.

CONFLICT OF INTEREST

The authors have no conflict of interest to be declared concerning this review paper. Also, the authors have checked all the ethical affairs comprising duplicates, misconduct, data making, informed consent, and plagiarism.

PUBLISHER'S NOTE

Tehran Urban Planning and Research Center remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS

CoRTN	Calculation of Road Traffic Noise
dB	decibel scale
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statements
FHWA	Federal Highway Administration
GTA	Graph-theoretic approach
GIS	Geographic Information System
IISD	International Institute for Sustainable Development
ITS	Intelligent Transportation Systems
LA_{eq} *or* L_{eq}	equivalent sound level
L_n	statistical noise levels
LOS	level of service
LAF_{max} *or* L_{max}	maximum sound level
NIA	Noise Impact Assessment
RLS-90	Richtlinien für den Lärmschutz an Straben
WHO	World Health Organization
USEPA	United States Environmental Protection Agency

REFERENCES

Abo-Qudais, S.; Alhiary, A., (2007). Statistical models for traffic noise at signalized intersections. Build. Environ., 42(8): 2939-2948 **(10 pages)**.

Aditya, K.; Chowdary, V., (2020). Influence of Honking on the Road Traffic Noise Generated at Urban Rotaries for Heterogeneous Traffic. Environ. Clim. Technol., 24(1): 23-42 **(20 pages)**.

Ahmadi Dehrashid, S.S., (2018). Designing noise maps using traffic noise models for routes A20 and A4 in the Netherlands. International Conference on civil engineering, architecture and urban development management in Iran, Tehran, CAUM01, 19 December 2018 **(24 pages)**.

Alam, P.; Ahmad, K.; Afsar, S.; Akhter, N., (2020). Noise

Monitoring, Mapping, and Modelling Studies- A Review. J. Ecol. Eng., 21(4): 82-93 **(12 pages)**.

Alam, P.; Ahmad, K.; Khan, A.H.; Khan, N.A.; Dehghani, M.H., (2021). 2D and 3D mapping of traffic induced noise near major roads passing through densely populated residential area of South Delhi, India. PLoS One, 16(3): 1-8 **(8 pages)**.

Alrawi, F., (2017). The importance of intelligent transport systems in the preservation of the environment and reduction of harmful gases. 3rd Conference on Sustainable Urban Mobility, 3rd CSUM 2016, 26 -27 May 2016, Volos, Greece. Transportation Research Procedia, 24: 197-203 **(7 pages)**.

Altaweel, M. (2017). Geographic Information Systems (GIS), LOUNGE: Monitoring livestock using GIS.

Ambühl, M., (2015). Research with a social relevance. Interview by Schmid, F., ETH News, Eidgenössische Technische Hochschule Zürich (ETH Zürich), 23.02.2015, Switzerland.

Aindra Labs, (2019). What is intelligent transportation system (ITS): Applications and Examples? Aindra Labs Blog, Aindra Labs Pvt. Ltd, Bangalore, India.

Anachkova, M.; Domazetovska, S.; Petreski, Z.; Gavriloski, V., (2020). Urban noise mapping: The impact of traffic noise level in the environmental noise pollution. Forum Acusticum, 7-11 December 2020, Lyon, France. 3071-3076 **(6 pages).**

Aumond, P.; Jacquesson, L.; Can, A., (2018). Probabilistic modeling framework for multisource sound mapping. Appl. Acoust., 139: 34-43 **(10 pages)**.

Avşar, Y.; Saral, A.; Gönüllü, M.T., (2004). Neural Network Modelling of Outdoor Noise Levels in a Pilot Area. Turkish J. Eng. Env. Sci., 28(3): 149-156 **(8 pages)**.

Babic, F.; Wheeler, A.F., (2015). Witness Statement of Frank Babic, P.Eng. Ontario Municipal Board Case No. PL141318, Bronte Green Corporation, Ontario, Canada **(11 pages)**.

Barry, T.M.; Reagan, J.A., (1978). FHWA highway traffic noise prediction model, Report No. FHWA-RD-77-108. Federal Highway Administration, Offices of Research & Development; Springfield, Va.: National Technical Information Service, Washington, United States **(290 pages)**.

Bendtsen, H., (1999). The Nordic prediction method for road traffic noise. Sci. Total Environ., 235(1-3): 331-338 **(8 pages)**.

Blanco, J.C.; Flindell, I.H., (2011). Property prices in urban areas affected by road traffic noise. Appl. Acoust., 72(4): 133-141 **(9 pages)**.

Bocher, E.; Guillaume, G.; Picaut, J.; Petit, G.; Fortin, N., (2019). Noise Modelling: an open source GIS based tool to produce environmental noise maps. Int. J. Geo-Inf., 8(130): 1-30 **(30 pages)**.

BOEM, (2021). Environmental Impact Statement (EIS) Format and content process. Bureau of Ocean Energy Management (BOEM), U.S. Department of the Interior, Washington, United States.

Bravo, L.; Chávez, M.; Puyana, V.; Lucio, J.; Garzón, C.; Pavón, I., (2019). A cost-effective approach to the evaluation of traffic noise exposure in the city of Quito, Ecuador. Case Stud. Transp. Policy, 7: 128-137 **(10 pages)**.

Breemen, T.V., (2008). Good Practice Guide on Port Area Noise Mapping and Management. NoMEPorts, Port of Amsterdam, The Netherlands **(62 pages)**.

Brown, K., (2006). Environmental Noise Impact Assessment. AWE International, Weymouth, England.

Cai, M.; Yao, Y.; Wang, H., (2017). A traffic-noise-map update method based on monitoring data. J. Acoust. Soc. Am., 141(4): 2604-2610 **(7 pages)**.

Calixto, A.; Diniz, F.B.; Zannin, P.H.T., (2003). The statistical modeling of road traffic noise in an urban setting. Cities, 20(1): 23-29 **(7 pages)**.

Cammarata, G.; Cavalieri, S.; Fichera, A., (1995). A neural network architecture for noise prediction. Neural Netw., 8(6): 963-973 **(11 pages)**.

Chen, S.; Wang, Z., (2020). Noise mapping in an urban environment: comparing GIS-based spatial modelling and parametric approaches. J. Digit. Landsc. Archit., 5: 122-129 **(8 pages)**.

Chowdhury, M.; Sadek, A., (2021). What is ITS? PIARC, Road Network Operations & Intelligent Transport Systems: A Guide for Practitioners, United States.

Cirrus Research plc., (2020). Noise terminology guide, United Kingdom **(28 pages)**.

Cho, D.S.; Kim, J.H.; Manvell, D., (2007). Noise mapping using measured noise and GPS data. Appl. Acoust., 68(9): 1054-1061 **(8 pages)**.

Choudhary, M., (2019). What is intelligent transport System and how it works? Geospatial World, India.

Convention on Biological Diversity, (2021). What is impact assessment? A part of UN environment programme.

Cox, J.E., (2013). System-wide OBSI study to evaluate success of diamond grinding to attain project noise reduction goal. Harris Miller Miller & Hanson Inc., Burlington, United States.

Crossman, A., (2019). Understanding Path Analysis. Thought Co., Learn Something New Every Day.

Cueto, J.L.; Lopez, F.; Perez, A.; Suarez, D.; Hernandez, R., (2010). Decision-making tools for action plans based on GIS: A case study of a Spanish agglomeration. Proceedings 39th International Congress on Noise Control Engineering: Noise and sustainability, INTERNOISE 2010, 13-16 June 2010, Lisbon, Portugal, 1-10 **(10 pages)**.

Der Bundesminister für Verkehr, (1990). Richtlinien für den Lärmschutz a Straßen (RLS-90). Abteilung Straßenbau, Bonn, Germany **(21 pages)**.

Douma, J.C.; Shipley, B., (2021). A multigroup extension to piecewise path analysis. Ecosphere, 12(5): 1-10 **(10 pages)**.

Drishti, (2020). Environmental Impact Assessment. Biodiversity and Environment Section, Drishti The Vision Foundation, New Delhi, India.

Dzhambov, A.M.; Dimitrova, D.D., (2015). Evaluation of the social and economic burden of road traffic noise-attributed myocardial infarction in Bulgarian urban population. Arh. Hig. Rada. Toksikol., 66(1): 15-21 **(7 pages)**.

Ekici, I.; Bougdah, H., (2003). A Review of Research on Environmental Noise Barriers. Build. Acoust., 10(4): 289-323 **(35 pages)**.

ENL-Acoustic Consultants, (2013). An Assessment of Environmental Noise Impact in Support of a Planning Application for the Beanstalk Land Development adjacent Birch Coppice Business Park Dordon, Warwickshire.

Environmental Noise Impact Assessment Report, ENL-Acoustic Consultants, Hayling Island Hants, England **(26 pages)**.

eNoise Control, (2021). Acoustic Consultant Expert Witness. Expert Witness, Westfield, United States.

Erwin, H.J.V.L.S. and van Banda, H., (2015). Noise mapping-State of the art-Is it just as simple as it looks?

In Proceedings of EuroNoise.

European Environment Agency, (2019). Road traffic remains biggest source of noise pollution in Europe. European Environment Information and Observation Network (Eionet). Retrieved August 1, 2020.

FHWA, (2021). Traffic Noise Model. Office of Planning, Environment, & Realty (HEP), Federal Highway Administration (FHWA), U.S. Department of Transportation, Washington, United States.

Galloway, W.J.; Clark, W.E.; Kerrick, J.S., (1969). Highway noise measurement, simulation, and mixed reactions. NCHRP Report, 78, Transportation Research Board, Washington, United States **(90 pages)**.

Garrido Salcedo, J.C.; Mosquera Lareo, B.M.; Echarte Puy, J.; Sanz Pozo, R., (2019). Management Noise Network of Madrid City Council. Noise Control for a Better Environment, The 48th International Congress and Exposition on Noise Control Engineering, INTER-NOISE 2019, 16-19 June 2019, Madrid, Spain, 1-12 **(12 pages)**.

Gharabegian, A.; Tuttle, E., (2002). Diamond grinding for roadway noise control. Sound Vib., December: 26-29 **(4 pages)**.

Gilani, T.A.; Mir, M.S., (2021). Modelling road traffic Noise under heterogeneous traffic conditions using the graph-theoretic approach. Environ. Sci. Pollut. Res., Published online: 11 March 2021 **(18 pages).**

Givargis, Sh.; Karimi, H., (2010). A basic neural traffic noise prediction model for Tehran's roads. J. Environ. Manage., 91(12): 2529-2534 **(6 pages)**.

Golmohammadi, R.; Abbaspour, M.; Nassiri, P.; Mahjub, H., (2009). A compact model for predicting road traffic noise. J. Environ. Health Sci. Eng., 6(3): 181-186 **(6 pages)**.

Gordon, R., (2016). Intelligent Transportation Systems: Functional Design for Effective Traffic Management. 2nd Edition. Springer International Publishing, Switzerland **(XVIII, 282 pages)**.

Guarnaccia, C.; Singh, D.; Quartieri, J.; Nigam, S.P.; Kumar, M.; Mastorakis, N.E., (2018). Honking noise contribution to road traffic noise prediction. Mathematical Methods and Computational Techniques in Science and Engineering II, AIP Conference Proceedings, 1982(1): 020042, 020042-1–020042-6.

Guijarro, F., (2019). Assessing the Impact of Road Traffic Externalities on Residential Price Values: A Case Study in Madrid, Spain. Int. J. Environ. Res. Public Health, 16(5149): 1-13 **(13 pages).**

Gulliver, J.; Morley, D.; Vienneau, D.; Fabbri, F.; Bell, M.; Goodman, P.; Beevers, S.; Dajnak, D.; Kelly, F.J.; Fecht, D., (2015). Development of an open-source road traffic noise model for exposure assessment. Environ. Model. Softw., 74: 183-193 **(11 pages).**

Gundogdu, O.; Gokdag, M.; Yuksel, F., (2005). A traffic noise prediction method based on vehicle composition using genetic algorithms. Appl. Acoust., 66(7): 799-809 **(11 pages)**.

Halim, H.; Abdullah, R.; Ali, A.A.A.; Nor, M.J.M., (2015). Effectiveness of Existing Noise Barriers: Comparison between Vegetation, Concrete Hollow Block, and Panel Concrete. International Conference on Environmental Forensics 2015 (iENFORCE2015), Putrajaya, Malaysia. Procedia Environ. Sci., 30: 217-221 **(5 pages)**.

Hoyle, R.H., (2012). Path analysis and structural equation modeling with latent variables. In: H. Cooper, P.M. Camic, D.L. Long, A.T. Panter, D. Rindskopf, & K.J. Sher (Eds.), American Psychological Association (APA) handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological. 333-367 **(35 pages)**.

International Institute for Sustainable Development (IISD), (2021). Winnipeg Head Office, Winnipeg, Manitoba, Canada.

Ireland Environmental Protection Agency, (2021). What is a strategic noise map? Noise mapping and action plans. Environmental Protection Agency (EPA), County Wexford, Ireland.

Jakovljevic, B.; Paunovic, K.; Belojevic, G., (2009). Road-traffic noise and factors influencing noise annoyance in an urban population. Environ. Int., 35(3): 552-556 **(5 pages)**.

Jeong, J.H.; Din, N.B.C.; Otsuru, T.; Kim, H.C., (2010). An application of a noise maps for construction and road traffic noise in Korea. Int. J. Phys. Sci., 5(7): 1063-1073 **(11 pages)**.

Kalaiselvi, R.; Ramachandraiah, A., (2016). Honking noise corrections for traffic noise prediction models in heterogeneous traffic conditions like India. Appl. Acoust., 111: 25-38 **(14 pages)**.

Kesten, S.; Umut, Ö; Ayva, B., (2019). Acoustic and structural design of a highway noise barrier. IOP Conf. Ser.: Mater. Sci. Eng., 800, 5th International Conference on New Advances in Civil Engineering (ICNACE 2019) 8-10 November 2019, Kyrenia, Cyprus **(14 pages)**.

Kim, P.; Ryu, H.; Jeon, J.J.; Chang, S.I., (2021). Statistical Road-Traffic Noise Mapping Based on Elementary Urban Forms in Two Cities of South Korea. Sustainability, 13(2365): 1-17 **(17 pages)**.

Manea, L.; Manea, A.; Florea, D.; Tarulescu, S., (2017). Road Traffic Noise Pollution Analysis for Cernavoda City. IOP Conf. Ser.: Mater. Sci. Eng. 252 012057, 1-8 **(8 pages)**.

McAlexander, T.P.; Gershon, R.R.; Neitzel, R.L., (2015). Street-level noise in an urban setting: assessment and contribution to personal exposure. Environ. Health, 14(18): 1-10 **(10 pages)**.

Middleton, T., (2021). What is an Environmental Impact Statement? Teaching Legal Docs, American Bar Association (ABA).

Monshaw, A., (2021). Public transport data and the next steps for better operations. Ticketer Group, Intelligent Transport, Kent, United Kingdom.

Morano, P.; Tajani, F.; Liddo, F.D.; Darò, M., (2021). Economic Evaluation of the Indoor Environmental Quality of Buildings: The Noise Pollution Effects on Housing Prices in the City of Bari (Italy). Buildings, 11 (213): 1-23 **(23 Pages)**.

Nassiri, P.; Dehrashid, S.A.; Hashemi, M.; Shalkouhi, P.J., (2013). Traffic noise prediction and the influence of vehicle horn noise. J. Low Freq. Noise V. A., 32(4): 285–291 **(7 Pages)**.

Noise solutions, (2020). Noise impact assessment. Noise

Solutions Inc., Calgary, Alberta, Canada.

Noori, K.; Zand, F., (2013). An investigation of traffic noise pollution effects on citizens' general and mental health (Case Study: Kermanshah City). J. Nov. Appl. Sci., 2(9): 344-349 **(6 Pages)**.

NOVA Acoustics, (2021). Noise impact assessment. Acoustic Consultants, Head Office, London, United Kingdom.

Oyedepo, S.O.; Adeyemi, G.A.; Olawole, O.C.; Ohijeagbon, O.I.; Fagbemi, O.K.; Solomon, R.; Ongbali, S.O.; Babalola, O.P.; Dirisu, J.O.; Efemwenkiekie, U.K.; Adekeye, T.; Nwaokocha, C.N., (2019). A GIS–based method for assessment and mapping of noise pollution in Ota metropolis, Nigeria. MethodsX, 6: 447-457 **(11 Pages)**.

Pagano, P., (2016). Intelligent transportation systems: from good practices to standards. 1st Edition. CRC Press, Taylor & Francis Group, London, United Kingdom **(205 Pages)**.

Parsons Brinckerhoff Quade; Douglas Inc., (2000). Roadway pavement grinding noise study: Final Report. Utah Department of Transportation, Salt Lake City, United States **(30 Pages)**.

Pallett, D.S.; Wehrli, R.; Kilmer, R.D.; Quindry, T.L., (1978). Design guide for reducing transportation noise in and around buildings. U.S. Department of Commerce, National Bureau of Standards, Washington, United States **(180 Pages)**.

Pina, M., (2021). ITS research fact sheets-benefits of intelligent transportation systems. Office of the Assistant Secretary for Research and Technology, Intelligent Transportation Systems, Joint Program Office, U.S. Department of Transportation, Washington, United States.

Polak, P., (2021). What Is Desk Research And How To Do It? INVO.

Population Health Methods, (2021). Path Analysis. Mailman School of Public Health, Columbia University, New York, United States.

Precision, (2021). Acoustical panel installation. Acoustic systems, precision: wall covering and painting, San Juan Capistrano, United States.

Quiñones-Bolaños, E.E.; Bustillo-Lecompte, C.F.; Mehrvar, M., (2016). A traffic noise model for road intersections in the city of Cartagena de Indias, Colombia. Transp. Res. D Transp. Environ., 47: 149-161 **(13 Pages)**.

Rahmani, S.; Mousavi, S.M.; Kamali, M.J., (2011). Modeling of road-traffic noise with the use of genetic algorithm. Appl. Soft Comput., 11(1): 1008-1013 **(6 Pages)**.

Rantakallio, S., (2021). Environmental impact assessment. Ministry of the Environment, Department of the Natural Environment, Bioeconomy, Helsinki, Finland.

Rastegar, M., (2006). Causal modeling – Path Analysis: A New trend in research in applied linguistics. The Linguist. J., 1(3): 97-109 **(13 Pages)**.

Rawool, S.; Stubstad, R., (2007). Effect of diamond grinding on noise characteristics of concrete pavements in California: report. California Department of Transportation, United States **(13 Pages)**.

Shaheen, S.A.; Finson, R., (2004). Intelligent transportation systems. Encyclopedia of Energy, 3: 487-496 **(10 Pages)**.

Singh, D.; Francavilla, A.B.; Mancini, S.; Guarnaccia, C., (2021). Application of machine learning to include honking effect in vehicular traffic noise prediction. Appl. Sci., 11(6030): 1-16 **(16 Pages)**.

Steele, C., (2001). A critical review of some traffic noise prediction models. Appl. Acoust., 62(3): 271-287 **(17 Pages)**.

Salkind, N.J., (2010). Path Analysis. In: Encyclopedia of research design (Vols. 1-0). Thousand Oaks, CA: SAGE Publications, Inc.

ScienceDirect, (2021). Path Analysis. Elsevier B.V.

Sharafi, S.M.; Makhdoum, M.; Ghafourian Bolouri Mashhad, M., (2008). Environmental impact assessment case study: Automobile Industry in Takestan. Environmental Sciences, 5(4): 27-42 **(16 pages)**.

Sharma, A.; Bodhe, G.L.; Schimak, G., (2014). Development of a traffic noise prediction model for an urban environment. Noise Health, 16(68): 63-67 **(5 pages)**.

Skarabis, J.; Stöckert, U., (2015). Noise emission of concrete pavement surfaces produced by diamond grinding. J. Traffic Transp. Eng., 2(2): 81-92 **(12 pages)**.

Strohmaier, S.; Røysland, K.; Hoff, R.; Borgan, Ø.; Pedersen, T.R.; Aalen, O.O., (2015). Dynamic path analysis-a useful tool to investigate mediation processes in clinical survival trials. Stat Med., 34(29): 3866-87 **(22 pages)**.

Systems Implementation Office, (2020). Quality/Level of Service Handbook. Department of Transportation, State of Florida, Tallahassee, United States **(90 pages)**.

Thom, D.J., (1983). The path analysis technique in educational research: Bridging the theory-empiricism gap. J. Educ. Adm., 21(1): 40-51 **(12 pages)**.

USEPA, (2020). Environmental Impact Statements (EIS). National Environmental Policy Act Review Process, United States Environmental Protection Agency (USEPA), United States.

Vogiatzis, K.; Remy, N., (2019). Environmental noise mapping as a smart urban tool development. smart urban development, Vito Bobek, IntechOpen, London, United Kingdom.

Walker, C.; Fleischer, S.; Winn, S., (2008). A path analysis of first-year social science students' engagement with their degree and Level 1 academic outcome. Enhancing Learning in the Social Sciences, 1(2): 1-19 **(19 pages)**.

Welsh Office, (1988). Calculation of Road Traffic Noise (CoRTN). Department of Transport, Welsh Office, London: Her Majesty's Stationery Office (HMSO), UK **(100 Pages)**.

Wilhelmsson, M., (2000). The impact of traffic noise on the values of single-family houses. J. Environ. Plan. Manag., 43(6): 799-815 **(17 Pages)**.

Wilmink, I.; Vonk, T., (2015). Applying intelligent transport systems to manage noise impacts. Proceedings 10th European Congress and Exposition on Noise Control Engineering, EuroNoise2015, 31 May-3 June 2015, Maastricht, The Netherlands, 1053-1058 **(6 Pages)**.

Wismans, L.J.J., (2012). Towards sustainable dynamic traffic management. Ph.D. Dissertation, University of Twente, the Netherlands **(226 Pages)**.

WSP, (2021). Intelligent transportation systems. WSP Advisory, Montreal, Quebec, Canada.

Wu, H.S., (2019). Introduction to Path Analysis. Center for Family and Demographic Research (CFDR), CFDR Workshop Series, **(23 Pages)**.

Younes, I.; Shafiq, M.; Ghaffar, A.; Mehmood, S., (2017). Spatial patterns of noise pollution and its effects in Lahore City. In: Bedey Media GmbH. Anchor Academic Publishing, Hamburg. 31 **(113 Pages)**.

HOW TO CITE THIS ARTICLE

Ahmadi Dehrashid, SS.; Jafari, H.R.; Amjad, A., (2022). Policy and societal relevance of traffic noise models in urban zones. Int. J. Hum. Capital Urban Manage., 7(2): 283-296.

DOI: 10.22034/IJHCUM.2022.02.10

url: http://www.ijhcum.net/article_251071.html