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A Study of Public Health Impacts during Road Construction Projects in Sri Lanka: A Glance from Experts' Opinion

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Abstract

The environmental impacts of road development, as well as the occupational health and safety of construction workers, have been widely acknowledged and, in many cases, addressed in recent initiatives. However, little consideration has been given to the health effects of road development on nearby communities during the construction process. This study aims to investigate the public health impacts during the construction stage of road projects. The main objective is to identify the potential health impacts that had occurred during the road construction projects. This study included the findings of expert semi-structured interviews and four case studies. Thirty-two expert interviews, along with twelve case study-based interviews, were carried out with the participation of experts on road construction projects, public health and environment management in Sri Lanka. The data was analysed thematically to explore the public health impacts that occurred during the road construction. More than twenty public health issues were identified, including air pollution, noise pollution, water pollution and some of the least discussed impacts, such as mosquito-borne diseases, accidents and wildlife issues. The findings of this study suggest that in order to measure the effects of transport decisions on public health, a more in-depth assessment of health issues is required. These findings highlight the vital significance of expanding capacity, both within and outside of government, to properly understand the public health implications of road development through the impact assessment process. Policymakers should conduct a full public health impact assessment for all road construction projects in order to address the broader public health issues that arise during the process.

Keywords: Nearby community, Public health, Road construction, Sri Lanka

1. Introduction

Road development provides many social, economic and practical advantages. It has a major role in urban development because it provides access to markets, education, occupation, health and other key services (Makarova *et al.*, 2017). Furthermore, road development has significantly improved the livelihoods of rural communities. These developments facilitate the timely and reasonable delivery of basic health, education, water, and

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sanitation services, empowering vulnerable groups (Laurance and Balmford, 2013).

Despite its many perceived and actual benefits, road development may have a negative impact on people, particularly in terms of public health. Traditional road planning takes into account some of the long-term public health effects of road construction, such as crash risk and environmental pollution. Some studies have identified threats to human health as air pollution, traffic injuries, and noise pollution (Egan *et al.*, 2003; Alamgir *et al.*, 2017; Riley-Powell *et al* ., 2018). However, it has also been reported that very few contractors and private developers take an effort to consider the environment and develop the concept of recycling building materials (Lam, 1997) because most of them ranked completion time as their top priority and pay little attention to the environment (Poon et al., 2001).

Previous studies have identified the impact on construction workers during the construction process. Pinto (2011) pointed out that the construction industry has advanced its practices to tackle occupational health concerns. Although occupational health issues during construction have been extensively discussed in the literature, there have been few studies on the broader health consequences for nearby communities during road construction. For example, a study in Cyprus revealed that construction projects have negative impacts on the residents who live in a neighbourhood of a construction project, and these impacts were overlooked by most of the impact assessments (Celik and Budayan, 2016). The following section describes some common public health impacts of road construction projects discussed in the existing literature.

2. Literature Review

2.1 Health impacts of air pollution

Particulate matter (PM) and its emissions during construction have been the primary focus of research in the construction industry. Construction work releases a large number of particles into the environment, which can endanger both construction workers and residents in the area. In most cases, the impact on nearby residents is indirect. However, exposure to PM has been identified as the cause of numerous health effects, including increased hospital admissions, emergency room visits, respiratory symptoms, exacerbation of chronic respiratory and cardiovascular diseases, decreased lung function, and premature death (Guaita et al., 2011; Halonen et al., 2009; Perez et al., 2012; Samoli et al., 2008). Furthermore, scientists believe that exposure to high particle levels may cause a variety of symptoms, including low birth weight in infants, pre-term deliveries, and possibly foetal and infant death. Inhaling

PM2.5 has been linked to mild symptoms such as shortness of breath (dyspnea), chest discomfort and pain, coughing, and wheezing (Guaita et al., 2011). However, the majority of these studies have focused on occupational health-related air pollution and its impacts rather than the public.

2.2 Health impacts of heavy metal contamination

Previous research has identified construction dust and waste as the primary sources of heavy metal contamination. Chemicals used in construction and demolition waste can enter the environment through waste handling, incineration, and/or leakage from disposal sites, where humans may be exposed directly through inhalation, skin deposits, or consumption or indirectly through soil and water contamination via food and water (Coelho & de Brito, 2012). Human exposure to various chemicals has been linked to several health outcomes, including ulcers, diarrhea, respiratory disorders, cancer, cardiovascular disease, liver damage, endocrine disruptions, neurotoxicity, and foetal malformations (Engwa et al., 2019).

2.3 Health impacts of construction noise

Previous studies have also evaluated the various impacts induced by construction noise. One study assessed the health impacts of construction noise on occupants depending on the degree of their noise exposure (Hong *et al.*, 2022). This study found that occupants are exposed to construction noise that exceeds the permissible noise level, which can lead to the loss of up to 270.55 years of healthy life. Liu et al. (2017) investigated the effects of construction noise on occupant mental health. These studies suggest that residents' exposure to construction noise can cause a variety of mental and physical disorders, including annoyance, stress, and hearing loss. These disorders can harm the health and quality of life of nearby residents in an urban community.

2.4 Other health impacts

Vector-borne diseases and infectious diseases have also been identified as a health concern. For example, a higher distribution of dengue and malaria cases near construction sites has been linked to an increased number of infections in the neighbouring communities and a higher likelihood of community transmission (Liu *et al.*, 2021). Barroso (2022) investigated an increased risk of bovine tuberculosis during the road construction process, which could pose a threat to the surrounding community. Patz et al. (2000) previously discussed the occurrence and distribution of these new epidemics, in which non-immune, unprotected populations, such as construction workers, loggers, miners, tourists, and conservationists, would be exposed to

indigenous and newly arrived vectors and parasites. However, despite the fact that such threats have been identified, the literature in the construction and road development sectors has paid relatively little attention to these other health impacts.

2.5 Road development and its public health impacts in Sri Lanka

As a developing country, Sri Lanka has also demonstrated a lack of attention to health impacts despite successive governments investing heavily in road transport infrastructure construction, development, rehabilitation, widening, and maintenance (Arunashantha, 2019). According to a study by Karunathilaka (2021), individuals living within 200 meters of the road corridor are exposed to contaminated air and noise emissions caused by road construction operations.

A previous study by Gamalath et al. (2014) identified potential impacts in six Sri Lankan transport development projects. According to the study's findings, no projects have taken into account the health and well-being of nearby communities or the general public. Furthermore, the primary concerns of the selected projects included only the direct environmental impact on air, water, soil, and noise. Identified impacts are considered during project planning, construction, and operation without any concern for the health and well-being of nearby communities. A clear gap was identified the existing literature on identification of public health impacts during road projects.

Despite a growing body of international literature on how human health is affected during development projects, most developing countries, including Sri Lanka, lack academic literature on road construction and public health impacts. To fulfil the above research gap, this study aims to investigate the consideration of public health impacts during the construction stage of road projects. The main objective of this study is to identify the public health impacts occurred during the road construction process. The study's findings will be used to provide an initial platform for understanding the public health impacts of road construction projects in Sri Lanka. The following sections describe the methodology and findings of a qualitative study conducted in Sri Lanka.

3. Materials and methods

The first phase of empirical investigations on potential public health impacts during road construction projects was collected via expert interviews. Semi-structured interviews were conducted with 32 academic and industry experts with at least two years of experience in road construction, public health and environment management (See Table 1). Semi-structured interviews are

frequently conducted in an informal setting, allowing the interviewee to freely communicate his or her ideas about the particular subject. Further, this informal setting permit the interviewer to follow up questions to clarify the issues, thus allowing a deeper investigation of the subject area rather than structure interviews (Burns, 2000). Combination of purposive sampling methods, expert sampling and snowball sampling was adopted to select these experts for the semi structured interviews.

Table 1: Selected expert categories for semi-structured interviews

No	Group	Group Category	Area of Expertise
01.	Academia on Environment Science	ES1	Environmental Impact Assessment, Environment Hydrology and Waste Management
02.		ES2	Transport Geography
		ES3	Physical Geography and Geology
03.		ES4	EIA/SIA
04.		ES5	Disaster Management
05.		ES6	Urban Sociology
06.	Academia on Construction and Civil Engineering	CC1	Civil Engineering
07.		CC2	Environment Engineering
08.		CC3	Environment Engineering
09.		CC4	Structural Engineering
10.		CC5	Environment Consultant
11.		CC6	Environment Impact
12.	Environment practitioners (Private)	EPP1	Environment Management
13.		EPP2	Environmental Impact Monitoring
14.		EPP3	Environmental Engineering
15.		EPP4	EIA and Legislations
16.		CEA1	EIA

17.	Road Development Authority	RDA1	Environmental and Social Safeguard Officer
18.		RDA2	Hydrology, EIA
19.	Road Contractors	RC1	Environmental Management and Monitoring
20.		RC2	Health and Safety
21.		RC3	Construction Management
22.	Health and Safety Officers	HS1	Environmental, Health and Safety Management and Monitoring
23.		HS2	Health and Safety Management and Monitoring
24.	General Practitioners	GP1	Environment and Public Health
25.		GP2	Public Health
26.	Health officials (Ministry of Health)	HO1	Community Medicine
27.		HO2	Public Health
28.		HO3	Public Health
29.	MOH- Public Health Inspectors	PH1	Public Health
30.		PH2	Public Health
31.		PH3	Public Health
32.	Village officials	GN1	Community issues

Data collection for the case studies followed the initial expert interview guidelines to identify the public health impacts. Multiple case studies were selected to better understand the public health impacts during road construction projects. Four road construction projects in Sri Lanka were selected as the cases for this research (See Table 2). The selection of four road construction projects as the case studies is based on four main factors: scale of the project, location of the project, and status of the project funding agency.

This research selected three expressway projects and one road widening project as the case studies.

To match the nature of the study, the project officers who engaged in public health, environment management and project management in each project were selected for interviews. Information on public health impacts was gathered to validate the expert interview result (Table 2).

Table 2: Selected experts and categories for case study semi-structured interviews

Designation	Code	Selected case study
Health and safety consultant	CE1	Case study 1
Road safety engineer	CE2	Case study 1
Assistant manager and construction engineer	CE3	Case study 1
Health and safety consultant	SO1	Case study 2
Environment and safety officer	SO2	Case study 2
Project manager and civil engineer	SO3	Case study 2
Health and safety executive officer	OA1	Case study 3
Planning engineer	OA2	Case study 3
Structural and civil engineer	OA3	Case study 3
Environment and safety officer	SE1	Case study 4
Health and safety consultant	SE2	Case study 4
Residential engineer	SE3	Case study 4

Data analysis was conducted using a priori/deductive coding technique where public health impacts were drawn using code-based content analysis. When interview data is transcribed and placed in text format, open coding is used to identify codes with no restrictions in order to determine the importance of meanings (Hahn, 2008). There will be no new codes or categories identified until theoretical saturation is reached. Then, in the next stage, previously established codes are investigated further by referring back to data. Based on the codes, themes were developed on potential public health impacts during road projects. The key findings of the classification are highlighted in the results and discussion section.

Both expert interviews and case studies were an opportunity to explore beyond the literature and allow additional concepts, themes, and areas of analysis to be discovered. Findings from this research provided a deeper

understanding of potential public health impacts during road projects' construction phase and beyond the theoretical discourse. They also showcased the research gaps and potential discrepancies with observations from practice.

4. Results

4.1 Public health impacts during road construction – Expert interviews

All interviewed experts reported increased frequency and severity of public health impacts during road construction projects and were very concerned about these projects' short - and long-term impacts. Some experts reported severe health impacts in recent years due to the increased frequency of road development projects. Such statements were, in particular, made by the interviewees whose expertise and professional experience were in health and safety and public health.

The most prominent health impacts described by the respondents were air pollution, noise pollution, water pollution and mosquito-borne diseases. Among these four impacts, almost all respondents agreed on the impact of air pollution on nearby communities. Apart from these four main categories, other health impacts were mentioned by the respondents, which were not significant in previous studies. For example, injuries and accidents, COVID-19, tuberculosis, sexually transmitted diseases and mental health issues. Other less common impacts mentioned by a few respondents included allergies, reptile bites and food poisoning (See Figure 1).

Both health and safety professionals (HS) and environment practitioners (EPP) also stated that some of the emerging health impacts were excluded in road construction projects as existing health and safety guidelines were limited to the impacts of air pollution and noise pollution. As an example, one of the environmental professionals (EPP1) in an existing road project emphasised how most projects tend to ignore the potential increase in sexually transmitted diseases.

> *"Most of the time you can see HIV prevention programmes without any consideration on other sexually transmitted diseases during construction, but these prevention campaigns has to be converted as HIV and other Sexually Transmitted Diseases".*
>
> *(Personal communication, February 26, 2022).*

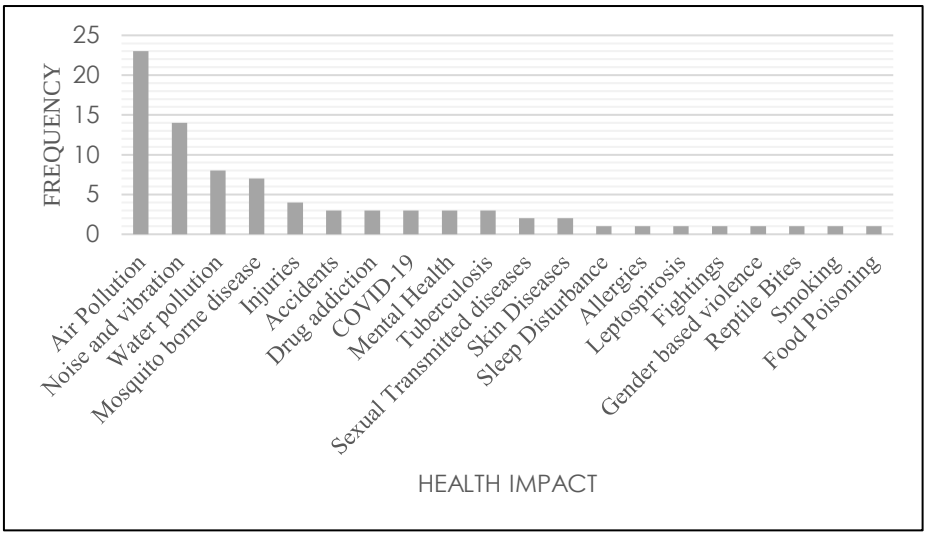

Figure 1: Potential health impacts of due to road construction

According to the HS1, current health and safety guidelines have been developed to address HIV as a health concern in road construction projects. Other sexually transmitted diseases, such as gonorrhoea, hepatitis, and herpes, have received little attention despite being a major challenge in the current situation. This scenario was also confirmed by one of the road contractors (RC1), who stated that HIV and other sexually transmitted diseases were never monitored during the construction phase of the road projects.

According to the respondents' statements, the majority of existing preventive measures that should have been considered under occupational health and public health and safety were ignored mainly during these road construction projects. According to a respondent from the Road Development Authority (RDA1), most road contractors ignore public health concerns, resulting in numerous complaints to the RDA, particularly about dust and noise. This was confirmed by general practitioners (GP1 and GP2), who stated that respiratory health issues were more prevalent than other public health impacts during the road construction stage. As stated by GP1, *"So many chronic patients are coming every week for treatments for asthma and panting."*

Some respondents also stated that the COVID-19 pandemic in Sri Lanka has resulted in more complex scenarios in the road construction sector due to changes in working conditions and public exposure during the construction phase. Almost all experts emphasised the practical difficulty of implementing safety measures during the working period. For example, the country's hot and humid climate made it difficult to wear gloves and masks while working on construction sites. As stated by one of the health and safety officers (HS2) of

an ongoing road project: *"It is the most difficult industry to adhere with the COVID-19 precautions due to the work environment."*

HS2 also stated that the environment was unsafe for the nearby community due to frequent interactions between workers and the public during shopping, lodging, commuting, and roaming activities. HS2 also identified several COVID-19 hotspots near road construction sites. It concluded that the nearby community is also at a high risk of contracting the disease as a result of interactions with road workers in the area. This was discovered in relation to other vector-borne diseases, such as Dengue and Malaria, where cases have increased in the vicinity of road construction sites. Public health inspectors (PH1 and PH2) have noticed these scenarios and named some road construction sites dengue hotspots, especially in the Western Province. This was further confirmed by a health professional (HO1) in the Ministry of Health, Sri Lanka, as recent Dengue outbreaks in the year 2021 were reported from the existing construction sites.

Aside from the health implications for nearby communities, some experts revealed that a few underappreciated scenarios occurred during their previous working experiences with leptospirosis and tuberculosis. As stated by a health and safety officer (HS2), he was able to detect and prevent a leptospirosis outbreak during an expressway project in Sri Lanka. Similarly, a public health inspector (PH2) contracted tuberculosis while working on a road widening project in Sri Lanka, but he was able to reduce the risk by enlisting the help of other public health inspectors in the region.

4.2 Public health impacts during road construction – Case studies

4.2.1 Dust nuisance

Almost all the respondents from each case study agreed on the impact of air pollution and dust nuisance on nearby communities. Most interviewees agreed that the dust issue was the major public health impact during the respective projects. During the construction of case study 4, the interviewee witnessed severe dust due to the project's geographical location. As revealed by one of the health and safety consultants (SE2)

> *Actually this entire highway part is a wind corridor. And therefore, the wind direction pattern was very severe, severely affecting the construction activity and because of that the main mission was preventing the dust issue during the project works. Sometimes, we had to evacuate the people immediately.*
>
> *(Personal communication, November 13, 2022).*

One of the interviewees from the case study 2 (SO3) also pointed out the impact on the day-to-day activities of nearby communities.

> *It was a short distance to the ROW. The transportation of materials by truck causes numerous health issues in the surrounding community. If they plucked the tea, the leaves would be dusty. This was also applied to washing clothes. Every time, their homes were covered in dust.*
>
> *(Personal communication, November 20, 2022).*

Several interviewees from two other case studies also highlighted the impact of dust due to the construction activities. These activities include soil compaction, ABC works, sub-base construction and base construction.

4.2.2 Noise nuisance

Most of the interviewees agreed that noise nuisance was the second most common impact during the construction works. The interviewees also emphasised the nighttime work as a critical factor in noise nuisance. Interviewees also highlighted the difficulties in controlling standard noise levels during construction. As revealed by an interviewee of the case study 3 (OA1) *"You know in Sri Lanka there are rules and regulations for noise limitation. But here we can't manage the noise because, normally with the vehicle movement it exceeds 75 decibel level."* A similar fact was highlighted by the interviewees of case study 2, where the plant operation generated continuous noise during the project period. As stated by the project's environment and safety officer, *"The contractor tries to establish all possible plants within the ROW. Therefore, the noise issue was inevitable during the operation time. These plants were operated for a maximum time. It means these plants were operated in both day and night."* Interviewees of case study 1 (CE2 and CE3) also agreed on the effect of plant operations on noise and highlighted the practical issues of controlling the noise levels during working hours.

4.2.3 Vibration nuisance

All the interviewees confirmed that all the selected projects had received complaints about vibration issues during the project work. However, more issues have been reported during the construction process of case study 3. The interviewees identified the area's soil condition as the main reason for vibration nuisance. Also, the project officers have received some vibration-related issues beyond the ROW of the project. As explained by a structural and civil engineer of the project (OA2), *"There were few impacts on vibration*

as well. The structure of the houses was somewhat good in this area. Due to the marshy lands of the region, we received some vibration issues beyond the ROW." This issue on nearby communities was reaffirmed by the health and safety officer of the project (OA1) *"It's around from first kilometer to the second kilometer as it is still a marshy land. Also, there was a garbage dumping area. Because of that reason, it is highly impacted."* The interviewees have received many complaints about house cracks and were urged to perform an intermediate crack survey during construction. The survey revealed that there were significant impacts on houses during the construction activities. With the complaints by the nearby community, a drainage line was constructed in advance to mitigate the vibration issue.

4.2.4 Water quality and usage

All interviewees highlighted water pollution as a major health impact during their respective projects. Chemicals, oils, and fuel were described as the main pollutants during road construction. Several interviewees from Case Study 4 (SO1 and SO2) and Case Study 1 (CE1 and CE3) noted that cement and bitumen also have an impact on water pollution during road construction. As experienced by one of the officers of case study 4*, "We sprayed bitumen, and there were some contaminations in the expressway. This happened during the rainy season. In these cases, we immediately removed them from the water bodies."* Interviewees from case study 3 also described a similar incident related to bitumen, which badly affected the nearby water sources. As the interviewee (OA 1) emphasized, heavy vehicle drivers should be responsible for contamination. *"But in some cases, we are not able to manage the road construction activities contaminations. Regarding Bitumen, the truck drivers sprayed them in some barren lands without our knowledge or involvement."* The oil spillage also affects the nearby water bodies due to heavy vehicles and machinery work.

4.2.5 Communicable diseases

A significant risk of communicable diseases has also been identified by the interviewees in all four case studies. Sexually transmitted diseases, COVID-19, Dengue and Malaria were among the main diseases highlighted by the interviewees. During the construction process of case study 4, interviewees observed the gradual increase of the Dengue risk in the area. The water stagnation due to higher rainfalls and floods was highlighted by the Interviewees (SE1 and SE2) as the main reason for the outbreak. A different scenario was revealed by the project manager and civil Engineer (SO3) of the case study 2. He pointed out the indirect impacts of noise and dust barriers, which were identified as breeding sites afterwards. As stated by the

interviewee, *"We used bamboo as dust and noise barriers. But it ended up as Dengue mosquito breeding sites. Even in the construction yards, we faced the same situation of Dengue. And there was a Dengue outbreak as well."* The interviewee further revealed an occurrence of Malaria cases during the project. Although Malaria was eradicated from Sri Lanka at that time, this was due to the involvement of the Chinese workers of the project who migrated from a malarious area outside Sri Lanka. However, he went on to declare that this health risk has been successfully controlled by the involvement of relevant regional authorities.

The interviewees from both case studies 1 and 3 highlighted the impact of COVID-19 on their respective projects. Interviewees from the projects confirmed the occurrence of COVID-19-positive cases during the construction process. As stated by a health and safety consultant (CE1) of the case study 1, *"we try to adhere to the COVID -19 prevention guidelines provided by the health officials. There were COVID-positive cases as well. We follow the standard method during these cases."* Another interviewee from the same project (CE2) explained the practical difficulties that arose during the project due to the COVID-19 pandemic.

> *In terms of COVID-19, this project was affected by the pandemic. At that time, we didn't have much knowledge about the disease. Therefore, we prepared some basic guidelines and conducted some meetings. After that, we planned patient isolation, camp operations, worker transportation, PCR, and Rapid antigen tests.*
>
> *(Personal communication, November 30, 2022).*

4.2.6 Injuries and accidents

Interviewees from case study 2 highlighted injuries and accidents as the second most impactful during the projects. All the project interviewees confirmed the occurrence of injuries and accidents due to road traffic or rock blasting. SO3 recalled some concerns related to rock blasting: *"Rock blasting, cause physical damages frequently. Deaths have also occurred. This was higher with explosive-based blasting than chemical blasting."* The interviewee also explained the reported injuries and deaths due to these rock-blasting activities. A similar situation was explained by the interviewees from case study 1, too. However, the interviewees revealed the adaptation of the temporary evacuation process during such scenarios. As recalled by one of the interviewees (CE1)

> *Even during the rock blasting, we informed the nearby community and tried to evacuate the people in the most dangerous zone (Up to 250m). We provide an evacuation fee as well. During other constructions, we try to evacuate the most vulnerable people, such as chronic patients.*
>
> *(Personal communication, November 25, 2022).*

The interviewees of the case study 4 revealed a distinct set of injuries and accidents. This was due to the human-elephant conflict in the construction area, where several accidents occurred due to the attacks of elephants. As experienced by one of the interviewees (SE 2),

> *One of my staff members was also killed due to the human-elephant conflict in the area. In the evening, they were off for the day. Somehow, elephants roamed around the area. There were several cases during the project. Some were not related to us. Sometimes, people face this situation in the evening when going home from work.*
>
> *(Personal communication, November 22, 2022).*

Another interviewee from the same project (SE 3) confirmed the increasing risk of elephant attacks during the project work. Further, he highlighted that the habitat degradation during the road project badly affects elephants in the nearby region and the aggressive behavior of the animals impacts the nearby community too.

4.2.7 Other health impacts

As found through the expert interviews, road construction projects have a negative impact on the wider health determinants of the nearby communities, too. The case studies also provided similar examples of negative impacts on wider health determinants too. This includes social factors such as accessibility disruptions, education and employment disruptions and the person's individual characteristics and behaviour risks such as illegal drug popularization, smoking and harmful use of alcohol.

5. Discussion

It was revealed through the experts' interview that the potential health impacts go beyond the typical health impacts that were commonly discussed on impact assessment reports. More than twenty impacts have been discussed by the interviewees, including those not widely discussed in the scientific literature. Table 3 indicates these health impacts, which were highlighted by

the experts, such as interconnection with workers, air quality nuisance, noise nuisance, water quality, etc. Identified impacts were categorized into a few aspects (Table 4) on the basis of the negative determinants of health (WHO, 2023). Air quality and noise nuisance were the mainly discussed categories during the interviews, whereas the determinants such as interconnection with workers, water quality, and risk-taking behaviour were the least discussed categories highlighted through the interviews. The research findings are similar to the previous international research on public health and road construction where air quality and noise were the frequently highlighted (Balaguera et al., 2018; Font et al., 2014; Jung et al., 2020).

The case study method was also employed to further identify and validate the health impacts during the road construction projects in Sri Lanka. Twelve interviews were carried out to collect the relevant information on public health impacts (See Table 3). Seventeen impacts were identified in case studies, and the impacts were categorised into six main categories: Dust nuisance, noise and vibration nuisance, communicable disease, water quality and water usage, injuries and accidents and other health impacts. Most of the identified impacts during the case studies were similar to the previous expert interview results. As highlighted in Table 3, several new health impacts have also been identified through case studies, such as wildlife issues and visual disturbances.

However, some of the health impacts identified in the Sri Lankan context were not evident globally, which explains the lack of research on public health impacts and road construction in the global context. Further, the results revealed the importance of a comprehensive public health impact assessment process which covers the whole range of public health impacts during road construction projects.

Table 3: Potential health impacts identified through the expert interviews and case studies

Expert interviews	**Case studies**
Air quality and dust nuisance	Air quality and dust nuisance
Noise nuisance	Noise nuisance
Vibration nuisance	Vibration nuisance
Water quality and water usage	Water quality and water usage
Water safety	Water safety
COVID 19	COVID 19
Dengue	Dengue

Malaria	Malaria
Diarrhea	Injuries and accidents
Allergies	Access disruptions
Skin diseases	Mental health (social isolation)
Injuries and accidents	HIV
HIV and other sexually transmitted diseases	Lifestyle-related risk (alcohol consumption, drug popularisation)
Leptospirosis	Aggressive behaviour (Fighting)
Access disruptions	Wildlife issues
Educational disruptions	Visual disturbances
Employment disruptions	Natural hazard risk (floods and landslides)
Food poisoning	
Aggressive behaviour (Fighting)	
Gender-based violence	
Mental health (Community cohesion)	
Lifestyle-related risk (alcohol consumption, beetle chewing, smoking, drug popularisation)	

Table 4: Identified negative determinants and the potential health impacts

Known negative determinant of Health	**Potential health Impact**
Interconnection with workers	Drug addiction
	Smoking
	Alcohol usage
	Beetle chewing
	Fighting
	Sexual harassments
	Child abuse
	HIV Aids
	Other sexually transmitted diseases
	COVID- 19
Air quality/dust nuisance	Asthma

	Bronchitis
	Cancer
	Asbestosis
	Allergies
	Skin diseases
	Tuberculosis
Noise nuisance	Sleep disturbances
	Stress
Water quality and water safety	Dengue
	Malaria
	Leptospirosis
	Diarrhea
	Food poisoning
	Kidney failure
	Dehydration
Soil pollution/Land contamination	Cancer
Community cohesion	Mental health issues
Educational disruption	Mental health issues
Social isolation	Mental health issues
Visual disturbance (Scenery Pollution)	Mental health issues
Access disruption (Road accessibility)	Accidents
	Injuries
Road safety	Accidents
	Injuries
Habitat degradation	Reptile bites
	Human – Elephant conflict
Natural hazard risk	Floods
	Landslides
Nonionising radiation/Heat	Cancers
Crime and fear of crime	Injuries

Risk-taking behaviour	Drug addiction
	Alcohol consumption
	Fighting
	Sexual harassments
	Child abuse

6. Conclusion

According to the findings, health concerns needed to be thoroughly investigated during the road construction process. This suggests that there needs to be more understanding and grasp of the inclusion of public health in the road development sector in Sri Lanka. In this research, empirical evidence indicates that there were major gaps in the existing knowledge where traditional public health impacts were the main concern in the road construction sector. The analysis does have certain limitations as any health or accident-related data were not considered for the analysis, and the expert interviews were the major source of data analysis. However, the qualitative analysis of the expert opinions provides an insight into the current understanding of such issues among the road construction industry and other relevant authorities.

These findings suggest that there is a need to build capacity both within and outside of government to appropriately incorporate the health consequences of road infrastructure projects. Health professionals and environmental practitioners could provide the necessary backdrop for road construction on how to use health data, properly map the causal linkages between exposures and health consequences, and account for the unequal distribution of health among population groups.

Further studies should be conducted to gain a more comprehensive knowledge about the potential health impacts. There is a need to support local health systems to deal with these potential health impacts. Properly integrating health professionals into the road construction sector could enhance these aspects during road construction projects. Improved continuity of training and awareness of road contractors and other relevant parties with the participation of health professionals could improve the attention to public health and accommodate necessary preventive measures during the road construction process. The findings of this paper can inspire researchers to progress further in this area, which will, in turn, advocate for a change in policies of the road construction industry.

References

Abdullah, A. Y. M., Masrur, A., Adnan, M. S. G., Baky, M. A. A., Hassan, Q. K., & Dewan, A. (2019). Spatio-temporal patterns of land use/land cover change in the heterogeneous coastal region of Bangladesh between 1990 and 2017. Remote Sensing, 11(7), 790.

Afsar, S., Ali, S. S., & Kazmi, S. J. H. (2013). Assessment the quality of life in Karachi city through the integration of space and spatial technologies. Journal of Basic & Applied Sciences, 9, 373.

Aslanov, I., Mukhtorov, U., Mahsudov, R., Makhmudova, U., Alimova, S., Djurayeva, L., & Ibragimov, O. (2021). Applying remote sensing techniques to monitor green areas in Tashkent Uzbekistan. In E3S Web of Conferences (Vol. 258, p. 04012). EDP Sciences.

Avtar, R., Komolafe, A. A., Kouser, A., Singh, D., Yunus, A. P., Dou, J., Kumar, P., Gupta, R. das, Johnson, B. A., Thu Minh, H. V., Aggarwal, A. K., & Kurniawan, T. A. (2020). Assessing sustainable development prospects through remote sensing: A review. Remote sensing applications: Society and environment, 20, 100402.

Bannari, A., Morin, D., Bonn, F., & Huete, A. (1995). A review of vegetation indices. Remote sensing reviews, 13(1-2), 95-120.

Butt, M. J., Waqas, A., Iqbal, M. F., Muhammad, G., & Lodhi, M. A. K. (2012). Assessment of urban sprawl of Islamabad metropolitan area using multi-sensor and multi-temporal satellite data. Arabian Journal for Science and Engineering, 37, 101-114.

Chen, S., Zeng, S., & Xie, C. (2000). Remote sensing and GIS for urban growth analysis in China. Photogrammetric Engineering and Remote Sensing, 66(5), 593-598.

Dimitrov, S., Georgiev, G., Georgieva, M., Gluschkova, M., Chepisheva, V., Mirchev, P., & Zhiyanski, M. (2018). Integrated assessment of urban green infrastructure condition in Karlovo urban area by in-situ observations and remote sensing. One Ecosystem, 3, e21610.

Faisal, K., & Shaker, A. (2017). An investigation of GIS overlay and PCA techniques for urban environmental quality assessment: a case study in Toronto, Ontario, Canada. Sustainability, 9(3), 380.

Franco, S. F., & Macdonald, J. L. (2018). Measurement and valuation of urban greenness: Remote sensing and hedonic applications to Lisbon, Portugal. Regional Science and Urban Economics, 72, 156-180.

Frick, A., & Tervooren, S. (2019). A framework for the long-term monitoring of urban green volume based on multi-temporal and multi-sensoral remote sensing data. Journal of geovisualization and spatial analysis, 3(1), 6.

Fu, B., Yu, D., & Zhang, Y. (2019). The livable urban landscape: GIS and remote sensing extracted land use assessment for urban livability in Changchun Proper, China. Land use policy, 87, 104048.

Ghaffarian, S., Kerle, N., & Filatova, T. (2018). Remote sensing-based proxies for urban disaster risk management and resilience: A review. Remote sensing, 10(11), 1760.

Gupta, K., Puntambekar, K., Roy, A., Pandey, K., Mahavir, & Kumar, P. (2020). Smart Environment Through Smart Tools and Technologies for Urban Green Spaces: Case Study: Chandigarh, India. Smart Environment for Smart Cities, 149-194.

Jensen, R., Gatrell, J., Boulton, J., & Harper, B. (2004). Using remote sensing and geographic information systems to study urban quality of life and urban forest amenities. Ecology and Society, 9(5).

Levering, A., Marcos, D., & Tuia, D. (2021, July). Liveability from Above: Understanding Quality of Life with Overhead Imagery and Deep Neural Networks. In 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS (pp. 2094-2097). IEEE.

Li, G., & Weng, Q. (2007). Measuring the quality of life in city of Indianapolis by integration of remote sensing and census data. International Journal of Remote Sensing, 28(2), 249-267.

Liu, Y., & Jiang, Y. (2021). Urban growth sustainability of Islamabad, Pakistan, over the last 3 decades: a perspective based on object-based backdating change detection. GeoJournal, 86, 2035-2055.

Mesquita, M. R., Agarwal, S., de Morais Lima, L. H. G., Soares, M. R. A., Barbosa, D. B. e. S., Silva, V. C., Werneck, G. L., & Costa, C. H. N. (2022). The use of geotechnologies for the identification of the urban flora in the city of Teresina, Brazil. Urban Ecosystems, 1-12.

Musse, M. A., Barona, D. A., & Rodriguez, L. M. S. (2018). Urban environmental quality assessment using remote sensing and census data. International journal of applied earth observation and geoinformation, 71, 95-108.

Nguyen, T. M., Lin, T. H., & Chan, H. P. (2019). The environmental effects of urban development in Hanoi, Vietnam from satellite and meteorological observations from 1999–2016. Sustainability, 11(6), 1768.

Prakash, M., Shukla, R., Chakraborty, A., & Joshi, P. K. (2016). Multi-criteria approach to geographically visualize the quality of life in India. International Journal of Sustainable Development & World Ecology, 23(6), 469-481.

Salata, S., Giaimo, C., Barbieri, C. A., Ballocca, A., Scalise, F., & Pantaloni, G. (2020). The utilization of normalized difference vegetation index to map habitat quality in Turin (Italy). Sustainability, 12(18), 7751.

Sapena, M., Wurm, M., Taubenböck, H., Tuia, D., & Ruiz, L. A. (2021). Estimating quality of life dimensions from urban spatial pattern metrics. Computers, environment and urban systems, 85, 101549.

Shan, W., Jin, X., Ren, J., Wang, Y., Xu, Z., Fan, Y., Gu, Z., Hong, C., Lin, J., & Zhou, Y. (2019). Ecological environment quality assessment based on remote sensing data for land consolidation. Journal of Cleaner Production, 239, 118126.

Shao, Z., Sumari, N. S., Portnov, A., Ujoh, F., Musakwa, W., & Mandela, P. J. (2021). Urban sprawl and its impact on sustainable urban development: a combination of remote sensing and social media data. Geo-Spatial Information Science, 24(2), 241-255.

Shaw, R., & Das, A. (2018). Identifying peri-urban growth in small and medium towns using GIS and remote sensing technique: A case study of English Bazar Urban Agglomeration, West Bengal, India. The Egyptian Journal of Remote Sensing and Space Science, 21(2), 159-172.

Thiyagarajan, G., Kannan, B., Manikandan, M., Nagarajan, M., & Selvaperumal, A. (2020). Urban Sprawl Assessment in the Coimbatore City Corporation using GIS for Balancing the Ecological and Economic System. Journal of Green Engineering, 10, 4566-4576.

Wang, R., Murayama, Y., & Morimoto, T. (2021). Scenario simulation studies of urban development using remote sensing and GIS. Remote Sensing Applications: Society and Environment, 22, 100474.

Wiatkowska, B., Słodczyk, J., & Stokowska, A. (2021). Spatial-temporal land use and land cover changes in urban areas using remote sensing images and GIS analysis: The case study of Opole, Poland. Geosciences, 11(8), 312.

Zafar, Z., Mehmood, M. S., Shiyan, Z., Zubair, M., Sajjad, M., & Yaochen, Q. (2023). Fostering deep learning approaches to evaluate the impact of urbanization on vegetation and future prospects. Ecological Indicators, 146, 109788.

Zhong, J., Jiao, L., Droin, A., Liu, J., Lian, X., & Taubenböck, H. (2023). Greener cities cost more green: Examining the impacts of different urban expansion patterns on NPP. Building and Environment, 228, 109876.