

# Assessment of Noise Pollution and Discomfort Levels of the Residents of the Champs De Manoeuvre Neighbourhood, Guelma, Algeria

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## Abstract

One of the most prevalent problems affecting people in their residences is noise, which represents a recognized environmental problem and a social health concern. In a contribution to raise the awareness of the population against the risks of noise, the objective of this study is to assess the noise sources and the degree of discomfort of the residents of five multistorey residential buildings located in the Champs de manoeuvre neighbourhood in Guelma, throughout a noise measurement campaign and a sociological survey using a questionnaire distributed on a sample of 80 dwellings. The analysis of the findings of the responses of the respondents showed the harmful effect of noise on these residents, where 70% of them live in a state of stress and anger or they were bothered in their rooms, mainly by the noise of the neighbours as well as road traffic noise, that reached up higher noise levels than the threshold recommended by the Algerian noise regulations. Subsequently, influencing the social and health living environment of the residents by this type of nuisance requires urgent actions by the responsible authorities.

**Key words:** Multistorey residential building, Neighborhood, Noise pollution, Noise measurement, Sound discomfort.

## INTRODUCTION

Healthy housing is a living space that promotes physical, mental, and social well-being. It provides a sense of belonging, privacy, as well as a sense of security from outer risks (WHO 2018). One of the popular risks that affect people in their residences is noise, mainly transportation noise, which is identified as a recognized environmental problem and a social health issue in all nations of the world, perceived by residents as a menace on their mental health and well-being, and as a critical factor in housing quality. It is for this reason, buildings are built in accordance with rules specified by public authorities and specialists who are expected to have a thorough understanding of user needs and expectations (Gopikrishnan and Topkar 2017) to gain on sound comfort.

### Noise Effect on Human Health

In recent years, this scourge has been highlighted as an important topic in several research-action surveys, clinical diagnoses on population living in urban areas. As a result, it is shown that the harmful effects of noise are multifaceted since hearing disorders are constantly increasing (Nassur 2018).

A research integrated cross-sectional data from a major public health survey in southern Sweden with road traffic noise data revealed that there was a proven association between exposure to road traffic noise levels exceeding 60 dB and cardiovascular risks (Bodin et al. 2009).

Another survey study based on a questionnaire distributed on 1000 individuals living in a municipality in Stockholm, showed that a feeling of annoyance was detected in sound pressure level above 50 dB emitted from traffic noise, and sleep disorder observation due to the fact of bedrooms with windows facing the street (G. Bluhm, Nordling, and Berglind 2004).

According to the Williams working group, surveys conducted in Europe, particularly in Germany, revealed that more than 75% of the population was irritated by noise nuisance caused primarily by road noise (Williams et al. 1998).

Sorensen's scientific team designed an investigative study on 29875 women aged 50-64 years in Denmark, where they linked short sleep duration, caused mainly by exposure to road noise, with increased risk of breast cancer through

suppression of melatonin, followed by increased estrogenic production, increased tumour growth and reduced DNA repair (Mette et al. 2013).

The intensity-duration combination of individual noise exposure is connected to the physical dimension of noise intensity; as a result, evaluating and controlling the impact of this relationship is a nuisance that has long disturbed the condition of well-being and social development. In this sense, all the scientific, medical and social researches studied the epidemiological estimation of the effects of noise and showed that the supreme cause of serious diseases is the high perceived noise intensity. According to the World Health Organization (WHO) there are also other causes such as tinnitus, hearing impairment, headaches, stress and fatigue, difficulty concentrating, radio-pathology, sleep disturbance and sometimes issues of excessive hormone releases such as cortisol or catecholamines (adrenaline, dopamine) that have cardiovascular consequences (WHO 2018).

Like road noise, it can raise blood pressure in people who reside in areas where the  $L_{day}$  (Sound level at daytime) is greater than 65 dB. It was also discovered that the degree of noise creates a sense of discomfort, aggravation, and invasion of privacy in the residences (Bodin et al. 2009). In addition, the excessive release of hormones such as cortisol or catecholamines (adrenaline, dopamine) could have cardiovascular consequences when a state of stress is induced by noise exposure. This was studied by (Gösta Bluhm and Eriksson 2011) on cortisol as a marker of stress, where he highlighted that those women exposed in the morning to airborne noise levels above 60 dB had a significant increase in cortisol levels in their bodies.

Also, a study is carried out on the damage of night-time road noise in relation to sleep disturbance in 2660 children in Norway. The results of this research denoted a great fatigue during the whole day in the exposed children and also huge school dropouts of most of them (Weyde et al. 2017).

In addition, the effects of annoyance include private dissatisfaction, public complaints to authorities, and the negative health effects mentioned earlier. Because annoyance can be more than a small irritation, it describes a significant decline in quality of life, which corresponds to a decline in health and well-being (Jariwala et al. 2017).

For (Sarah Mahdjoub-Assaad 2018) who developed a diagnostic study in Lyon on the health effects of road traffic noise, in the conclusion of his research, she stated that transportation noise is no longer a life quality issue, but it is an environmental health issue and that the risk of arterial hypertension in relation to transportation noise gives a Relative Risk (RR) of 1.10 per 5 dB(A) of noise increase.

As a last illustration, an Irish research found that ambient noise from road traffic, railways, and aviation sources was responsible for 256 noise-induced ischemic heart disease cases, 296,471 high irritation cases, and 109,951 high sleep disruption cases (Faulkner and Murphy 2022).

In this regard, all epidemiologists and scholars agree that road noise, in particular, is an issue that must be addressed by the right application of sound scientific principles.

### **Worldwide and Algerian Action Examples Against Noise**

The problem of noise pollution has been recognized since the 1960s, when the Swiss Parliament (Bundesrat) established the first panel to determine environmental noise restrictions. In fact, this panel developed a structure that is now employed in Switzerland's anti-noise legislation (Schade 2003). Several measures can be taken to improve the noise environment for citizens and residents to combat this type of pollution, which is why many countries around the world have adopted the necessary legislation and policies to address this issue, the primary objective of which was to try to control the emittance of noise and mitigate noise levels to thresholds recommended for hearing comfort indoors and outdoors.

On June 4, 2010, the Regulation on Environmental Noise Assessment and Management was published in the Turkish Official Gazette with the number 27601. It addresses needs such as noise limits (road noise is limited to an average of 67 dB during 24 hours) and noise control zones, as well as the incorporation of the Environmental Noise Directive into Turkish law (Benliay et al. 2019).

The European Directive on Environmental Noise (END) 2002/49/EC, which mandates that European member States use a methodological approach based on the principle of noise mapping. This technic has been used to prevent or mitigate the negative effects of noise exposure, particularly from road noise. It provides a five-year cycle for developing and submitting strategic noise maps and noise control plans to the European Commission (King and Murphy 2016).

Since 1974, the United States Environmental Protection Agency (EPA) has established a 24-hour exposure limit of 55 dBA in residential areas to safeguard the population from detrimental health and welfare consequences. Furthermore, the United States Environmental Protection Agency (EPA) proposes a second exposure limit of a 24-hour continuous average sound exposure level [Leq(24)] of 70 dBA, which is used as a limit to avoid hearing damages (Hammer, Swinburn, and Neitzel 2014).

In India as well, noise pollution restrictions were enacted in the year 2000 to address and avoid noise pollution in industrial, commercial, and residential sectors, as well as to conserve noise pollution in calm spaces such as hospitals, educational institutions, and libraries. The ambient noise level in residential areas shall be 55 dB during the day and 45 dB at night (Poddar 2017).

Algeria, like other countries, is dealing with an increasing problem of noise pollution. It is a significant concern throughout the country's metropolitan regions, especially in medium-sized cities like Guelma, due to a significant growth in population density, the volume of traffic fleet, and a lack of suitable urban planning. The Algerian government has addressed the problem of noise pollution through the environmental protection law since 1983 (Gramez 2010), consisting of two laws, a decree, and a technical regulatory document (DTR), where the general idea of preserving the sound comfort in residential buildings against external noise was by a simple maximum limitation of outdoor noise to a threshold of 70 dB, mentioned in the national executive decree n°93-184 of July 27 (JORA 1993). The acoustic regulation in residential buildings, according to article 66 of the national official gazette n°51 corresponding to September 2011, also included in article 69 of the national official gazette n°06 corresponding to January 2013, set a sound level of 38 dB perceived inside the dwelling during the day and 45 dB during the night in the living rooms and service spaces.

However, less attention is given to this issue by the local authorities and few studies have attempted to assess noise pollution in Algeria, although it could help raise public awareness on noise health impact and emphasize key solutions to mitigate noise levels outdoors and indoors, in order to provide a better outdoor soundscape and a good indoor environment.

Therefore, this study focuses on highlighting how the health dimension and discomfort levels of the residents of the neighbourhood of Champs de manoeuvre (CDM) who are affected from the reception of a certain noise levels in this urban area. The results of this study may serve as a contribution to raise public awareness and understanding of the implementation of effective solutions for residences affected by noise pollution.

## **METHODOLOGY**

### **Approach**

The aim of this study is to assess the noise sources and the degree of discomfort of the residents of multi-storey residential buildings located in the Champs de manoeuvre neighbourhood in Guelma. The investigation in this study was based on a mixed approach for data-collection. Firstly, in order to assess the noise pollution in the studied area, a quantitative approach was adequately useful for collecting noise data, throughout real-time field measurements with the necessary instruments, such as a sound level meter to capture and measure the noise. Secondly, in order to support the results of the noise measurement campaign, a qualitative approach was adopted for gathering the residents-response on noise pollution, through a social survey, where the use of a questionnaire as a data-collection tool was needed.

### **Case Study Presentation**

This study was conducted in the neighbourhood of Champs de Manoeuvre, located in southeast of Guelma; a city in the northeast of Algeria. This residential area was built in 1986-1990, limited from the north by the Guahddour Tahar neighbourhood, the 8 mai 1945 university from the south, the 19 June residential area from the east and from the west by Guelma's city-center (Figure 1). It has an estimated population of nearly 20 000 inhabitants, a built environment surface of 1,6 ha (nearly 620 collective dwellings) and a vehicle road surface of 3,2 ha. The CDM neighbourhood was chosen as a case study mainly because of:

- The important traffic flow (light and heavy vehicles) passing through on a daily basis.
- The high population comparing to other sites in Guelma.
- The existence of multiple potential noise sources (schools, hospital, university, ...etc.).



**Figure 1.** The Champs de Manoeuvre neighborhood localization (Source: Google earth, modified by the authors, 2022)

## Noise Measurements Protocol and Survey Design

The noise measurements were carried out twice a week, on Saturday 12<sup>th</sup> and on Tuesday the 15<sup>th</sup> of February 2022 (a week-end day and a week day), during the day time, under satisfactory weather conditions from 9:30 am to 15:30 pm, at 17 stations (sound meter level positions), near to roadway. In order to assess the perceived noise using the calibrated SLM25TK sound level meter, fixed at 1,5m above the ground and far from reflective surfaces, the noise measurement campaign was set to tackle the following sound descriptors:

- The equivalent continuous sound pressure level ( $L_{eq,1min}$ ); to present the amount of sound energy during a given period of time.
- The maximum sound pressure level ( $L_{max}$ ) to describe the highest sound level measured during vehicles pass by in a given period of time.
- The noise level exceeded for 10% of the measurement period ( $L_{10}$ ) is discovered to be a valuable descriptor of road traffic noise since this statistical indicator correlates well with the disruption people experience when they are near busy roadways.

As for the second part of this study, a social survey was conducted by distributing a printed questionnaire, to five buildings, but only for the lower floors (ground level, first level, second level and third level) with four dwellings per floors. These buildings are judged to be the most exposed buildings to noise pollution in this studied area. A sample of 80 dwellings received the printed questionnaire, containing 15 questions that basically tackled qualitative variables divided into four sections stating: Personal information – Dwelling characteristics – Noise perception – Awareness. Overall, a total number of 60 respondent (75% of the total sample size) collaborated with the authors and their answers were retrieved and found valid for analysis, and developed into representative graphs using Origin software.

## RESULTS AND DISCUSSION

After taking adequate noise measurements for two days during the day-time at 17 stations, spread along the main two-lane road crossing the neighbourhood of CDM, in the vicinity of the five surveyed residential buildings, and after retrieving the answers from the distributed questionnaire from the 60 persons who collaborated with the authors (Figure 2), the results obtained from this study are shown in the following sections.



**Figure 2.** Location of the noise measurement stations and the surveyed buildings (Source: Google earth, modified by the authors, 2022)

### Noise Measurement Results

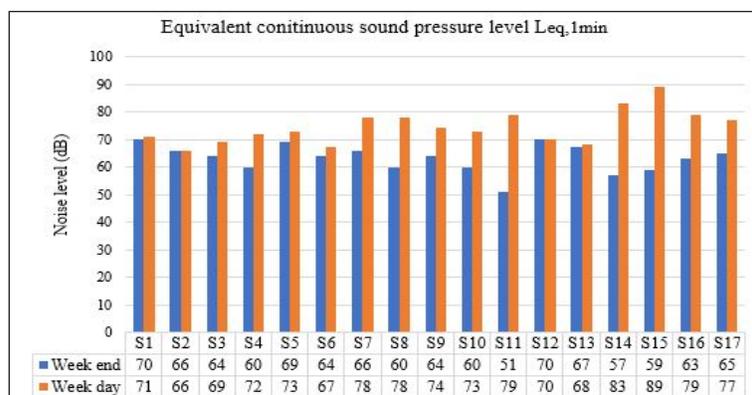
Geographical localization of the stations selected for noise measurement campaign are presented in Table 1.

**Table 1.** Geographical localization of the 17 stations

Stations points	GPS coordinates	
S1	36°45'96.26"N	7°43'15.2"E
S2	36°27'34.3"N	7°25'53.6"E
S3	36°27'33.3"N	7°25'54.2"E
S4	36°27'32.6"N	7°25'54.7"E
S5	36°27'32.1"N	7°25'55.1"E
S6	36°27'31.5"N	7°25'55.3"E
S7	36°27'31.5"N	7°25'55.0"E
S8	36°27'31.1"N	7°25'55.4"E
S9	36°27'30.9"N	7°25'55.7"E
S10	36°27'30.5"N	7°25'55.6"E
S11	36°27'30.0"N	7°25'55.8"E
S12	36°27'27.2"N	7°25'56.1"E
S13	36°27'26.2"N	7°25'54.9"E
S14	36°27'25.3"N	7°25'54.2"E
S15	36°27'24.9"N	7°25'53.5"E
S16	36°27'23.8"N	7°25'51.4"E
S17	36°27'24.1"N	7°25'51.1"E

According to Figure 3, the overall results of noise measurements along the roadside at the 17 stations from 9:30 am to 15:30 pm revealed that Leq,1min levels during the week-end (Saturday, February the 12<sup>th</sup>) varied between 59 dB < Leq,1min < 70 dB. Due to the low volume of road traffic during the week-end, only three stations (18%) recorded noise values of Leq 69 dB and 70 dB, while the rest 14 stations (82%) recorded lower noise values.

However, during the week day (Tuesday, February the 15<sup>th</sup>), the majority of the stations (77%) recorded high noise values that varied between 70 dB < Leq,1min < 89 dB, because of the important traffic volume of both light and heavy vehicles passing by this neighbourhood, particularly at cross-roads and at the existing roundabout in that area. Subsequently, these values exceeded the noise limit of 70 dB admitted by the Algerian noise regulation in the vicinity of residential buildings.



**Figure 3.** Fluctuations of Leq values during week-end and weekday at 17 stations

As seen in Figure 4, although it was a week-end, 9 out of 17 stations (53%) recorded high maximum noise levels (Lmax) from 9:30 am to 15:30 pm, with noise values that varied between 73 dB and 78 dB, while at the same time, lower noise values of Lmax were recorded at the rest of the stations. Furthermore, very high noise levels of the maximum noise

pressure level Lmax were recorded 100% in all 17 stations during the week day, certainly because of the important traffic flow in that urban area as mentioned before and due to vehicles acceleration and car horns, which in consequence it showed a non-compliance with the maximum noise limit of 76 dB admitted in the national noise regulation.

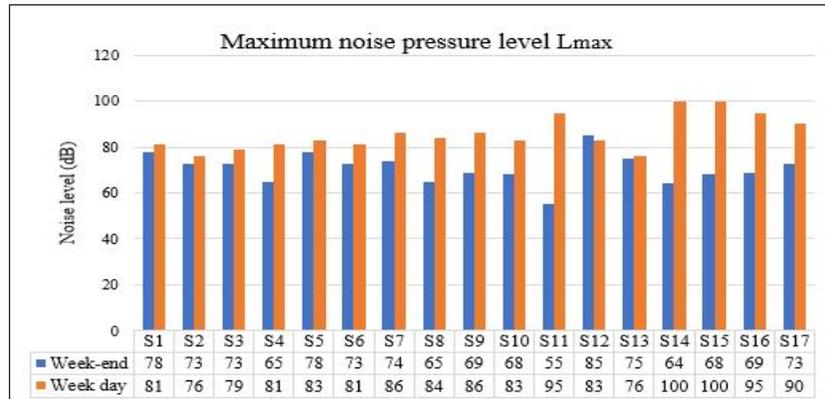


Figure 4. Fluctuations of Lmax values during week-end and weekday at 17 stations

In addition, exceeded noise levels for 10% (L10) of the measurement time (6h), the noise values fluctuated over 60 dB during the two days of measurement in all 17 stations, reaching up to high level of 92 dB, which could easily create a feeling of discomfort and annoyance for the residents of the Champs de Manoeuvre (CDM) neighbourhood, due to high sound intensity emitted by road traffic noise.

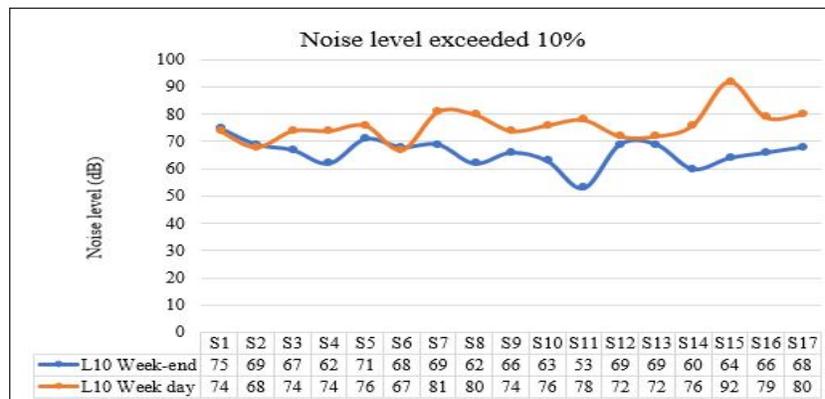


Figure 5. Fluctuations of L10 values during week-end and weekday at 17 stations

### Survey results

For the first section of the questionnaire concerning the respondent’s personal information, it was shown in Figure 6a that almost 53% of the respondents were women occupying the surveyed dwellings, stating that they spent almost the majority of their time during the day in their homes, so that they were certainly subject to noise, while 47% of the respondents were men. Figure 6b shows that there are three age groups, with 42% of the respondents aged between 20 and 40 years and over 50 years, while only 17% of them were aged between 40 and 50 years, which subsequently explains why the majority of the inhabitants are homeowners, representing 82% of the respondents (Figure 6c). The acquisition of such statistics indicated that these respondents are adults and are qualified to offer valid responses.

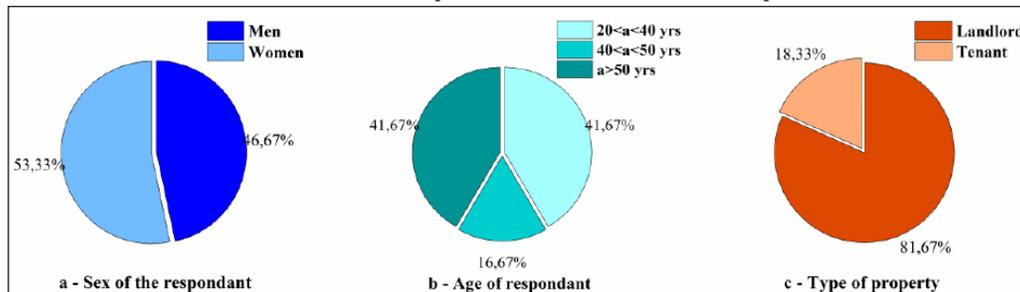


Figure 6. Personal information of the respondents (Source, authors, 2022)

The next section of the questionnaire was concerned about the characteristics of the surveyed dwellings. Figure 7a shows that 35 respondents (58%) declared that they live in a dwelling that faces the main road, while 25 respondents (42%) answered that their dwelling is either next to the main road or far from it. Moreover, from Figure 7b, it was found that 39 respondents (65%) live in flats in the ground floor, 10 respondents (17%) live in the first-floor flats, while only 8 persons (13%) live in the second-floor flat and 3 persons (5%) live in the third-floor flats. The reason why the authors chose only these three floors because of the noise propagation theory; as the distance from a linear sound source (e.g., a roadway) is doubled, the sound pressure level is reduced by 3 dB (Hamayon 2010). Figure 7c indicates that a total number of 34 respondents (57%) answered that they live in a flat type F3 (two bedrooms and a living room), which explain the high percentage of the dwelling tenancy from the above-mentioned results. Only 15 of the respondents (25%) live in F4 flat, while the rest of the respondents (18%) live in F5 flat.

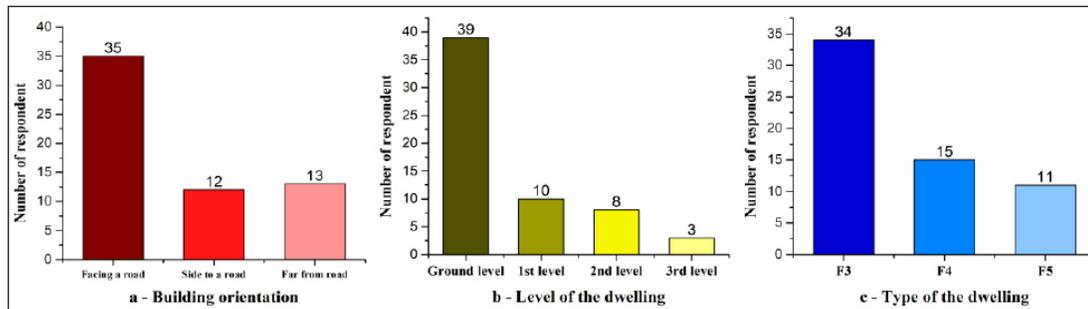


Figure 7. Characteristics of the dwellings (Source, authors, 2022)

The third section of the questionnaire addressed the outdoor and indoor noise perceived by the residents. It was observed that 50% and 33% of the residents of the CDM neighbourhood considered that the city center of Guelma has a noisy and a very noisy soundscape, respectively, while only 17% of them claimed that it is calm and peaceful (Figure 8a). However, the CDM neighbourhood seems calm and moderately noisy on specific periods for 12% and 48% of the respondents, respectively. 35% of them considered it noisy to a very noisy neighbourhood (Figure 8b).

In addition, 50% of the residents surveyed confirmed that they are annoyed mostly from road traffic noise in their dwellings (during 1min, an average of 15 light vehicles, 2 motor-cycles and 1 mini bus), which means in this case that more than half of the surveyed dwellings are likely to be subjected to road traffic noise due to the building position near to the roadway. 47% of them complained about the neighbour noise, while only 3% of the rest of them accused other types of noise like animals and kids (Figure 8c). 70% of the respondents suffer from outdoor noise particularly during the day-time (from 5am to 13pm), while 30% of the rest declared that they are annoyed at the evening and at night (from 17pm and 3am) because of the motor-cycles noise (Figure 8d).

Furthermore, 25% and 43% of the respondents affirmed that their living rooms and bedrooms are subjected to outdoor noises (Figure 8e) due mainly to unfavorable spatial distribution of interior spaces and poor sound insulation properties of the façade panels (walls and windows). Also, 13% and 18% of the respondents perceived noise nuisance in their wet rooms and balcony, respectively.

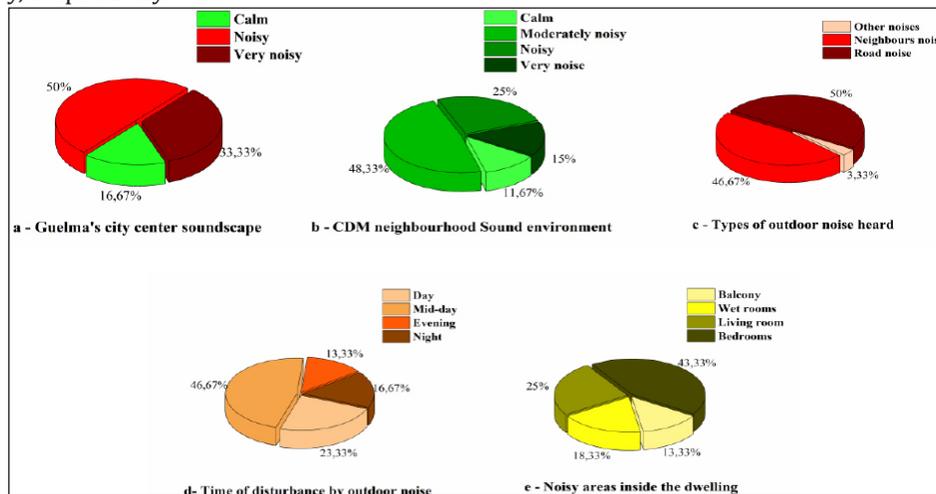


Figure 8. Outdoor noise perception by the respondents (Source, authors, 2022)

As for the indoor noise, 15 respondents informed that they hear neighbours' conversation noise, while 12 respondents suffer from footsteps noise any only 10 of them criticized the behaviour noise of the neighbours, when other are annoyed from other types of pink noise like household appliances noise, occasionally DIY and noise of kids playing(Figure 9a). Since the residents were annoyedand presented a high rating of sound discomfort against neighbours noise (with a score of 4/5), it was found that 42 respondents (70%) had psychological effect from noise and are living in a state of stress and anger, while an average of 4,5 respondent got used to it, got outside, asked nicely to lower it down or even complained about the noise heard (Figure 9b), this is why on Figure 9c, it shows that 26 respondents (43%) are thinking about moving out of their dwellings due to unbearable noise heard, yet 34 of them (57%) chose to stay in.

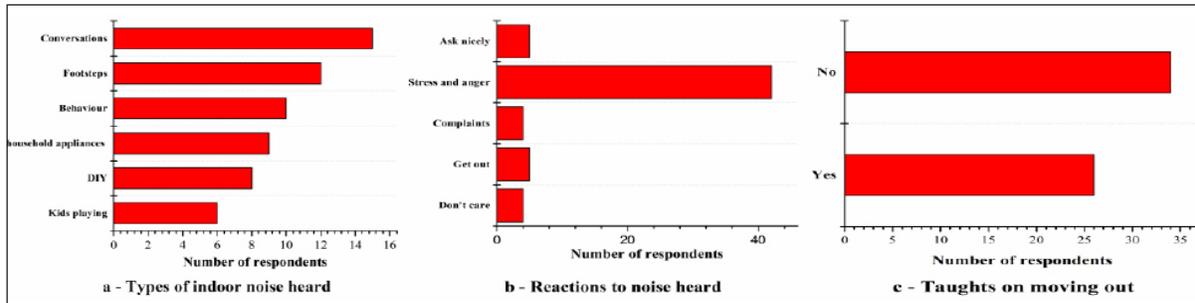


Figure 9. Indoor noise perception by the respondents (Source, authors, 2022)

The last section of the questionnaire was devoted to the awareness rating of the respondents. It seemed that the majority of the respondents (58%) are unfamiliar with the existence of the Algerian noise regulation, 30% of them have an idea about it and only 12% of the rest of them acknowledge the regulations (Figure 10a). Besides, 65% of the respondents are not aware that the noise has negative effects on the human health, 27% of them have a humble idea about it while only 8% of the respondents declared that they acknowledge the risks provoked by noise (Figure 10b). As a result, the collective awareness of the inhabitants of the Champ de Manœuvres neighbourhood about the national acoustic regulations in force and the health noise effects remains evasive.

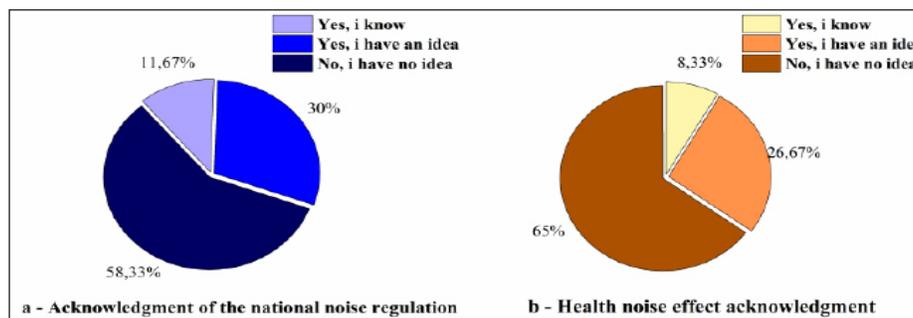


Figure 10. Awareness rating of the respondents (Source, authors, 2022)

In short, it wasevident that the level of noise discomfort among the respondents in relation to their daily exposure to noise is high. Consequently, the health dimension of the inhabitants of the Champs de Manœuvre neighbourhood in Guelma is affected quiteseverely by the omnipresent noise nuisance, particularly road noise, which seems to exceed the thresholds recommended by national regulations of 76 dB.Other studiescarried out in residential areas in different districts in Thailandstated similar findings, in which Leq and Ldn noise levels exceeded the limits admitted in the noise regulation of Thailand and annoyance levels of the residents were detected with high scores, referring to their dissatisfaction with noise in their living environment(Thareejit, Sihabut, and Patthanaissaranukool 2020); (Bunnakrid, Sihabut, and Patthanaissaranukool 2017).

## CONCLUSION

This study illustrated based on the results of a noise measurement campaign and a sociological survey, an assessment of noise pollution and discomfort level of the residents of the Champs de Manoeuvre neighbourhood in Guelma.The results obtained from the analysis have made it possible to know that both of road traffic noise, with an average equivalent continuous sound pressure level Leq of 63 dB during the week-end and 75 dB during the week day, and neighbours' noise are the two main sources causing noise nuisance, at a time when about 70% of the residents surveyed have suffered from stress and anger, due to outdoor noise, which can consequently cause important morbidities such as

cardiovascular disorders and hypertension. 30% of the respondents believed that this is due to the poor orientation of their dwellings and the poor technical properties of the buildings with regard to the high noise levels heard. It is preferable in the first instance to reduce noise at its source and limit its propagation by implementing a set of direct and indirect actions and by raising society's awareness through educational programmes and opinion polls, involving experts and specialists in the field of acoustics and environmental noise to discuss and explain the consequences of this problem, to improve the social living environment and maintain human health.

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### **Competing of Interests**

The author(s) declare that they have no competing interests.

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