Chapter

Influence of Noise in Ambulance Vehicles on Emergency Service Personnel

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Abstract

Every day, noise is a ubiquitous potential hazard to our body. Importance is already dedicated early in history and still continues by steady investigations in terms of protecting the personnel in loud environment. "Worldwide, 16% of hearing loss in adults is attributed to occupational noise." Noise-induced hearing loss (NIHL) is a sensorineural hearing loss, explained by permanent threshold shift of hearing sensitivity. NIHL not only affects the auditory system but also has psychosocial effects and is proved to have interference with general health by sleep disturbances or cardiovascular symptoms. This study aims to detect and define the sound pressure levels that ambulance service workers are exposed to during their shifts in ambulance vehicle, especially with the focus on differences during signal and non-signal use and different speed levels and determining whether the noise has hazardous character. The collection of study data is composed of two parts. The first part is the indication of noise level in the ambulance vehicle with the help of a sound level meter. The second part included a questionnaire that constituted 14 questions sent electronically. In total, 207 workers responded.

Keywords: Noise-induced hearing loss, emergency service personnel, ambulance vehicle

1. Introduction

Historically, the earliest descriptions about the danger of noise-induced hearing loss (NIHL) were described in 1713 by the Italian physician Bernardino Ramazzini (1633–1714). In his book "De Morbis Artificum" (Diseases of Workers), he firstly demonstrated the impact of hearing loss together in a relation to prolonged exposure to noise by his observations based on his examinations on coppersmith workers who were constantly exposed to noise and gradually suffered from hearing loss [1].

During the eighteenth century with onset of rapid industrialisation, the incidence of NIHL increased drastically and lead to the first ideas of preventive actions.

Almost 200 years later, the Hungarian biophysicist Georg von Békésy (1899–1972) analysed the travelling wave of sound in the cochlea, for which he received a Nobel Prize in 1961 and simultaneously set the cornerstone for the start of investigations of noise and hearing loss in relation to exposure time [2].

The origin of the noun "noise" is found in Latin language from the term "nausea", which later via detours through French language was introduced as "noise" to the English language [3]. Both words have much more in common than suspected before.

Substantially, there is no difference between sound and noise. But enlightening the differences more closely, sound refers to the sense of perception that usually occurs on voluntary basis and delights the listener as it is for example by listening to music. On the other hand, noise is defined as an unwanted sound that may cause displeasure, annoyance and pain or, referring back to its word origins, nausea.

Investigations have shown that continuous noise exposure has an enormous damaging impact not only on hearing but also on the general health status of the population.

Although preventable, NIHL is one of the most widespread irreversible occupational diseases worldwide and thus was declared as a serious occupational hazard [4].

Several studies gave evidence that noise creates physical and psychological stress, commonly presented as reduced assessment, sleep disturbances, cardiovascular dysfunction and mental health alteration [5, 6].

The protection of health and safety from hazards at work should be our all interest. Therefore, our research is aimed at evaluating the impact of occupational noise on hearing, general security of health, quality of life and productivity of those working in stressful environments shown at the example of emergency service working personnel, who give constantly their best to protect and save our health during emergency.

2. Literature review

2.1 Basics of acoustics

Noise can be described as rapid fluctuations in atmospheric pressure, which affects the human body as vibrations that are perceived by the human ear and finally can be classified as sound.

Sound propagates as a pressure wave and is able to travel through any elastic medium (e.g., air, water, wood, and metal).

Important units for measurements of noise attributes are hertz (Hz) and decibels (dB), and together with some basic knowledge of physics of waves, frequency, wavelength, amplitude, refraction, absorption and transmission, we are able to understand the behaviour of noise and can develop controls and preventions. When molecules start to move due to atmospheric pressure changes, the moving air molecules pass their energy on to neighbouring molecules, which results in the spread of their energy over and over until an increasingly larger volume is created. This principle can be compared to the ripples when a stone is thrown into water. These described pressure changes are detected by the eardrum, which in return vibrates as response. In return, the vibrations are further transferred to the middle ear, which is constructed of three tiny bones facing towards the fluid-filled inner ear. The inner ear contains tiny inner and outer hair cells, which convert the vibrations into electrical nerve impulses that then are sent to the brain. Finally, the brain is then able to process these impulses into meaningful sounds [5, 7].

The perception of loudness of a sound is determined by two factors: sound pressure and frequency. The frequency (number of vibrations per second) is related to "pitch". The higher the frequency, the shaper the sound heard by the subject [7].

Important issues about noise perception are as follows: Sound pressure levels are measured in (dB). They describe the amplitude of the sound waves. They are related to the loudness of the sound. The A-weighted sound pressure levels are measured in dB(A). A-weighting considers the non-linear response to sound of the human ear, and also its non-homogeneous response to sounds of different frequencies and intensities. This level is determined by using a standardised weighting at different frequencies and then, summing logarithmically these sound pressure levels. The A-weighted sound pressure levels better represent the auditee's perception of noise. They are used for many applications, from community noise ordinances to occupational noise exposure regulations.

2.1.1 Noise as a dangerous hazard

Every day, we are naturally exposed to loud, distracting and possibly hazardous noise. A common experience for everyone may be the example of continues ringing after a great concert or muffled sounds after working with loud tools (chainsaw, grass cutter, etc.).

Noise at prolonged exposure at 80 dB has unsafe effects to the auditory system but also to general health [5, 7, 8].

Studies proved that the risk for NIHL increases exponentially in noise-exposed population, who are exposed to noise level beyond 85 dB(A) for a prolonged time [9].

Table 1 shows critically how noise is correlated with health that is shown in three different stages of noise levels in dB(A).

At the example of "Conversation", it can be nicely illustrated in what manner noise level has an impact on health.

A standard conversation is measured at approximately 50 dB(A), which at a prolonged exposure may lead to mental reactions (e.g., low concentration and annoyance); at 80 dB(A), for communication, the voice needs to be elevated remarkably that interferes with health shown in physical reactions (e.g., hypertonus); and at 90 dB(A), communication is not possible anymore, which in return in long term is unbearable and triggers pain threshold.

2.1.2 Noise exposure and limit values

Determining the limit of noise exposure is crucial to take three components in consideration:

1. Worker (genetic predisposition)

2. Character of noise: sound pressure level and frequency

3. Duration of exposure

Generally, the potential and stage for hearing loss by noise are related to the workers' duration of noise exposure and stage of noise loudness.

Halving acoustic energy can be done reducing sound pressure level by the 3 dB or halving the exposure time [10].

For better understanding, see the following examples. These noise exposures are the same:

Noise level and body reaction	Type of noise	Sound pressure levels in dB(A)	Sound sense
I 30–65 dB(A) Mental reaction	Fine ticking of a clock, whispering	30 dB(A)	Very quiet
	Library, bedroom at night	40 dB(A)	Pretty quiet
	Conversation	50 dB(A)	Normal
	Quiet office	60 dB(A)	Moderate to loud
II 65–90 dB(A) Physical reaction	Shouting, car in 10 m distance	70 dB(A)	Loud to very loud
	Street noise in heavy traffic	80 dB(A)	Very loud
III 90–120 dB(A) Hearing loss, ear pain	Loud factory hall	90 dB(A)	Very loud
	Car horns in 7 m distance	100 dB(A)	Very loud to unbearable
	Full symphony orchestra	110 dB(A)	Very loud to unbearable
	Jet engine, live rock band	120 dB(A)	Unbearable to painful
		130 dB(A)	Intolerable

Table 1.
Overview of noise level and impact on human body.

- 80 dB for 8 h
- 83 dB for 4 h
- 86 dB for 2 h
- 89 dB for 1 h
- 92 dB for 30 min

International standards recommend an "equivalent sound pressure level of 85 dB(A) at 8-h working day average as the exposure limit for occupational noise" for preservation of the personnel's hearing when working in a noisy environment. However, in reality, it shows that this limit does not guarantee safety, especially for the hearing system of workers, since 80 dB(A) is already indicating harmful effects [11].

Therefore, Noise at Work Regulations recommend a "three action levels for occupational noise level" depending on equivalent noise level for 8-h working day (see **Table 2**).

2.2 Overview of hearing loss

Hearing loss can be categorised depending which parts of the hearing system are damaged. There are three basic types of hearing loss: conductive hearing loss, sensorineural hearing loss, and mixed hearing loss [12].

Conductive hearing loss occurs due to damage of outer structures of the auditory system.

The sound waves are not properly conducting through the outer ear canal, the eardrum and ossicles of the middle ear. It is characterised by a reduction of sound level perception or the ability to hear weak sounds. Good treatment options are surgery or medication depending on issue.

Action level	$L_{Aeq}8h$
First action level (minimum) provide protection	80 dB(A)
Second action level mandatory protection	85 dB(A)
Maximum exposure limit value	87 dB(A)

Table 2.
Three action levels for occupational noise level.

Causes of conductive hearing loss are as follows:

- Fluid in the middle ear
- Ear infection (otitis media or otitis externa)
- Poor eustachian tube function
- Trauma, e.g., perforated eardrum
- Obstacle such as cerumen, tumour or foreign body

Sensorineural hearing loss appears in case of damage to inner structures such as cochlea or to the nerve pathways from the inner ear to the brain.

Characteristically, it is described by the reduced ability to hear faint sounds. Even when speech is loud enough to hear, it may still appear to be unclear or sound muffled. Unfortunately, there is no treatment option.

Examples:

- Ototoxic medication
- Genetic or hereditary
- Ageing
- Head trauma
- Exposure to loud noise

2.2.1 Noise-induced hearing loss

NIHL is one of the most common occupational illnesses, because it is often ignored since there are no visible effects or pain sensation in early stages.

Factors that especially predispose one to NIHL are found in high-frequency noise exposure, which is known to be much more harmful than low-frequency noise, and also continuous stimuli are more damaging than interrupted stimuli.

NIHL starts with a temporary threshold shift (TTS). Physiologically explained, while the ear is exposed to the noise, there originates a release of ATP from stria cochlearis, which provides the necessary energy for the function of the hair cells. In case of prolonged elevated noise exposure, a mismatch occurs between energy supply and consumption, as the ATP needs to reach the hair cells by diffusion. The hair cells get tired due to energy depletion and result to be less sensitive. This leads to a shift in hearing threshold but has still potential to recover completely when the harmful stimulus is removed [13].

If the exposure to the harmful noise still continues, the cellular integrity of the hair cells of the Corti organ disrupts gradually and ultimately the nerve fibres that innervate the hair cells will disappear, thus resulting in permanent threshold shift (PTS), and henceforth, irreversible hearing loss at higher frequencies will be noted. In most cases, it is described affecting both ears symmetrically [14].

NIHL can be classified into four stages: mild, moderate, severe and profound [15].

1. Mild NIHL is a high-frequency hearing loss of sounds between 20 and 40 dB.

2. Moderate NIHL, between 40 and 60 dB.

3. Severe NIHL, between 60 and 80 dB.

4. Profound NIHL, greater than 80 dB.

Limitations in hearing are evident when listening to high frequencies. First noticed problems are trouble understanding speech during present background noise. NIHL progresses gradually, and people have difficulty understanding high-pitched voices (e.g., women and children) even in quiet conversational situations, whereas conversation on the telephone is generally unaffected.

TTS slowly progresses to PTS, post exposure tinnitus, and TTS serves as warning signs of impending permanent NIHL [14].

2.2.2 Audiogram

Hearing loss is detectable by performing an audiogram and is presented as a graph that shows the weakest sounds a person can hear at different frequencies. It can be used to detect the concrete severity of sensorineural hearing loss or for check-up reasons.

For TTS, there is a chance that the shift regresses again after the noise is removed.

Therefore, the sound pressure level during the recovery period is kept below 70 dB(A) and a recovery time of at least 10 h.

In case the recovery period is not respected, an accumulation of the individual TTS may occur and leads to PTS, which can be detected in the audiogram (see **Figure 1**).

NIHL is typically shown with selective loss of hearing at around 4000 Hz, which is apparent in the audiogram as a notch-like depression.

If exposure to harming noise is continued, the notch gradually deepens and widens. It can also take over to the middle frequencies. In very severe cases, even the lower frequencies may eventually become involved [5].

2.3 Consequences of NIHL

Consequences of NIHL may severely interfere with both social and occupational environment. NIHL as a reason for limited communication ability with co-workers and family may develop anxiety, irritability and decreased self-esteem resulting in loss of productivity and, eventually, social isolation.

Figure 1.
Audiogram characterising early NIHL.

In terms of safety, NIHL often runs together with a reduced ability of assessment and to monitor work environment such as warning signals or equipment sounds and immensely increase the danger of injuries.

2.3.1 Health risks

Noise creates physical and psychological stress that can interfere with health leading to extra aural health risks. Common early symptoms can be found psychosocially as sleep disturbances, concentration difficulties and clumsiness.

Depending on the extent of sound pressure level, it can influence the vegetative system by a shift in favour towards the sympathetic nervous system. Examples are tachycardia, hypertonia, tachypnoea, increased adrenal secretion of stress hormones such as cortisol and decrease in gastric secretion for protection of gastric mucosa. In the long term, these symptoms have potential to interfere severely with health [16].

3. Methods and materials

3.1 Study design

The data were collected through a retrospective cohort study using a questionnaire with a total sample size of 207 workers from two main emergency ambulance service centres located in Riga, Latvia, and Aurich, Germany.

Additionally, the noise level was detected by measurements with a sound level meter.

3.2 Description of data collection

Materials of use:

1. Questionnaire (14 questions)
2. Sound level meter

The collection of data is divided into two parts.

The first part includes the collection of basic personal and working information via a questionnaire of 14 questions. Hundred and five Latvian and hundred and two German emergency service workers responded to the questionnaire. The questionnaire was shared as electronic survey at http://www.visidati.lv and also distributed as printed paper to the different working stations. The collection of personnel information started in January 2016 and ended in May 2016.

The research data were collected and statistically processed in Microsoft Office Excel 2010 and SPSS 22.0.

The second part refers to the measurement of noise level by use of a sound level meter reviewing non-signal and signal noise exposures during 12-h shifts and by this giving the basis to analyse the average noise level that an emergency service personnel is presented to.

The collection of measurement started in January 2016 and ended in February 2016.

Digital sound level meter model LUTRON SL-4013 conforms to IEC 651 Type 2 with 0'. Noise was measured using a standard microphone head that was placed in the front passenger compartment of an ambulance during emergency driving. The equipment was programmed to collect data in fast mode, using the weighting curve "A". Also, a protective foam in the microphone in order to minimise the other noise effects was used.

The measurements were recorded during 20 emergency trips with a duration range from 10 to 15 min. These measurements were performed in different days, periods and shifts. The noise levels were carefully recorded at different velocities under the following conditions:

- Asphalt street and good surface conditions of the street
- Measuring device placed in the centre of the cabin at level of the ears of workers
- Taking measured number at stable driving of 50, 70 and 100 km/h
- Mostly free field as surrounding (no high density of high houses)
- No talking, no funk communication
- Radio turned off
- Windows closed
- No rain, calm wind

The ambulance car is analysed in terms of technical specification and physical dimensions.

For proper comparison of the ambulance service in Germany and Latvia, we chose similar cars in model and age.

Both countries use the Mercedes-Benz, Sprinter 315, CDI model, 4-door, manual and manufacturing year 2010 (Riga, Latvia) and a similar model from year 2012 (Aurich, Germany) This model is a standard Sprinter with high ceilings. The front cabin design layout constituted likewise.

The sirens are located bilaterally on the roof and front spoiler of the ambulance car. The type of sirens and frequency for Latvia and Germany differ especially in frequency of sound melody. Germany is using sirens of type "Martin-Horn 2298 GM" DIN 14610 EC with a 4′ membrane-bell and sound pressure level of 125 dB(A) at a distance of 1 m.

In Latvia, there is no standardised sound melody throughout a signal trip. During signal trips, the driver can choose manually between different frequencies.

4. Research results

4.1 Sound level meter measurements

The average sound levels based on the measurements performed during numerous emergency trips are as shown in **Table 3**.

In Germany, the minimum noise level is measured at 50 km/h without signal use with 63.5 dB(A) and the maximum is measured at 100 km/h with signal use with 84.8 dB(A).

In comparison, in Latvia, the minimum is measured at 50 km/h without signal use with 67.3 dB(A) and the maximum is measured at 100 km/h with signal use with 90.7 dB(A).

For both countries, it is noticeable that the noise level during signal use is enormously elevated than during trips without signal use. Comparing the Latvian with German emergency cars, non-signal trips are measured with a higher average noise level with an average difference of 5.2 dB(A) and during signal use the noise level in Latvian emergency cars is also higher by a difference average of 2.4 dB(A). This means, the Latvian emergency personnel is exposed to an overall higher noise level during emergency trips than German emergency personnel.

4.2 Questionnaire

The research included in total count 207 emergency workers from different emergency service centres. Hundred and two German and hundred and five

	Germany		**Latvia**	
	Without signal	**With signal**	**Without signal**	**With signal**
Average	66.5	84.7	71.9	86.6
50 km/h	63.5	84.4	67.2	83.3
70 km/h	65.2	84.8	72.4	85.9
100 km/h	71.4	84.8	76.1	90.7

Table 3.
Measured sound pressure level in dB(A) according to speed and considering all data together, for Germany and Latvia.

Latvian emergency workers answered fourteen questions in an electronic form at http://www.visidati.lv or in printed version.

4.2.1 Population characteristics

In total, the respondents are defined by 116 (56%) men and 91 (44%) women aged between 18 and 65 years.

In Germany, the majority of personnel is formed by men (35%), while in Latvia, the majority is dominated by female workers (30%) (see **Figure 2**).

The age distribution shows that the Latvian emergency personnel in general are composed of a rather young team in the age range of 18–30 years (18–25 years = 57.1%, 26–30 years = 30.5%), and in return, the German personnel show a wider range of age distribution, which majorly is observed to be between 18 and 40 years (18–25 years = 46.1%, 26–30 years = 22.5%, 31–40 years = 16.7%). Consequently, the emergency workers in Germany are older compared to the Latvian emergency workers (see **Figure 3**).

Relating the personnel's age and years of employment, a correlation is apparent. The vast majority of the young Latvian workers have been working for 1–5 years (84.8%) and then an abrupt decrease of employment time by approximately 80% is seen, while the investigated German ambulance service also has its peak employment time at 1–5 years (54.9%) but then gradually decreases by 50% (see **Figure 4**).

According to the amount of shifts per week and the density of emergency occurrence, both countries have four shifts of 12 h during a 7-day working week and parallels are seen for the average amount of trips that are set at approximately six non-signal and five signal trips for both countries.

Evaluating the amount of hours the worker is exposed to noise during trips, the German ambulance service personnel are approximately 1.5 h (63 min) longer exposed to noises from signal and 0.71 h (43 min) longer exposed to non-signal noises during a 12-h shift. Comparing both countries for their total emergency

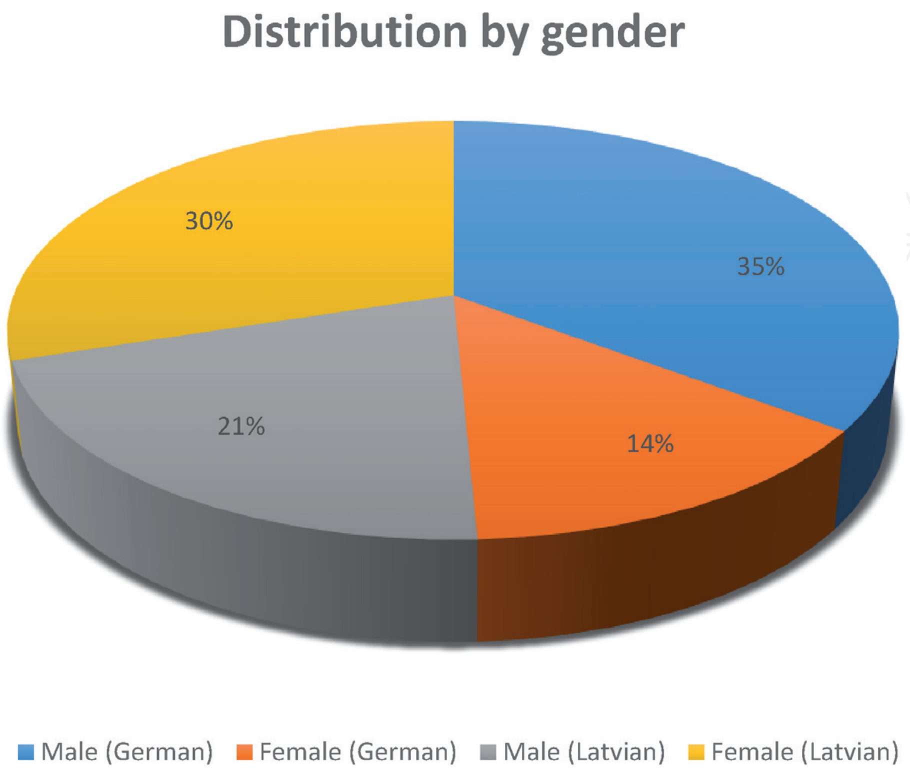

Figure 2.
The percentage of survey population by gender.

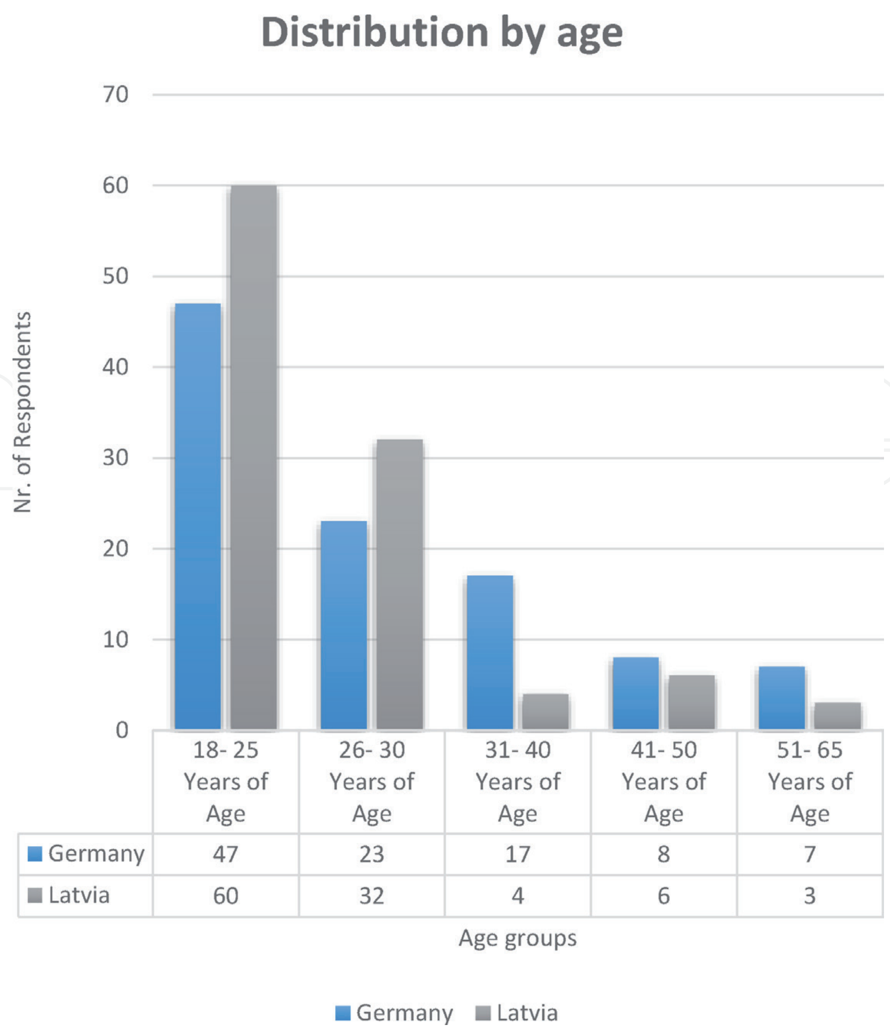

Figure 3.
The distribution in absolute numbers of survey population by age, Latvia and Germany in comparison.

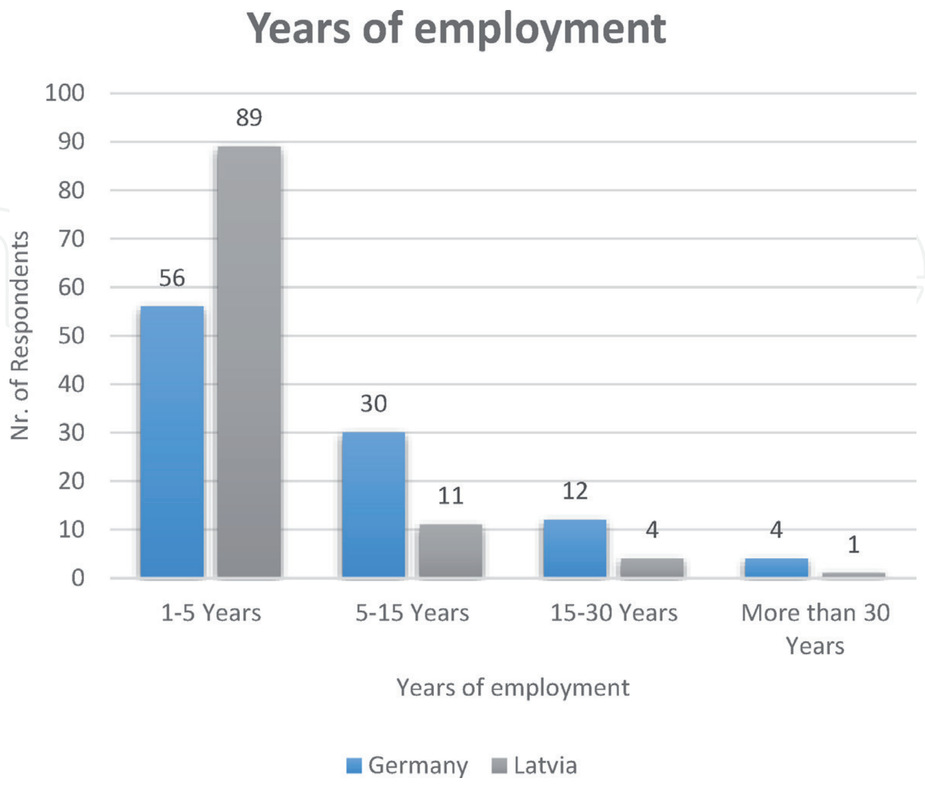

Figure 4.
The distribution in absolute numbers of survey population by years of employment, Latvia and Germany in comparison.

trip-related noise exposure during a 12-h shift, German personnel are in total 68% exposed to noise and Latvian personnel in total 53% (see **Figure 5**).

The time that the worker is not sitting in the car and presented to the evaluated noise is categorised as “other” in **Figure 5**, which stands for the time, e.g., in the hospital, patient house or guardhouse. It is impossible to measure these noise levels; nonetheless, it should be taken into consideration, since presentation to noise is ubiquitous and affecting the body.

4.2.2 Symptom prevalence

In the questionnaire, respondents were allowed to choose more than one symptom and indeed, most respondents indicated more than one symptom. In comparison, Germans assigned 1–2 fitting symptoms and Latvians choose 2–3 (see **Figure 6**).

For both countries, a common pattern of complaints and also highest incidences were found in following two symptoms: difficulties of understanding during background noises (Germany 30.2%, $N = 42$ and Latvia 26.6%, $N = 46$) and tinnitus (Germany 38.8%, $N = 52$ and Latvia 23.8%, $N = 41$).

Other similarities but with lower frequency are given for hyperacusis (Germany 6%, $N = 6$ and Latvia 5.8%, $N = 10$), pain or pressure in the ear (Germany 13.4%, $N = 18$ and Latvia 13.4%, $N = 23$) and difficulties understanding speech, particularly women and children (Germany 7.9%, $N = 11$ and Latvia 10.4%, $N = 18$).

Comparing main differences, Latvian emergency workers show a much higher incidence of symptoms such as vertigo (23.8%, $N = 41$), changes in sound perception (7.5%, $N = 13$), difficulties in determination of sound direction (5.8%, $N = 10$) and difficulties using the phone due to poor understanding of the partner (13.3%, $N = 23$).

German emergency personnel showed higher prevalence only for difficulties understanding electronic audio devices such as TV and radio and thus the need to increase the volume (20.9%, $N = 28$).

Concluding, Latvian emergency personnel clearly dominate in 8 from 10 auditory symptoms with higher absolute number.

For a closer accurate evaluation risks for NIHL, also an average noise exposure during free time was requested giving a defined range from 1 (low noise exposure) to 10 (high noise exposure). Both indicated an average free time exposure to noise at 5.

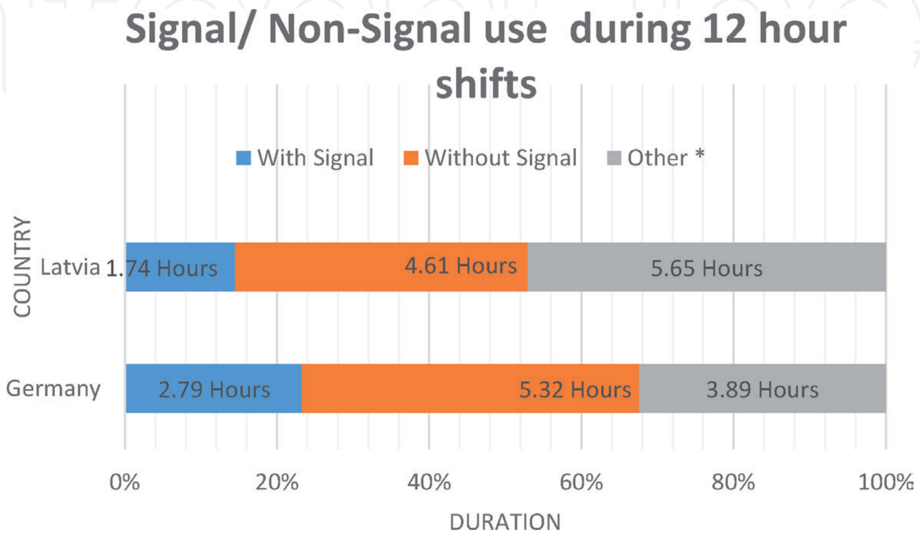

Figure 5.
*Time of exposure of the survey population to signal and non-signal trips during a 12-h shift. *Others include the time during the 12-h shift outside the emergency car.*

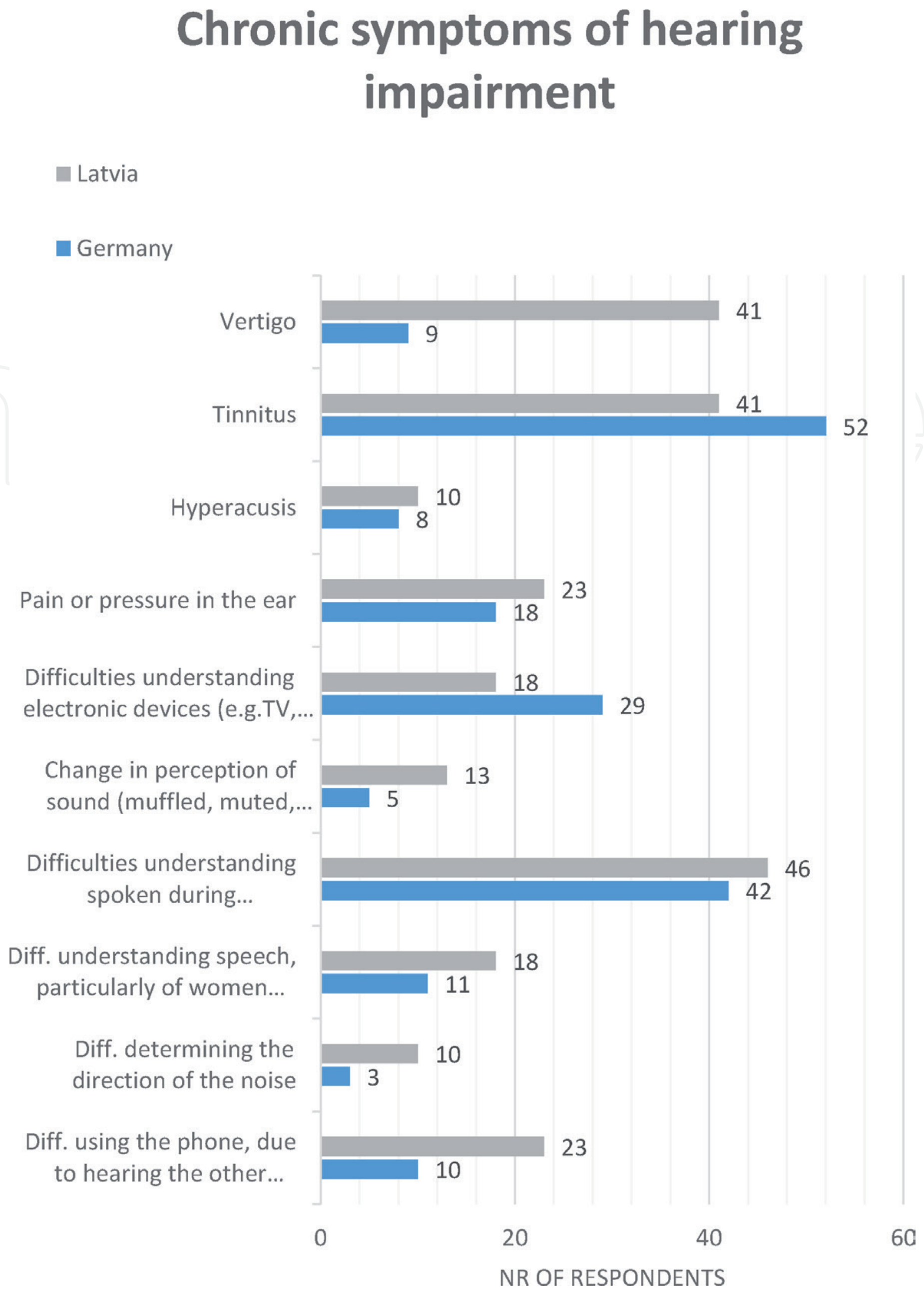

Figure 6.
Prevalence of chronic hearing symptoms for each country of the survey population in absolute number, Germany and Latvia in comparison.

4.2.3 Statistical data

Statistical investigations for relations according to the study showed that there is no significant relation between countries, age, gender or length of employment towards symptoms ($p > 0.05$) and thus cannot be attributed to the general population.

5. Discussion

When persons with normal hearing are exposed to high noise levels over a prolonged period of time and by this reaching or exceeding the limit of permissible noise level exposure equivalent of 85 dB(A) during 8 h, a shift of hearing threshold may result. Under a threshold shift is meant an average deterioration of hearing of 10 dB(A) or more in the frequency ranges of 2000, 3000 and 4000 Hz in both ears, defined by Occupational Safety and Health Act (OSHA).

This deterioration of hearing can be of a temporary nature (TTS), or in opposite at continuous exposition can result to a permanent threshold shift (PTS) and hearing loss.

The amount of hearing loss results from the sound pressure level, the duration of exposure, the frequency of noise and the individual predispositions.

The study focuses on the distribution of symptoms that determine the current state and assess the future trend of NIHL risks. The Latvian ambulance service personnel are exposed up to 5.2 dB(A) (non-signal) and 2.4 dB(A) (with signal) louder noise than German personnel. Both countries demonstrate an exposure to hazardous noise level of approximately 85–90 dB(A) during signal trips, which reaches and partly exceeds the exposure limits of 85 dB(A).

Sound measurements of this study show that during non-signal trips, the noise pressure level varies depending on speed by 2–6 dB(A). The faster the speed level, the greater the noise level. During signal trips, for Latvians, the increase in noise level is by 2–4 dB(A) depending on speed level seen, but for Germans, the noise level stays almost constant at different speed levels.

However, during a 12-h shift, the Latvian survey population is exposed for approximately 2 h to signal trips with an average noise level of approximately 87 dB(A) and the German survey population approximately 3 h to signal trips with an average noise level of 85 dB(A).

Referring to OSHA regulations, both countries are not exceeding the limit of permissible noise level exposure equivalent. Thus, the exposure to noise during emergency trips with signal is considered to be safe for the auditory system.

Nonetheless, especially the Latvian emergency personnel indicate a great dominance for auditory changes, as clearly shown in my study data.

Possible explanations for the contrary facts may be found when considering the sirens of the ambulance vehicles. The frequencies of ringtones that can be selected in Latvian cars are usually higher and thus more harmful to the hearing system. Also the majority of streets are in rather poor condition, which increases the noise level by its vibrations. Furthermore, accumulations of numerous unrecovered TTS by short and extreme fluctuations of noise level may also trigger NIHL. Moreover, the natural limitations of the study need to be taken into account. Firstly non-job-related noise exposure such as listening to a walkman loudly for long time or being a member of an orchestra and giving a concert has a great impact on hearing, which limits the accuracy of the study. Secondly, during the last 5 years, both ambulance services invested enormously into new cars and equipment. Thus, the symptoms can be a result from the older cars, where presumably the noise level must have been presented far louder.

5.1 Preventive measures

Personal:

- Regular medical examinations of workers
- Personal protective devices (e.g., filter-type earplugs)
- Education of both workers and the management staff in order to prevent NIHL
- Planning and organisation to avoid streets of bad quality, which produce excessive noise or need of prolonged signal use due to a crowded traffic

- Intelligent planning of the duty roster to provide rest from loud noise exposure
- Keeping the noise level and its exposure during leisure time safe
- Audiogram check-ups to make the personnel more aware of the auditory status

Vehicle:

- Acoustic insulation and sound proofing to doors, walls and ceilings
- Fixing all loose equipment in the cabin for safety reasons but also noise reduction
- Positioning of sirens as far away as possible from the personnel, e.g., front of the spoiler

6. Conclusion

1. NIHL is one of the oldest and most common occupationally induced health issues worldwide.
2. Common pattern and highest prevalence for auditory symptoms for both Latvian and German ambulance services are:
    - Difficulties of understanding during background noises
    - Tinnitus
    - Vertigo
    - Difficulties understanding electronic audio devices such as TV and radio and thus the need to increase the volume
3. The Latvian ambulance service personnel have a higher risk of developing NIHL reasoned by high frequency of sound melody of the sirens and exposure to higher sound level during signal trips, caused by poor street conditions.
4. For both countries, the noise level is remarkably elevated during signal trips compared to non-signal trips.
5. Speed level influences the noise level during trips without signal by 2–6 dB(A). The higher the speed, the higher the noise level during non-signal trips.
6. During emergency trips with signal use, the noise level is reaching and partly exceeding the safety limits of 80–85 dB(A).
7. Education of the ambulance workers and management about preventive measures, the importance of NIHL development and risk as well as regular audiometry check-ups are needed.

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