European Agency for Safety and Health at Work

RISK OBSERVATORY

EN 2

THEMATIC REPORT

Noise in figures

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NOISE IN FIGURES

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Foreword

Working life in Europe is changing at an ever-increasing speed, which can give rise to new risk areas or change the way that occupational safety and health needs to be managed. This has implications for workplaces themselves and also for the occupational safety and health system. This is why the Community strategy on health and safety at work 2002–06 ([1]) called on the European Agency for Health and Safety at Work to 'set up a risk observatory'. One of the priorities identified in the strategy is the need to 'anticipate new and emerging risks, whether they be linked to technical innovation or caused by social change'. This is to be done by 'ongoing observation of the risks themselves, based on the systematic collection of information and scientific opinions'. Additionally, the strategy emphasised that 'this kind of analysis is an integral part of a preventive approach'.

This report is the first in a series of risk observatory thematic reports dedicated to a specific risk, sector or group of workers. The aim is to provide as comprehensive a picture as possible of the potential related risks and health effects in the world of work. These activities are part of a larger project, the goal of which is the earlier identification of emerging trends and risks at work in order to assist in better targeting of resources and to enable more timely and effective interventions.

This report sets out to describe the situation in Europe as regards exposure to noise at work, to identify groups at risk, to highlight trends and emerging issues of concern. This includes non-auditory effects and other health risks related to noise exposure, with a reference to research on noise and stress and combined exposures with chemicals. It also attempts to compare collected information with expert's views on emerging issues.

A growing proportion of workers are employed in the service sector. This is why this report not only includes information for the traditionally well-known noise-exposed sectors such as construction, manufacturing or agriculture, but also for more female-dominated service-oriented professions, such as education or call centres.

It also supports the 2005 European Week for Safety and Health at Work, Europe's largest OSH campaign, focusing on the issue of noise at work, under the slogan 'Stop that noise!', with the tagline, 'Noise at work — it can cost you more than your hearing' and backed by all Member States, candidate and EFTA countries, the Luxembourg and United Kingdom EU Presidencies, the European Commission and Parliament, trade unions and employers federations.

The Agency would like to thank the Members of the Topic Centre for their contributions to the information used in this report.

The Agency would also like to thank its Focal Points, Expert Group and Advisory Group for their valuable comments and suggestions.

European Agency for Safety and Health at Work
December 2005

([1]) Communication from the Commission, Adapting to change in work and society: a new Community strategy on health and safety at work, 2002–06, COM(2002) 118 final.

Summary

Exposure to noise

Exposure to loud noise is not notably rising, and there are no changes to be observed. Typical sectors for male workers affected by loud noise include construction, agriculture, forestry, manufacturing of metal and wood, mining and quarrying. Craftspeople, skilled workers, agricultural workers and armed forces are most exposed to noise at work — the percentage of workers exposed in these occupation groups is higher than average.

In selected sectors, women can be considerably exposed to noise. The percentage of women reporting noise exposure is much higher in the new Member States than for the EU-15. In the Czech Republic, for example, 75 % of workers exposed to noise in the textile production are female, followed by 50 % in food production.

In the new Member States, the sectors with the highest percentage of workers exposed to noise all or almost all the time are agriculture and mining, followed by manufacturing. It should be kept in mind that the proportion of workers working in these sectors is higher in the new Member States. Also, workers in the new Member States generally report higher exposure to physical risk factors, such as noise, vibrations and painful positions. Conditions in some of these sectors (temperature extremes, noise, vibrations, etc.) may explain, at least in part, over-exposure to these physical risk factors.

Noise levels still regularly exceed limit values in many sectors, such as agriculture, construction, engineering, foods and drinks industry, woodworking, foundries or entertainment. The exposure to loud noise seems to be affecting more and more younger workers. This trend needs to be further confirmed and possible consequences assessed.

The exposure to loud noise seems to be affecting more and more younger workers.

According to European and some national sources, employees with full-time non-permanent contracts are most exposed to loud noise. This group often has less information available relating to health and safety issues, less training and less formal supervision and control in the workplace.

Health effects

Hearing loss

Noise-induced hearing loss is still one of the most prominent and most recognised occupational diseases in the Member States of the European Union. According to a study by Eurogip ([2]), the cost of hearing loss due to noise represents about 10 % of the total cost of compensation of occupational diseases (period 1999/2001). The classification of the disease may, however, be different in terms of recognition and in terms of cost. Whereas in 2000 hearing loss ranked first among the diseases most

Noise-induced hearing loss is still one of the most prominent and most recognised occupational diseases in the Member States of the European Union.

([2]) 'Costs and funding of occupational diseases in Europe', Eurogip-08-E, August 2004. http://www.eurogip.fr/pdf/Eurogip-08E-cost.pdf

commonly recognised in Germany and second in Denmark, its ranking in terms of cost is third and fourth respectively.

The trend of recognised incidence of hearing loss is different depending on country and recognition policy.

The trend of recognised incidence of hearing loss is different depending on country and recognition policy. While in some countries figures are slightly decreasing, they are more or less stable and even increasing in other countries. The highest numbers of cases are registered in the age groups 50–54 and 55–60.

Sectors with a high prevalence include agriculture, forestry and fishing; mining and quarrying; extraction, energy and water supply, manufacturing and construction. While there may be some under-reporting and under-recognition especially for female workers, figures also depend on the threshold applied for the definition of hearing loss. Different countries use different criteria for defining hearing loss caused by noise. The level decisive for notifying and recognising the occupational illness is variable. The number of occupational illnesses reported is also influenced by the level of impairment that makes the injured person eligible for financial compensation. In some countries, such as Germany, the number of recognised cases of hearing loss are stabilising and decreasing with regard to the degree of impairment.

Self-reported hearing problems

According to European survey results [3], self-reported hearing problems have increased slightly. According to the ESWC-data, about 7 % of European workers consider that their work affects their health in terms of hearing disorders. **Reported hearing loss due to the work increased from 6 % in 1995 to 7 % in 2000.**

Workers who report high exposure to noise also report higher rates of hearing problems. There are significant differences between the sectors. Mining and manufacturing, construction and transport and communication report hearing problems more often than the average. Except for communication and transport, these sectors also report higher rates of exposure to noise.

Blue-collar workers report the highest rate of hearing problems. This group is also significantly more exposed to noise due to the various processes and machinery involved. **In particular, employees on apprenticeship or other training scheme reported more hearing problems in 2000 than in 1995.**

Self-employed workers report the least hearing problems.

Tinnitus

Noise-induced hearing loss is often accompanied by tinnitus, or ringing in the ears. Data on tinnitus are scarce. Research carried out in 2003 estimates that 170 000 people in the UK suffer deafness, tinnitus or other ear conditions as a result of exposure to excessive noise at work. In 2001, on the basis of the risk estimates made and the prevalence of occupational noise exposure, it was estimated that 153 000 men and 26 000 women aged 35–64 years had severe difficulties of hearing attributable to noise at work, and about 266 000 men and 84 000 women in this age band had attributable persistent tinnitus. Further monitoring should help to assess the dimension of the problem throughout Europe.

[3] European Survey of Working Conditions ESWC.

Acoustic shock

Acoustic shock is usually a term used to describe the physiological and psychological symptoms a person may experience after hearing a sudden, unexpected, loud sound (referred to as an acoustic incident), via a telephone headset or handset. Call/contact centre telephone operators are thought to be the type of workers most at risk. The problem may be exacerbated if call centres are so noisy that the operators need to have the volume controls on their telephones turned up higher than would be necessary in a quieter place. Acoustic shock was also highlighted by the Agency expert surveys on emerging risks as an issue of concern.

Non-auditory health effects

There is evidence of several health effects due to medium-level noise, including voice problems, stress, cardiovascular diseases and neurological issues.

There is evidence of several health effects due to medium-level noise, including voice problems, stress, cardiovascular diseases and neurological issues. Noise below the levels usually associated with hearing damage can cause regular and predictable changes in the body. Even 'ear-safe' sound levels can lead to non-auditory health effects if they chronically interfere with recreational activities such as sleep and relaxation, if they disturb communication and speech intelligibility, or if they interfere with mental tasks that require a high degree of attention and concentration. In general, the suspected effects include cardiovascular function (hypertension, changes to blood pressure and/or heart rate), and changes in breathing, annoyance, sleep, physical health and mental health.

Noise in education is reported by workers in several Member States and voice disturbances have a significant impact on teachers' absenteeism rates. WHO guidelines recommend a noise level of 35 dB(A) for school classrooms during class to avoid disturbance of communication. Actually noise levels in schools frequently exceed these limits and can reach as much as 60–80 dB(A) in normal classes and can even go beyond limit values for workplaces in school workshops and sports areas.

The importance of the voice as an occupational tool is also growing with the development of voice-activated technology and the increase in the number of individuals working in call centres, where vocal demands are high.

Combined effects

It is worth noting that many sectors with high exposures of workers to noise also have high exposures to dangerous substances (such as pesticides and solvents) and vibrations.

Exposure to chemical solvents can also affect hearing, and such effects may be underestimated. Known ototoxins include solvents (carbon disulfide, n-hexane, styrene, toluene, trichloroethylene, xylene), metals (arsenic, organic tin, mercury and derivatives, manganese), drugs (some chemotherapy agents, antibiotics and aspirine and related medication) and asphyxiants (carbon monoxide). Exposure to such chemicals may increase the effects of noise on hearing loss. It is worth noting that many sectors with high exposures of workers to noise also have high exposures to dangerous substances (such as pesticides and solvents) and vibrations. Industries with potentials for hazardous combined exposure include printing, painting, boat building, construction, glue manufacturing, metal products, chemicals, petroleum, leather products and furniture making, agriculture and mining. Combined exposure to noise, vibration and heat can also occur in foundries. Many of these sectors are more predominant in the new Member States than they are in the EU-15.

Several studies have assessed the effects of noise and chemicals, but the results are still awaited from major EU-funded research projects.

Noise and accidents

Noise can interfere with communication. Noise does not just harm a worker's hearing: it can also be a cause of accidents. Workers wearing hearing protection may not be able to hear verbal instructions and warnings. As an example, fatal accidents have been reported that involved backup manoeuvres on construction sites, even when the vehicles had functional sound alarms complying with current regulations.

Several projects have also set out to work out a method of predicting speech intelligibility while wearing hearing protectors. The effects of hearing protection on speech intelligibility and the perception of acoustic signals are also discussed.

Prevention

Control measures and the use of personal protective equipment

In studies of noise control measures at workplaces, there was a range of different management approaches found to noise control and some had effective or partly effective hearing protection programmes in place. The smaller companies had very limited noise control procedures and relied heavily on personal protective equipment. Further efforts are needed to reduce noise in workplaces.

Noisy occupations and professions typically use a wide range of processes and machinery for forming, shaping and removing material.

Noisy occupations and professions typically use a wide range of processes and machinery for forming, shaping and removing material. Such processes have the potential to create substantial and prolonged high noise levels in the workplace. Any setting that involves heavy machinery can be hazardous to the hearing. Further improvements are needed to effectively lower emission levels.

Whereas some measures address noise at the source (e.g. noise reduction of machinery), **room acoustic measures should also be kept in mind.** As an example, analysis of German and international references shows that classroom acoustics have been neglected. Measurements of classrooms in everyday use have revealed acoustical conditions that permit less than half of the speech to be understood. Generally, the problems are caused by improper wall, ceiling, and floor finishes and by noisy ventilation equipment. Considerable reductions could be achieved by acoustic measures, and acoustical guides have been issued.

Where concentration is needed, noise levels need to be kept low. Some recommendations for noise levels in offices, schools and healthcare are included in this report.

The complexity of work and the necessity to carry out additional administrative tasks has increased in professions such as healthcare work and teaching, but also industrial production. Where concentration is needed, noise levels need to be kept low. Some recommendations for noise levels in offices, schools and healthcare are included in this report.

Some measures cited address the reduction of medium-level noise. This includes, for example:

- for the education sector: acoustic measures in classrooms, the application of noise-avoiding teaching methods;
- for call centres: technical standards for headphones, work organisational measures, acoustic measures in workplaces;

- for offices: avoiding noisy machinery, noise reduction measures in offices, work organisational measures.

Research needs

Data are scarce for exposure to noise in specific sectors such as healthcare, catering or hotels and restaurants. Further investigations are also needed to assess combined effects of noise and vibration, noise and chemicals and the effect of noise on pregnant workers.

Research should also support prevention efforts regarding hearing-impaired workers and the interference with warnings and signals.

More research is also needed to aggregate information about and further investigate the exposure to medium-level noise.

1. INTRODUCTION

The World Health Organisation (WHO) defines noise as 'unwanted sounds'. Generated by road, rail and air traffic, industry, and other activities, noise can be a serious nuisance and a health hazard. Noise is all around us. At unsafe decibel levels, exposure to loud noise can be harmful and permanently damage hearing. There are four main environments in which we are at risk for exposure to toxic noise: workplace, home, recreation and travel.

According to EU figures, about 40 % of the population in the EU countries is exposed to road traffic noise at levels exceeding 55 dB(A), and 20 % is exposed to levels exceeding 65 dB(A) during daytime. More than 30 % is exposed to levels exceeding 55 dB(A) during night-time. Excessive exposure to noise has a significant negative impact on human health.

Noise can interfere with communication, cause sleep disturbance and cardiovascular effects, affect mental health, reduce performance, cause annoyance responses, and can alter social behaviour. At sufficiently high levels, it can impair hearing. In addition, it seems to affect children's ability to learn. It is hard to estimate the exact impact of noise on health because it is often accompanied by other hazards such as air pollution or exposure to chemicals. In general, the higher the noise level the greater is the damage. Noise level and duration of exposure together with individual susceptibility determine the cumulative detrimental effect on the human body and in particular the hearing mechanism. Once the hearing is damaged there is no recovery of lost function.

This report sets out to describe the situation in Europe as regards exposure to noise at work, to identify groups at risk, to highlight trends and emerging issues of concern. This includes non-auditory effects and other health risks related to noise exposure, with a reference to research on noise and stress and combined exposures with chemicals and vibration. It also attempts to compare collected information with expert views on emerging issues.

The description is based on the collection of data from European and national OSH monitoring systems, complemented with forecasts and literature reviews.

The Agency commissioned its Topic Centre Research on Work and Health (TCWH) with data collection on noise exposure and noise-related hearing loss from national monitoring systems, studies and reports. At the same time, a first forecasting exercise focused on emerging physical risks, including noise, has been carried out. The results of this expert survey as regards noise at work are included in section 'The Agency surveys on emerging risks.' Information from both activities was integrated into this report.

2.

EXPOSURE TO NOISE AT WORK

What is noise?

Noise is essentially a form of energy. The energy is transmitted through the air as pressure waves. The ear is capable of detecting these pressure waves, which it perceives as sound or noise.

Noise can be described in terms of intensity or amplitude (perceived as loudness) and frequency (perceived as pitch). Both the intensity and the duration of noise exposure determine the potential for damage to the hair cells of the inner ear. Even sounds perceived as 'comfortably' loud can be harmful. High-frequency noise is much more damaging than low-frequency noise; therefore, intensity alone cannot predict risk. For this reason, a special scale has been developed for measuring environmental noise when the purpose is to assess its potential to produce hearing loss. Simply measuring the physical intensity of the stimulus as a sound pressure level cannot assess the potentially damaging effect of noise. The human ear does not respond equally to all frequencies — high frequencies are much more damaging than low frequencies at the same physical intensity levels. Consequently, most sound level meters are equipped with a filter that is designed to de-emphasise the physical contribution from frequencies to which the human ear is less sensitive. This filter is referred to as the A filter, and measurements taken using the A filter are reported as dBA. This is known as the A-weighting on a sound level meter.

The loudness of sound is measured in units called decibels. Sound pressure level (SPL) is the basic measure of the magnitude of the acoustical vibrations of the air that make up sound. Because the sound pressure range that human listeners can detect is very wide, (10-5 to 102 Pascal (Pa)), these levels are measured on a logarithmic scale with units of decibels. For example, usual conversation is approximately 60 decibels, the humming of a refrigerator is 40 decibels and city traffic noise can be 80 decibels.

***The 'shout' test:** if it is necessary to shout to converse with someone 2 metres away in the workplace, noise levels are potentially hazardous.*

In order to assist in determining noise levels this basic rule of thumb can be applied: if you have to shout, or have difficulty being understood by someone around 2 metres away, then the levels would be around 85 dB(A); if the same applies at a distance of 1 metre, then the level is likely to be around 90 dB(A).

Noise level assessments are not straightforward, particularly when calculating average exposures. This operation requires competent persons and the use of specialist equipment.

If it is anticipated that high levels are likely to be reached then a risk assessment should be carried out. If the assessment identifies that the personal exposure of staff, usually measured over an eight-hour day, is of this magnitude then certain actions will be required.

These actions include engineering and administrative controls to reduce noise exposures, employee training in the use of hearing protection and annual audiometry for all workers who are exposed to noise. The Agency provides information on noise prevention in the workplace for its European Week for Safety and Health at Work 2005 campaign at http://ew2005.osha.eu.int. Additional information can be found at http://europe.osha.eu.int/good_practice/risks/noise/.

Table 1: Typical noise levels (general) [4]

Common sounds	Decibel levels (dB(A))
Rock concert, jet take-off, gun shot	120 to 140
Chain saw, air gun, portable stereo, dance club, boiler room,sandblasting, heavy lorry (7 m away)	100 to 120
Power tools, motorcycle, headphones, snowmobile, manufacturing plant, hydraulic press, pneumatic drill, school technical workshop	90 to 100
Lawnmower, dishwasher, computer room, subway, busy restaurant or kitchen	75 to 90
City traffic, hair dryer, office equipment, cell phone, loud radio	70 to 80
Normal conversation	50 to 70
Quiet office	40 to 45
Whisper, countryside with rustling leaves	20 to 50

Sources: 'Hearing for life', Workplace Safety and Insurance Board Ontario; Norfolk City Council Education, 'Noise at Work'.

Noise can cause permanent hearing loss at chronic exposures equal to an average SPL of 85 dB(A) or higher for an eight-hour period. Based on the logarithmic scale, a 3-dB increase in SPL represents a doubling of the sound intensity. Therefore, four hours of noise exposure at 88 dB(A) is considered to provide the same noise 'dose' as eight hours at 85 dB(A), and a single gunshot, which is approximately 140 to 170 dB(A), has the same sound energy as 40 hours of 90-dB(A) noise.

(4) 'Hearing for life', Workplace Safety and Insurance Board Ontario website. http://www.wsib.on.ca/wsib/wsibsite.nsf/LookupFilesPreventionToolsHearingforLife_3224A/$File/3224A.pdf. 'Noise at work', Education resources. Norfolk City Council website. http://www.norfolkesinet.org.uk/ FileSystem/upfile/j00015/noise_guidance.do

2.1. Exposure to loud noise

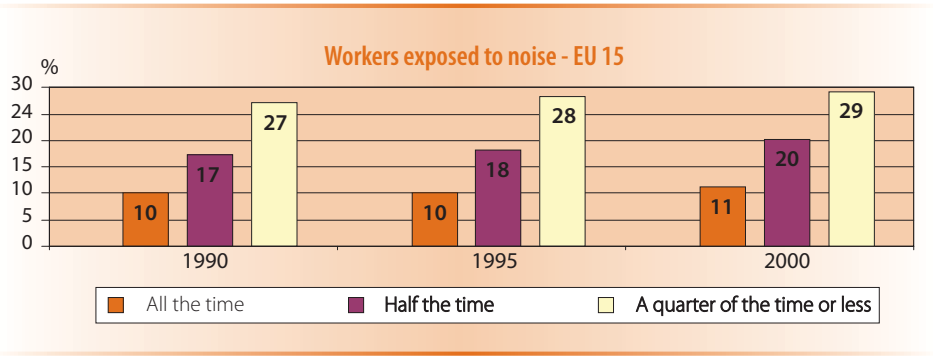
General prevalence

Data on work-related noise exposure is provided by various surveys both at European and national levels. According to the latest figures from 2000–01, **approximately a quarter to a third of the workforce is exposed at some stage (at least a quarter of the time) to high-level noise (29 % for EU-15, 35 % for new Member States).** It also shows a slight increase in noise exposure in the EU-15. The European-wide trend is corroborated by national sources (for example in Spain ([5]) and France ([6]), see also Table 2 and Figure 2).

In 2000, 29 % of workers in the EU-15 and 35 % in the new Member States report being exposed to high-level noise at least one quarter of the time and 11 % all the time (15 % in the new Member States)

In 2000, 29 % of workers in the EU-15 and 35 % in the new Member States report being exposed to high-level noise at least one quarter of the time and 11 % all the time (15 % in the new Member States) ([7]). EU-15 data also shows a slight increase in noise exposure.

Figure 1.



Source: ESWC.

([5]) INSHT — Encuesta Nacional de Condiciones de Trabajo, 2003.

([6]) INSEE-DARES Enquêtes Nationales Conditions de Travail.

([7]) 'Working conditions in candidate countries and the European Union — Résumé', European Foundation for Living and Working Conditions. http://www.eurofound.ie/publications/files/EF0246EN.pdf

Table 2: Exposure to noise

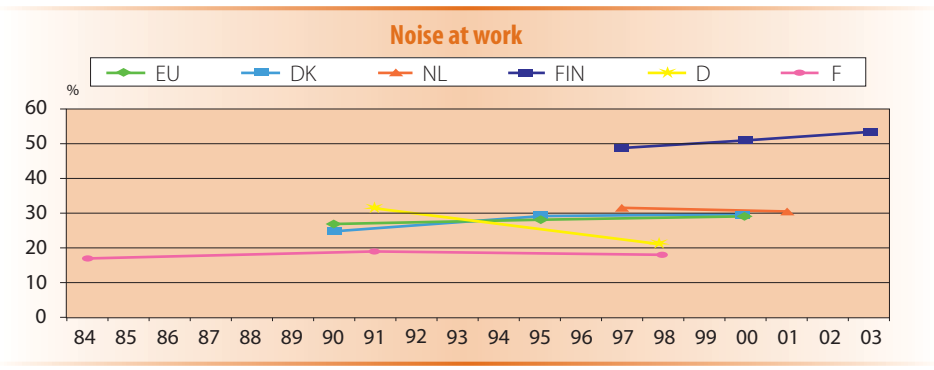
%	EU15 (1)	ACC12 (2)	DK (3)	FIN (4)	F (5)	NL (6)	SP (7)	UK (8)	D (9)
Raising voice >=1/4 time	29	35						29	
Raising voice all & almost all time	11	15						11	
No exchange >3m					14		8		
Not hearing >3m					4		2		
Not hearing >1m				8					
Having to talk loudly						21			
Noisy environment			30			31			21

Sources: (1) ESWC 2000; (2) ESWC 2001; (3) DWECS 2000; (4) FWHS 2003; (5) ENCT 1998; (6) POLS 2001; (7) ENCT 2003; (8) ONS Omnibus survey 1995; (9) BIBB/IAB 1998/1999.

The above table aims at providing an indication of the scale of noise exposure in Europe rather than national comparisons .The data comes from work surveys (self reported). Questions used (see Section 'How noise at work is monitored'), scales and frequencies are generally different. Nevertheless, the overall conclusions are that:

- between 8 and 15 % of workers are exposed to very high-level noise (to the point of impeding communication);
- between 21 and 35 % of workers are exposed to high-level noise (to the point of having to raise the voice to be heard).

Figure 2. Trends



Sources: France/Enquêtes Conditions de travail 1987, 1991, 1998; Denmark/DWECS 1990, 1995, 2000; Finland/FWHS 1997, 2000, 2003; Germany/BIBB-IAB 1991/92, 1998/99; Netherlands/POLS 1997, 2001; EU-15/ ESWC 1990, 1995, 2000.

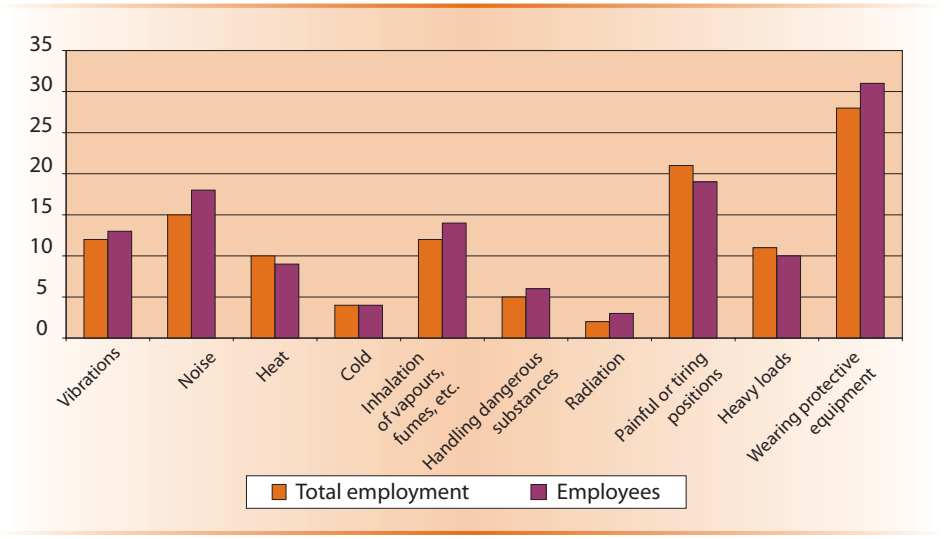
Since 1990, the European survey on working conditions (ESWC) is registering the number of workers exposed to loud noise in the workplace. In these surveys, the participants are asked to describe for how long they are exposed to noise so loud that they have to raise their voice to talk to other persons.

The ESWC data from 2000 confirm the trends previously observed in 1995 and 1990. Mainly there are no improvements reported on this issue. In 2000, approximately a quarter of the workforce (29 %) is exposed at least a quarter of the time to high-level noise. Some 20 % of European workers are exposed, half or more of their working time, to noise so loud that they would have to raise their voice to talk to other people. Around 10 % of the workers are exposed (almost) permanently to high-level noise.

The main European source of information on exposure to noise in new Member States is the first candidate countries survey on working conditions conducted by the European Foundation for the Improvement of Living and Working Conditions in Dublin in 2001.

In general, workers report to be more exposed to noise than to other physical risks — except for painful positions.

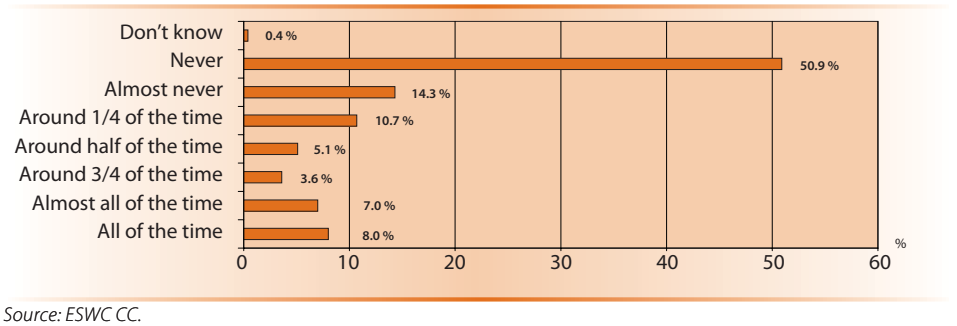
Figure 3: Work involving physical risks in the new Member States (all or almost all of the time)



Source: ESWC CC.

In 2001, about 35 % of workers in New Member States were exposed to noise at work for more than a quarter of their working time. About 15 % of workers in the new Member States were exposed to noise so loud that they had to raise their voice to talk to people all the time or almost all the time and a further 19.4 % of workers were exposed to noise from a quarter to three quarters of their working time (see Figure 4).

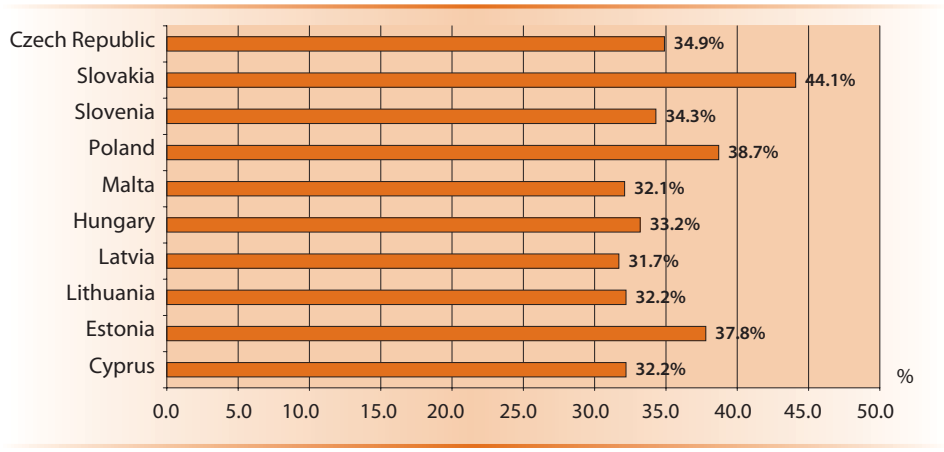
Figure 4: Workers exposed to noise at work in new Member States by time of exposure



Source: ESWC CC.

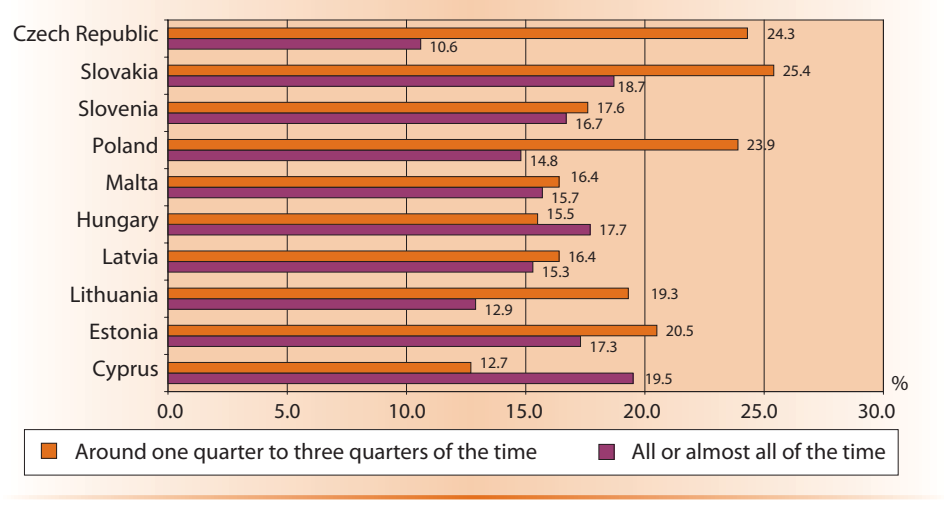
The percentage of workers exposed to noise for more than a quarter of their working time varies from country to country, ranging from 31.7 % in Latvia to 44.1 % in Slovakia (Figure 5). In Slovakia, Poland and Estonia, exposure is higher than the average for new Member States.

Figure 5: Exposure to noise (at least a quarter of the time) in new Member States, by country



Source: ESWC CC.

Figure 6: Exposure to noise in new Member States by country



Source: ESWC CC.

Noise exposure — data from Member States

Belgium

The ESWC results of 2000 reveal a rising trend in noise exposure in the Belgian workplace. In 2000, about 25 % of the workers are exposed to noise for a quarter of the time. This is an increase of 5 % compared to 1995. There was also a decrease with 4 % of workers who are never exposed to noise, in comparison with 1995.

Czech Republic

In the Czech Republic, in April 2005, a total of 220 800 employees are performing work connected with noise, that is, 55.5 % of all employees involved in risk-involving work, of which 19 % are women, the number of exposed men is therefore about three times higher than the number of women. Another 416 000 workers are exposed to noise at levels which do not reach the level considered risk-involving, for which the

exposure to noise, as recalculated for an eight-hour work day, ranges between 75 and 85 dB (A).

Denmark

The percentages of workers exposed to noise in Denmark increased from 25 % in 1990 to 30 % in 2000. In the Danish Work Environment Cohort Study (DWECS), 30 % report being exposed to noise so high that they must raise their voice in order to be able to talk with colleagues. Some 10 % of the workers are exposed for three quarters of their working time or more.

Finland

In Finland, around a quarter of all workers are exposed at some stage (at least a quarter of the time) to high-level noise. The figures indicate a rising trend since 1997. According to Finnish work and health surveys, about half of the workforce has been exposed to noise at work. The Finnish quality of work life surveys indicate an increased noise working environment over the last 25 years.

France

According to the French 'Enquête sur les conditions de travail' (survey on working conditions), a general increase of the percentages of workers who declared to be exposed to noise was observed between 1984 and 1998. In 2003, more than 3 million workers declared to be exposed to noise levels exceeding 85 dB(A), which is the intensity considered as the one beyond which irreversible impairments of the hearing function are likely to occur. Almost one third of the workers were exposed to occasional very loud or very high sounds in 1998. One worker out of seven was exposed to disturbing noise in 1994.

Germany

Between 1992 and 1999, the percentage of workers reporting to be exposed to noise has been reduced by 10 %. In 1999, 20 % were exposed to noise often or almost all of the time.

Hungary

According to European data sources, about 18 % of workers in Hungary are exposed to noise so loud that they have to raise their voice to talk all of the time or almost all the time. On the whole approximately 33 % of workers are — to various degrees — exposed to noise. According to national data sources, noise exposure above limit values has increased from 4.2 % in 1995 to 9.7 % in 2003.

Netherlands

The percentage of employees frequently exposed to detrimental sound levels has remained stable at 17 % for the past 10 years. Approximately 17 % of the employees regularly work in a noisy environment, whereas 14 % sometimes do.

Poland

For more than 200 000 Polish workers, exposure to noise in 2003 was higher than the MAL value (85 dB). From 1995 to 2003, the number of employees exposed to noise

decreased. However, in 2003, more than 4.5 % of workers were still exposed to an excessively high level of noise. According to the first European survey on working conditions, about 15 % of workers in Poland are exposed to noise so loud that they have to raise their voice to talk all of the time or almost all the time. Approximately 39 % of workers are — to various degrees — exposed to noise.

Slovakia

According to the first candidate countries survey on working conditions in 2001, about 20 % of workers in Slovakia were exposed to noise so loud that they had to raise their voice to talk all of the time or almost all the time. On the whole, approximately 45 % of workers were — to various degrees — exposed to noise at work. According to the data of the Institute of Public Health of the Slovak Republic, the number of workers exposed to noise decreased in 1995–2000 by about 15 %, but after this period there have been no significant changes in the percentage of workers exposed. About 89 000 workers were exposed to noise at work in 2003. The percentage of women exposed to noise decreased from in 22 % in 1995 to about 18 % in 2000.

Slovenia

According to European data sources, almost 17 % of workers in Slovenia are exposed to noise so loud that they have to raise their voice to talk all of the time or almost all the time. On the whole, approximately 35 % of workers are — to various degrees — exposed to noise. According to a survey in selected Slovene companies carried out in 1999, workers are most exposed in processing industries (metal, wood and non-metal), agriculture, electrical and textiles industry, and construction. On average, about 14 % of workers were exposed to noise above 85–90 dB.

United Kingdom

In the early 1980s, the Health and Safety Commission estimated that, in British manufacturing alone, 600 000 workers were exposed to potentially injurious levels of noise (90 dB(A)). Presently, it is estimated that over 2 million people in Britain are regularly exposed to loud noise at work. About 1.7 million workers are thought to be exposed to noise above levels considered safe. About 1.1 million are exposed above 85 dB(A), where there is a significant risk to health. HSE indicates that there are 1 097 000 workers exposed to between 80 dB and 85 dB; 696 800 workers exposed to 85 dB to 90 dB, and 438 300 workers exposed to more than 90 dB.

In a study of 1995, it has been estimated by the HSE that 11 % of employed men and 6 % of employed women in Britain nearly always need to raise their voices to be heard in the workplace, and that 3 % of men and 2 % of women encounter working conditions that leave them with ringing in their ears or temporary deafness on a daily basis.

Case study

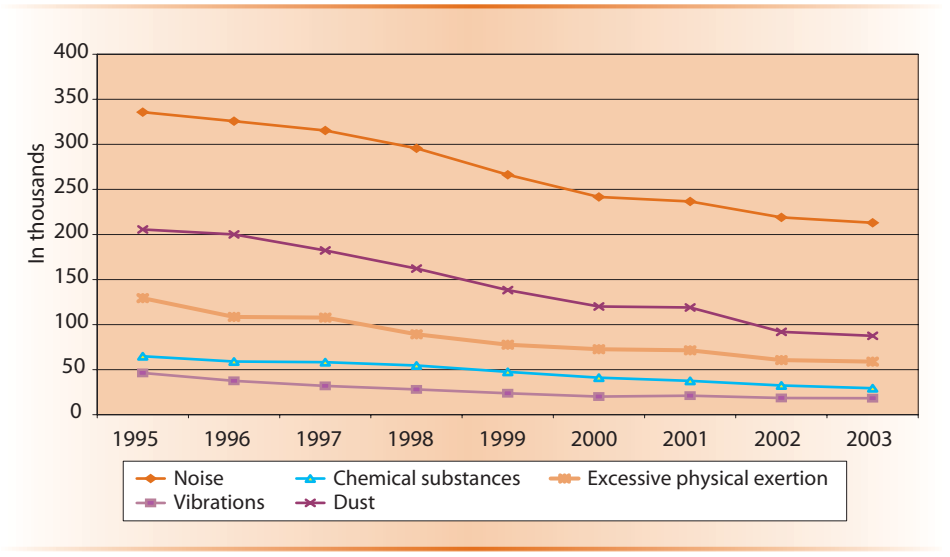
Poland — exposure to noise and other risk factors

In Poland, data on occupational exposure to different risk factors are registered by the Central Statistical Office on the basis of annual surveys on working conditions (Z-10). The main objective of the survey is to obtain data on the numbers of persons for whom exposure to risks factors in the working environment (chemical

substances, dust, noise, vibrations, microclimate, etc.) is higher than the admissible values established in legal requirements.

For more than 200 000 Polish workers, exposure to noise in 2003 was higher than the MAL value (85 dB in Poland). In 1995–2003, the number of employees exposed to noise decreased (Figure 7). However, in 2003, more than 4.5 % of workers were still exposed to an excessively high level of noise.

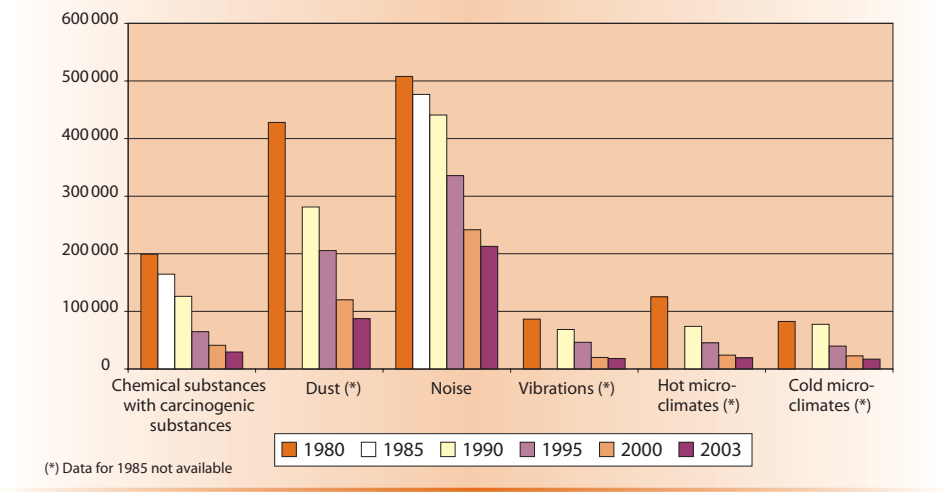
Figure 7. Number of employees for whom exposure to risk factors exceed admissible values (MAC or MAL) in 1995–2003 in Poland



Source: Annual surveys on working conditions (Z-10).

According to national statistical data, noise is the main risk factor in the working environment in Poland. For years, the number of workers exposed to noise was bigger than the number of workers exposed to other risk factors such as dust or chemical substances, vibrations, etc. (Figure 7).

Figure 8. Exposure to chemical, physical and ergonomic hazards by year



Source: Annual surveys on working conditions (Z-10)

Noise exposure — which are the groups most concerned?

Sectors at risk

Figure 9. Exposure to noise by occupations in the EU-15 (ESWC 2000)

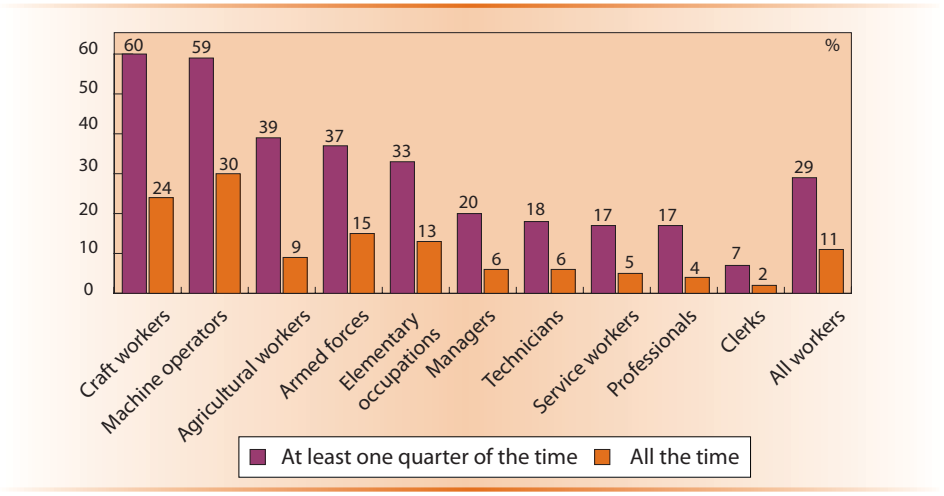
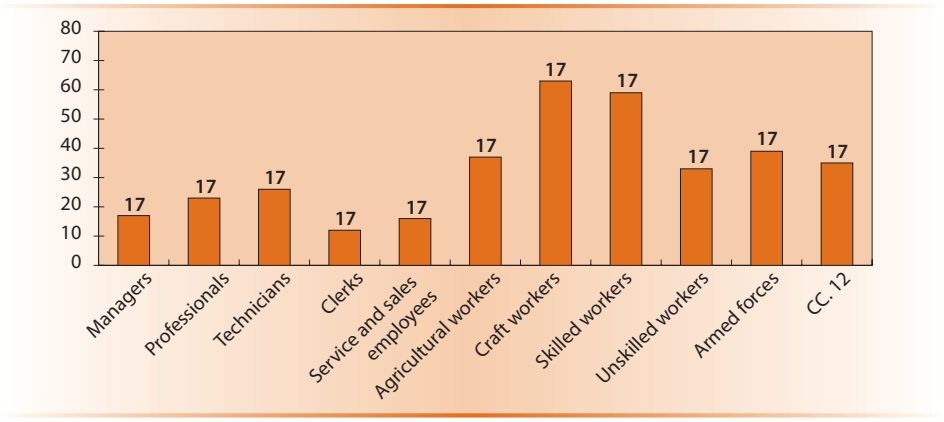


Figure 10. Workers exposed to noise by occupational categories (at least a quarter of the time) in the CC-12 (ESWC 2001)



Typical sectors for male workers affected by loud noise include construction, agriculture, forestry, manufacturing of metal and wood, mining and quarrying.

Allgemeine Unfallversicherungsanstalt, Austria

The ESWC data identifies the construction sector as the category with the highest percentage of workers reporting exposure to noise in the EU-15. The manufacturing sector has the second highest percentage of workers reporting exposure to noise. In both sectors, about 40 % of the workers are exposed to noise at work half of the time or more. Since 1995, the figures are increasing for both categories.

Typical sectors for male workers affected by loud noise include construction, agriculture, forestry, manufacturing of metal and wood, mining and quarrying.

Blue-collar workers are significantly more exposed to noise: 'craft and related trade workers' is the occupation category with the highest percentage of workers reporting exposure to noise in the workplace, the second highest exposed occupation category is 'plant and machine operators and assemblers'. Since 1995, there has been a rise in the number of 'craft workers' and 'plant operators' exposed to noise.

For the new Member States, the sectors with the highest percentage of workers **exposed to noise all or almost all the time are agriculture (40 %) and mining (34 %).** A high percentage of workers are also exposed to noise in manufacturing (19 %).

Likewise, in the new Member States, craftspeople, skilled workers, agricultural workers and armed forces are the most exposed to noise at work — the percentage of workers exposed in these occupation groups is higher than average.

It has to be kept in mind that the proportion of workers working in these sectors is higher in the new Member States. As an example, the proportion of people employed in agriculture is higher (21 % compared to 5 %), but there are wide differences between countries ([8]). Also, workers in the new Member States generally report exposure to physical risk factors, such as noise, vibrations and painful positions, to be higher. The specific nature of working conditions in some of these sectors (temperature extremes, noise, vibrations, etc.) may explain, at least in part, over-exposure to these physical risk factors.

Craftspeople, skilled workers, agricultural workers and the armed forces are most exposed to noise at work — the percentage of workers exposed in these occupation groups is higher than average. Among the occupations at risk for hearing loss are police officers, fire fighters, construction workers, farmers, military personnel, and musicians. While office environments tend to be less hazardous, any setting that involves heavy machinery can be hazardous to the hearing.

Men are exposed to noise more than twice as often as women in the EU-15. Male workers have traditionally been employed in the sector and occupational categories identified to be at the highest risk from noise exposure.

According to the first candidate countries survey on working conditions, exposure to noise at least a quarter of the time is reported by 38 % of men and 30 % of women. The percentage of women reporting noise exposure is much higher than for the EU-15.

Women are generally reporting to be more exposed to medium level noise. However, in selected sectors, women can be more exposed to noise than men.
Typical occupations include education, healthcare, restaurants, offices and call centres.

Women are generally reporting to be more exposed to medium level noise ([9]). However, in selected sectors, women can be more exposed to noise than men. As an example, in the Czech Republic 75 % of workers exposed to noise in the textile production are female, followed by 50 % in food production.

([8]) 'Working conditions in candidate countries and the European Union — Résumé', European Foundation for Living and Working Conditions. http://www.eurofound.ie/publications/files/EF0246EN.pdf

([9]) 'Gender issues in safety and health at work — a review', European Agency for Safety and Health at Work, 2003, pp. 74–77. http://osha.eu.int/publications/reports/209/en/index.htm

Typical occupations include education, healthcare, restaurants, offices and call centres. But in these professions, exposure to loud noise also occurs. As an example, sound pressure levels during school classes frequently exceed values recommended for work that requires mental concentration ([10]). A French study ([11]) described the situation at French schools and the programme set up by the French government. They report on values of up to 70 dB(A) in classrooms. In vocational schools or high school technical workshops, 95-100 dB(A) are not unusual. The same is true for sports rooms or swimming pools.

Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany

Typical sectors for female workers ([12]) exposed to loud noise also include the textile and food industries. Women report higher exposure in the new Member States than in the EU-15, but are less exposed to noise than men: according to the first candidate countries survey on working conditions, exposure to noise at least a quarter of the time is reported by 38 % of men and 30 % of women.

Typical sectors for female workers exposed to loud noise also include the textile and food industries. According to the first candidate countries survey on working conditions, exposure to noise at least a quarter of the time is reported by 38 % of men and 30 % of women.

The following table collates more information on noise exposures in some occupations.

([10]) H.-G. Schönwälder, J. Berndt, F. Ströver, G. Tiesler, 'Belastung und Beanspruchung von Lehrerinnen und Lehrern' (Professional stress and strain in teachers), Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Research report Fb 989, Dortmund, 2003. http://www.baua.de/english/fors/fb03/fb989_e.htm

([11]) 'Réduire le bruit en milieu scolaire' (Reducing noise in school environments). In: Federation of Acoustical Societies of Europe (FASE), Proceedings of the 8th Symposium on Environmental Acoustics, Zaragoza, 1989, pp. 161–164.

([12]) 'Gender issues in safety and health at work — a review', European Agency for Safety and Health at Work, 2003, pp. 74–77. http://osha.eu.int/publications/reports/209/en/index.htm

Table 3. Typical noise levels.

Trade/job profile	Average exposures
Construction [a], [b]	
Tower crane operator	75–87
Construction workers/labourers	84–94
Plumber	79–92
Track maker	80–98
Fitter	79–93
Road maker	79–107
Specialized civil engineering worker	82–95
Corrosion protectors	74–107
AGRICULTURE AND FORESTRY [c]	70–102
Food Production [d],[e]	
Drinks [f] (incl. bottling halls)	85–100
Meat	80–110
Milling	85–100
Bakery	85–92
Dairy	85–95
Confectionery	85–95
METAL MANUFACTURE [g]	80–125
Foundries [h],[i]	
Fettling	100–110
Rumbling	89–111
PRINTING SECTOR [j]	88–90
Education	
Quiet work	50–60
School rooms [k]	60–80
Recreational areas, sports lessons, music lessons	80–up to 95 [l]
Nurseries [m]	75-85
High School technical workshops and swimming pools [n]	90–105
HOSPITAL WARDS [o] [k]	62–105
CALL CENTRES [a]	50–60
Offices [p]	
Computer print room	80
Offices	45–60

[a] BIA-Project on noise exposure in construction – mapping of typical workplace exposures BIA Report 3/04,BIA Report 3/97. See ref. 31 and 32

[b] Alic H Suter. Construction Noise: Exposure, Effects, and the Potential for Remediation; A Review and Analysis, http://www.cdc.gov/elcosh/docs/d0100/d000054/d000054.html

[c] Lärmbekämpfung in Holzverarbeitungsbetrieben, Allgemeine Unfallversicherungsanstalt Austria Website. Available at http://www.auva.at/mediaDB/48675.PDF.

[d] Reducing noise exposure in the food and drink industries. HSE information sheet. Food Information sheet No 32. HSE Website. Available at http://www.hse.gov.uk/pubns/fis32.pdf.

[e] Probst, W. Geräuschemissionswerte von ausgewählten Maschinengruppen (Holzverarbeitung-Giesserei-, Getränkeabfüll- und Industrienähmaschinen) Noise emission data and noise reduction measures for some machine families (woodworking, metal, filling drinks, foundry). Dortmund 2003. Bundesanstalt für arbeitsschutz und Arbeitsmedizin. Research Report Fb 978. Available at http://www.baua.de/english/fors/fb03/fb978_e.htm.

[f] Noise-Measurement of noise. OSH Answers - Physical agents resources page. Canadian Centre for Occupational Health and Safety Website. Available at http://www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html.

[g] Noise in the metal fabrication industry. Workplace health and safety resources. Queensland Government Website. Available at http://www.whs.qld.gov.au/workplace/subjects/noise/industry/metal/index.htm.

[h] Hazards associated with foundry processes : fettling-noise hazards, HSE information sheet, Foundries Sheet no.6. Foundries - free leaflets. HSE Website. Available at http://213.212.77.20/pubns/fnis06.pdf.

Trade/job profile	Average exposures

[i] Hazards associated with foundry processes: rumbling – noise hazards, HSE information sheet, Foundries Sheet no.7. Foundries - free leaflets.

[j] Hejkrlik, I. Schallschutz in Arbeitsräumen. In: Bericht der österreichischen Arbeitsinspektion (Annual report of the Austrian labour inspection) 2002, Vienna 2003. Available at http://at.osha.eu.int/statistics/jb2002.pdf.

[k] Schönwälder, H-G.J. Berndt, F. Ströver, G Tiesler. Lärm in Bildungsstätten. Ursachen undMinderung (Noise in schools - causes and reduction), Dortmund, Berlin, Dresden, 2004. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. Research Report Fb 1030. Available at http://www.baua.de/fors/fb04/fb1030.pdf.

[l] Berndt, J, Schönwälder, H -G, F. Ströver, G. Tiesler. Belangstung und Beanspruchung von Lehrerinnen un Lehrern, 2003, in: Materialien zu Akustik in Klassenräumen (Contributions to psychological Acoustics). Schule und Gesundheit (School and health resources). Hessisches Kulturministerium Website. Available at http://schuleundgesundheit.hessen.de/module/arbeitsschutz/laerm/materialce/06-5tiesler.pdf.

[m] Voss, P. Noise in children's daycare centres. In: magazine 8. Noise at Work. European Agency for Safety and Health at Work 2005; 23-25 Available at http://osha.eu.int/publications/magazine/8/en/magazine8_en.pdf.

[n] Noise at work. Education resources. Norfolk City Council website. Available at http://norfolkesinet.org.uk/FileSystem/upfile/j00015/noise_guidance.doc.

[o] Gender issues in safety and health at work - a review. European Agency for safety and Health at Work, 2003; 74-77. Available at http://osha.eu.int/publications/reports/2009/en/index.htm.

[p] Office noise and accoustics, Office health and safety resources. Canada Safety council Website, Available at http://www.safety-council.org/info/OSH/noise.htm.

Sources: See references and dedicated sections of this report.

Noise and loud machinery

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Noise exposure and technological changes in agriculture

Case study 1

A review ([13]) of trends in farm practices and machinery development was undertaken, based on a search of literature and electronic information sources for published data on noise exposure in agriculture. That search yielded rather little to add to a report produced for the HSE in 1988. The bulk of UK agriculture is still represented by family-owned units employing small numbers of staff, often on a casual basis. Whilst such

([13]) Evans, J. P., Whyte, R. T., Price, J. S., et al., 'Practical solutions to noise problems in agriculture', *HSE research report* 212, Health and Safety Executive, 2004. http://www.hse.gov.uk/research/rrpdf/rr212.pdf

enterprises probably use the services of agricultural contractors for specific tasks (e.g. harvesting, silage making), day-to-day operation has remained largely unchanged, particularly if livestock form part of the enterprise. Today's agricultural industry uses fewer, larger, more productive machines, frequently selected to enable labour force reductions. Whilst such equipment generally embodies higher technological content and improved levels of operator comfort, its higher purchase price necessitates greater annual usage in order to offset depreciation costs. In many cases this amounts to a situation in which fewer workers are exposed to noise sources for longer durations.

Noise sources include a range of stationary and mobile machinery, as well as animal handling activities.

Table 4: Noise exposure in agriculture

Source	Likely noise levels [dB(A)]
Tractors without cabins	>90
Self propelled harvesting machines	up to 91
Wood chippers	101–120
Chain saws	up to 110
Grain driers	91–96
Hop machninery	up to 94
Vegetable packing stations	up to 92
Angle grinders	91
Animals (pig stalls)	~110
Seasonal turkey production	99
Turkey housing	94
Farriers (shoe fiiting)	98–102

Source: HSE research report 212.

Case study 2

Noise in construction

Allgemeine Unfallversicherungsanstalt, Austria

As part of their prevention activities and in the framework of investigations of occupational diseases, the measurement services of the BGs for the constructive industry perform noise emission measurements at workplaces. The evaluation results of the trades investigated in BIA Report 3/04 are summarised in Table 5. This report continues a series entitled 'Noise exposure in construction jobs'. In summary, findings indicate that some construction vocations are significantly exposed to noise pollution. Average exposures are likely to exceed limit values for these work activities.

Table 5: Evaluation results for the construction trades

Trade/job profile	Average noise level (rounded to nearest 0.5 dB) in dB			Level range with 90% of all daily mean levels (rounded to full dB) in dB	
	L_{Aeq}	L_{Aleq}	K_I	L_{Aeq}	L_{Aleq}
Plumber					
a) Workshop only	83.5	92 (*)	9 (*)	78–88	86–96
b) Site only	88.5	96.5	8	82–93	91–101
Combined activities: All jobs (a : b = 42 : 58%)	87	95	8	79–92	87–100
Tower crane operator					
a) Crane cab only	80 (*)	88 (*)	8 (*)	74–84	79–93
b) Remote control only	84	92 (*)	8 (*)	77–88	82–98
Combined activities: All jobs (a : b = 40 : 60%)	83	91	8	75–87	80–97
Construction workers/labourers					
Building construction	≈ 89 (**)	–	≈ 5	–	–
Civil engineering	≈ 89 (**)	–	≈ 5	–	–

(*) These mean levels do not belong to accuracy class 1 according to DIN 45 645.
(**) These mean levels belong to accuracy class 3 according to DIN 45 645.

Source: published in BIA Report 3/04 ([14]).

The evaluation results of the trades investigated in the BIA Report 'Noise exposure at building site workplaces, Part V' (2/97) are summarised in the following table.

Table 6: Evaluation results for the construction trades

Trade/job profile	Average noise level (rounded to nearest 0.5 dB) in dB			Level range with 90% of all daily mean levels (rounded to full dB) in dB	
	L_{Aeq}	L_{Aleq}	K_I	L_{Aeq}	L_{Aleq}
Track maker	94.5	97.5	3	80–98	96–102
Fitter					
a) Steel construction only	91 (*)	100	9	82–97	88–105
b) Excluding steel construction	85.5	92.5	7	79–90	84–98
Combined activities: All jobs (a : b = 33 : 66%)	88.5	96.5	8	79–93	84–101
Road maker					
a) Base course	89.5	93.5	4	79–94	85–98
b) Tarmac	91	95.5	4.5	82–95	87–100
c) Concrete	93.5	95.5	3	86–98	89–100
d) Road marker	89.5	92.5	3	87–92	91–94
e) Crash barrier	101 (*)	106 (*)	5	87–107	91–112

([14]) Knipfer, C., 'Lärmexposition an Baustellenarbeitsplätzen —Teil VI' (Noise exposure in construction jobs — Part VI), Hauptverband der gewerblichen Berufsgenossenschaften 2004, *BIA-Report* 3/2004. http://www.hvbg.de/d/bia/pub/rep/rep04/bia0304.html

Trade/job profile	Average noise level (rounded to nearest 0.5 dB) in dB			Level range with 90% of all daily mean levels (rounded to full dB) in dB	
Specialised civil engineering worker	92	98	6	82–95	87–100
Corrosion protectors					
a) Very noisy jobs	106.5	110 (*)	3.5	100–111	100–115
b) Noise jobs	95	98.5	3.5	88–100	91–103
c) Quieter jobs	83	88.5	5.5	76–87	88–92
Combined activities:					
(a : b = 37 : 63%)	103 (*)	106 (*)	3	87–109	90–112
(b : c = 46 : 54%)	92 (*)	95.5	3.5	75–99	82–101
All jobs					
(a : b : c = 21:36:43%	100 (*)	104 (*)	4	74–107	81–109

(*) These mean levels do not belong to accuracy class 1 according to DIN 45 645.

L_{Aeq}: equivalent continuous sound pressure level

K_i: impulse coefficient

NB: To prevent misunderstandings, it must be pointed out that, without tests, the values for the average noise level given here cannot be regarded as the assessment levels for each individual worker. In fact, they represent the energy mean for all workers who carry out the various categorised activities in the time distribution within an eight-hour day or a 40-hour week (see construction workers).

The given average noise values for a particular trade describe the typical long-term exposure of a worker carrying out the work described. When a worker within a work group mainly carries out certain particularly noisy or particularly quiet jobs, the noise level may deviate from these values. In the assessment of the noise level, it should be borne in mind in each case that, although the average daily mean level given for an eight-hour day in this report is identical to the average assessment level, irregular daily working hours and, associated with this, higher assessment levels can be expected in many construction trades. Periods during the winter season with short-time working or unemployment have a noise-reducing effect.

Source: Published in BIA Report 2/97 ([15]).

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([15]) Knipfer, C., Funke, H.-W., 'Lärmexposition an Baustellenarbeitsplätzen Teil V' (Noise exposure in construction jobs — Part V), Hauptverband der gewerblichen Berufsgenossenschaften 1997, *BIA-Report* 3/1997. http://www.hvbg.de/d/bia/pub/rep/rep02/bia0297.html

Case study 3

Noise in the food and drinks industry ([16])

Most food and drink industries have processes which emit high noise levels exceeding 85 dB(A) and 90 dB(A), levels at which employers are required to take action. Typically noise levels range from 85 dB(A) to over 100 dB(A).

Central Labour Inspectorate, Ministry of Economics and Labour, Austria

INSHT, Instituto Nacional de Seguridad e Higiene en el Trabajo, Spain

Table 7: Noise exposure in the foods and drinks industry

Activity		Likely noise exposure $L_{EP,d}$
Drinks	Bottling halls	85-95
	Bottle filling/labelling	85-95
	De-crating/washing	85-96
	Casking/kegging	85-100
	Cooperage machines	>95
Meat	Animals in lairage	80-110
	Powered saws	up to 100
	Blast-freezers/chillers	85-107
	Bowl-choppers	>90
	Packing machinery	85-95

([16]) 'Reducing noise exposure in the food and drink industries', *HSE information sheet, Food Information Sheet* No 32. http://www.hse.gov.uk/pubns/fis32.pdf

Activity		Likely noise exposure $L_{EP,d}$
Milling	Mill areas	85-95
	Hammer mills	95-100
	Grinders	85-95
	Seed graders	90
	Bagging lines	85-90
Bakery	Dough-mixing room	85
	Baking plant	85
	De-panning	90
	Bread slicing	85-90
	Fruit washing	92
Dairy	Production areas	85-95
	Homogenisers	90-95
	Bottling lines	90-95
	Blast-chillers	87-95
	Pneumatics	85-95
Confectionery	Hopper feed	95
	Mould-shakers	90-95
	Wrap/bagging	85-95
	High boiling	85

Source: HSE Food Information Sheet No 32.

Groups at risk — Information from the Member States

Belgium

Construction and manufacturing are two sectors that show very high rates of exposure to noise. In both sectors, half of the workers report being exposed to noise at least 25 % of the time in their workplace. Also in transport and communication, hotels and restaurants, electricity, water and gas and in agriculture, rates are higher than average. Results are broadly confirmed by a national data source, with high exposures to be seen in food processing and the textile industry.

The highest prevalence of noise exposure is observed in agricultural occupations, crafts, elementary occupations, and plant and machine operation.

Noise seems to be more a problem for the 25–39 age category.

Men are more exposed to noise than women. In the male group, figures are increasing over the years. For women, rates are stable. Self-employed workers are the least exposed. Employees with full-time non-permanent contracts are most exposed to loud noise.

Czech Republic

According to European data sources, about 35 % of workers report exposure to noise.

Sectors with the highest number of workers exposed to noise include metallurgy and machinery, wood processing, textile production and the production of motorised vehicles, followed by construction, rubber and plastics production, the food industry, and forestry.

Of the 220800 employees performing work connected with noise, 19 % are women, the number of exposed men is therefore about three times higher than the number of women. Within the sectors at risk, there are considerable differences with regard to the proportions of male and female workers exposed. For example, within textile production, 75 % of workers significantly exposed are female, followed by almost 50 % in food production.

Denmark

In 2000, about 32 % of male workers and 28 % of female workers regularly had to deal with noise at work.

Since 1990, exposures were highest for workers aged 18–29. In 2000, 34 % reported to regularly be exposed to noise at work.

In many industrial trades more than half of the respondents answer that they must raise their voice and the percentage is even higher among school teachers and day-care workers. The most remarkable trend in the overall exposure is that new groups report noise exposure more than average: school teachers and other groups with pedagogical work, with a majority of women.

The rates are also higher for workers in manufacturing, construction and agriculture.

Percentages of workers regularly exposed to noise are highest for workers with full-time contracts (35 hours/week or more).

Finland

In 2003, about 40 % of the male workers and 36 % of the female workers reported ever to be exposed and bothered by noise at their workplace. Data show slight increase in exposure for both genders.

Workers in agriculture, and the construction, hotel and restaurant, and manufacturing sectors, seem to be more exposed than other sectors. Manufacturing especially shows a large increase over the years.

The highest prevalence of noise exposure is observed in agricultural occupations, crafts, and plant and machine operation. Exposure appears to have increased in many occupations, but the increases are most notable among technicians and associate professionals, craft and related trades workers, and elementary occupations.

The 25–39 age group reports higher levels from exposure. Noise exposure increases in all age groups. Workers with seasonal or irregular work are more exposed to noise.

France

The general profile of French workers with the highest incidence of exposure to noise can be summarised as follows:

- **Age**
  Exposure to very loud or very high sounds: under 24 years old
  Exposure to noise levels above 85 dB(A): between 40 and 54 years old
  General increasing trends over the time for workers under 24
- **Gender**
  Twice as many men as women exposed to noise but two to four times more women than men exposed in employee occupations and in education, health and social work
- **Sector**
  Highest rates of workers exposed in construction, industry, agriculture and transport
  Highest absolute numbers of workers exposed in the tertiary sector (sales, personal services, education, health and social works)
- **Occupation**
  Highest prevalence for blue-collar workers
  Rising trends for managers, for workers in education, health and social work and for employees, particularly in the public sector, in commercial activities and in direct personal services
- **Organisation status and size**
  Private organisations with more than 50 workers
  Rising trend for organisations with 1 to 49 workers and for local authorities.

Germany

In 1999, the highest percentage of workers reporting to be exposed to noise (about 24 %) almost all the time or often was less than 25 years old. Self-reported noise exposure is decreasing with age. About 18 % of workers over 55 reported to be exposed.

The percentage of male workers reporting to be exposed to noise almost all of the time or often has decreased from about 39 % in 1992 to 28 % in 1999. About 11 % of female workers reported to be exposed to noise in 1999.

Workers in construction (50 %) and manufacturing and mining (48 %) are most exposed to noise, followed by workers in agriculture and transport (26–27 %). Overall, noise exposure has decreased in all these occupations between 1992 and 1999.

Measurement services have conducted systematic noise emission measurements at workplaces for some years. Results presented for selected construction trades show that average exposures are likely to exceed exposure levels.

In 1999, about 44 % of workers exposed reported wearing hearing protection. Rates were highest in construction, manufacturing and mining and agriculture, as compared to transport, where only about half as many workers wear hearing protection.

Netherlands

About one third of the exposed workers are female and two thirds are men. The industrial sector claims the highest exposure rate. About 25 % of all employees are frequently exposed to detrimental sound-levels. The construction sector shows a remarkable increase of 4 % from 16 % to 20 %. The increase of large projects to do

with infrastructure is possibly the cause of this increase. Sectors in which employees are most regularly confronted with damaging levels of noise are construction, agriculture, hunting, forestry & fishing, manufacturing, electricity, gas & water and transport and communication. Workers in hotels and restaurants and education also indicate regularly having to deal with noise at work. In this sector, the percentage of employees dealing with noise is varying over the years.

The higher the age the less employees 'regularly' have to deal with noise at work, but mainly older employees (> 55) indicate that there is a high level of noise exposure. It is also mainly the older (> 55) employees that want measures to be taken to prevent exposure to noise.

Blue-collar workers show a higher degree of exposure to noise than white-collar workers due to their specific work environments.

People who work (almost) full-time are more often confronted with noise at work than people who work part-time.

According to a 2002 survey, almost all companies that have taken measures against damaging noise (90 %) have distributed hearing protection aids among employees. About one third have taken measures related to the source of the noise. In 2002, only 44 % of exposed employees regularly used the protective equipment. The necessity of measures against noise exposure is mainly seen in the sectors that have a high exposure to noise: construction, industry and transport.

Poland

The highest percentage of exposed employees — about 15 % — has been registered in mining and quarrying, followed by manufacturing, electricity, gas and water and construction.

United Kingdom

Occupations most at risk include metal, electrical, textile and other processing, security and protective services, construction, but also teaching and work in catering.

The highest-risk occupation is metal processing with a rate three and a half times the average. Repetitive assembly and inspection and other transport and machinery operatives have rates nearly three times the average. Construction and electrical processing have rates which were more than double the average.

Female school teachers, among whom no hearing difficulty was reported, reported often having to shout in an average working day.

Noise levels still exceed limit values regularly in many sectors, such as agriculture, construction, engineering, foods and drinks industry, woodworking, foundries or entertainment.

In a study, a number of companies with noisy processes were surveyed. There was a range of different management approaches to noise control and generally the larger companies had effective or partly effective hearing protection programmes in place.

The smaller companies had very limited noise control procedures and relied heavily on personal protective equipment.

Relationship with age

The exposure to loud noise seems to be affecting more and more younger workers.

According to the first candidate countries survey on working conditions, the youngest workers are more exposed to all physical factors.

In Denmark, since 1990, exposures were highest for workers aged 18–29. In 2000, 34 % reported to regularly be exposed to noise at work. In Finland, there has been little difference between age groups regarding noise exposure, although the 25–39 age group has slightly higher exposure levels than the others. Based on the data, noise exposure has increased in all age groups from 1997–2003. In France, according to the working conditions survey in 1998, the younger the workers were, the higher were the exposure rates to very loud or very high sounds (40 % of the workers under 20 as compared to 25 % for the workers over 55). Moreover, the younger the workers, the more the rates increased over time, although the total number of workers in these age groups decreased (from 1 997 000 to 1 115 000). In the Netherlands, it can be said in general that the higher the age the less employees 'regularly' have to deal with noise at work. Possible causes include the 'healthy worker effect' and labour market changes. This trend needs to be further confirmed and possible consequences assessed

The exposure of very young workers is difficult to assess and varying, as they are not or to a low degree included in the surveys. According to the corresponding directive, young workers should not be exposed to loud noise.

Noise in the entertainment sector

The 2003 EU directive on work-related noise requires Member States to work with social partners to produce practical guidance for the music and entertainment sectors, however they may be defined within different Member States.

Case study 1 ([17])

A teenage girl was seen for a school physical examination. Screening audiometry performed in the office revealed a 30-dB (mild) elevation of hearing thresholds at 4 000 Hz. A confirmatory audiogram taken by an audiologist showed a sensorineural loss in a 'notch' pattern at 4 000 Hz. In response to questioning, the girl reported spending several hours a day listening to music through headphones. The previous night, she had spent several hours at a rock concert without wearing hearing protection. Afterward, she noticed that her ears were ringing and 'felt like there was cotton in them'. Several days later, her hearing had returned to normal.

([17]) Rabinowitz, P.M., 'Noise-induced hearing loss', *American Family Physician* [serial online] Vol. 61/No 9 (1 May 2000), http://www.aafp.org/afp/20000501/2749.html

This is an example of a person who has experienced a 'temporary threshold shift'. Temporary threshold shifts are common in persons exposed to excessive noise, and they represent transient hair cell dysfunction. Although complete recovery from a given episode can occur, repeated episodes of such shifts occurring after noise exposures give way to permanent threshold shifts because hair cells in the cochlea are progressively lost.

Case study 2

Noise in clubs and pubs (literature review) ([18])

The objectives of this study were to carry out a review of the literature, published since 1985 to establish what is known about the noise levels and noise exposure to workers in pubs and clubs.

All of the LEP,d values reported in the literature, with the exception of a few conducted in pubs, exceed 85 dB(A). In the majority of cases, employees are subjected to exposure levels greater than 90 dB(A). Even taking into account the casual nature of this form of employment, there is a significant potential for employees to incur some level of hearing loss the extent of which is dependent on the noise levels and the period of employment.

Table 8: Summary of the individual noise exposure data calculated from data presented in the literature

Task/ occupation	Number of measurements	Average LEP,d dB(A)	Standard deviation dB(A)	Average hours per week
DJ	53	**96,3**	4,8	16,5
Bar Staff	204	**92,3**	4,2	15,7
Floor staff	32	**92,9**	4,4	
Security	10	**96,2**	3,2	

Source: HSE research report 026.

Case study 3 ([19])

In Sweden, a demonstration project is being carried out with the aim of improving the sound and reducing the risk of hearing loss and tinnitus for musicians, the audience and the employees. The idea is to lower the volume while improving the sound quality. The Swedish Institute for the Work Environment, Arbetslivsinstitutet, is behind the project.

([18]) Smeatham, D., 'Noise levels and noise exposure of workers in pubs and clubs — a review of the literature', *HSE research report 026*, Health and Safety Executive, 2002. http://www.hse.gov.uk/research/rrpdf/rr026.pdf

([19]) Auris 2004, No 5. Cited in press hear-it, Hear-it AISBL website. http://www.press.hear-it.org/page.dsp?page=3565

Small venues are particularly hazardous to one's hearing because the audience is close to the music, making the noise extremely intense. Many night club guests endanger their hearing because they are unaware of the real noise intensity in their club.

The project is designed to investigate if it is possible to improve the sound quality through modifications to the facilities and to determine the cost.

A Gothenburg venue, with a 250-guest maximum capacity, will be the first club to be remodelled. 'Acoustic, as well as technical, changes are involved. Some rebuilding will be carried out, such as changes in the stage and bar configuration', said project manager Kim Kähäri of the Arbetslivsinstitutet to the Swedish journal for hearing impaired people, *Auris*.

Opinion polls will be taken among musicians, employees and guests before and after the project is carried out. They will be asked to assess the sound quality and how it may be affected by the lowering of the volume.

Relationship with employment status

According to European and some national sources, **employees with full-time non-permanent contracts are most exposed to loud noise.** This group often has less information available relating to health and safety issues, less training and less formal supervision and control in the workplace.

Self-employed workers are less likely to be exposed to noise (particularly all or almost all the time) than employees. Among employees, those with fixed-term contracts are more exposed than those with permanent contracts.

Wearing personal protective equipment and information about the risk

Allgemeine Unfallversicherungsanstalt, Austria

In the EU-15, all sectors report an increase in wearing personal protective equipment and an improvement in risk awareness, except the transport and communication sector. There seems to be an improvement in risk awareness for both employed and self-employed and among employees for all employment status categories. Nevertheless, temporary agency workers remain, as in 1995, the least informed about risks. This group reports the highest rate of wearing personal protective equipment.

According to the ESWC, there is an improvement in coping with noise exposure.

Firstly, information on possible risks has improved (from 71 % in 1995 to 76 % in 2000). About 41 % of Europeans consider themselves to be very well informed about risks at work and another 36 % consider they are well informed.

Secondly, the use of protective equipment has increased (from 16 % in 1995 to 21 % in 2000). There is an improvement in risk awareness for both employed and self-employed and among employees for all employment status categories. Nevertheless,

temporary agency workers remain, as in 1995, the least informed about risks. This group reports the highest rate of wearing personal protective equipment. This can be explained by the higher exposure to noise while they are working in conditions with less prevention measures focused on attacking the source of noise.

Case study 1:

In a UK study ([20]), a range of companies with noisy processes was surveyed. There was a range of different management approaches to noise control and generally the larger companies had effective or partly effective hearing protection programmes in place. The smaller companies had very limited noise control procedures and relied heavily on personal protective equipment.

This report describes a study in which the various factors influencing workers' attitudes and behaviours towards hearing protection were examined. Subsequently, workplace intervention programmes were designed and carried out to improve the acceptance and overall use of hearing protection. This work was carried out in two distinct phases. In Phase 1, a range of companies with noisy processes was surveyed and information was collected from employers and employees by means of self-administered questionnaires. These identified various organisational and personal factors that play a major part in worker behaviour. The questionnaire surveys were supplemented by independent observations on working practices and conditions to minimise any potential biases.

The companies surveyed were from a range of industries and covered large, medium, small and very small employers. There was a range of different management approaches to noise control and generally the larger companies had effective or partly effective hearing protection programmes in place. The smaller companies had very limited noise control procedures and relied heavily on personal protective equipment. Control of noise exposure was seen as a low-priority issue across many companies, large and small. This is likely to be due to the natural tendency to give higher priority to other coexisting physical or chemical hazards, which have more immediate health effects. In general, the employees that responded to the questionnaires had a high level of risk awareness and medium to high levels of knowledge about noise.

Table 9: Summary of noise exposure ranges and source noise levels by factory location

Work activity observed	No. of employees at site ([1])	Company size	Range of measured noise levels ([2])	Range of daily noise exposures % ([3])	Usage ([4])
Compressed gas supply depot	25	Large	85–94	80–90	10
Paper coating/ laminating	200	Large	81–88	84–88	25
Ship building (blacksmith shop)	1 500	Large	90–110	90–95	28
Roadstone quarry	30	Large	80–105	80–93	50

([20]) Hughson, G. W., Mulholland, R. E., Cowie, H. A., 'Behavioural studies of people's attitudes to wearing hearing protection and how these might be changed', *HSE research report* 028, Health and Safety Executive, 2002. http://www.hse.gov.uk/research/rrpdf/rr028.pdf

Work activity observed	No. of employees at site (1)	Company size	Range of measured noise levels (2)	Range of daily noise exposures % (3)	Usage (4)
Light engineering (fabrication)	500	Large	84–105	85–93	50
Joiner's workshop	6	Large	90–97	79–84	66
Ship building (heavy fabrication)	1 500	Large	83–106	88–99	80
Light engineering (machine shop)	31	Large	84–92	84–93	100
Food processing	107	Large	87–94	89–92	100
Coal fired power station	268	Large	93–102	85–102	100
Light engineering (power presses)	230	Medium	83–103	83–91	10
Light engineering (fabrication)	100	Medium	83–95	82–92	20
Bottling	130	Medium	84–92	84–97	95
Textiles (twisting & winding)	94	Medium	88–92	85–94	100
Light engineering (fabrication)	30	Small	93–102	80–88	0
Ferrous foundry	15	Small	81–112	86–108	50
Stone mason	15	Small	92–105	82–99	100
Construction services (core drilling)	25	Small	101–107	89–99	17
Road stone quarry	10	Very small	85–106	82–94	10
Light engineering (boring and turning)	8	Very small	92–103	90–98	50
Construction (road maintenance)	4	Very small	101	85–94	100

NB:

1. The total number of employees on the site, used to classify company by size.
2. The range of source noise levels measured in the work areas observed.
3. The range of measured personal noise exposures during the observation period.
4. Defined as the percentage ratio of the number of workers regularly wearing hearing protection inside the ear protection zone by the total number of workers in this zone.

Source: HSE research report 028.

Case study 2:

In the Netherlands, according to a 2002 survey, almost all companies that have taken measures against damaging noise (90 %) have distributed hearing protection aids among employees. About one third have taken measures related to the source of the noise. In 2002, only 44 % of exposed employees regularly used the protective equipment. The necessity of measures against noise exposure is mainly seen in the sectors that have a high exposure to noise: construction, industry and transport.

2.2. Combined exposures

The fact that loud noise causes hearing impairment is well documented. So, when a person exposed to a noisy working environment develops hearing problems, the effect is readily blamed on the noise level. Yet exposure to chemical solvents can also affect hearing, and such effects are probably underestimated. Known ototoxins include solvents (carbon disulfide, n-hexane, styrene, toluene, trichloroethylene, xylene), metals (arsenic, organic tin, mercury and derivatives, manganese), drugs (some chemotherapy agents, antibiotics and aspirine and related medication) and asphyxiants (carbon monoxide).

It is worth noting that sectors with high exposures of workers to noise also have high exposures to dangerous substances (such as pesticides and solvents) and vibrations. Industries with potentials for hazardous combined exposure include printing, painting, boat building, construction, glue manufacturing, metal products, chemicals, petroleum, leather products and furniture making. This is also the case for agriculture and mining. This might enhance the effects of noise on hearing loss. Combined exposure to noise, vibration and heat can also occur in foundries. Many of these sectors are more predominant in the new Member States than they are in the EU-15 ([21]).

Some information on related research can be found in section 'Health effects' of this report.

([21]) European Survey of Working Conditions *ESWC*.

2.3. Impulse noise

The effect from impulse sound can be instantaneous and can result in an immediate hearing loss that may be permanent. The structures of the inner ear may be severely damaged. This kind of hearing loss may be accompanied by tinnitus, an experience of sound like ringing, buzzing or roaring in the ears or head, which may subside over time. Hearing loss and tinnitus may be experienced in one or both ears, and tinnitus may continue constantly or intermittently throughout a lifetime.

There are indications that the proportion of workers exposed to impulse/sudden noise is slightly rising. Impulse noise can cause more severe hearing loss than steady state noise. The additional effect of occupational impulse noise on hearing has been shown to be from 5 to 12 dB at 4 kHz audiometric frequency. Reported cases for compensated for hearing loss are prevalent in occupations where noise is impulsive. High noise levels, particularly those of short duration such as impulse or impact noise are, for example, present in many metal fabrication workshops. Examples of machinery emitting impulse noise are electric angle grinders, metal presses, cutting saws and hammering and banging on metal objects. Further sources may be found from welding and gouging which all cause high noise levels to be emitted.

One study ([22]) indicates that there is no valid method to combine steady state and impulse noise and that various national risk criteria for the assessment of impulse noise differ from international risk criteria. The authors conclude that 'there is an urgent task to develop risk assessment method and risk criteria for impulsive noise to meet the requirements of the […] European Union noise directive'.

The number of female workers occasionally exposed to sudden and disturbing noises noise can be considerably higher than for male workers. As an example, for France, although the general incidence rates for men were higher than for women, according to the breakdown by occupations and by gender more than twice as many women as men are exposed to loud/high sounds in education, health and social work. Some new occupations affected include call centres (use of headphones) ([23]). For more information on research about acoustic shock see section 'Health effects' of this report.

([22]) Starck, J., Toppila, E., Pyykko, I., 'Impulse noise and risk criteria', Noise and Health, 5(20) 2003, pp. 63–73.

([23]) Paulsen, R., 'Call-Center: Auswahl geeigneter Headsets' (Call-centres: selecting suitable headsets), *BIA-Report* 1/2003, Hauptverband der gewerblichen Berufsgenossenschaften, 2003. http://www.hvbg.de/d/bia/pub/rep/rep04/pdf_datei/biar0103.pdf

2.4.

Medium-level noise

There is ample evidence showing that high noise levels interfere with speech and communication, cause sleep disturbance, decreased learning ability and scholastic performance, increase stress-related hormones, blood pressure changes, ischaemic heart disease as well as the use of psychotropic drugs and medicines ([24]) ([25]). Women are generally reporting to be more exposed to medium-level noise. Typical professions include education, healthcare, restaurants, offices and call centres. These are also professions where the exposure to stress is rated high.

Women are generally reporting to be more exposed to medium-level noise. Typical professions include education, healthcare, restaurants, offices and call centres. These are also professions where the exposure to stress is rated high.

Noise in education

Sound pressure levels during school lessons frequently exceed values recommended for 'mental' or 'informational' work considerably ([26]).

An analysis of German and international references shows that classroom acoustics have been neglected. Measurements of several classrooms in everyday use have revealed acoustical conditions that permit less than half of the speech to be understood. Generally, the problems are caused by improper wall, ceiling, and floor finishes and by noisy ventilation equipment.

A Canadian study ([27]) reviewed existing Canadian data and noted that the acoustics problem is particularly severe in schools built in the 1960s and 1970s. In a typical first grade classroom, the pupils hear just two thirds of what the teacher says. The other third is lost in the bad acoustics and in the noise from the pupils, from the outside and from the ventilation. The two Canadian researchers call for a cooperative effort among educators, architects and audiologists.

The German project ([28]) 'Noise in education facilities: causes and reduction' analysed the problems in four elementary schools and one secondary school. In these schools, several classrooms (N=30) were analysed for reverberation time and speech transmission index. Additionally the sound pressure level (SPL) was monitored for

([24]) Press Release WHO/57, 31 July 1998. WHO website. http://www.who.int/inf-pr-1998/en/pr98-57.html

([25]) Nemecek, J., Turrian, V., Sancin, E., 'Disturbances caused by noise in offices', *Soz Praventivmed*, 21(4), 1976, pp. 133–4.

([26]) Schönwälder, H.-G., Berndt, J., Ströver, F., Tiesler, G., 'Belastung und Beanspruchung von Lehrerinnen und Lehrern' (Professional stress and strain in teachers), *Research Report* Fb 989, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dortmund, 2003. http://www.baua.de/english/fors/fb03/fb989_e.htm

([27]) Picard, M., University of Montreal, Bradley, J. S., National Research Council, Ottawa, Canada. Accoustical Society of America, 133rd Meeting Lay Language Papers and Howard Leight Hearing Protection. Cited in press hear-it, Hear-it AISBL website. http://www.hear-it.org/page.dsp?page=2153

([28]) Schönwälder, H.-G., Berndt, J., Ströver, F., Tiesler, G., 'Lärm in Bildungsstätten — Ursachen und Minderung' (Noise in schools — causes and reduction), *Research Report* Fb 1030, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dortmund, Berlin, Dresden, 2004. http://www.baua.de/fors/fb04/fb1030.pdf

565 lessons. Two observers inside the classroom registered all activities relevant for noise. The results were as follows.

1. Only a few of the classrooms comply with the standards of the DIN 18041 of 1965, no classroom with the actual DIN 18041 of 2004 (national standard for acoustic requirements).
2. Three model classrooms comply with the standard of the actual DIN 18041 after structural sanitation.
3. During lessons, levels from 50 to 60 dB(A) in phases of silent work and 60 to 80 dB(A) during conversation were measured. The most important source of noise is the human voice.
4. Noise levels during lessons depends on the age of the students, younger students produce more noise than older ones.

Intensive behaviour training with school-beginners has the effect of reducing noise level, whereas training in higher classes shows a lower effect. The study concludes that complaints about bad acoustical working environment seem to be valid; structural sanitation of classrooms combined with early behaviour training is recognised as most suitable for reducing such noise problems.

Children in a day-care facility learn how to adapt their noise levels
Landesunfallkasse NRW, Germany

Another study ([29]) concludes that limits required for the time of reverberation (that is, the time that would be required for the sound pressure level in the enclosure to decrease by 60 decibels after the source has been stopped) in school rooms are largely exceeded. Reverberation (commonly known as an echo) is defined as the persistence of sound in a room after the source has stopped. In a reverberant space, successive syllables blend into a continuous sound, through which it is necessary to distinguish the orderly progression of speech. This is a consequence of the large room volume coupled with an abundance of hard surfaces. School designers frequently overlook the need for reverberation control in gymnasiums, cafeterias, and other large school rooms. The high level of reverberation promotes a high noise level and interferes with speech intelligibility. The study provides guidance for acoustic measures to

([29]) 'Leitfaden Raumakustik in Unterrichtsräumen — ein aktuelles Thema der Schulhygiene — Auswirkungen auf Sprachverständlichkeit und Stimmbelastung' (Acoustics in school rooms — effects on speech intelligibility and voice strain), Deutscher Arbeitsring für Lärmbekämpfung Texte und Materialien, Sozialministerium Mecklenburg-Vorpommern, 2001. http://www.dalaerm.de/materialien/schulraumakustik1.pdf

tackle the problem. The US National Clearinghouse for Educational Facilities also provides links to more information on the topic ([30]).

Following a Danish study on noise in children's day-care centres ([31]), an official guide for the establishment of day-care centres has been issued, prepared by working environmental authorities. The guide, entitled *Guide on the establishing of day-care centres*, presents all requirements from different regulations relevant to day-care centres together with practical advice on how to meet these requirements. Other guidance to reduce noise in schools also includes acoustic ([32]) as well as educational measures ([33]).

Recommended noise levels

The figures above should also be put in perspective with the 'WHO guidelines for community noise' which require less than 30 dB(A) during the night for a sleep of good quality and less than 35 dB(A) in classrooms to allow good teaching and learning conditions.

Some increasing occupations, such as VDU workplaces in manufacture also merit specific measures as these tasks require special attention, but noise levels might easily exceed limits for office work ([34]).

Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany

([30]) Classroom Acoustics Resource Lists. US National Clearinghouse for Educational Facilities. http://www.edfacilities.org/rl/acoustics.cfm

([31]) Voss, P., 'Noise in children's day-care centres', *Magazine*, Issue 8 'Noise at work', European Agency for Safety and Health at Work, 2005, pp. 23–25. http://osha.eu.int/publications/magazine/8/en/magazine8_en.pdf

([32]) Classroom Acoustics, Technical Committee on Architectural Acoustics of the Acoustical Society of America, 2000. http://asa.aip.org/classroom/booklet.htm

([33]) Lärm in Bildungseinrichtungen – ein Lern- und Gesundheitsproblem (Noise in educational establishments — a learning and health problem). Thema des Monats Juni 2005. Landesunfallkasse Nordrhein-Westfalen. Available at http://www.luk-nrw.de/praev/thema/thema_05_06.asp.

([34]) Probst, W., Bildschirmarbeit — Lärmminderung in der Produktion. Beurteilung und Minderung des Lärms an Bildschirmarbeitsplätzen im Büro und in der Produktion. Arbeitswissenschaftliche Erkenntnisse — Forschungsergebnisse für die Praxis Nr. 124, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dortmund, 2002.

The following table sums up some recommendations for noise exposures in offices and similar occupations:

Table 10: Recommended noise levels.

Occupation/Workplace	Recommended limit [a],[b],[c],[d] [dB(A)]
School rooms	30–40
Offices	30–40
Open plan offices	35–45
Laboratories with routine work	35–50
Control stations	35–55
Manufacturing workplaces, workshops	65–70
Health sector	30–45

[a] EN ISO 11690-1

[b] NTP 503: Confort acústico: el ruido en oficinas (Acoustical comfort: noise in offices). Notas Técnicas de Prevención. INSHT Website. Instituto Nacional de Seguridad e Higiene en el Trabajo, Spain. Available at http://www.mtas.es/insht/ntp/ntp_503.htm. Accessed Sep 20, 2005.

[c] Bildschirmarbeit – Lärmminderung in kleinen Büros, Lärmminderung in Mehrpersonenbüros (VDU work - Noise reduction in small offices, noise reduction in open plan offices). Dortmund 2003. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. Arbeitswissenschaftliche Erkenntnisse Nr. 123 und 124.

[d] DIN 33410

Sources: See references.

WHO guidelines for noise ([35])

Guideline values for community noise (listing also critical health effects ranging from annoyance to hearing impairment), set up by WHO include for example:

Table 11: WHO recommended noise levels

Environment	Critical health effect	Sound level dB(A)*	Time hours
Outdoor living areas	Annoyance	50–55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
School classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

(*) The guidelines also offer recommendations to governments for implementation, such as extending (and enforcing) existing legislation and including community noise in environmental impact assessments.

([35]) 'Occupational and community noise', *Fact Sheet* 258 (rev. Feb. 2001). Fact sheets. WHO website. http://www.who.int/mediacentre/factsheets/fs258/en/

3.

HEALTH EFFECTS

Noise can cause a number of negative health effects including:

- temporary hearing loss from short-term exposure to high noise levels, with normal hearing returning after a period of rest;
- permanent hearing loss after prolonged exposure to high noise levels;
- tinnitus — a ringing or buzzing in the ears or head;
- increased blood pressure and stress;
- inability to sleep, fatigue and other sleep problems;
- a sense of isolation and interference with general workplace communications;
- inability to hear warnings of imminent safety hazards due to excessive noise.

The effect of noise can also be potentiated by chemicals.

level	Noise source	Health effects
140dB	Jet plane take off, firecracker, gun shot	Sudden damage to hearing
130dB	Pain threshold exceeded	
120dB	Ambulance siren, pneumatic drill, rock concert	
110dB	Night clubs, disco	
100dB	Motor cycle at 50km/h	
90dB	Heavy goods vehicle at 50km/h	
85dB	Hearing protection recommended in industry	Hearing loss, tinnitus
75dB		Cardiovascular effects
70dB		Sleep disturbances
65dB		Stress effects
60dB		Annoyance
55dB	Desirable outdoor level	
50dB	Normal conversation level	
40dB	Quiet suburb	
30dB	Shoft whisper	
20dB	Normal conversation level	

Source: Nopher, a European Commission concerted action to reduce the health effects of noise pollution. http://www.ucl.ac.uk/noiseandhealth/EC%20Brochure1.pdf

3.1. Noise-induced hearing loss

In Europe, 22.5 million individuals suffer form hearing impairment, with 2 million being profoundly deaf. All together, in Europe, the financial cost of hearing impairment has been estimated to be EUR 78 billion per year (based on an average of EUR 3 500 per patient annual costs for special education, speech therapy, hearing aids, physician and specialists fees, and other expenses). This is more than the combined economic costs of epilepsy, multiple sclerosis, spinal injury, stroke and Parkinson's disease. Furthermore, this figure is likely to grow continuously in time due to noise pollution and ageing. Hearing loss is the third most common chronic disability following arthritis and hypertension ([36]).

Noise-induced hearing loss represents excessive 'wear and tear' on the delicate inner ear structures. Hair cells and inner ear structures can be injured by noise in two different ways: from an intense brief impulse, such as an explosion, or from continuous exposure to noise, such as that in a woodworking shop.

Symptoms of hearing loss

The symptoms of noise-induced hearing loss that occur over a period of continuous exposure increase gradually. Early stages of hearing loss will make it difficult to hear children's voices, followed by women's voices. Sounds may become distorted or muffled, and it may be difficult for the person to understand speech. The individual may not be aware of the loss, but it can be detected with a hearing test.

In addition, hearing loss may affect workers in ways they may not have considered, such as:

- ringing or buzzing in the ears or head (called tinnitus)
- elevated blood pressure
- fatigue
- stress
- social isolation from co-workers, family and friends.

The UK HSE Textiles Sector Group has launched an *audio clip* ([1]) showing the effect of exposure to noise over a working life. The deafness simulations all include the effects of noise exposure and ageing. At the end of each simulation the normal hearing for the age can be heard.

([1]) http://www.hse.gov.uk/noise/demonstration.htm

([36]) 'World Deafness Day: European funding brings major research results on deafness', European Commission Joint Research Centre press release, 1 September 2003. http://www.jrc.cec.eu.int/default.asp@sidsz=more_information&sidstsz=press_releases&sanchor=449.htm

Noise-induced hearing loss can be caused by a one-time exposure to loud sound as well as by repeated exposure to sounds at various loudness levels over an extended period of time. Occupational noise-induced hearing loss, as opposed to occupational acoustic trauma, is hearing loss that develops slowly over a long period of time (several years) as the result of exposure to continuous or intermittent loud noise. The diagnosis of noise-induced hearing loss is made clinically by a medical professional and should include a study of the noise exposure history.

Definition: Noise-induced hearing loss ([1]) ([2])

The principal characteristics of occupational noise-induced hearing loss are as follows.

- It is always sensorineural, affecting hair cells in the inner ear.
- Since most noise exposures are symmetric, the hearing loss is typically bilateral.
- The rate of hearing loss due to chronic noise exposure is greatest during the first 10–15 years of exposure, and decreases as the hearing threshold increases. This is in contrast to age-related loss, which accelerates over time.
- Typically, the first sign of hearing loss due to noise exposure is a 'notching' of the audiogram at 3000, 4000, or 6000 Hz, with recovery at 8000 Hertz (Hz) ([2]). The exact location of the notch depends on multiple factors including the frequency of the damaging noise and the length of the ear canal. Therefore, in early noise-induced hearing loss, the average hearing thresholds at 500, 1000, and 2000 Hz are better than the average at 3000, 4000, and 6000, and the hearing level at 8000 Hz is usually better than the deepest part of the 'notch'. If exposure is continued, the notch gradually deepens and widens. Eventually, retention of good hearing in the higher frequencies is lost, and the resulting hearing loss appears only as a relatively steep high-frequency loss beginning at 3000 Hz and becoming more severe at each higher frequency over a period of many years. Persistent noise exposure progressively encroaches on the middle frequencies. In the most severe cases, even the lower frequencies may eventually become involved. This 'notching' is in contrast to age-related hearing loss, which also produces high frequency hearing loss, but in a down-sloping pattern without recovery at 8000 Hz ([3]).
- Noise exposure alone usually does not produce a loss greater than 75 decibels (dB) in high frequencies, and 40 dB in lower frequencies. However, individuals with superimposed age-related losses may have hearing threshold levels in excess of these values.

([1]) 'Noise-induced hearing loss, position statements/guidelines', American College of Occupational and Environmental Medicine, 2002.. http://www.acoem.org/position/statements.asp?CATA_ID=53

([2]) Roland, P. S., 'Inner ear, noise-induced hearing loss', E-Medicine website. http://www.emedicine.com/ent/topic723.htm

General prevalence

Noise-induced hearing loss is still one of the most prominent and most recognised occupational diseases in the Member States of the European Union. According to

data from 2001 — results of Eurostat statistical assessment EODS for the EU-15 ([37]) — cases of noise-induced hearing loss were recognised in all but two of the 12 Member States and there were 4 068 cases in total (6 700 if extrapolated to the EU-15 according to Eurostat). In this assessment, averaged over the 12 countries, noise-induced hearing loss was the fourth most common occupational disease recognised in 2001. The incidence rate was 4.7 per 100 000 current workers. About 97 % of the cases occurred in men. Of the cases with known economic activity of the employer, 51 % were reported in the manufacturing sector, followed by construction (17 %), but cases occur in all sectors. The development regarding this disease is different depending on country and recognition policy. While in some countries figures are slightly decreasing, they are more or less stable in other countries and even increasing. The highest numbers of cases are registered in the age groups 50–54 and 55–60.

Sectors with a high prevalence include agriculture, forestry and fishing; mining and quarrying; extraction, energy and water supply, manufacturing and construction.

While there may be some under-reporting and under-recognition especially for female workers, figures also depend on the threshold applied for the definition of hearing loss.

Table 12: Number of occupational diseases by diagnosis

Diagnosis	EU-12	EU-15 Extrapolated
Diseases of the sensor organs	4 077	6 749
Noise induced hearing loss	4 068	6 734
Other diseases of the sensory system	9	15

Source: EODS.

These figures do not provide an exact picture of noise-induced hearing losses in Europe as the national occupational diseases compensation or reporting schemes are very different. The data on recognised occupational diseases reflect not only the occurrence of such diseases, but inevitably also the way in which the concept of an occupational disease has been integrated into the social security system ([38]). Different countries use different criteria for defining hearing loss caused by noise. The level decisive for notifying and recognising the occupational illness is variable. The number of occupational illnesses reported is also influenced by the level of impairment that makes the injured person eligible for financial compensation.

For example, in Finland, in 1964, only four cases of occupational hearing loss were reported or compensated. After a legislative change in 1968, when the compensation threshold was lowered from 45 dB to 20 dB permanent threshold, an increase to 1 656 cases reported per annum in 1975–79 was seen. The cases of hearing loss therefore need to be seen in the light of the threshold of impairment and the possible link to compensation applied when recognising the disease as occupational.

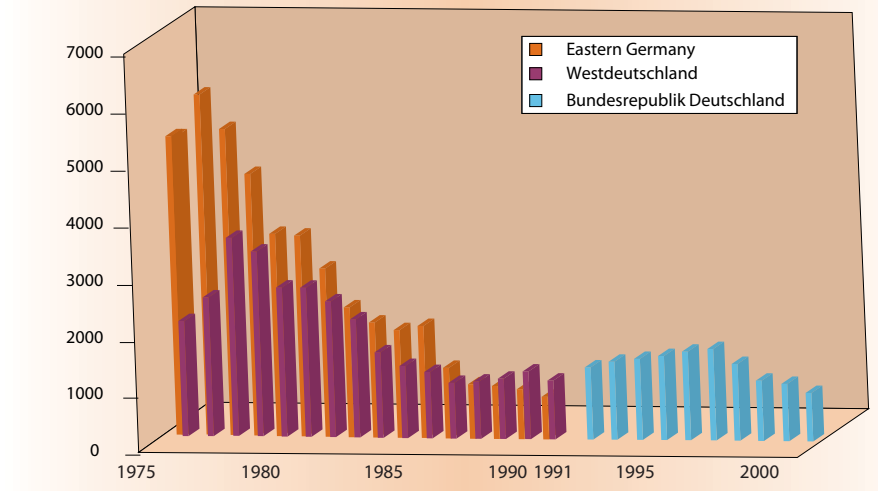
([37]) Karjalainen, A., Niederlaender, E., 'Occupational diseases in Europe in 2001', *Statistics in Focus* No 15/2004, Eurostat, 2004.http://epp.eurostat.cec.eu.int/cache/ity_offpub/ks-nk-04-015/en/ks-nk-04-015-en.pdf

([38]) 'European occupational diseases statistics, European health and safety at work statistics' — Eurostat supporting paper submitted by Eurostat, Joint ECE-Eurostat-ILO Seminar on Measurement of the Quality of Employment (Geneva, 3–5 May 2000).

According to EODS 2001, Finland, with a working population of about 2.4 million, reported 821 cases out of the 4 068 cases. As, according to the ESWC, exposure to high-level noises in Finland is very close to the EU average, one could extrapolate from the Finnish figures; an equivalent EU figure would be in the region of 50 000 cases.

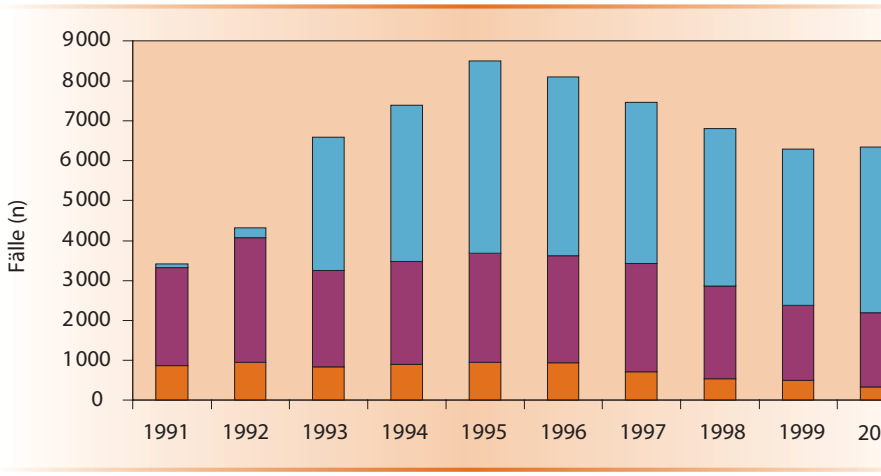
In Germany, a country that is not included in the EODS data collection, after a rise in 1995, the number of recognised cases of hearing loss are stabilising and decreasing with regard to the degree of impairment.

Figure 11: Recognised (compensated) cases of hearing loss 1975–2000



Source: http://bb.osha.de/docs/laermschwerhoerigkeit.pdf ([39]).

Figure 12: Germany — Recognised cases of hearing loss by degree of impairment (> 20 % brown, 10–15 % pink, < 10 % blue)



Source: http://bb.osha.de/docs/laermschwerhoerigkeit.pdf

([39]) Jürgens, W. W., 'Lärmschwerhörigkeit — Aspekte aus arbeitsmedizinisch-gewerbeärztlicher Sicht (Noise-induced hearing loss — occupational health aspects), Vortrag Lärmkonferenz Cottbus, 15 November 2001, German OSHA network website. http://bb.osha.de/docs/laermschwerhoerigkeit.pdf

A shift to cases with lower impairment is confirmed by Finnish data and a similar trend could be at the origin of decreases in figures in other Member States (Poland, France and Italy (INSERT Links to national data).

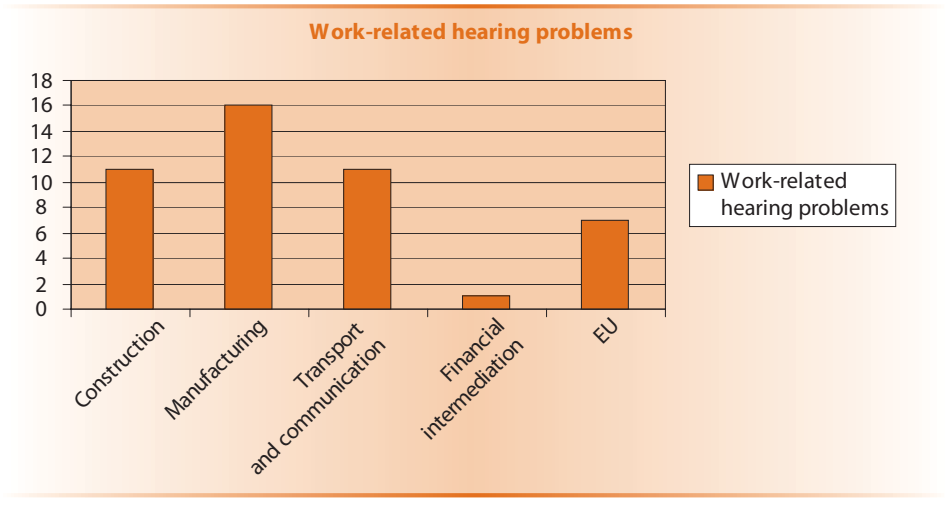
In other countries, such as Belgium, hearing loss has diminished for workers in occupations traditionally linked to noise exposure such as craft workers and mechanics, but is still rising for others, such as agriculture.

In the United Kingdom, in the last four years the numbers of cases of disablement benefit for noise-induced deafness has shown little change, following a long-term decline since at least the 1980s.

According to European survey results ([40]), self-reported hearing problems increase slightly. About 7 % of European workers consider that their work affects their health in the form of hearing disorders according to the ESWC data. Reported hearing loss due to the work increased from 6 % in 1995 to 7 % in 2000.

Workers who report high exposure to noise also report higher rates of hearing problems. There are significant differences within the sectors. Mining and manufacturing, construction and transport and communication report hearing problems more often than the average. Except for communication and transport, these sectors report also higher rates of exposure to noise.

Figure 13: % of workers reporting work-related hearing problems by sector (ESWC, 2000)



Source: ESWC.

Table 13: % of workers reporting health and hearing problems (general)

EU	1995	2000
Hearing problems	6,4	7,2

Source: European survey, 1995–2000.

([40]) European Survey on Working Conditions ESWC.

Hearing problems are more reported in the group 40–54. This is also the group with the highest exposure to noise. Men suffer more from hearing problems than women, but it is worth noting that in Poland cases of hearing loss in women are increasing. Men report such a risk more than three times as often as women in the EU-15. Figures also show an increase for men from 1995 to 2000. Women report the same figure in 2000 as in 1995.

Hearing loss due to work is reported especially in the manufacturing, construction and transport sectors, while it is virtually non-existent in the sector of financial intermediation. The construction sector and the manufacturing sector also have the highest percentage of workers exposed to loud noise in the workplace. In the new Member States, significant prevalence can also be observed in mining and quarrying. Rates of recognised hearing loss among women are also higher. In Poland, in 2003, they rose up to 38 %.

Blue-collar workers report the highest rate of hearing problems. It is most likely that this group is also significantly more exposed to noise. These occupation categories are exposed to noise through their direct working association with the various processes/machinery involved.

Self-employed workers report the least hearing problems. Within employees, the figures show an increase of 1 %. Employees on apprenticeship or other training schemes especially report more hearing problems in 2000 than in 1995.

Hearing loss — information from the Member States

What is the extent of the problem?

Belgium

Some 5 % of Belgian workers report hearing problems due to their work. This is a slight increase since 1995. Occupational deafness makes up a major part of occupational diseases. In 2001, it ranked second on the list of accepted cases of occupational diseases after vibration-induced illness. There seems to have been an increase between 2000 and 2003.

Czech Republic

In 2000–02, a significant decrease in the number of recognised cases of occupational hearing loss was observed (more than 40 %), but in 2003 the number of recognised diseases was again higher and reached the number recognised in 1996.

Denmark

A total of 1 639 notifications of potential work-related hearing loss were received in 2002. The number of notifications steadily decreased since 1993.

Finland

The number of reported cases has decreased in 1987–2002 from about 2 000 annual cases to less than 1 000 annual cases. Information on severity was provided in 55 % of the reported cases of noise-induced hearing loss. In nearly 70 % of these, the severity was below 10 %, that is, below the cut-off level of financial reimbursement.

France

In the 'Régime général' (most important group of insured workers from the private sector), the number of new compensated noise-induced hearing losses decreased by 43 % in France between 1988 and 2002, although the total number of new compensated occupational diseases has increased continuously from 3 972 cases in 1987 to 21 697 in 2000. Noise-induced hearing loss still remains the fifth most important occupational disease in 2002.

Germany

In 1995 and 2001, hearing loss was the second most reported occupational disease after skin diseases. After a rise in 1995, the number of recognised cases of hearing loss are stabilising and decreasing with regard to the degree of impairment. Notified occupational hearing loss cases sank from 10 861 in 2001 to 9 918 in 2003.

Hungary

In the first candidate countries survey on working conditions, approximately 9.6 % of workers in Hungary reported hearing problems.

Italy

On the whole, the incidence of hearing losses among workers is decreasing.

Netherlands

Some 25 % of the number of occupational disease reports at the Netherlands Centre for Occupational Diseases (NCvB) concern hearing disorders. They are the second most reported diseases. The number of reported cases of hearing loss is increasing.

Poland

From 1980 to 1990, the number of recognised cases of occupational hearing loss increased from approximately 17 to 22 per 100 000 persons employed. From 1990 to 2003, the number of registered cases decreased significantly to approximately five per 100 000 persons employed.

United Kingdom

The number of people in the UK suffering from hearing difficulties as a result of exposure to noise at work was estimated at 509 000 by a Medical Research Council (MRC) survey in 1997–98. It is much larger than the estimate from HSE's 'Self-reported work-related illness' (SWE) surveys. In 2003–04, an estimated 81 000 people in the UK believed they were suffering from a hearing problem that was caused or made worse by their current or past work.

In the last four years, the number of cases of disablement benefit for noise-induced deafness has shown little change, following a long-term decline since at least the 1980s.

Which are the groups most concerned by hearing loss?

Belgium

Most hearing problems are reported by workers in the agriculture sector and the electricity, gas and water distribution sector. Craft and related trade workers suffer the most from occupational deafness followed by plant and machine operators and assemblers. The rate in these groups has been rising since 2000. An increase can be observed for professionals, service workers and shop and market sales workers, skilled agriculture and fishery workers.

After the age of 40, the rates show a considerable increase. After 55 years occupational deafness is most prominent. Occupational hearing loss is increasing between both sexes. The major part of this disease affects male workers.

France

Blue-collar workers in the metallurgy or construction sector and drivers, aged between 50 and 59, are the group with the highest incidence of compensated hearing losses.

Almost all new compensated hearing losses were observed for male workers in 2002.

Finland

About 95 % of the cases in 1999 were reported among men, and the incidence of reported cases was highest in those aged 50 to 54 years. Over 90 % of the cases in 2002 were reported among men, and the incidence of reported cases was highest in those aged 55 to 59 years. In 2002, the industry-specific incidence per current number of employed workers was highest in the manufacture of transport equipment and in the manufacture of pulp, paper and paper products. The highest occupation-specific incidence rates were observed in chemical processing and pulp and paper-making work, and in metal, foundry and engineering work.

Germany

Acknowledged occupational diseases as a result of noise exposure are the highest in the age between 50 and 60. The sector with the highest acknowledged occupational diseases as a result of noise exposure are the machine and vehicle construction, metal electrical technique and the high building assembly. No real trends can be monitored in the sectors, only gradual changes can be found in the last five years. The highest number of noise-induced hearing loss can be monitored in the population of metalworkers, mechanics and construction workers.

Hungary

According to national data sources, mining and quarrying are the sectors with the highest incidence rates of occupational hearing loss. Relatively high incidence rates have been also recorded in manufacturing and electricity, gas and water supply.

Italy

The highest prevalence of hearing loss caused by noise concerns the age group 50–54 (an average of 25 % approx.). An increase of the percentage of the age range

of 55 years and older is to be expected. Hearing losses compensated by INAIL are prevalent in the male population.

Between 1985 and 1999, the number of compensated cases in the female population with regard to hypoacousis or deafness decreased. Both for 'industries' and 'service sector' and for 'agriculture' a decrease of hearing losses complaints is reported from 1999 to 2003. In 1999, 'mechanics' is the most frequent occupation (13 %) receiving compensation for hearing losses. Nevertheless, its weight is decreasing (7.8 % in the five-year period 1995–99), overrun by 'bricklayers' (12.6 % in the same period), 'joiners' (12.8 %) and 'operators' (12.2 %).

INSHT, Instituto Nacional de Seguridad e Higiene en el Trabajo, Spain

Netherlands

Occupational hearing loss is particularly prevalent among older employees. Over 45 % is older than 50 years of age. Over 80 % of the reports concern people over 40 years.

Another major concern, however, is the growing number of cases of hearing loss among young people.

Most cases of noise-induced hearing loss are reported in the construction sector (66 %) and industry (21.4 %). The construction sector shows a high increase in the last years; but this is mainly due to a change in the reporting system.

Poland

The highest numbers of cases are registered in the 50–54 and 55–60 age groups. In 1995, the incidence rate was also high in the 40–44 age group.

Cases of occupational hearing loss are registered mostly in mining and quarrying, followed by manufacturing, construction, transport, storage and communication and electricity, gas and water supply.

The percentage of women in the total number of occupational hearing loss cases is the highest in the 50–54 age group (38 % in 2003). This percentage has been growing — almost in all age groups it was higher in 2003 than in 2000, and in the 50–54 age group it was the highest since 1990.

United Kingdom

Significant hearing difficulties and tinnitus are quite common in men and women from the older working age range. Moderate or worse hearing difficulties among

men were most prevalent in transport and machinery operatives, construction workers, material moving and storage workers and repetitive assembly and inspection workers. Severe hearing difficulty mostly affects construction workers and material moving and storage workers.

Among women, moderate or worse hearing difficulty was most common in caterers and cleaners.

Research in 2003 estimates that 170 000 people in the UK suffer deafness, tinnitus or other ear conditions as a result of exposure to excessive noise at work. Some 153 000 men and 26 000 women aged 35–64 years have severe difficulties of hearing attributable to noise at work.

About 266 000 men and 84 000 women in this age band have attributable persistent tinnitus.

What is the cost of hearing loss?

According to a study by Eurogip ([41]), the cost of hearing loss due to noise represents about 10 % of the total cost of compensation of occupational diseases (period 1999–2001).

That is from 2.52 % of the total cost of compensation in Denmark, over 13.9 % in Germany to 29.89 % in Italy (period 1999–2001).

Table 14: Breakdown of the cost of occupational diseases by disease group (% of total cost of compensation) over the period 1999/2001

Type of disease (cancers included)	Diseases caused by exposure to asbestos dust	Skin diseases	Diseases of the respiratory tract (except asbestos and silica)	Locomotor apparatus (MSDs and lumbago included)	Deafness due to noise	Diseases caused by exposure to silica	Total
Germany	20,50%	10,90%	8,80%	8,10%	13,90%	22,90%	85,10%
Belgium -2002	4,69%	4,32%	9%	25,59%	4,75%	37,50%	85,85%
Denmark (2000/2002)	17,60%	15,35%	1,70%	37,60%	2,52%	0,85%	75,62%
France	48%	0,30%	2%	35%	0,50%	1,50%	87,30%
Italy	17,66%	12,71%	5,85%	11,56%	29,89%	6,39%	84,06%
Switzerland	30,20%	17,90%	10,80%	5,20%	10,20%	3,50%	77,80%
Average	23,10%	10,20%	6,30%	20,50%	10,30%	12,10%	82,50%

Source: Costs and funding of occupational diseases in Europe, Eurogip, 2004.

The classification of the disease may, however, be different in terms of recognition and in terms of cost. Whereas in 2000, hearing loss ranked first among the diseases most commonly recognised in Germany and second in Denmark, its ranking in terms of cost is third and fourth respectively.

([41]) 'Costs and funding of occupational diseases in Europe', Eurogip-08-E, August 2004. http://www.eurogip.fr/pdf/Eurogip-08E-cost.pdf

Effects of sudden/varying/impulse noise

In general, continuous noise exposure over the years is more damaging than interrupted exposure to noise, which permits the ear to have a rest period. However, short exposures to very high levels of noise in occupations such as construction or firefighting may produce significant loss ([42]) ([43]).

Occupational acoustic trauma is a sudden change in hearing as a result of a single exposure to a sudden burst of sound. Welding sparks (to the eardrum), blows to the head, and blast noise are examples of events capable of producing acoustic trauma.

Any noise of short duration, usually less than one second, and of high intensity, with an abrupt onset and rapid decay is called impulse noise. Noise causes acute mechanical damage to hair cells of the cochlea in the inner ear when the short-term sound intensity or peak impulse noise levels are very high {LAF (A-weighted sound pressure level) > 120 dB; LCpk (C-weighted peak sound pressure level) > 135 A-weighted decibels [dB(A)]}. Impulse noise can cause more severe hearing loss than steady state noise. The additional effect of occupational impulse noise on hearing has been shown to be from 5 to 12 dB at 4 kHz audiometric frequency. Reported cases for compensated hearing loss are prevalent in occupations where noise is impulsive.

Acoustic shock

Acoustic shock injury can be caused by a sudden, loud or piercing sound at a high decibel level. Acoustic shock is usually a term used to describe the physiological and psychological symptoms a person may experience after hearing a sudden, unexpected, loud sound (referred to as an acoustic incident), via a telephone headset or handset. Such noises can travel over telephone communication equipment due to electronic feedback, fax modems or even malicious callers who use devices such as whistles. These signals are variously called acoustic shocks, audio shocks, acoustic shrieks, or high-pitched tones. The exact source of an individual acoustic shock is usually unknown, but various sources are possible, such as alarm signals, signalling tones, or feedback oscillation.

It is not the same as acoustic trauma, which is caused by very high (greater than 140 dB(C)) peak noise levels. Call/contact centre telephone operators are thought to be the type of workers most at risk ([44]) ([45]). Although these high-pitched tones can affect anyone, people using a regular hand-held telephone can quickly move the phone away from their ear, thus limiting their sound exposure to a fraction of a second. Call-centre operators, however, usually use a headset, which takes considerably longer to remove from the ear were an intense sound to occur. They thus receive a greater noise exposure than for people using hand-held phones. The problem may be exacerbated

([42]) Lusk S.L., Kerr M. J., Kauffman S. A., 'Use of hearing protection and perceptions of noise exposure and hearing loss among construction workers', *Amer Indust Hygiene Asso J.* 59(7), 1998, pp. 466-70.

([43]) Tubbs R. L., 'Noise and hearing loss in firefighting', *Occup Med*, 10(4), 1995, pp. 843-56.

([44]) Noise Advisory Standard 2004 — Appendix 7 — 'Acoustic shock'. Queensland Government website. http://www.dir.qld.gov.au/workplace/law/codes/noise/appendix7/#sources

([45])'Shocking news about call centres', Occupational safety and health resource, Canada Safety Council website. http://www.safety-council.org/info/OSH/acoustic.html

if call centres are so noisy that the operators need to have the volume controls on their telephones turned up higher than would be necessary in a quieter place.

Acoustic shock may lead to:

- temporary or permanent damage to the inner ear;
- loss of hearing, tinnitus (ringing in the ear), earaches and reduced tolerance to noise;
- headaches and nausea;
- dizziness and impaired balance;
- fatigue and anxiety.

The number of call centre workplaces is increasing (Germany)
Hauptverband der gewerblichen Berufsgenossenschaften, Germany — Pressebilder

The German BAuA (national OSH institute) and the UK Health and Safety Executive ([46]) have issued guidance for call centres ([47]) including acoustic measure, noise limits, and ergonomical requirements for headsets and VDU workplaces.

The Communication Workers Union in the UK and the Australian Council of Trade Unions have identified acoustic shock as a significant risk. Both have released or contributed to guidance ([48]) ([49]) for call centre workers. These organisations recommend preventive strategies such as the following:

- a detailed noise reporting procedure, which calls for the supervisor to complete an incident report;
- measures to reduce noise in the workplace; for example, isolation of call centres from other noisy work areas and machinery. Often call centre agents will adjust their headsets to a higher volume to cope with the noise around them;
- strict maintenance requirements for electronic equipment;

([46]) Advice regarding call centre working practices, Health and Safety Executive / Local Authorities Enforcement Liaison Committee (HELA) (rev. Dec. 2001). http://www.hse.gov.uk/lau/lacs/94-1.htm

([47]) Schalltechnische Anforderungen an Call-Center und an die entsprechenden Arbeitsplätze und Arbeitsräume. BAuA Praxis resources. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (rev. 19.06.02). http://www.baua.de/prax/call.htm

([48]) 'ACTU launches "Head set safety kit" for call centre operators', 11 December 2001, Australian Council of Trade Unions website. http://www.actu.asn.au/public/campaigns/callcentral/headsetsafety.html

([49]) 'Call centres: health and safety in call centres', CWU website. http://www.cwu.org.uk/default.asp?Step=4&pid=173

- use of new technologies such as sound shields to filter narrow band tones, which may cause acoustic shock.

Noise and ototoxic substances

Kooperationsstelle Hamburg, Germany

It is estimated that some 30 million people may work in environments where industrial chemicals may pose a serious hazard to hearing and balance ([50]). The effect of solvents on hearing has largely gone unnoticed as hearing impairment has been attributed to exposure to noise, which coexists in industry and the possibility of potentiation by solvents remains unchecked. Combined exposures to organic solvents occur in occupations with high exposures to noise (e.g. textile industry, metal and other manufacturing) ([51]) ([52]) ([53]). These exposures can lead to notable hearing loss.

Ototoxic chemicals include chemical asphyxiants, organic solvents, and metals. Adverse interactive effects with noise have also been demonstrated for heavy metals like lead, arsenic, and mercury. Several organic solvents are known to be ototoxic by themselves ([54]) including toluene, styrene, carbon disulfide, n-butanol, and trichloroethylene .

([50]) 'Noise and industrial chemicals: interaction effects on hearing and balance'. NoiseChem project description, RTD projects database, Cordis (COmmunity Research and Development Information Service) website. http://ica.cordis.lu/search/index.cfm?fuseaction=proj.simpledocument&PJ_RCN=5267523&CFID=51899&CFTOKEN=27235854

([51]) Chang S. J., Shih T. S., Chou T. C., Chen C. J., Chang H. Y., Sung F. C., 'Hearing loss in workers exposed to carbon disulfide and noise', *Environ. Health Perspectives*, 111 (13), 2003, pp. 1620–4.

([52]) P. Campo., 'Agents ototoxiques et exposition au bruit', *Documents pour le médecin du travail*, No 86, 2001, pp. 177–182. Institut National de Recherche et de Sécurité. http://www.inrs.fr/INRS-PUB/inrs01.nsf/inrs01_catalog_view_view/D2A43D36A12B00B4C1256DBA00502335/$FILE/tf103.pdf

([53]) Sliwinska-Kowalska, M., Zamyslowska-Szmytke E, Szymczak W, et al., 'Ototoxic effects of occupational exposure to styrene and co-exposure to styrene and noise', *J Occup Environ Med*. 45(1), January 2003, pp. 15–24.

([54]) *Community noise*, edited by Birgitta Berglund and Thomas Lindvall, Stockholm, Stockholm University and Karolinska Institute, 1995. http://www.nonoise.org/library/whonoise/whonoise.htm#7.1.5.1

In the Danish EPA draft risk assessment report on toluene ([55]), realistic worst case exposure to toluene from the occupational use of products containing toluene during printing and gluing were regarded as within the same order of magnitude as in animal studies. The study concludes that it cannot be excluded that functional damage (hearing loss) can occur during normal handling and use in occupational settings. The risk assessment of toluene within chemicals regulations clearly states an ototoxic effect of toluene ([56]).

Likewise, simultaneous exposure to carbon disulfide and noise may have a combined effect on hearing impairment. A study ([57]) investigated hearing loss in 131 men with exposure to noise [80-91 dB(A)] and CS_2 (1.6-20.1 ppm) in a viscose rayon plant. The study suggests that CS_2 exposure enhances human hearing loss in a noisy environment and mainly affects hearing in lower frequencies.

According to another study ([58]), laboratory studies have yielded a finding not expected, namely that when simultaneous exposure to noise and chemicals occur, the hearing loss observed was greater than the expected hearing loss from noise added to the expected hearing loss from the chemical. The authors conclude that, if this synergism is verified in humans, then changes will be required in the limits that are set for occupational hazards in order to prevent occupational hearing loss.

Studies have also attempted to assess combined effects with noise and effective levels of asphyxiants (hydrogen cyanide and carbon monoxide) ([59]) ([60]).

In 2002, the US National Institute for Occupational Safety and Health and the National Hearing Conservation Association co-sponsored the 'Best practices workshop: combined effects of chemicals and noise on hearing'. An article summarises the

([55]) Classification proposal for toluene, Danish Environmental Protection Agency, March 2000. http://ecb.jrc.it/classlab/2200_DK_toluene.doc

([56]) Opinion on the results of the risk assessment of: toluene — Human health and Environment — Final report — March 2001 carried out in the framework of Council Regulation (EEC) 793/93 on the evaluation and control of the risks of existing substances. Scientific Committee on Toxicity, Ecotoxicity and the Environment. DG Public Health website. http://europa.eu.int/comm/health/ph_risk/committees/sct/docshtml/sct_out104_en.htm

([57]) Morata, T. C., Dunn, D. E., Kretschmer, L. W., Lemasters, G. K., Keith, R. W., 'Effects of occupational exposure to organic solvents and noise on hearing', *Scand J Work Environ Health*,19(4), 1993, pp. 245–54.

([58]) Morata T. C., Little M., 'Suggested guidelines for studying the combined effects of occupational exposure to noise and chemicals on hearing', *Noise and Health*, 4(14), 2002, pp. 73–87.

([59]) Morata, T.C., 'Interaction between noise and asphyxiants: a concern for toxicology and occupational health',*Toxicological Sciences*, 66(1), 2002, pp. 1–3. http://toxsci.oxfordjournals.org/cgi/content/full/66/1/1

([60]) Fechter, L. D., Chen, G. D., Rao D., Larabee J., 'Predicting exposure conditions that facilitate the potentiation of noise-induced hearing loss by carbon monoxide', *Toxicological Sciences*, 58(2), 2000, pp. 315–323. http://toxsci.oxfordjournals.org/cgi/content/full/58/2/315#SEC2

main results of the workshop ([61]). Speakers provided an overview of the effects of chemicals on the auditory system ([62]).

French studies ([63]) ([64]) ([65]) have also addressed the problem of combined exposure to noise and ototoxic substances (pharmaceuticals such as aspirine, some antibiotics, diuretics and cytostatic agents as well as solvents and asphyxiants). The authors advise a precautionary approach and put into question limit values for persons vulnerabilised by medication or other exposures to ototoxic substances and ageing workers. They also recommend to consider offering audiometric testing for persons exposed to ototoxic substances and noise.

The organisation has also participated in the EU-funded NoiseChem project ([66]), which aimed to clarify this by:

- developing tests for evaluating noise- and solvent-caused damage to the hearing and balance systems;
- determining dose/effect relationships among workers exposed to different solvent-noise combinations; of exposure to toluene, styrene, xylene, trichloroethylene, and carbondisulfide alone and in the presence of noise in workers exposed to these in industries across Europe;
- using tests on humans and animal models to see where and how solvents and noise exert their effects;
- determining the mechanisms of action of the toxicants and the influence of other risk factors;
- developing hearing conservation schemes taking both factors into account.

NoiseChem is a European Commission research project involving partners in several countries examining the effects on human audio-vestibular systems using systematic standardised procedures through epidemiological investigations and also working with animals to determine the mechanisms of ototoxic damage due to noise and chemical interactions through laboratory investigations. The aim of a related Swedish study conducted by the National Institute for Working Life in cooperation with the Center for Hearing and Communication Research of the Karolinska Institutet is to investigate the effects of occupational exposure to low levels of styrene and noise on the auditory and vestibular system. Part of the study of 313 workers is finished and

([61]) Morata, T. C., 'Chemical exposure as a risk factor for hearing loss', *J. Occup. Environ. Med*, 45(7), 2003, pp. 676–82.

([62]) 'Current research on noise and hearing loss', NIOSH Safety and Health Topics website. http://www.cdc.gov/niosh/topics/noise/research/noiseandchem/noiseandchem.html

([63]) Campo, P., Lataye, R., 'Noise and solvent, alcohol and solvent: two dangerous interactions on auditory function', *Noise and Health*, 3(9), 2000, pp. 49–57.

([64]) Campo, P., 'Agents ototoxiques et exposition au bruit'. Institut National de Recherche et de Sécurité. *Documents pour le médecin du travail*, 86; 2001, pp. 177–182. http://www.inrs.fr/INRS-PUB/inrs01.nsf/inrs01_catalog_view_view/D2A43D36A12B00B4C1256DBA00502335/$FILE/tf103.pdf

([65]) ED 5028 'Bruit et agents ototoxiques', Le point des connaissances sur…. Institut National de Recherche et de Sécurité, 2005. INRS website. http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/ED %205028/$File/ed5028.pdf

([66]) 'Noise and industrial chemicals: interaction effects on hearing and balance', NoiseChem project description. RTD projects database. Cordis (COmmunity Research and Development Information Service) website. http://ica.cordis.lu/search/index.cfm?fuseaction=proj.simpledocument&PJ_RCN=5267523&CFID=51899&CFTOKEN=27235854

the results show a higher prevalence of high-frequency hearing loss in the groups exposed to styrene alone or simultaneously to noise, compared to the controls or the noise-exposed group. Significantly poorer auditory thresholds at 2, 3, 4, and 6 kHz were observed in the styrene-exposed workers in both ears, compared to both of the two groups not exposed to styrene. The findings suggest that exposure to styrene even below recommended values had a toxic effect on the auditory system ([67]). The authors announce that the study will continue by investigation of balance problems in this group of workers. The results from all studies conducted within NoiseChem will also be analysed together.

([67]) 'Can solvents cause hearing loss? Research resources, ongoing projects', Karolinska Institutet website. http://www.ki.se/cfh/research/cansolvents_anki_en.html

3.2. What other effects can noise cause?

Tinnitus/ringing in the ear

Noise-induced hearing loss is often accompanied by tinnitus, or ringing in the ears. It has also been recognised as an important issue for further measures by national authorities ([68]).

A UK assessment amongst audiologists shows a high proportion of male workers exposed to loud noise suffer ringing in the ear. Likewise, amongst the female workers assessed, a number of workers also report these health problems. Tinnitus can be perceived differently by male and female workers ([69]).

In the UK, for both men and women over 35, the risk of reporting severe hearing difficulty and persistent tinnitus rose according to years worked in a noisy job, and according to age, and was associated with complaints of frequent headaches, and frequent tiredness or stress ([70]). Among women, the relationship to duration of noise exposure was less clear-cut. On the basis of the risk estimates made and the prevalence of occupational noise exposure in the sample, it was estimated that nationally some 153 000 men and 26 000 women aged 35–64 years have severe difficulties of hearing attributable to noise at work, and that 266 000 men and 84 000 women in this age band have attributable persistent tinnitus. Occasional tinnitus was common and similarly prevalent in all age bands, affecting around a quarter to a third of all respondents.

Table 15: UK study on prevalence of tinnitus by age and sex

	Tinnitus					
	Never		Sometimes		Most or all the time	
	No	%	No	%	No	%
MEN						
16-24	478	64	256	34	9	1
25-34	1006	71	371	26	32	2
35-44	1028	69	396	27	61	4
45-54	1059	69	366	24	104	7
55-65*	746	61	316	26	154	13
All	4317	68	1705	27	360	6

([68]) 'Health effect of noise in the work environment (work-related noise)', News 24 May 2004. AMI News archive 2004. AMI website, Denmark. http://www.ami.dk/Nyheder/Nyhedsarkiv/2004/Helbredseffekter %20af %20st %C3 %B8j %20i %20arbejdsmilj %C3 %B8et.aspx

([69]) 'Gender issues in safety and health at work — a review', European Agency for Safety and Health at Work; No 76, 2003. http://osha.eu.int/publications/reports/209/en/index.htm

([70]) Palmer, K. T., Coggon, D., Syddall, H. E., Pannett, B., Griffin, M. J., 'Occupational exposure to noise and hearing difficulties in Great Britain', *HSE contract research report* 361, Health and Safety Executive, 2001. http://www.hse.gov.uk/research/crr_htm/2001/crr01361.htm

	Tinnitus					
	Never		Sometimes		Most or all the time	
	No	%	No	%	No	%
WOMEN						
16-24	458	64	237	33	16	2
25-34	957	74	323	25	18	1
35-44	1012	77	273	21	35	3
45-54	851	71	294	25	49	4
55-65*	671	68	261	27	49	4
All	3949	72	1388	25	167	3

Source: SWC 95.

But persistent tinnitus (tinnitus occurring most or all of the time) increased markedly with age. As with hearing difficulty, this complaint was more common in men than women — overall (6 % vs. 3 %) and especially in the survey's oldest age band (13 % vs. 5 % in those aged 55–64 years).

Tinnitus was more common in those with hearing difficulties. Among men, the age standardised prevalence of persistent tinnitus was around three times greater in those who had severe hearing difficulty and/or wore a hearing aid than in those with slight or no difficulties in hearing. In women, it was approximately 12 times more common.

When analysis was confined to those who had never worked in a noisy job, a similarly strong relationship was found. Thus, the age-standardised prevalence of persistent tinnitus was 3.1 % in men with no hearing difficulties, as compared with 18 % in men who had severe difficulties or wore a hearing aid; and the corresponding figures in women were 2.2 % and 27.1 % respectively.

The objectives of this research were to determine the prevalence of self-reported hearing difficulties and tinnitus in working-aged people from the general population, and to estimate the risks from occupational exposure to noise and the number of attributable cases nationally.

Exposure of pregnant workers to high noise levels

Noise at work can affect the unborn child ([71]) ([72]) ([73]) ([74]). 'Prolonged exposure to loud noise may lead to increased blood pressure and tiredness. Experimental evidence suggests that prolonged exposure of the unborn child to loud noise during pregnancy

([71]) Nurminen, T., Kurppa, K., 'Occupational noise exposure and course of pregnancy', *Scand J Work Environ Health*, 15, 1989, pp. 117–24.

([72]) Lalande, N. M., Hetu R., Lambert, J., 'Is occupational noise exposure during pregnancy a risk factor of damage to the auditory system of the fetus?', *Am J Ind Med*, 10(4), 1986. pp. 427–35.

([73]) Richards, D. S., Frentzen, B., Gerhardt, K. J., McCann, M. E., Abrams R. M., 'Sound levels in the human uterus', *Obstet Gynecol*, 80(2), 1992, pp. 186–90.

([74]) 'Noise: a hazard for the fetus and newborn', *American Academy of Pediatrics*, 100, 1997, pp. 724–727. Committee on Environmental Health. http://aappolicy.aappublications.org/cgi/content/full/pediatrics;100/4/724

may have an effect on later hearing and that low frequencies have a greater potential for causing harm' ([75]). The use of hearing protection at work is of no benefit to the foetus, as it is not similarly protected.

Intrauterine measurements showed that the foetus was not significantly protected against loud noises ([76]). The authors cite a study in human volunteers which found a maximal intrauterine noise attenuation of 10 dB at 4000 Hz. In a study of ewes, the noise attenuation was 20 dB at 4000 Hz, but the noise inside the uterus was 2 to 5 dB greater at 250 Hz. In comparison, foam plugs offer attenuation of 12 to 20 dB and are considered to be the least effective hearing protection. This is also why it was concluded that the sensitivity of the foetus to sounds in the low frequency range may result in increased susceptibility to auditory system damage arising from exposure to intense low frequency sounds ([77]).

([75]) Communication from the Commission on the guidelines on the assessment of the chemical, physical, and biological agents and industrial processes considered hazardous for the safety or health of pregnant workers and workers who have recently given birth or are breastfeeding (Council Directive 92/85/EEC).

([76]) Czarnecki, F., 'The pregnant officer', *Clinics in Occupational and Environmental Medicine*, 3(3), 2003, pp. 641–648. http://www.theppsc.org/Staff_Views/Czarnecki/pregnant_officer.htm

([77]) Hepper, P.G., Shahidullah, B.S., 'Development of fetal hearing', *Archives of Disease in Childhood — Fetal and Neonatal edition*, 71, 1994, pp. 81–87.

3.3. Non-auditory effects of noise ([78]) ([79]) ([80])

The World Heath Organisation ([81]) states that noise in the environment or community seriously affects people, interfering with the daily activities at school or work and at home and during leisure time. WHO guidelines identify the main health risks of noise:

- pain and hearing fatigue;
- hearing impairment including tinnitus;
- annoyance;
- interferences with social behaviour (aggressiveness, protest and helplessness);
- interference with speech communication;
- sleep disturbance and all its consequences on a long and short-term basis;
- cardiovascular effects;
- hormonal responses (stress hormones) and their possible consequences on human metabolism (nutrition) and immune system;
- performance at work and/or school decrements.

Hearing loss from long-term exposure to noise has been recognised as a hazard for a long time. However, what the non-auditory effects of noise are is still not certain. Even ear-safe sound levels can cause non-auditory health effects if they chronically interfere with recreational activities such as sleep and relaxation, if they disturb communication and speech intelligibility, or if they interfere with mental tasks that require a high degree of attention and concentration. In general, the suspected effects include cardiovascular function (hypertension, changes to blood pressure

([78]) Floru, R., Cnockaert, J. C., ‚Effets non traumatiques du bruit sur la santé, la sécurité et l'efficacité de l'homme au travail — Etude bibliographique' (Non-traumatic effects of noise on health, safety and effectiveness at work. Bibliographical review). Cahiers de notes documentaires INRS, 154, 1994, pp. 69–97.

([79]) 'Report on the non-auditory effects of noise', Leicester, Institute for Environment and Health, 1997. Summary available at http://www.le.ac.uk/ieh/pdf/ExsumR10.pdf

([80]) Babisch, W., Ising, H., Gallacher, J. E. J., et al., 'Traffic noise, work noise and cardiovascular risk factors: the Caerphilly and Speedwell collaborative heart disease studies', *Environ Int*., 16, 1990, pp. 425–435.
Babisch, W., Ising, H., Gallacher, J. E. J., et al., 'Traffic noise, work noise and cardiovascular risk factors: the Caerphilly and Speedwell collaborative heart disease studies, *Environ. Int*., 16, 1990, pp. 407–35.
Babisch, W., Ising, H., Gallacher, J. E.J., Sharp, D. S., Baker, I. A., 'Traffic noise and cardiovascular risk: the Speedwell study, first phase. Outdoor noise levels and risk factors', *Arch Environ Health*, 48, 1993, pp. 401–05.
Babisch, W., Ising, H., Elwood, P. C., Sharp, D. S., Bainton, D. 'Traffic noise and cardiovascular risk: the Caerphilly and Speedwell studies, second phase. Risk estimation, prevalence, and incidence of ischemic heart disease', *Arch Environ Health*, 48(6), 1993, pp. 406–13.
Babisch, W., Ising, H., Gallacher, J. E. J., Sweetnam, P. M., Elwood, P. C. 'Traffic noise and cardiovascular risk: the Caerphilly and Speedwell studies, third phase-10-year follow up', *Arch Environ Health*, 54, 1999, pp. 210–216.
Babisch, W., 'The noise/stress concept, risk assessment and research needs', *Noise Health*, 4, 2002, pp. 1–11.
Babisch, W., Beule, B., Schust, M., Kersten, N., Ising, H., 'Traffic noise and risk of myocardial infarction', *Epidemiology*, 16, 2005, pp. 33–40.

([81]) Noise and health resources. WHO website. http://www.euro.who.int/noise/

and/or heart rate), and changes in breathing, annoyance, sleep, physical health and mental health. This wide range of effects has led researchers to believe that noise has the ability to act as a general, non-specific stressor.

Stress due to noise (schools, healthcare, restaurants, offices, call centres)

Protection against noise focuses principally on the hearing function. Some research related to workplace issues, however, addresses the relationship between medium-level noise occurrence and stress ([82]) ([83]) ([84]). These effects can be related to speech intelligibility and having to raise the voice (e.g. in the education or healthcare sector, or in call centres).

Some research indicates that noise at work may induce hypertension ([85]) ([86]) ([87]) ([88]) and cardiovascular disease for male and female workers. Some health effects due to medium-level noise and impulse noise in the environmental field have been addressed by European Community policies ([89]) ([90]).

Among other non-auditory health end points, short-term changes in circulation (including blood pressure, heart rate, cardiac output, and vasoconstriction) as well as in levels of stress hormones (including epinephrine, norepinephrine, and corticosteroids) have been studied in experimental settings for many years ([91]) ([92]). From this, the hypothesis emerged that persistent noise stress increases the risk of cardiovascular disorders including high blood pressure and ischemic heart disease. Classical biologic risk factors have been shown to be elevated in subjects who were exposed to high levels of traffic noise. Nowadays the biological plausibility

([82]) Evans, G. W., Jonson, D., 'Stress and open office noise', *Journal of Applied Psychology,* 85(5), 2000, pp. 779–83.

([83]) Stress resources. CCOHS website. http://www.ccohs.ca/oshanswers/psychosocial/stress.html

([84]) Evans, G., 'Even low-level office noise can increase health risks', *Journal of Applied Psychology*, 85(5), 2000, pp. 779–783.

([85]) Zhao, Y., Zhang, S., Selvin, S., Spear, R. C., 'A dose-response relationship for occupational noise-induced hypertension', *Schriftenr Ver Wasser Boden Lufthyg*, 88, 1993, pp. 189–207.

([86]) Powazka, E., 'A cross-sectional study of occupational noise exposure and blood pressure in steelworkers', *Noise Health*, 5(17), 2003, pp. 15–22.

([87]) Tomei, F., Fantini, S., Tomao, E., Baccolo, T. P., Rosati, M. V., 'Hypertension and chronic exposure to noise', *Arch Environ Health*, 55(5), 2000, pp. 319–25.

([88]) Melamed, S., Fried, Y., Froom, P., 'The interactive effect of chronic exposure to noise and job complexity on changes in blood pressure and job satisfaction: a longitudinal study of industrial employees', *J Occup Health Psychol*, 6(3), 2001l, pp. 182–95.

([89]) Green Paper on Future Noise Policy. European Commission. COM (96) 540 Final, 1997. http://europa.eu.int/en/record/green/gp9611/noise.htm

([90]) The noise policy of the European Union, Year 2 (1999–2000). DG Environment Noise Team 2000. http://europa.eu.int/comm/environment/noise/pdf/noisebrochure.pdf

([91]) Babisch, W., 'Stress hormones in the research on cardiovascular effects of noise', *Noise Health*, 5(18), 2003, pp. 1–11.

([92]) Berglund, B., Lindvall, T., 'Community noise', *Archives of the Center for Sensory Research*, vol 2, No 1, Stockholm, Center for Sensory Research, 1995.

of the association is considered to be established. Its rationale is the general stress concept ([93]) ([94]):

- sound/noise is a psychosocial stressor that activates the sympathetic and endocrine systems;
- acute noise effects do not occur only at high sound levels in occupational settings, but also at relatively low environmental sound levels when, more importantly, certain activities such as concentration, relaxation, or sleep are disturbed.

A study ([95]) has also shown that chronic noise exposure increases fatigue symptoms and post-work irritability. It found that, after the workday was over, these fatigue symptoms and post-work irritability made relaxing and being able to unwind extremely difficult. Noise protection that attenuated the unwanted background noise by 30–33 dB for seven days produced significant improvement in irritability and fatigue symptoms. Furthermore, urinary cortisol secretion was shown to increase with unwanted background noise. The increased urinary cortisol levels decreased toward normal after seven days of noise attenuation.

German organisations organised a symposium where they focused on conditions of hearing in schools, including occupational issues. A study ([96]) was performed on professional stress of female and male teachers. Assessments included measurements of heart beat rates (long-term electrocardiograms) and noise level assessments ([97]). Methods employed were a questionnaire on the subjective perception of stress and stress factors, a number of medical and psychological tests to evaluate psychophysical state, long-term ECG to obtain heart frequency as an indicator of psychophysical load. School lessons were observed and recorded for one week per class. Increased heart beat rates and high noise levels were reported. In some cases, sound pressure levels were recorded during lessons in classrooms, workrooms, gyms, and during musical education. Results show remarkable deficits of the psychophysical state in a high percentage of teachers and a poor recreational effect of pauses. Psychophysical performance is thus deteriorated from the first through the following lessons of the day.

A study group investigated low-frequency noise effects and concluded that 'it can lead to vibroacoustic disease, a whole-body noise-induced pathology, that is not particularly related to the ear'. The human ear captures sound within a specific window of the acoustic spectrum, generally within the 20–20 000 Hz range. However, it is most responsive to sounds within the mid-frequencies: 1 000–10 000 Hz. Noise exposure

([93]) Babisch, W., 'The noise/stress concept, risk assessment and research needs', *Noise Health*, 4(16), 2002, pp. 1–11.

([94]) Babisch, W., 'Noise and health', *Environmental Health Perspectives*, 113(1), 2005, pp. A 14–15. http://ehp.niehs.nih.gov/docs/2005/113-1/EHP113pa14PDF.pdf

([95]) Melamed, S., Rabinowitz, S., Green, M. S., 'Noise exposure, noise annoyance, use of hearing protection devices and distress among blue-collar workers', *Scand J Work Environ Health*, 20(4), 1994. pp. 294–300.

([96]) Schönwälder, H.-G., Berndt, J., Ströver, F., Tiesler, G., 'Belastung und Beanspruchung von Lehrerinnen und Lehrern', (Professional stress and strain in teachers), *Research Report* Fb 989, Dortmund, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2003. http://www.baua.de/english/fors/fb03/fb989_e.htm

([97]) 'Lärm belastet Lehrer' (Noise affects teachers). Symposium 'Bedingungen des Hörens in Schulen' in Oldenburg. Amtliche Mitteilungen der Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 1, 2003, p. 8. http://www.baua.de/down/am1_03.pdf

protection focuses primarily on these frequencies, because its goal is to prevent hearing loss. Acoustic phenomena within the low frequency (LF) range (* 500 Hz) are also audible, but require a higher intensity to be perceived. Infrasound (* 20 Hz) is non-audible to humans; it is therefore considered to have no impact upon hearing loss, and consequently, noise assessments within the infrasonic range are a rarity.

The review study ([98]) describes the disease as follows: 'Vibroacoustic disease (VAD) is a noise-induced, whole-body pathology, of a systemic nature, caused by excessive and unmonitored exposure to low-frequency noise. It has been identified in aeronautical technicians, military pilots, commercial pilots and cabin crewmembers, and disc-jockeys. The classification of VAD stages was grounded on a study of 140 aeronautical workers, who had been selected from an initial group of 306 individuals ([99]). Low-frequency-noise is a stressor, and, as such, initial exposure causes disorders generally considered as 'stress-related', such as gastrointestinal dysfunction or infections of the oropharynx. However, low-frequency noise-specific features of vibroacoustic disease can be identified in the mild stage, such as thickened cardiac structures, increased frequency of sister chromatid exchanges, immunological changes, altered values of hemostasis and coagulation parameters, and specific neurophysiological and cognitive changes. In the severe stages of VAD, as mentioned above, more serious disorders can develop'. The authors also conclude that 'there is an urgent need to include LF in all noise assessments, and use prevention medicine against this ubiquitous environmental hazard'. Further research is needed to confirm these observations.

Effects of hearing impairment

Hearing impairment can be a major cause of psychological fatigue at the workplace. Particularly in work situations with high communication demands, such complaints should prompt an examination to assess noise levels and hearing ability.

An extensive Danish survey among 1 600 hearing impaired people aged between 16 and 60 examined the impact of hearing loss at work and in education ([100]). The survey was conducted by the Danish Institute for Social Research in 2003 and resulted in the following conclusions.

- People with hearing loss leave the labour market sooner than their normal-hearing colleagues; 18 % receive disability pension compared with 7 % in the general population.
- It is harder for hearing impaired people to find work: 7.5 % are unemployed compared to the general 4.8 % unemployment rate.
- Hearing loss leads to loss of employment: 8 % of hearing impaired employees are either terminated or choose to resign.

([98]) Alves-Pereira, M., Branco, N. C., 'Vibroacoustic disease: the need for a new attitude towards noise', *Public Participation and Information Technologies*, 1999, chapter 1, published by Citidep & DCEA-FCT-UNL. http://www.citidep.pt/papers/articles/alvesper.htm

([99]) Castelo Branco, N. A. A., 'The clinical stages of vibroacoustic disease', *Aviation Space Environmental Medicine*, 70 (3, Suppl), 1999, pp. A32–9.

([100]) 'Når hørelsen svigter. Om konsekvenserne af hørenedsættelse i arbejdslivet, uddannelsessystemet og for den personlige velfærd', Udført af det danske Socialforskningsinstitut, 2003. (‚When hearing fails: impact of hearing loss on work, education and personal health'. Danish Institute for Social Research). cited in http://www.press.hear-it.org/page.dsp?page=2666

- More than one quarter (27 %) believe that their hearing loss makes it hard to find a job; 9 % find it impossible.
- Hard of hearing people often feel mentally or physically exhausted at the end of the workday: 47 % say they are mentally exhausted as compared to 36 % in the general population; 51 % of hearing impaired people say they are physically exhausted as compared to 31 % in the general population.
- Hearing problems at work affect leisure activities too: 13 % find that they are so drained of energy from their work that they are unable to pursue leisure activities.
- Hearing impaired people who want to pursue an education must make an extra effort: 40 % say they must prepare better than other students in order to keep up in the classroom, 80 % say they are mentally exhausted after a long day in school.
- Approximately one half of the hearing impaired students find that fellow students are helpful. But only 31 % believe that their teachers never take special steps to make it easier for them to participate in the classroom.

In the UK, for both men and women over 35, the risk of reporting severe hearing difficulty and persistent tinnitus rose according to years worked in a noisy job, and according to age, and was associated with complaints of frequent headaches, and frequent tiredness or stress ([101]). The objectives of this research were to determine the prevalence of self-reported hearing difficulties and tinnitus in working-aged people from the general population, and to estimate the risks from occupational exposure to noise and the number of attributable cases nationally.

Case study

A 55-year-old factory worker ([1]) consulted his family physician because of ringing in his ears and depression that began soon after the onset of the tinnitus. He had seldom worn hearing protection at work, where he had to shout to communicate with co-workers. Away from work, he had difficulty understanding conversations in crowded rooms, and he said he often argued with his wife about the volume of the television set. His physical findings were normal. An office audiogram showed a high-frequency hearing loss. The patient was referred to an audiologist, who confirmed a sensorineural hearing loss that was probably caused by excessive noise exposure, with superimposed age-related changes.

A hearing aid was prescribed.

This case shows that noise-induced hearing loss can interfere with speech discrimination and social functioning. The high-frequency deficit causes difficulty in perceiving and differentiating consonant sounds; patients often report that words 'run together'. High-pitched sounds, such as a baby crying or a distant telephone ringing, may not be perceived at all. Tinnitus is a common symptom of noise

([1]) Rabinowitz, P. M., 'Noise-induced hearing loss', *American Family Physician* [serial online] vol. 61/No 9 (1 May 2000), http://www.aafp.org/afp/20000501/2749.html

([101]) Palmer, K. T., Coggon, D., Syddall, H. E., Pannett, B., Griffin, M. J., 'Occupational exposure to noise and hearing difficulties in Great Britain', Health and Safety Executive, 2001. *HSE Contract research report* 361. http://www.hse.gov.uk/research/crr_htm/2001/crr01361.htm

overexposure, and it further interferes with hearing acuity, sleep and concentration. These impairments have been associated with social isolation, depression and an increased risk of accidents.

A study ([102]) on hearing impairment and verbal communication at the workplace recommends a noise level 5 to 20 dB lower for hearing impaired persons, in order to be able to understand as well as persons with normal hearing. The aim of the study was a summary of most common models for predicting speech intelligibility and an evaluation in regard to their applicability to different kinds of hearing impairments and acoustical conditions of the environment. Hearing loss is described particularly under the aspect of reduced acoustic communication and speech intelligibility. That means in detail the more or less suitable handling of hearing loss of people concerned, its effects on employment, behaviour, communication, the ability of interaction as well as the general and psychological health. Beyond that some important factors of influence on speech intelligibility — like noise, reverberation, direction hearing — are presented.

Noise and problems with oral communication

In the workplace, non-auditory effects of noise include problems with oral communications ([103]). Speech intelligibility is the ability to understand spoken words. The presence of noise interferes with the understanding of what other people say. This includes face-to-face talks, telephone conversations, and speech over a public address system. The signal:noise ratio (in terms of signal processing) should be at least 10 dB(A) to ensure undisturbed communication. In noisy work situations, people are able to converse with difficulty at a distance of 1 metre for a short time in the presence of noise as high as 78 dB(A). In order to be intelligible, the sound level of speech must be greater than the background noise at the ear of the listener. For prolonged conversations, the background noise level must be lower than 78 dB(A). In social situations, people often talk at distances of 2 to 4 metres. In such cases noise level should not exceed 55 to 60 dB(A). In outdoor play and recreational areas, people communicate at distances of 5 to 10 metres. In such cases background noise should not exceed 45 to 55 dB(A). Average sound pressure levels of the human voice at 1 metre distance range between 60 dB (normal conversation) and 75 dB (speech) ([104]).

They can also lead to higher accident risk because of impaired communication between workers and disturbed attentiveness to signals.

([102]) Bormann, V., Sust, Ch. A., Heinecke-Schmitt, R., Fuder, G., Lazarus, H., 'Schwerhörigkeit und Sprachkommunikation am Arbeitsplatz' (Hearing impairment and verbal communication at the workplace). Dortmund 2005. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. Research Report Fb 1041. http://www.baua.de/english/fors/fb05/fb1041_e.htm

([103]) OSH answers physical agents, non-auditory effects of noise. CCOHS website. http://www.ccohs.ca/oshanswers/phys_agents/non_auditory.html

([104]) Hejkrlik, I., 'Schallschutz in Arbeitsräumen', In: *Bericht der österreichischen Arbeitsinspektion* (Annual report of the Austrian labour inspection) 2002, Vienna 2003. http://at.osha.eu.int/statistics/jb2002.pdf

Noise and accidents

Noise does not just harm a worker's hearing; it can also be a cause of accidents. Workers wearing hearing protection may not be able to hear verbal instructions and warnings. Several projects have set out to work out a method of predicting speech intelligibility while wearing hearing protectors ([105]) ([106]). The effects of hearing protection on speech intelligibility and the perception of acoustic signals are discussed. Hearing performance seems to be the lower the higher the protective effect (sound abatement) and the higher the frequency of the signal. It is important to take into account the nature and spectrum of the noise occurring in the workplace.

In Canada, in the last few years, a series of fatal accidents have been reported that involved backup manoeuvres on construction sites, even when the vehicles had functional sound alarms complying with current regulations. Various factors can explain the ineffectiveness of these sound devices in alerting nearby workers, amongst others surrounding noise from other sources or hearing problems of workers. Hence, the interest in considering independent mechanisms of hearing perception in designing safer systems. A study ([107]) analysed current personnel detection techniques that could complement or replace these devices, and determined the safety criteria that are applicable to vehicles used on construction sites. The conclusions could apply to other mobile equipment, mainly in mines and the agricultural environment.

A study of occupational injuries among workers with disabilities from 1985 to 1994 data of the US national health interview survey concludes that workers with disabilities, especially sensory impairments, appear to have an elevated risk for occupational injury and that further research in the design and evaluation of improved workplace accommodations for workers with these disabilities is needed ([108]).

Whereas these effects are obvious for loud noise in high-risk sectors and a relationship can be clearly established, they need to be further assessed in service activities.

Noise and voice disturbances

Teaching is one of the most vocally demanding professions. It demands long periods of speaking. Often added to that is environmental noise competing with the voice for the students' attention, inadequate ventilation, few opportunities for resting the

([105]) Kotabinska, E., Kozlowski, E., 'Speech intelligibility in noise when hearing protectors are used', *Magazine*, Issue 8 'Noise at Work', pp. 29–31. European Agency for Safety and Health at Work 2005.

([106]) Bormann, V., Sust, Ch. A., Heinecke-Schmitt, R., Fuder, G. , Lazarus, H., 'Schwerhörigkeit und Sprachkommunikation am Arbeitsplatz' (Hearing impairment and verbal communication at the workplace). *Research Report* Fb 1041, Dortmund: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2005. http://www.baua.de/english/fors/fb05/fb1041_e.htm

([107]) Blouin, S., 'Bilan de connaissances sur les dispositifs de détection de personnes lors des manoeuvres de recul des véhicules dans les chantiers de construction' (Review of the knowledge on personnel detection devices used during vehicle backup maneuvers on construction sites), *Bilans de connaissances* / Rapport B-067, IRSST publications 2005. http://www.irsst.qc.ca/en/_publicationirsst_100131.html

([108]) Zwerling, C., Whitten, P. S., Davis, C. S., Sprince, N. L., 'Occupational injuries among workers with disabilities: the national health interview survey, 1985-94', [published erratum appears in *JAMA* 1998:6; 279:1350]. *JAMA*, 278, 1997, pp. 2163–6.

voice, extra vocal burdens such as tutoring, lunchroom monitoring, parent–teacher conferences. WHO guidelines (see Table 11) recommend a noise level of 35 dB(A) for school classrooms during class to avoid disturbance of communication. Actually noise levels in schools frequently exceed these limits and can reach as much as 60–80 dB(A) in normal classes and can even go beyond limit values for workplaces in school workshops and sports areas. As explained in the section 'Noise in education', measurements of several classrooms in everyday use have revealed acoustical conditions that permit less than half of the speech to be understood. Generally, the problems are caused by improper wall, ceiling, and floor finishes and by noisy ventilation equipment.

The effect of trying to compete with an acoustically difficult environment creates a problem of severe strain on the vocal chords for many teachers. While not as well-known or studied as the listener's ability to understand, voice strain is belatedly being recognised as a serious and potentially incapacitating problem for teachers. Ingo Titze, Director of the National Centre for Voice and Speech at the University of Iowa, estimates the number of teachers with voice disorders in the USA at 3.1 million. In the United States, teachers form the main group of patients with voice disorders ([109]) ([110]). Estimates based on empirical data suggest that, considering only lost workdays and treatment expenses, the societal cost of voice problems in teachers alone may be of the order of about USD 2.5 billion annually in the United States ([111]).

A German survey ([112]) amongst teachers found that 58 % of the female and 42 % of male respondents had voice problems, 16 % even reported having temporarily suffered voice loss. These data are compared with about 5 % having suffered voice problems in other professions.

The importance of the voice as an occupational tool is also growing with the development of voice-activated technology and the increase in the number of individuals working in call centres, where vocal demands are high. It has been estimated in 2001 that 1.6-2 % of the UK working population worked in such centres ([113]). Guidance for call centres also includes advice on how to avoid and tackle additional strain on the voice, including climatic and ergonomic considerations ([114]) ([115]).

([109]) Roy, N., Merrill, R. M., Thibeault, S., Parsa, R. A., Gray, S. D., Smith, E. M., 'Prevalence of voice disorders in teachers and the general population', *J Speech Lang Hear Res*, 47(2), 2004, pp. 281–93.

([110]) Schick, A., Klatte, M., Meis, M., 'Noise stress in classrooms', In: Schick, A., Meis, M, Reckhardt, C., 'Contributions to psychological acoustics: results of the 8th Oldenburg Symposium on Psychological Acoustics', pp. 533–569. Oldenburg: Bibliotheks- und Informationssystem der Universität Oldenburg, 2000. http://www.hoerzentrum-oldenburg.de/web/public_files/dokumente/schick_classroom.pdf

([111]) Verdolini K., Ramig, L. O., 'Review: occupational risks for voice problems', *Logopedics Phoniatrics Vocology*, 26(1), 2001, pp. 37–46.

([112]) Claudia Hammann, University of Wuerzburg, Germanyhttp://www.uni-protokolle.de/nachrichten/id/98314/

([113]) Williams, N. R., 'Occupational voice disorders due to workplace exposure to irritants — a review of the literature', *Occupational Medicine*, 52, 2002, pp. 99–101.

([114]) 'Voice health', in: *Advice regarding call centre working practices*, Health and Safety Executive / Local Authorities Enforcement Liaison Committee (HELA) (rev. Dec. 2001). http://www.hse.gov.uk/lau/lacs/94-1.htm

([115]) Ccall. Erfolgreich und gesund Arbeiten im Call Center, Verwaltungs-Berufsgenossenschaft http://www.ccall.de/downloads/index.htm

4.

THE AGENCY SURVEYS ON EMERGING RISKS

The Community strategy on health and safety at work 2002–06 called on the European Agency for Health and Safety at Work to 'set up a risk observatory'. One of the priorities identified in the strategy is the need to 'anticipate new and emerging risks, whether they be linked to technical innovation or caused by social change'. This is to be done by 'ongoing observation of the risks themselves, based on the systematic collection of information and scientific opinions'. Additionally, the strategy emphasised that 'this kind of analysis is an integral part of a preventive approach'.

Responding to these needs, the Agency commissioned its Topic Centre Research on Work and Health (TCWH) with the identification of emerging OSH risks. A first forecasting exercise focused on physical risks has been carried out so as to provide as comprehensive a picture as possible of the potential emerging risks in the world of work. An 'emerging OSH risk' is any occupational risk that is both new and increasing.

The first report, *Expert forecast on emerging physical risks related to occupational safety and health,* published 2005, presents the results of the expert forecast on emerging physical OSH risks complemented by a literature review. These results should provide a basis for debate and reflection between policy makers at various levels for setting research and action priorities. More information can be found at the Agency's risk observatory website, including a link collection to new research information that is continuously being updated.

For the formulation of the expert forecast on emerging OSH physical risks, a questionnaire-based survey was run in three consecutive rounds following the Delphi method. This method was chosen so as to reach a broad consensus and to obtain scientifically founded opinions.

In total, 137 experts were invited to participate in the survey following their nomination by the Agency's Focal Points and Topic Centre Research. A total of 66 valid questionnaires were returned from 53 organisations covering 14 European countries and the USA (response rate: 48 %). Participating experts were required to have at least five years' experience in the field of OSH and physical risks. Respondents were mainly researchers (33 %) and heads of departments in organisations involved in OSH activities (33 %). Other respondents included labour inspectors, professors and lecturers, those in charge of policy or standards development, or of enforcement, consultants, or those involved in testing and certification.

The risks that were identified in the expert survey are related to musculoskeletal disorders (MSDs), noise, vibration, thermal risks, risks related to ionising and non-ionising radiation, to machinery, work processes and technologies, as well as various ergonomic risks.

More generally, the experts especially emphasised 'multi-factorial risks' in a generic item with a high degree of consensus. A lot of literature examines call centre workplaces, which are typical workplaces with multi-factorial exposure. The various risk factors call centre agents are exposed to are prolonged sitting, background noise and poor room acoustics, inadequate headsets, poor room atmosphere, inadequate lighting conditions, poor ergonomic design of the work equipment, inappropriate arrangement of the working premises, and factors of human and organisational

nature such as low job control, high time pressure, poor work organisation, and high mental and emotional demands. Various health outcomes could be observed such as MSDs, varicose veins, nose and throat diseases, voice disorders, fatigue, stress and burnout.

4.1. Expert survey results — emerging risks related to noise

In the following section, the exact descriptions of the risk related to noise rated by the experts are listed in tables together with the number of respondents to each item, the mean value of the ratings and the standard deviation. These figures are also compiled in diagrams. For some of the risks, references are made to literature, legislations and national historical data if relevant and, when available, experts' comments are added in order provide some context and to support the experts' evaluation.

Sixteen experts out of the 66 respondents to the survey had more than five years of experience in the field of risks related to noise and answered this part of the questionnaire.

Figure 14: Nationalities of experts who answered the part related to noise (N=16)

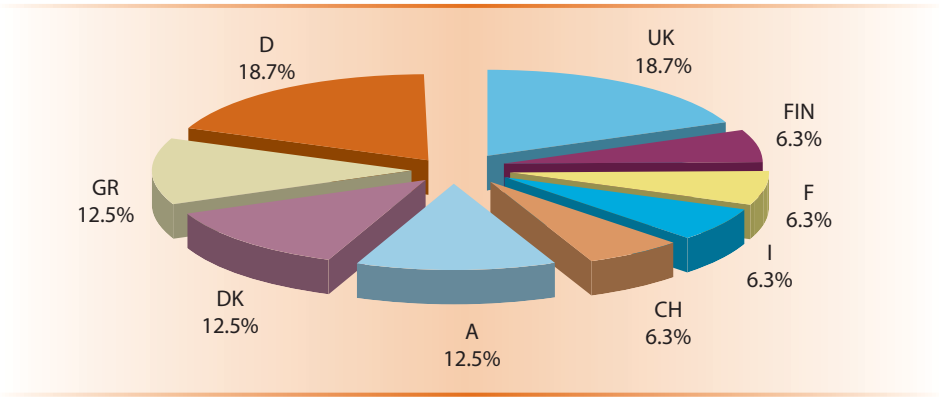
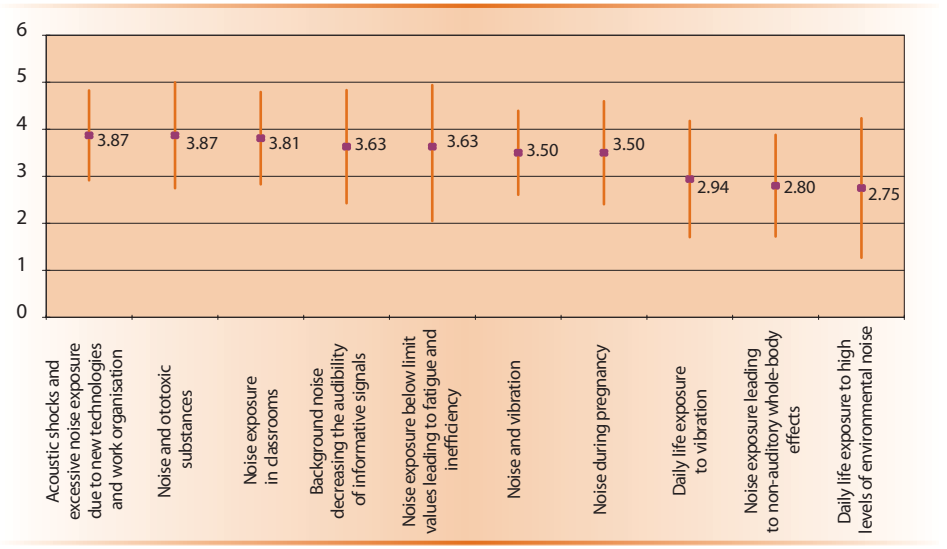


Figure 15: Risks related to noise identified in the survey (mean values; standard deviations)



'Acoustic shocks and excessive noise exposure due to new technologies and work organisation' was identified as an emerging risk mainly because of the increasing number of call centres where headphones are used ([116]). Acoustic shocks are abnormal sound burst transmitted through the headset caused, for example, by electronic sounds from fax machines or accidental electronic impulses that can damage the hearing of the user ([117]).

Acoustic shocks, noise exposure during pregnancy, at low level or combined with ototoxic substances or vibration are emerging risks.

'Simultaneous exposure to noise and ototoxic substances', as well considered by the experts as one of the 'top' emerging risks related to noise, is also confirmed by French national data ([118]): those workers most exposed to noise are also those with the highest exposure to dangerous substances. Therefore, the current occupational exposure limit may need to be reconsidered with regards to combined exposure to ototoxic substances ([119]).

The expert forecast also highlights 'noise exposure in classrooms'. Workers in education, health and social work in France, especially women, have increasingly reported noise exposure since 1984. In 1998, almost half a million French workers were exposed to occasional very loud or high sounds in these occupations ([120]). Increases in the percentages of workers in the education and health sector who report noise exposure are also seen in Finland ([121]) (29 % reported to 'be exposed to noise and somewhat bothered' in 1997 as opposed to 34 % in 2003) and in the Netherlands ([122]) (13 % reported to 'regularly have to deal with noise at work' in 1998 and 19 % in 2002). Noise in schools is perceived as a disturbing factor impeding the transfer of knowledge, which is mainly based on verbal communication. Teachers try to compensate for the noisy background by raising their voice ([123]). As a result, noise levels in the classroom become progressively higher and teachers not only suffer higher mental and emotional strain, but vocal chord disorders as well.

Even though below the intensity considered to harm the hearing function, 'background noise' is seen as an emerging risk in that it makes it harder for workers to

([116]) 'Shocking news about call centres', Occupational safety and health resources, Canada Safety Council website. http://www.safety-council.org/info/OSH/acoustic.html

([117]) What is 'acoustic shock'? TUC Worksmart website. http://www.worksmart.org.uk/health/viewquestion.php?eny=194

([118]) Ministère de l'emploi et de la solidarité, DARES: 'Expositions aux contraintes et nuisances dans le travail' SUMER 1994, *Les dossiers de la DARES*, vol. 5-6, 1999.

([119]) ED 5028 'Bruit et agents ototoxiques'. Le point des connaissances sur…. Institut National de Recherche et de Sécurité 2005. INRS website. http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/ED %205028/$File/ed5028.pdf

([120]) Ministère du travail, de l'emploi et de la cohésion sociale, DARES: Enquête sur les conditions de travail — Efforts et risques au travail - Environnement de travail — Les nuisances sonores. http://www.travail.gouv.fr/etudes/etudes_i.html

([121]) Finnish Institute of Occupational Health (FIOH): Finnish work and health survey. http://www.occuphealth.fi

([122]) Central Bureau of Statistics: Permanent Onderzoek Leefsituatie (POLS). http://statline.cbs.nl

([123]) Schönwälder, H.-G. J. Berndt, F. Ströver, G. Tiesler., 'Lärm in Bildungsstätten — Ursachen und Minderung' (Noise in schools — causes and reduction), Dortmund, Berlin, Dresden, 2004. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. *Research Report* Fb 1030. http://www.baua.de/fors/fb04/fb1030.pdf

hear safety warnings and thus potentially leads to accidents. Nevertheless, one expert commented that it is less the background sound than the 'communication sound that decreases the audibility of informative signals when wearing communication systems'.

The exposure to 'noise levels below the limit value' is also perceived as an emerging risk leading to 'fatigue and inefficiency', which may increase the occurrence of occupational accidents. Low-level noise in open-plan offices generated by equipment such as photocopiers, computers or ventilation systems, or by the ringing of a telephone impairs concentration and communication and increases the workers' mental and emotional strain ([124]). Non-relevant conversations of colleagues also affect a worker's performance. Recent studies show that it is less the content of the conversation than the acoustic variation of the noise that plays a role ([125]).

The combined exposure to 'noise and vibration' was identified as an emerging risk not only by the 16 experts who answered the 'noise' part of the questionnaire, but also by the 16 experts who answered the 'vibration' part (12 experts rated the item in both parts). The almost identical mean ratings (3.50 and 3.56 respectively) may be considered to validate the forecast.

'Noise during pregnancy' was also highlighted. Noise has been identified as an agent 'causing foetal lesion and/or likely to disrupt placental attachment' in the Council Directive 92/85/EEC ([126]).

The ratings of the items 'noise and ototoxic substances', 'background noise decreasing the audibility of informative signals' and 'noise exposure below limit values leading to fatigue and inefficiency' did not achieve a high consensus.

'Noise exposure leading to non-auditory whole-body effects' was not rated as an emerging risk. One expert specified that environmental noise like 'traffic sound (from cars, lorries, trains, aircrafts) is the main problem but not noise at the workplace, as shown by the study NaRoMI (Noise and Risk of Myocardial Infarction) published by the Umweltbundesamt' ([127]).

([124]) 'Office health and safety — Noise and acoustics', Canada Safety Council website. http://www.safety-council.org/info/OSH/noise.htm

([125]) 'Health effect of noise in the work environment (work-related noise)', News 24.05.04. AMI News archive 2004. AMI website, Denmark. http://www.ami.dk/Nyheder/Nyhedsarkiv/2004/Helbredseffekter %20af %20st %C3 %B8j %20i %20arbejdsmilj %C3 %B8et.aspx

([126]) Commission of the European Communities: Council Directive 92/85/EEC of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding, OJ L 348 , 28.11.1992. pp. 0001–0008. http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=31992L0085&model=guichett

([127]) Babisch, W., 'Die NaRoMI-Studie' (Noise and risk of myocardial infarction) — Auswertung, Bewertung und vertiefende Analysen zum Verkehrslaerm, In: *WaBoLu-Hefte* 02/04, pp. I1-I59. Umweltbundesamt, 2004. http://www.umweltbundesamt.org/fpdf-l/2621.pdf

Table 16: Prioritised list of the risks related to noise (N=number of experts answering the specific item; mean value; standard deviation)

MV>4: risk strongly agreed as emerging

3.15<MV≤ 4: risk agreed as emerging

2.85≤ MV≤ 3.15: status undecided

2≤ MV<2.85: risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging (MV<2)

Risks related to noise	N	Mean Value (MV)	Standard Deviation (SD)
Acoustic shocks and excessive noise exposure due to new technologies and work organisation (e.g. headsets in call centres)	16	3.87	0.957
Combined exposure to noise and ototoxic substances	15	3.87	1.125
Noise exposure in classrooms due to poor acoustic properties of educational buildings located in loud urban areas	16	3.81	0.981
Background noise decreasing the audibility of informative signals when wearing communication systems (e.g. in the construction sector)	16	3.63	1.204
Noise exposure below limit values but which leads to fatigue and inefficiency (e.g. in call centres)	16	3.63	1.310
Combined exposure to noise and vibration	16	3.50	0.894
Noise during pregnancy	16	3.50	1.095
Daily life exposure to vibration increasing the sensitivity to occupational noise	16	2.94	1.237
Noise exposure leading to non-auditory whole-body effects (e.g. cardiovascular diseases)	15	2.80	1.082
Daily life exposure to high levels of environmental noise increasing the sensitivity to occupational noise	16	2.75	1.483

Additional potential emerging risks proposed by the experts in the third questionnaire

'Because of the new action levels set by the EU directive 2003/10/EC, which is to be transposed into national law by 15 February 2006 at the latest, the number of employees exposed to noise levels above the (new) action levels will increase by about 40 % as compared to now.'

5.

METHODOLOGY

5.1. Data collection methodology of the Agency's risk observatory

The data collection is based on existing and available sources. All data have been collected from published and online available statistical sources. Existing tables and graphics have been used in this presentation. Not all sources present the data in a similar way or combine the same breakdown criteria, as a result of which the data are difficult to compare.

Statistics from these sources were complemented by analytical studies and literature reviews. The aim of the studies is to give some interpretation and background information on the statistical data. A number of research studies have been used to complement the European survey data, mainly originating from the European Foundation for the Improvement of Living and Working Conditions and the European Agency for Health and Safety at Work.

Where available, efforts have been made to use the raw data sources, which are then treated according to the expected output. This is, for example, the case for the data from the European working conditions survey (with regard to European and Belgian data), the occupational diseases statistics in Belgium and the Danish work environment cohort study.

The sources are both statistical and analytical background documents. The statistical sources are a combination of administrative registers and statistics (occupational disease registers, exposure registers), surveys, voluntary reporting systems and inspection reports. A global risk picture can thus be presented by combining different sources.

The data collection mainly depends upon the availability of harmonised administrative data (occupational accident and disease registers) and self-reported data from worker surveys. These data sources are available both at European level and in most of the European countries.

A study on national and EU monitoring systems (Issue 406, 'A review and analysis of a selection of OSH monitoring systems' (working paper) was commissioned by the Agency and is available for download from the Agency website (http://agency.osha.eu.int/publications/reports/406/en/index.htm). The Agency has also prepared detailed descriptions of national OSH monitoring systems on its website.

There are a wide variety of approaches towards monitoring occupational safety and health in the European Union aiming to describe the situation at different levels from the company level to a national overview. It has become a very dynamic area with a number of new models and strategies. The overview of systems has shown that no single data source can provide a complete and adequate description of occupational safety and health.

The different approaches for monitoring OSH at national level include monitoring health outcomes, describing the workplace environment, and describing the infrastructure and the level of prevention at national and at enterprise level. The 'traditional' data collection approaches, based on outcome factors such as accident and diseases data, have been complemented by some new initiatives that combine data sources and monitor the infrastructure and resources at different levels. The general trend in the monitoring activities of the Member States is to combine several data sources in order to have a more complete picture of a given situation (that is, important risk factors, groups at risk, uprising issues), identify information gaps and be able to take decisions on future measures to apply. Such approaches effectively recognise that the available data on health outcomes, by themselves, are not yet sufficiently robust for the purpose of measuring progress against targets: other indicators will need to be developed to supplement them. These must be embedded in a model, to compile a set of 'surveillance indicators' for occupational health.

All these initiatives strive to reach the goal of having as complete a picture as possible of occupational safety and health at the level chosen, that is, for the purpose of 'early warning', decision-making and possible corrections. A seminar on this theme was held in Bilbao on 30 September and 1 October 2002. The proceedings ([128]) and summary ([129]) are available on the Agency's website. This feature will be continually updated as a key element in the Agency's efforts to contribute to a systematic approach to OSH monitoring and to a better understanding of the situation of occupational safety and health in the European Union.

Administrative data sources

Accidents at work

The European Statistics on Accidents at Work (ESAW) have been used to collect statistical data on accidents at work. The statistics are available from 1994 onwards. They allow a uniform presentation for European and Member State statistics and a comparison between the Member State statistics.

A harmonised methodology for data collection has been created. Information is collected on the following variables: economic activity of the employer, occupation of the victim, age and sex of the victim, type of injury, part of body injured, time of the accident, size of the enterprise, employment status of the victim and days lost. Phase 3 of the ESAW methodology is gradually implemented from reference year 2001 onwards. In addition to the variables above, it includes information concerning the circumstances and events leading to the accidents ([130]).

([128]) Workshop on OSH monitoring systems, Bilbao, 30 September and 1 October 2002, jointly organised by the Danish Presidency and the Agency in cooperation with the European Commission. Proceedings. http://europe.osha.eu.int/systems/osm/proceedings/index.stm

([129]) 'Forum 11 — Monitoring occupational safety and health in the European Union', European Agency for Safety and Health at Work, 2003. http://agency.osha.eu.int/publications/forum/11/en/index.htm

([130]) 'Work and health in the EU: a statistical portrait, 1994–2002', European Communities, Eurostat, Catalogue No KS-57-04-807-EN-N.

The details of the ESAW methodology are described in detail in publications available from Eurostat ([131]). A resume of the concepts and the coverage of the data can also be found in 'Work and health in the EU: a statistical portrait, 1994–2002'.

Occupational diseases

Both the European statistics on occupational diseases (ESOD) and the national data sources have been used to collect statistical data on occupational diseases. The project on European statistics on occupational diseases (EODS) started with a pilot data collection for the reference year 1995 and the first data according to the Phase 1 methodology was collected for the year 2001.

The Phase 1 methodology of EODS includes detailed information on the causative agent of the occupational diseases and collection of information on the use and purpose of these causative agents is planned as well. The main drawback of both of these data collection systems is that not all workers are covered by the national data collection systems in all the Member States. For occupational diseases, problems arise also from under-reporting and differences between the national social security systems.

Exposure registers

An alternative to concentrating on the occurrence of disease is to monitor exposures. An exposure register records data relevant to occupational health and safety outcomes. It is different from a disease register in that it concentrates on workplace exposures rather than the disorders they may cause.

The measurement services of the institutions for statutory accident insurance and prevention (BGs) in Germany perform exposure measurements at workplaces. The data are stored in the BG/BIA exposure database.

Voluntary reporting of occupational diseases by specialist doctors

Sentinel surveillance uses a network of health providers to report cases of occupational diseases. This approach is similar to a register of occupational diseases, but there are some important differences. Sentinel networks may not try to achieve total coverage and can operate in a restricted geographical area or involve a sample of physicians.

In the UK, the THOR project is responsible for the collection of specialist-based work-related ill-health data. The scheme relies on the systematic, voluntary and confidential reporting of new cases by consultant thoracic physicians throughout the country. Regular reports are required from physicians detailing the number of new cases in each of 10 diagnostic categories and individual data for each case on age, sex, place of residence, type of work and suspected agent. The occupational surveillance scheme for audiologists (OSSA) operates within the THOR network.

([131]) 'European statistics on accidents at work (ESAW) — Methodology', 2001 edition. European Communities, Directorate-General for Employment and Social Saffairs, Catalogue No KE-36-019-60EN-C.

Inspections

In some countries, the medical inspections carried out by the labour inspectorate play an essential role in ensuring that laws and regulations governing workers' health surveillance are properly applied.

Arbomonitor in the Netherlands provides representative information on the state of affairs of working conditions in Dutch companies: risks, policies and (preventive) practices. The information is gathered through the labour inspection on their company visits.

Surveys

Labour force survey

The European labour force survey (LFS) has been used to collect data on employment and related variables in Europe. Information has been obtained with regard to the labour market in the EU, the employment status, demographical characteristics and company size and turnover. Data are available since 1983.

Epidemiological surveys, as well as studies and research in occupational health and safety, are very useful approaches in the surveillance of diseases due to work. European data have been collected from two major sources: the European working conditions survey and the labour force survey.

Surveys on work-related diseases and working conditions

The European working conditions survey, edited by the European Foundation for the Improvement of Living and Working Conditions, monitors trends in working conditions for employees and self-employed throughout the European Union. The survey provides information on the occurrence of exposure to risk factors and on perceived work-related health risks.

The 1999 labour force survey contained an ad hoc module on accidents at work and work-related health problems. Eleven questions were added to the LFS interviewing the respondents about the occurrence of occupational accidents or the suffering of work-related health problems during the last 12 months. The detailed methodology of the 1999 LFS ad hoc module is described in 'European social statistics — accidents at work and work-related health problems', European Commission, ISBN 92-894-3601-8.

All survey questions, which are used for retrieving data, have been stored in one indicators database. This allows the potential user to have an overview of possible survey questions and to do 'question-shopping'. The same principle is used for the database of sources.

Additional sources

Statistics from these sources were complemented by analytical studies. The aim of the studies is to give some interpretation and background information on the statistical data. A number of research studies have been used to complement the European survey data, mainly originating from the European Foundation for the Improvement

of Living and Working Conditions and the European Agency for Health and Safety at Work.

Comparability of data

A summary on comparability of ESAW and EODS can be found in 'Work and health in the EU: a statistical portrait, 1994–2002', European Communities, Eurostat. Catalogue No KS-57-04-807-EN-N.

The comparability of national working conditions surveys has been studied in the 'Working conditions surveys: a comparative analysis', European Foundation for the Improvement of Working and Living Conditions, 2003. Despite the differences lies one of the main interests in the frequency with which certain aspects or characteristics are repeated in the surveys.

Time trends

To allow identification of trends in the exposure and the hearing loss time series are proposed from 1980 to today. Noise-induced hearing loss will typically develop within one or two decades from the beginning of exposure, but the time required is influenced by the level of noise, the daily duration of exposure, the frequency of the noise and the number of intense noise peaks. The cases of noise-induced hearing loss in 200x are thus usually related to exposure in the 1980s.

5.2. How noise at work and its effects are monitored

The table below provides a description of the main indicators used to monitor noise exposure at work and the outcomes of such exposure. For more detailed information on the general methodology adopted, it is advised to see the source description or access directly the source.

The Agency also provides more detailed description of the data sources on its dedicated risk observatory website. Source descriptions are included in the national reports about noise exposure and hearing loss.

Table 17: Monitoring of noise at work and hearing problems

Parameter	Country	Source	Survey question
Noise exposure	NL	Dutch Central Bureau of Satistics	- Does noise hinder you at work?
	NL	Statline survey, POLS survey, TNO survey	- Are you exposed at work to noise so loud that you would have to raise your voice to talk to people?(yes, regularly/yes, sometimes/no)
	DK	DWECS	- Are you exposed to noise so loud that you must raise your voice to be able to talk to people?
			- Are you exposed to other disturbing noises?
	EU	EWCS	- Are you exposed at work to noise so loud that you would have to raise your voice to talk to people?(all the time, almost all the time, around three quasters of the time, around a quaster of the time, almost never, never)
	UK	Self-reported Working Conditions Survey	- In order to get an idea of how noisy your workplace is/was, do/did you ever have to raise your voice while talking to people from a normal talking distance?
			- How often does/did this happen? (always/almost always, about three quarters of the time, about half of the time, about a quarter of the time, less often)
			- Do/did you ever have work tasks that leaves/left you with a ringing in your ears or a temporary feeling of deafness?
			- How often does/did this happen? (daily, weekly, less often)
	F	French Survey on Working Conditions	- Does performing your task involve being attentive to brief or unexpected sound signals or to signals that are difficult to hear?
			- While working, when a person located 2 to 3 metres far from you talks to you: Can you hear this person if he or she talks normally? Can you hear if he or she speaks louder? You can not hear him or her?
			- Are you sometimes exposed to very loud or very acute noise? (yes/no)
			- Does a moderate level of noise affect your ability to perform your tasks? (yes/no)

Parameter	Country	Source	Survey question
	F	SUMER	The employees are asked to indicate - The exposure to a noise level over 85 dB(A) (yes/no/duration) - The exposure to noise with shocks or impulses (yes/no/duration) - The exposure to other disturbing noise (yes/no/duration) - The exposure to ultra-sounds (yes/no/duration). The reference period is the last working week. The answer possibilities range between <2 hours/ 2<x<10/ 10<x<20/ >20 hours.
	FIN	Finnish Work and Health Survey	- While working, when a person located 2 to 3 metres far from you talks to you: Can you hear this person if he or she talks normally? Can you hear if he or she speaks louder? You can not hear him or her?
	D	BIBB/IAB	- The employee is asked to indicate on a scale from 1–9 if he/she is performing noise-exposed work. If the indication on the scale is 1, 2 or 3 the employee is asked if he/she had to wear PPE (yes/no). Furthermore from a list of health complaints, the employee is asked to indicate if he/she suffers from hearing problems during or immediately following the exposure.
	SP	National Survey on Working conditions	- Is noise level such that you cannot communicate with a person 3 metres away from you? - Is noise level such that you cannot hear a person 3 metres away even though raising her voice?
Time of exposure	D	BG/BIA Noise exposure database	Data can be found on the noise exposure duration, as indicated by the employee.
	FIN	NoiseScan database	Estimation of lifetime occupational and non-occupational exposure to noise, based on questions, available measurement data and expert judgement
	UK	UK Self-reported work-related Illness survey	Investigates the estimated prevalence, incidence and associated rates of a self-reported illness (hearing problems) by length of employment in that job (less than 1 year, 1–2 years, 2–5 years, 5–10 years, 10–20 years, 20 years and more).
Level of exposure	NL	Arbomonitor	Monitors workplaces where the noise exposure is over 80 dB(A).
Mental ill health	FIN	Finnish Work and Health Survey	Monitors the perceived harm (both mental and physical: sorted) due to exposure to noise. The aim of this survey is to produce follow-up information on working conditions and other factors related to working life, well-being, work ability, lifestyle related to health, the use of health services and the evaluation of occupational health services.
	FIN	NoiseScan database	Includes EQoL5 (European Quality of Life) measurements of health status according to the European Quality of Life index

Parameter	Country	Source	Survey question
Physical ill health	DK	DWECS	Investigates the following health related complaints:
			- How often do you feel it is unpleasant or painful to hear common noises such as a chair being moved, chinking cutlery, clear voices? (Always, Often, Sometimes, Seldom, Never);
			- Have you experienced a ringing in the ears within the last three months? (Yes, daily, Yes, approx. every week, Yes, approx. every month, or No);
			- Does this ringing in the ears annoy you? (Always, Often, Sometimes, Seldom, or Never);
			- Is your hearing ability so reduced that you find it difficult to follow a conversation when several people are gathered? (without using a hearing aid). (Yes, or No);
			- How difficult is it to follow a conversation when several people are gathered? (Very difficult, Difficult, or Not so easy).
	UK	Self-reported Work Related Illness	- Within the last twelve months, have you suffered from any illness, disability or other physical or mental problem that was caused or made worse by your job or work done in the past?;
			- How many illnesses have you had (in the last twelve months) that have been caused or been made worse by your work?;
			- How would you describe this illness? (Hearing problems figured in the list of possible answers).
	UK	Self-reported Working Conditions Survey	Respondents are asked a selection of questions about different aspects of their job and working conditions that might be associated with the occurrence of work-related illness. Each condition has been grouped into one of five categories: job demands, control and support; physical conditions; noise and vibration; ergonomic aspects and violence.
	EU	ESWC	Asks the employee whether he is suffering from hearing problems and headaches due to his/her work.

6.

LEGISLATION

6.1. European workplace legislation on noise exposure

Protection against noise effects has been one of the priorities at European level since an early stage of the development of the occupational health and safety policy. Already in 1986, the Council had adopted Directive 86/188/EEC on the protection of workers from the risks related to exposure to noise at work. This directive had already set up exposure limit values for workers as well as the main elements of the prevention policy to be applied by employers.

In 2003, Directive 2003/10/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) was adopted. This directive is to be transposed into the national legislation of all Member States before 15 February 2006 ([132]). The main characteristic of the new noise directive is to establish a clear and coherent prevention strategy capable of protecting the health and safety of workers exposed to noise.

Article 5(1) of the directive requires that, taking into account technical progress and the measures available to control the risk at source, 'the risks arising from exposure to noise shall be eliminated at their source or reduced to a minimum'. In order to avoid irreversible damage to workers' hearing, the directive foresees exposure limit values of 87 dB(A) and a peak sound pressure of 200 Pa, above which no worker may be exposed; the noise reaching the ear should, in fact, be kept below these exposure limit values. The directive also foresees upper and lower exposure action values of respectively 85 dB(A) (and 140 Pa) and 80 dB(A) (and 112 Pa), which determine when preventive measures are necessary to reduce the risks to workers. It is important to note that, when applying the exposure limit values, the determination of the worker's effective exposure shall take account of the attenuation provided by the individual hearing protectors worn by the worker. The exposure action values shall not take account of the effect of any such protectors.

In order to assess correctly the exposure of workers to noise and taking into account that it is useful to apply an objective measuring method, the directive refers to the generally recognised standard ISO 1999:1990. On the basis of the risk assessment and as soon as the exposure action values are exceeded, the employer shall establish and implement a programme of technical and/or organisational measures intended to reduce the exposure to noise.

The directive also foresees detailed rules for the information and training of workers who are exposed to noise at work at or above the lower exposure action value.

Reinforced health surveillance is one of the main points of the directive: it confers, in particular, a right to the worker to have his/her hearing checked by a doctor or by another suitably qualified person under the responsibility of a doctor when the

([132]) Replacing Directive 86/188/EEC.

upper exposure action values are exceeded. Preventive audiometric testing shall also be available for workers whose exposure exceeds the lower exposure action values, where the assessment and measurement of the noise exposure level indicate a risk to health.

The particular characteristics of the music and entertainment sectors require practical guidance to allow for an effective application of the provisions laid down by the directive. Member States are entitled to make use of a transitional period of a maximum of two years for the development of a code of conduct providing for practical guidelines that would help workers and employers in those sectors to attain the levels of protection established by the directive.

The new Noise Directive 2003/10/EC therefore:

- provides increased protection for workers in all sectors of the economy, including the maritime and air transport sectors (excluded from the existing Directive 86/188/EEC);
- recognises the specificity of the music and entertainment sectors by providing for a two-year transitional period during which codes of conduct shall be established for helping workers and employers in these sectors to meet their legal obligations as laid down by the directive;
- reduces the exposure limit value from 90 dB(A), as set up in the 1986 directive, to 87 dB(A), which represents clear progress ([133]).

The next step will be the transposition, by Member States, of the provisions of the new noise directive into national law, for which the deadline is fixed at 15 February 2006, and the development by Member States, in consultation with the social partners, of a code of conduct providing for practical guidelines to facilitate implementation in the music and entertainment sectors. The Commission intends to produce, in consultation with the Advisory Committee for Health and Safety at Work, European guidelines that could serve as a source of inspiration to Member States to develop national ones.

([133]) 'A new directive on noise', José Biosca de Sagastuy, Directorate-General for Employment, Social Affairs and Equal Opportunities, European Commission, in *Magazine*, Issue 8 'Noise at Work', European Agency for Safety and Health at Work 2005.

6.2. Other EU policy areas

Machinery ([134])

Manufacturers of machinery and other equipment also have the responsibility to reduce noise levels. According to the Directive 98/37/EC, machinery should be 'designed and constructed (so) that risks resulting from the emission of airborne noise are reduced to the lowest level, taking account of technical progress and the availability of means of reducing noise, in particular at source'.

Compliance with codes of good practice to reduce noise

The directive requires the designer to use all available means to reduce noise by design (such as by choosing non-metallic materials, by assembling components of a shape, thickness and size calculated to avoid resonance, by inserting joints to damp vibration, by preventing parts from falling from too high, and by regulating the flow of compressed air exhaust, etc.). It is more effective to take measures to reduce noise at source than to take additional protective measures (such as enclosing the machinery). Additional measures can in fact pose problems (more difficult for the operator to see the requisite information, unwanted heating, smaller openings for supply or removing parts, etc.) and are generally less effective than integrated design measures to reduce noise.

The directive does not lay down limit values for noise emission. However, the CEN memorandum (CEN/CR 1100) states, with very careful wording, that standards could indicate the average levels achieved at a given date for a type of series-manufactured machinery (where appropriate by power category, technological type, etc.). These standards also clearly state the test codes used and the measuring conditions (materials worked, rate of work, etc.).

The directive does not cover disturbances in surrounding areas. Moreover, the noise emitted by machinery should not be confused with the noise to which people and the environment are exposed. The latter depends on many factors, such as the number of machines operating in the same room, the noise emitted by the other machines and the siting of the machine (next to a wall, nature of the wall, ceiling height, etc.). Any limit laid down for an individual machine is without prejudice to its influence on the health of operators or environmental quality. The European Commission (Directorate-General for the Environment) is drawing up a proposal for a directive designed to lay down noise emission limits for machinery used outdoors. The aim of this proposal for a directive is to extend the scope of existing 'old approach' directives on the matter, targeting in particular construction site equipment and lawnmowers.

([134]) Machinery/noise pages of the European Commission's Directorate-General for Enterprise. http://europa.eu.int/comm/enterprise/mechan_equipment/machinery/guide/annex1-15.htm

Environmental noise

For more than 20 years, Community environmental noise policy has essentially consisted of legislation fixing maximum sound levels for vehicles, aeroplanes and machines with a single market aim, or to implement international agreements in the case of aircraft, linked to certification procedures to ensure that new vehicles and equipment are, at the time of manufacture complying with the noise limits laid down in the directives.

In Europe, according to environmental surveys ([135]) ([136]) ([137]), an estimated

- 113 million people are exposed to noise levels high enough to have serious health consequences;
- 10 million people are exposed to ambient noise levels that can lead to hearing loss;
- 30 million people are exposed to occupational noise that endangers their hearing.

Thanks to this legislation and technological progress, significant reductions of noise from individual environmental sources have been achieved. For example, the noise from individual cars has been reduced by 85 % since 1970 and the noise from lorries by 90 %. Likewise for aircraft, footprint around an airport made by a modern jet has been reduced by a factor of nine compared to an aircraft with 1970s technology ([138]).

Further to its 1996 Green Paper (COM(96)540), the European Commission developed a new framework for noise policy, based on shared responsibility between the EU, national and local level, and including measures to improve the accuracy and standardisation of data to help improve the coherency of different actions. This document led to a comprehensive set of measures, including:

1. the creation of a noise expert network, whose mission is to assist the Commission in the development of its noise policy;
2. the directive on environmental noise aimed at requiring competent authorities in Member States to produce strategic noise maps on the basis of harmonised indicators, to inform the public about noise exposure and its effects, and to draw up action plans to address noise issues;
3. the directive on equipment used outdoors that simplifies the legislation about many noisy equipments;
4. the follow-up and development of existing EU legislation relating to sources of noise, such as motor vehicles, aircraft, railway rolling stock and the provision of financial support to different noise-related studies and research projects.

([135]) Noise pages of the EU Commission's Directorate-General for Research. http://europa.eu.int/comm/research/quality-of-life/ka4/ka4_noise_en.html

([136]) 'Nopher, Noise pollution, health effects, reduction', Brochure describing the project. http://www.ucl.ac.uk/noiseandhealth/EC %20Brochure1.pdf

([137]) Rodrigues C., 'Health effects of noise indicators and research needs', presentation at CALM Workshop, Objectives for Health Effects from Noise, Brussels, 18 March 2004. http://www.calm-network.com/calm1/index_preports.htm

([138]) Noise pages of the EU Commission's Directorate-General for the Environment. http://europa.eu.int/comm/environment/noise/greenpap.htm.

This Green Paper is the first step in the development of such a programme and aims to stimulate public discussion on the future approach to noise policy. It reviews the overall noise situation in the Community and national action taken to date followed by the outline of a framework for action covering the improvement of information and its comparability and future options for the noise from different sources. One of the main aims of this paper is to help to give noise abatement a higher priority in policy making. It is focusing on the areas where Community action in cooperation with Member States and local authorities can be of added value.

Existing noise control legislation can be divided into four categories ([139]). The noise emissions from motor vehicles are covered by two directives introducing sound level limits. Three directives limit noise emissions from aeroplanes by reference to the Convention on international Civil Aviation. Noise emission from household appliances has been the object of a framework directive on household appliances. The last sector, construction equipment, is based in the EEC conformity assessment procedure framework directive, which led to the adoption of seven daughter directives on particular types of equipment. Permissible sound power levels are laid down within the framework of directive 84/532/EEC on the EEC type-examination for construction plant and equipment, with regard to harmonised requirements for these types of equipment, in seven separate directives, each of them concerning particular equipment ([140]).

All the seven 'daughter' directives require that the products covered must be labelled with a mark indicating the noise levels guaranteed by the manufacturer, and contain annexes which define a method of measuring airborne noise and a spot check procedure for checking the conformity of production models with the type examined. Member States are not allowed to keep equipment which meet these requirements out of their markets, but are allowed to regulate the use of the equipment in areas they consider sensitive (e.g. near hospitals). EEC type-examination certificates are valid for a period of five years and may be renewed.

On 3 January 2002, the 'Noise emission in the environment by equipment for use outdoors' directive became mandatory. Manufacturers of a wide range of equipment for use outdoors (57 types, ranging from construction equipment to gardening equipment) are required to label each and every machine to indicate the 'guaranteed' sound power level. This label, the CE-mark and a declaration of conformity are all

([139]) Guide to the approximation of European Union Environmental Legislation, Part 2, 'Overview of EU environmental legislation, Noise from vehicles and machinery'. http://europa.eu.int/comm/environment/guide/part2h.htm

([140]) Directive 84/533/EEC lays down noise limits for the environment and related requirements for the issuance of an EEC type-examination certificate for compressors, Directive 84/534/EEC lays down noise limits for the environment, noise limits at the operator's position, and related requirements for the issuance of an EEC type-examination certificate for tower cranes. Directive 84/535/EEC lays down noise limits for the environment and related requirements for the issuance of an EEC type-examination certificate for welding generators, Directive 84/536/EEC lays down noise limits and related requirements for the issuance of an EEC type-examination certificate for power generators, Directive 84/537/EEC lays down noise limits for the environment and related requirements for the issuance of an EEC type-examination certificate for concrete breakers. The Member States may limit the noise level at the work place, Directive 86/662/EEC lays down noise limits and related requirements for the issuance of an EEC type-examination certificate for earth-moving machines used on civil-engineering and building sites. Additional it requires labelling of the products with the noise level at the operator's position. The Member States may limit the noise level at the work place.

necessary if the equipment is to be sold in the EU market. The 'guaranteed' sound-power level has been defined in the directive as the sound-power level of the device with uncertainties (due to production variations and measurement procedures) that the manufacturer declares will not be exceeded. Of the 57 categories, 22 are subject to noise limits. For those categories, notified bodies (appointed by EU Member States) must be involved in the auditing of conformity assessment procedures. Of these 22 categories, 11 were already subject to noise limits laid down in seven older directives that are now withdrawn and replaced by the new directive. The other 11 types are subject to noise limits for the first time.

Failure to comply with these regulations may result in products being prohibited from the EU marketplace. The implementation of the directive has a number of objectives. It contributes to the smooth functioning of the EU internal market; it harmonises the existing legislation of the EU Member States; it implements a framework for future noise reduction; it protects the health and well-being of citizens as well as protecting the environment; and it provides the public with information on the noise emitted by such equipment ([141]).

The Swiss Noise Ordinance and Policy ([142]) and the German Noise Ordinance 'TA Lärm' ([143]) are national examples of such noise policies.

Research on noise

Some research under key action 4 of the fifth framework programme focuses on noise-related health effects and providing scientific evidence for establishing noise limits in the EU. The Nopher project, a European Commission concerted action to reduce health effects of noise pollution, with 51 partners from 16 countries, comprises workshops and working parties in which European scientific, technical, and medical experts are tackling numerous problems related to research on noise pollution and its adverse effects on health. It aims to determine the health effects of chronic exposure to transport noise, to develop strategies for pharmacological protection against noise trauma, to determine effects of combined chemicals and noise exposure on hearing and balance (see NoiseChem, above), to devise ways to identify those individuals vulnerable to noise damage, and to develop a 'noise and health' information system.

Within the sixth European RTD framework programme, the thematic EU network CALM acting from October 2001 to October 2004 aimed at the definition of a strategy plan for future noise research in Europe. It shall promote the EU-wide reduction of environmental noise. The aim of the CALM network is to establish the 'Community noise research strategy plan'. This plan shall identify strategies for future research that will be designed to promote EU-wide reduction of environmental noise. Therefore, the network has to identify the strategic research needs in the fields of noise emission (with special focus on noise caused by road traffic, railway transport, aircraft and

([141]) 'EU noise emission directive — do you comply?' Brüel & Kjær. http://www.bksv.com/default.asp?ID=2422

([142]) Lärmschutz-Verordnung (LSV), 1986.

([143]) http://www.bmu.de/pressearchiv/13_legislaturperiode/pm/248.php

outdoor machinery), noise propagation, noise exposure and the adverse effects of noise, particularly in urban areas.

CALM has formulated research needs for outdoor equipment ([144]): the visionary target is to halve the noise annoyance caused. For this target, the most important areas of future research are:

- in-use compliance (to avoid an increase in noise during the life-cycle of equipment);
- correlation between noise emission, performance parameters and real operation nuisance (to make possible more efficient noise regulation);
- effect of single and combined noise sources on noise perception (to enable a more efficient reduction of noise annoyance.

The WHO programme on noise and health ([145]) reviews the main health effects on noise from a dose-effect perspective and identifies the needs of specific vulnerable groups. Working in close cooperation with other WHO programmes, the programme develops indicators for noise and health, analyses exposure-response relationships for different health effects and studies the long-term effects of night exposure to noise (long-term sleep disturbance and cardiovascular problems). WHO recommendations for noise limits were already mentioned in section 'Medium-level noise.'

([144]) Rust, A. .et al.,'CALM — strategic planning of future noise research in Europe', Presentation at 'Internoise 2004', the 33rd International Congress and Exposition on Noise Control and Engineering. http://www.calm-network.com/calm1/index_preports.htm

([145]) See Noise pages of the WHO for further information. http://www.euro.who.int/Noise

7.

CONCLUSIONS

7.1. Implementing the new directive in practice

This new piece of legislation constitutes a major improvement in the protection of workers against noise at work, in line with the prevention philosophy of the framework directive.

The Commission, in a contribution to the 2005 European campaign on noise, concludes that, '… the best legislation will not achieve its intended effects of reduction of loss of hearing due to noise exposure if it is not properly applied and enforced. It is therefore for the social partners, as the main actors in prevention of noise in the workplace, and enforcement authorities to ensure that work-related deafness will no longer be an issue in the EU.'

Targeting specific sectors

Exposure to loud noise is not notably rising, but there are no significant improvements to be observed. Typical sectors for male workers affected by loud noise include construction, agriculture, forestry, manufacturing of metal and wood, mining and quarrying. The ESWC-data identifies the construction sector as the category with the highest percentage of workers reporting exposure to noise in the EU-15. The manufacturing sector has the second highest percentage. In both sectors, about 40 % of the workers are exposed to noise at work half of the time or more. Since 1995, the figures are increasing for both categories.

Allgemeine Unfallversicherungsanstalt, Austria

The sectors with the highest percentage of workers exposed to noise in the new Member States all or almost all the time are agriculture (40 %) and mining (34 %). It has to be kept in mind that the proportion of workers working in these sectors is higher in the new Member States than in the EU-15. As an example, the proportion of people employed in agriculture in 2000 was higher on average (21 % compared to 5 %), although there were wide differences between countries. A study from the UK has shown that although technologies in agriculture have changed and machinery noise levels have decreased, fewer workers might be exposed more intensively to noise.

Noise prevention measures need to further target known high-risk sectors.

A high percentage of workers in the new Member States are also exposed to noise in manufacturing (19 %). Also, workers in the new Member States generally report higher exposure to physical risk factors, such as noise, vibrations and painful positions. Conditions in some of these sectors (temperature extremes, noise, vibrations, etc.) may explain, at least in part, over-exposure to these physical risk factors.

Craftspeople, skilled workers, agricultural workers and the armed forces are most exposed to noise at work — the percentage of workers exposed in these occupation groups is higher than average.

Data on noise levels in these occupations are available. Noise-prevention measures need to further target these known high-risk sectors.

In selected sectors, women can be considerably exposed to noise. In the Czech Republic, for example, within the textile production, 75 % of workers significantly exposed are female, followed by almost 50 % in food production. The percentage of women reporting noise exposure is much higher in the new Member States than for the EU-15. It is worth noting that the number of cases of hearing loss is increasing for women in Poland. In 2003, they rose up to 38 %.

In selected sectors, women can be considerably exposed to loud noise

INSHT, Instituto Nacional de Seguridad e Higiene en el Trabajo, Spain

Allgemeine Unfallversicherungsanstalt, Austria

Women are generally reporting to be more exposed to medium-level noise. Typical occupations include education, healthcare, restaurants, offices and call centres. But in these professions, exposure to loud noise also occurs. Measures need to equally address problems in these sectors. The same principles as regards tackling loud noise apply, replacing noisy equipment, acoustic measures, work organisational issues and general noise-prevention measures.

The new directive requires that, in the risk assessment, attention should be paid also to impulsive noise. A statistical method for the measurements of industrial impulse noise is needed. Measures are also needed to address the risks due to impulse noise.

Further efforts are needed to support and improve the implementation of collective measures against noise

Control measures and the use of personal protective equipment

In studies of noise control measures at workplaces, there was a range of different management approaches to noise control and some had effective or partly effective hearing protection programmes in place. The smaller companies had very limited noise control procedures and relied heavily on personal protective equipment. Further efforts are needed to support and improve the implementation of especially collective measures against noise.

Loud machinery

Allgemeine Unfallversicherungsanstalt, Austria

Further improvements are needed to effectively lower emission levels of machinery and equipment used in workplaces.

Further efforts are needed to reduce noise in workplaces. Noisy occupations and professions typically use a wide range of processes and machinery for forming, shaping and removing material. Such processes have the potential to create substantial and prolonged high noise levels in the workplace. Any setting that involves heavy machinery can be hazardous to the hearing. According to the European Commission's Directorate-General for the Environment ([146]), for some sources such as railways and a wide range of noisy equipment used outdoors, there are no Community or international standards setting emission limits.

A number of Member States are planning national legislation for these products, which could cause problems for the functioning of the single market.

Further improvements are needed to effectively lower emission levels of machinery and equipment used in workplaces.

Acoustic measures

Whereas some measures address noise at the source (e.g. noise reduction of machinery), room acoustic measures should also be kept in mind.

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Acoustic measure in a day-care centre Landesunfallkasse NRW, Germany

([146]) 'Noise — the Green Paper, analysis of existing noise abatement actions in the European Union, 2005. http://europa.eu.int/comm/environment/noise/greenpap.htm

As an example, analysis of German and international references shows that classroom acoustics have been neglected. Measurements of several classrooms in everyday use have revealed acoustical conditions that permit less than half of the speech to be understood. Generally, the problems are caused by improper wall, ceiling, and floor finishes and by noisy ventilation equipment. Considerable reductions could be achieved by acoustic measures and acoustic guides have been issued. The Agency provides information about acoustic measures on its website dedicated to noise prevention ([147]) and its Noise at Work magazine publication ([148]) ([149]) ([150]).

Medium-level noise

The complexity of work and the necessity to carry out additional administrative tasks has increased in professions such as healthcare work and teaching, but also industrial production. Where concentration is needed, noise levels need to be kept low

Noise below the levels usually associated with hearing damage can also cause regular and predictable changes in the body. Even 'ear-safe' sound levels can cause non-auditory health effects if they chronically interfere with recreational activities such as sleep and relaxation, if they disturb communication and speech intelligibility, or if they interfere with mental tasks that require a high degree of attention and concentration. In general, the suspected effects include cardiovascular function (hypertension, changes to blood pressure and/or heart rate), and changes in breathing, annoyance, sleep, physical health and mental health.

The complexity of work and the necessity to carry out additional administrative tasks has increased in professions such as healthcare work and teaching, but also industrial production. Where concentration is needed, noise levels need to be kept low.

Some measures have addressed the reduction of medium-level noise. This includes for example:

- for the education sector: noise reduction measures in classrooms, the application of noise-avoiding teaching methods;
- for call centres: technical standards for headphones, work organisational measures, noise reduction measures in workplaces;
- for offices: avoiding noisy office equipment, noise reduction measures in offices, work organisational measures.

But further information gathering and design for noise reduction in occupations especially in the services sector and new occupations (hospital wards, education, entertainment, call centres) is needed. Some parts of the service sector may need to develop a safety culture and OSH authorities may need to provide more support to this sector. These issues need to be further addressed and tackled in prevention.

([147]) http://3geu.osha.eu.int/good_practice/risks/noise/

([148]) Gaafar, A., 'Acoustics in indoor workplaces', *Magazine*, Issue 8 'Noise at Work', 2005, pp. 14-18. European Agency for Safety and Health at Work.

([149]) Christ, E., 'Acoustic measure in sheltered workshops', *Magazine*, Issue 8 'Noise at Work', 2005, pp. 18–20, European Agency for Safety and Health at Work.

([150]) Kurtz, P., 'Noise reduction in offices', *Magazine*, Issue 8 'Noise at Work', 2005, pp. 26–28. European Agency for Safety and Health at Work.

Addressing the needs of specific groups

The exposure to loud noise seems to be affecting more and more younger workers.

The exposure to loud noise seems to be affecting more and more younger workers. Special focus should therefore be given to training and education of young workers

According to the first candidate countries survey on working conditions, the youngest workers are more exposed to all physical factors. Member States' data also indicate that the exposure to loud noise seems to be affecting younger workers than in previous years. This is further underpinned by the fact that according to the European survey especially employees on apprenticeship or other training scheme report more hearing problems in 2000 than in 1995. This trend needs to be observed and further confirmed.

Special focus should therefore be given to training and education of young workers in the workplace. Also, their health problems need to be more specifically addressed to clarify such issues. It is worth noting that young workers are also one of the high risk groups for occupational accidents.

Among employees, those with fixed-term contracts are more exposed than those with permanent contracts. Full-time employees with non-permanent contracts need special attention: This group of workers is highly exposed to noise in the workplace. Nevertheless they are the least informed about the risks. This group needs more information available relating to health and safety issues, more training and more formal supervision and control in the workplace.

Disablement due to noise

The Community strategy on health and safety at work 2002–06 states that 'SMEs, very small firms and craft trade workers […] and organisations must be made aware of the need to reintegrate disabled people into employment, with special reference to creating an adapted work environment.' and that 'The need to adapt the workplace to the needs of disabled people is covered by Directive 89/654, and the concept of 'reasonable adaptations' is defined in Directive 2000/78 ([151])'. Following the requirements of the strategy, the Agency has compiled various resources related to occupational safety and health and people with disabilities, to help those interested in this topic find information, ideas and practical solutions: The Agency key documents section includes a fact sheet on 'ensuring the safety of health of workers with disabilities'. The web pages were launched to support the European Year of People with Disabilities (2003) ([152]).

Additional accident risks for workers with hearing impairment have been identified in this report. Further research in the design and evaluation of improved workplace accommodations for workers with hearing impairment is needed. This has also to be seen in light of ageing of the work population. A study ([153]) on hearing impairment and verbal communication at the workplace recommends a noise level 5 to 20 dB

Further research in the design and evaluation of improved workplace accommodations for workers with hearing impairment is needed.

([151]) OJ L 303/16, 2 December 2000.

([152]) There are links to websites of organisations providing relevant material -providers- listed by country and there are links to resources organised by topics. The Agency key documents section includes a Factsheet on 'ensuring the safety of health of workers with disabilities'. The web pages were launched to support the European Year of People with Disabilities (2003). See http://europe.osha.eu.int/good_practice/person/disability/, for further information.

([153]) Bormann, V., Sust, Ch. A., Heinecke-Schmitt, R., Fuder, G., Lazarus, H., 'Schwerhörigkeit und Sprachkommunikation am Arbeitsplatz' (Hearing impairment and verbal communication at the workplace), *Research Report* Fb 1041, Dortmund: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2005. http://www.baua.de/english/fors/fb05/fb1041_e.htm

lower for hearing-impaired persons, in order to be able to understand as well as those persons with normal hearing.

7.2. Research needs

Monitoring health effects

Noise-related hearing loss cases as an effect of these exposures has been reduced, but still is one of the most prominent and most frequently recognised diseases in some Member States. Figures related to noise effects, even for a well-assessed health effect such as hearing loss, are very diverse. Further efforts are needed to improve the assessment of such health effects.

More research is also needed to aggregate information about and further investigate the exposure to medium-level noise, related to other health effects than hearing loss such as stress, voice disorders, cardiovascular diseases, tinnitus, vibroacoustic disease and combined health effects. More reliable data would be helpful to assess more thoroughly the extent of the problem and the trends to be observed.

More research is needed for other health effects than hearing loss such as stress, voice disorders, cardiovascular diseases, tinnitus, vibroacoustic disease and combined health effects.

Assessing exposures in specific workplaces

Data on noise exposure and related effects are especially scarce in female-dominated sectors such as the hotels and restaurants sector and healthcare. The same is true for the transport sector. Targeted investigations for these occupations would help identify issues to be addressed by prevention.

Acoustic shocks and excessive noise exposure due to new technologies and work organisation were also identified by the Agency's expert surveys and related scientific literature as an emerging risk, mainly because of the increasing number of call centres where headphones are used.

Other research areas identified include noise exposure of pregnant workers and noise and accident risks.

Targeted investigations in selected occupations (health care, hotels and restaurants, transport, call centres) would help identify issues to be addressed by prevention.

Combined exposures

Hearing loss can also be caused or potentiated by the use of chemicals (e.g. solvents, asphyxiants). The combined exposure to 'noise and vibration' was also identified as an emerging risk by the experts who answered the Agency's expert surveys on noise and vibrations. More research is needed to investigate the effect of combined risks for workers exposed to high-level noise, for example, with vibration and dangerous substances.

More research is also needed to assess the importance of noise outside the audible range, such as low-frequency-noise, define how to perform a workplace risk assessment in order to assess and describe the potential effects, and implement appropriate preventive measures.

More investigations into the effect of combined risks for workers exposed to high-level noise, e.g. with vibration and dangerous substances are needed.

8.

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European Agency for Safety and Health at Work

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