

Hearing conservation in Switzerland – long-term perspective and latest results

Beat W. Hohmann

Swiss National Accident Insurance Fund Suva, Physics Section (corresponding author)

Corresponding author's e-mail address: beat.hohmann@suva.ch

ABSTRACT

According to ISO 1999, noise-induced hearing loss (NIHL) occurs in the first years of noise exposure whereas the age-related hearing loss adds gradually as we grow older. Therefore, if NIHL wants to be prevented, hearing must be protected from the very first moment of noise exposure.

Since 1973, the Swiss National Accident Insurance Fund Suva runs a comprehensive hearing conservation programme for all noise-exposed workers. The audiometric database contains the results of the hearing examination as well as data about occupation, noise exposure and hearing protection. The percentage of workers showing NIHL decreased from 37% in 1973 to 8% in recent years. In order to prevent occupational NIHL completely, an indicator for early detection of NIHL was developed: dHV346 is the yearly average additional hearing loss at 3, 4 and 6 kHz (where NIHL occurs) and applicable to individuals or groups. If the percentage of workers with unacceptable dHV346 exceeds 10%, the company has to verify if their workers are protected sufficiently and take action for example by using Suva's new "earplug check".

SUVA'S HEARING CONSERVATION PROGRAMME

In Switzerland, about 7 percent of all the employees or 150'000 persons are still exposed to potentially harmful noise exceeding a daily noise exposure level of 85 dB(A). Despite considerable progress in industrial noise control and individual hearing protection, noise-induced hearing loss is still one of the most frequent occupational diseases.

The Swiss National Accident Insurance Fund (Suva) is the supervisory body for the prevention of occupational accidents and diseases all over Switzerland. Suva's Acoustics Team supports companies in noise control at workplaces.

Since more than 40 years, Suva runs a centralized hearing examination service using 5 mobile units or "Audiomobiles" 1.

Layout and principles

In the first few years of this hearing conservation programme, the efforts were directed mainly towards identifying and preventing severe noise-induced hearing loss, particularly also with

appropriate individual instructions. Therefore, a so-called "screening audiometry" was applied, that means that only the auditory threshold down to 20 dB hearing level was measured.

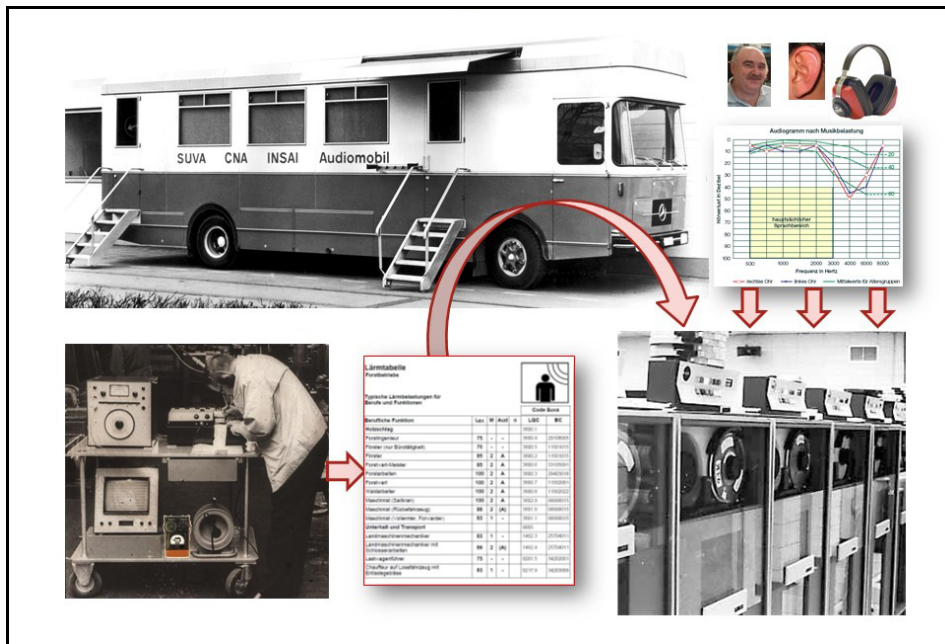


Figure 1: Audiometric results and noise exposure data come together on the audiobile.

From the beginning, for every person not only the audiometric results were recorded, but also the noise exposure (based on Suva's noise level tables, see figure 1) as well as ear diseases and the use of hearing protecting devices (HPDs).

The screening audiometry turned out to be a severe limitation because early signs of NIHL in younger people were missed (see figure 4). Mainly age-related hearing loss was seen.

Early results

Nevertheless, with these examinations, and especially with the audio-visual information and the personal advice given, it was possible to increase the rate of wearing of appropriate hearing protectors according to the statements of those investigated (figure 2).

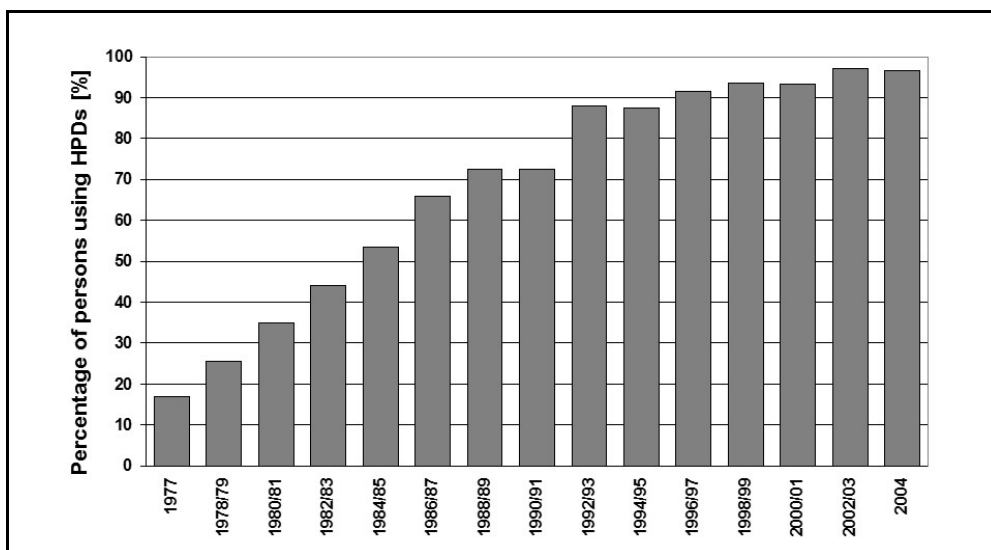


Figure 2: Use of hearing protectors from 1977 to 1997

Over the years, a considerable decrease of the fraction of workers with mild or severe hearing loss could be seen (figure 3):

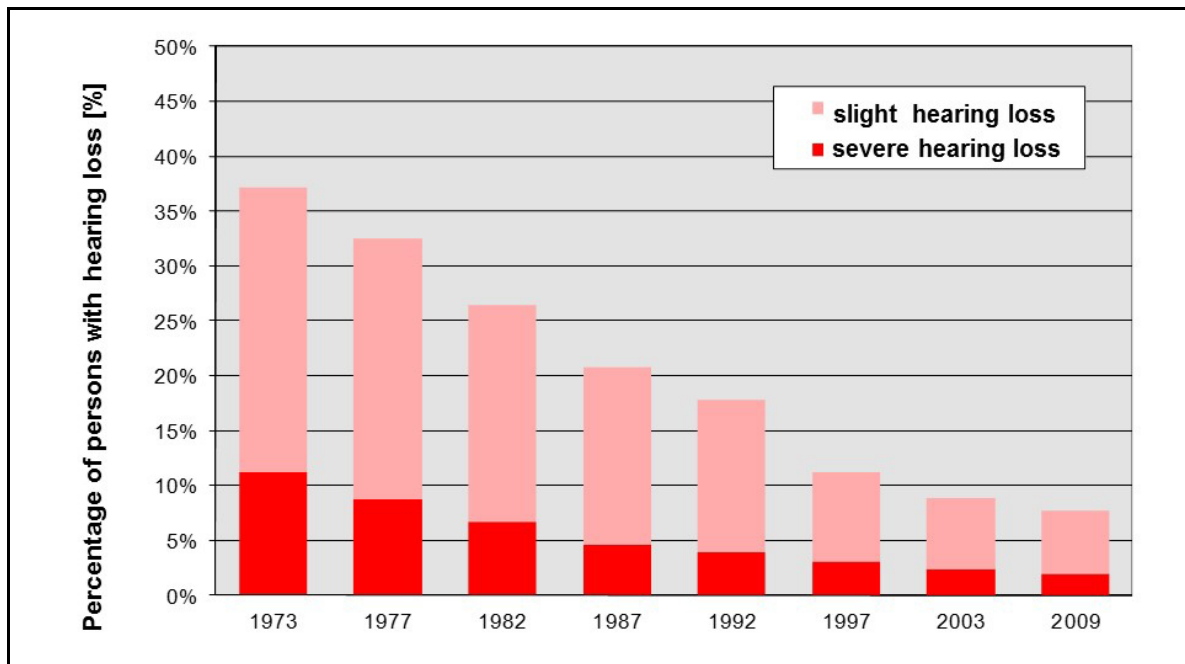


Figure 3: Results of hearing examinations (about 40'000 per year)

The audiometric hearing at losses in dB at 0.5 / 1.0 / 2.0 / 4.0 kHz were converted into a one-number value using a modified CPT-AMA-value with weighting factors of 15 / 30 / 40 / 15 % for the different frequencies. The CPT-AMA weighting is appropriate for an estimation of the loss of communication capabilities in quiet surroundings, but of loss of communication capabilities in noisy surroundings (where communication depends very much on the hearing loss at 4 kHz). Moreover, it is not helpful for the early detection of NIHL, which most often starts at 4 kHz and 6 kHz.

Figure 3 also shows that the fraction of persons suffering from hearing loss stayed almost constant after the year 2000 and reveals limitations of the hearing conservation programme.

LIMITATIONS OF HEARING CONSERVATION BASED ON AUDIOMETRY

During many years, the hearing conservation programme had been a flagship programme of Suva's prevention of occupational accidents and diseases. It had proven to be successful in the early years, but despite the vast (over 1 Mio persons) and comprehensive (noise and hearing data combined) data base, an advanced statistical analysis showing its effectiveness was never attempted.

The Royster review of Suva's hearing conservation programme (1990)

Larry and Julia Royster, specialists for audiometric data analysis (ADBA) [1] and authors of the relevant ANSI standard, agreed to evaluate the effectiveness of Suva's hearing conservation programme. Their analysis looked at the differences in hearing loss of each individual person between two subsequent examinations. They could confirm the general effectiveness of Suva's hearing conservation, but commented that it would be more efficient to use the audiometric equipment of the automobiles to evaluate the effective attenuation of the earplugs as they are worn by the workers instead of measuring repeatedly their hearing loss.

In the following year, Suva reinforced the instruction of the workers how to apply hearing protectors correctly, but no attempt was made to measure their real effectiveness.

A closer look into ISO 1999

A closer look into international standard ISO 1999 reveals that (at least for groups), noise-induced hearing loss increases fast during the first years of noise exposure, whereas age-related hearing loss starts slowly in younger years and increases progressively with age, as is shown in figure 4.

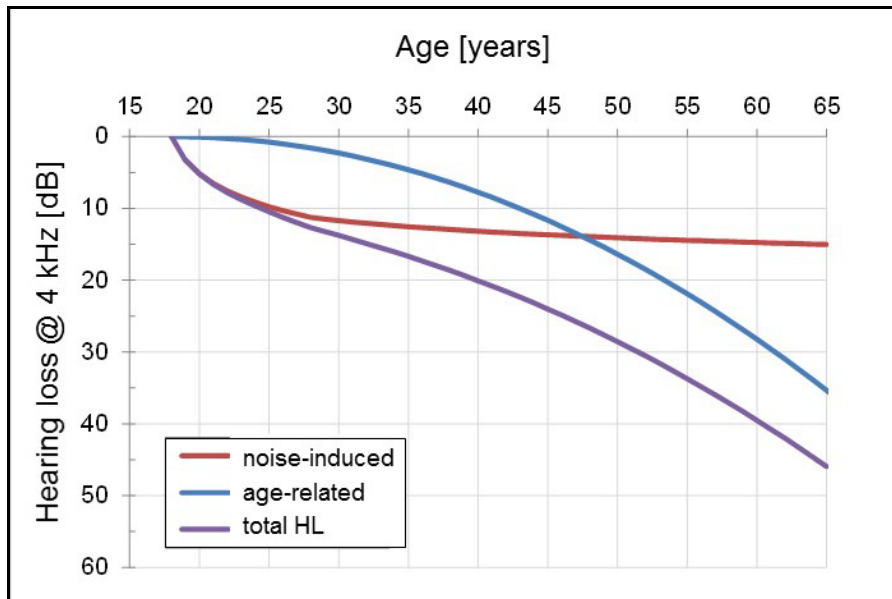


Figure 4: Noise-induced and age-related hearing loss at 4 kHz for men when occupational noise exposure starts at the age of 18 years.

Therefore hearing protection must be worn from the very first moment of noise exposure (independent of age) to be effective. Only when NIHL is detected right at the beginning, it will be possible to prevent its further development.

LATEST DEVELOPMENTS

In order to improve the effectiveness and at the same time reduce the costs (about 10 million CHF per year), Suva's hearing conservation programme was reviewed. One of the aspects to deal with was the fact that many workers – despite the many hearing examinations all over the years – finally suffered from considerable hearing loss. Obviously the hearing conservation program did not succeed in avoiding NIHL.

Concentration on workers where NIHL may still be avoided

Based on ISO 1999, Suva decided to concentrate hearing examinations onto younger workers below 40 years of age, because they are most probably still in the first years of occupational noise exposure, and there is still a chance that NIHL can be avoided. Older workers, but in their first years of noise exposure will be invited to the hearing examination as well as persons with known noise susceptibility (“conditional aptitude for work in noise”).

Early detection of NIHL with dHV346

For a better detection of early signs of NIHL, the indicator dHV346 was developed, which is the differential hearing loss in the high frequency range (3, 4, and 6 kHz) per year. This indicator is applied to an individual person for medical decisions regarding aptitude for work in noise. On a group basis, this indicator serves to detect companies, professions or branches where hearing protection is not yet implemented properly and where the workers hearing is still at risk. Such companies will be visited by Suva's acoustic engineers in order to find and remove the weak points in their hearing conservation system.

Development of an "Earplug checker"

In recent years, the individual use of hearing protectors has been identified in several investigations and studies as the weak point in hearing conservation [3]. A simple and low-cost check of the effectiveness of the hearing protection is a need for companies whose workers show signs of NIHL (i.e. a high fraction of workers with dHV346 above the reference).

Suva's low-cost hearing protection check (HPC) [4] is based on audiometry (but with finer steps as the 5 dB in conventional audiometry) without and with HPD (figure 5) at 500, 1000, 2000 and 4000 Hz Figure 5).

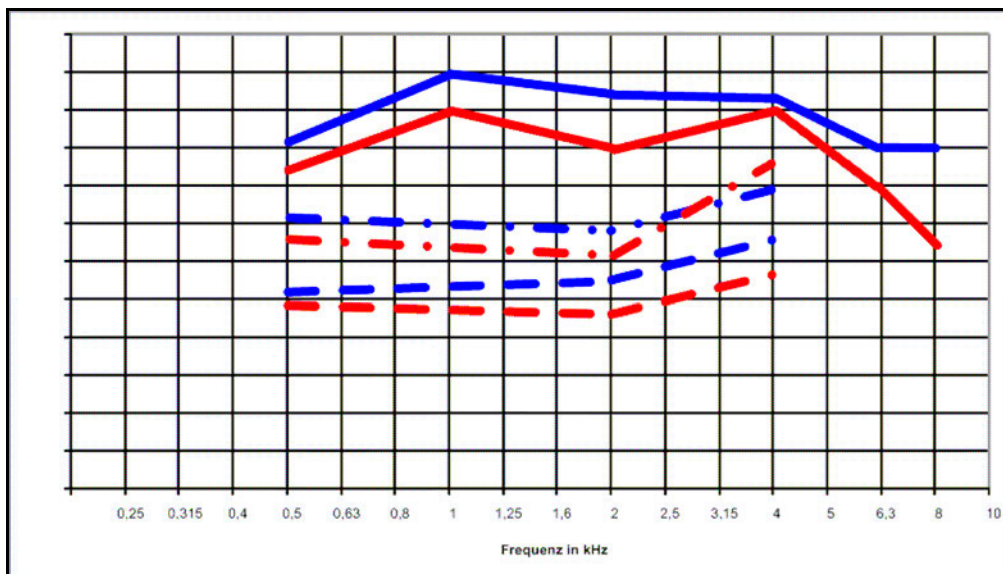


Figure 5: Principle of simple low-cost hearing protection check system based on audiometry without (above) and with up to three different HPDs

As free-field audiometry is not practical outside laboratories, headphones with sufficient inner volume and a high rejection of external noise are used. Therefore, this HPC may be used for all kinds of HPDs worn in the ear canal, but not for earmuffs. The HPC delivers directly the noise exposure level up to which the person is protected (instead of the SNR or similar value, which is more difficult to understand for non-specialists). The safety engineer can compare this sound level with the real noise exposure level the worker is exposed to (known from measurements or from of Suva's noise level tables) and will immediately see if the worker is protected sufficiently, i.e. if the residual noise at the ear is below 80 dB(A).

As the HPC is used in companies where there is some doubt about the effectiveness of

hearing conservation, it may still be considered as a reactive but not preventive measure. It would be preferable to check the effectiveness of HPDs before any NIHL is detected.

Integration of the earplug check into the Audiobiles

With the experience gained with the Hearing protection checker, it will be possible to develop a hearing protector check that can be integrated into the hearing examination process on the audiobile. This will only take a few additional minutes, as the audiogram (without HPD) is at the same time the baseline for the HPC.

CONCLUSIONS

During the 40 years of Suva's hearing conservation programme, the following lessons were learnt [5]:

- hearing protection must be worn and be effective from the first moment of noise exposure;
- when NIHL is detected, it is too late for prevention;
- the time and attention devoted to a person is much more important than the audiogram, and
- instruction about the practical use of HPDs is much more important than the technical specifications of hearing protectors.

Taking these points into account, Suva hopes that its hearing conservation programme manages to avoid new occupational NIHL at working places in Switzerland.

REFERENCES

- [1] Suva (1989/2013). *Verhütung der beruflichen Lärmschwerhörigkeit*. Suva 1909/1.
- [2] Royster J., Royster L.-H.: *Hearing conservation programmes*. Levis Publishers Inc. 1990.
- [3] Dantscher S., Sickert P., Liedtke M. (2009). *Schalldämmung von Gehörschützern in der betrieblichen Praxis* www.dguv.de/ifa/publikationen/reports-download/reports-2009-bis.../index.jsp.
- [4] Hohmann B. W. (2017). *Kostengünstiger Gehörschutzcheck*. Paper presented at the DAGA conference 2017 in Kiel, Germany.
- [5] Hohmann B. W. (2016). *Wirkungsoptimierte Gehörvorsorgeuntersuchungen nach ISO 1999*. Paper presented at the DAGA conference 2016 in Aachen, Germany.