Noise exposure abatement: a perspective from industry occupational health risk assessment reports

O Rikhotso[1], TJ Morodi[1], DM Masekameni[2]

[1] Environmental Health, Tshwane University of Technology, Tshwane, South Africa
[2] Occupational Health Division, School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Correspondence:
Oscar Rikhotso
e-mail: rikhotsoo@tut.ac.za

Oscar Rikhotso and Daniel Masekameni are SAIOH members

Keywords: hearing conservation programmes, administrative controls, engineering controls, risk evaluation, risk identification

How to cite this paper: Rikhotso O, Morodi TJ, Masekameni DM. Noise exposure abatement: a perspective from industry occupational health risk assessment reports. Occup Health Southern Afr. 2022; 28(4):128-135.

ABSTRACT

Background: Occupational health risk assessments are building blocks for occupational health programmes, allowing for the rating of identified risks and the continuous re-evaluation of the effectiveness of abatement measures. In South African industry, occupational health risk assessments are formally documented in reports, which can be presented as demonstration of legal compliance with legislation.

Objective: To identify noise abatement measures recorded in noise risk assessment reports of four manufacturing companies and to rate their effectiveness.

Methods: We analysed the occupational health risk assessment reports from 21 operational facilities in four South African companies from the manufacturing and utilities sectors to evaluate, through document analysis, the recorded noise abatement measures. Noise abatement measure effectiveness was rated using a pre-assigned effectiveness percentage scale.

Results: Administrative controls and hearing protection devices were the most commonly used noise exposure abatement measures, but hearing conservation programmes were generally poorly formulated. There were inter- and intra-company differences in the qualitative risk assessment approaches used for rating or ranking the noise risk, which led to different risk conclusions and prioritisation outcomes. The calculated control effectiveness of the abatement measures showed that noise exposure remained largely unacceptable: 16 of the 21 operational units had unacceptable noise exposures, four had tolerable exposures, and one had broadly acceptable exposures.

Conclusion: The four companies' common noise abatement measures, as elements of formalised hearing conservation programmes, which included administrative controls and hearing protection devices, were not effective in reducing noise exposure to the broadly acceptable level, reflective of limited use of engineering controls.

INTRODUCTION

Activities performed in almost all economic sectors expose employees to a myriad of occupational health and safety hazards, the extent of which varies widely from sector to sector. Employees in the manufacturing sector, in particular, with its diverse subsectors, continue to experience adverse health outcomes. With a view to mitigating these adverse health impacts, the labour-intensive manufacturing sector has established occupational health and safety policies and systems.[1] As it has proved impossible to eliminate all hazards,[2] it is important to reduce risks as much as possible.[3] Noise remains the most pervasive health hazard in the manufacturing industry, with recorded exposure levels among the loudest of those in all sectors.[4] Regulatory authorities, worldwide, have developed regulations and standards governing noise exposure in the workplace.[5-7]

In addition to prescribing the health and safety standard for noise in industry, the South African Noise-Induced Hearing Loss (NIHL) Regulations,[6] birthed by section 43 of the Occupational Health and Safety Act No. 85 of 1993,[8] require employers to conduct risk assessments and record the outcomes.[6] In so doing, employers fulfil the general duties of maintaining a workplace free of hazards and providing systems to ensure safe working conditions.[8]

A risk assessment is defined as the *"overall process of risk identification, risk analysis and risk evaluation"*,[9] conducted continuously and proactively.[10] During the identification phase of the risk assessment, the risk assessor uses a mixture of methods, including a workplace walkthrough, employee interactions or interviews, and review of historic and existing documentation relating to standard operating procedures, incident reports, safety data sheets, first aid/injury records, and employee health records to identify hazards associated with activities. The information collected during this interactive process enables the risk assessor, during the risk analysis and risk evaluation phases, to prioritise abatement measures directed towards identified hazards.[3]

The risk assessment process, hazards and risks, and other outcomes of the assessment are entered into a formal record, which, according to the NIHL Regulations, should be kept by the employer for a minimum of 40 years.[6] This ensures that focus is maintained in following up on the proposed abatement measures while also assisting in the management of other risks and hazards similar to those recorded in the assessment. Additionally, record keeping provides evidence that the risk assessment was conducted in line with legal requirements.[3] One important aspect recorded during the risk assessment is the assessment regarding reasonable deterioration

in, or failure of, any control measures that have been implemented.[6] The NIHL Regulations require the implementation of the abatement measures to be hierarchical; engineering controls are the foremost option, followed by administrative controls and hearing protection devices (HPDs).[6] When the risk assessment is conducted, the assessed risks from identified hazards should factor in the effectiveness of these exposure abatement measures.[10]

Hearing conservation in terms of the South African National Standard (SANS) 10083 (2013), within the reasonably practicable philosophical context, pits engineering controls against a hearing conservation programme (HCP), with engineering control given legal preference.[11] The risk assessment should be completed as accurately as possible, as it is used by management as a decision-making tool in the risk management process.

The noise risk assessment, as envisaged in the NIHL Regulations and the SANS 10083 (2013) requirements, encompasses all exposure aspects of noise, providing a comprehensive view of measures implemented to prevent NIHL. The review of a company's noise risk assessment report(s) provides useful insight into the extent and nature of industry noise abatement measures.

The objective of this study was to identify noise abatement measures recorded in noise risk assessment reports from four manufacturing companies, and to rate their effectiveness.

METHODS

Company enrolment

Four companies in the manufacturing and utilities sectors were selected to participate in the study, using convenience sampling, viz. an electricity manufacturing company (Company A, with 11 operational facilities), a petroleum refinery (Company B, with two operational facilities), a radioisotope manufacturing company (Company C, with six operational facilities), and a cement manufacturer (Company D, with two operational facilities). Workers employed in these companies are exposed to a myriad of chemical, physical, biological, and ergonomic hazards.[12-16] An operational facility represents a single plant or business unit of a parent company, operating as an independent entity.

Report review for control identification

We evaluated noise abatement measures recorded in risk assessment reports of four companies in the manufacturing and utilities sectors, and assessed their effectiveness. The reviewed reports had a time lag, imposed by the review frequency prescribed in the NIHL Regulations. In total, 21 risk assessment reports covering the period 2018 to 2021, recording occupational health hazards, including noise, were evaluated. Companies were requested to submit the most recently conducted and recorded risk assessment for the respective operational facilities. The evaluation criteria for the participating companies' risk assessment reports covered the control aspects stated in Regulation 10 of the NIHL Regulations; the controls are divided into engineering controls, administrative controls, and HPDs.

Document analysis

Document analysis, a type of qualitative research method and a data collection method,[17] was used to evaluate the risk assessment reports systematically and to identify noise abatement measures in use by the operational units of the four companies. The READ approach to document analysis was used to 1) ready the materials, 2) extract the data, 3) analyse the data, and 4) distil the findings.[18]

Effectiveness of existing abatement measures

The recorded exposure abatement measures were weighted in accordance with an effectiveness scale (Table 1), whereby the engineering measures (elimination, substitution and separation) were rated as having higher effectiveness than administrative controls and HPDs.[3, 19] Elimination carries a higher weighting as it excludes the noise source from the work area.

The Health and Safety Executive (HSE) framework on tolerability of risk[20] classifies risks into tolerable, broadly tolerable, and unacceptable categories. Following the control measure weighting, it was used to determine the tolerability of risk, using predefined effectiveness percentages that translated into residual risk scores, as shown in Table 1. In terms of this HSE framework, when applying the 'as low as reasonably practicable principle' employers are required to allocate more resources towards efforts to reduce risks rated as unacceptable. Conversely, employers are required to allocate fewer financial resources for the reduction of risks rated as broadly acceptable.[20, 21]

The HSE framework on tolerability of risk also outlines the level of risk acceptance relative to stated objectives, determines the significance of risk in terms of predetermined categories, and supports decision-making processes. The framework should, however, be aligned with companies' risk management frameworks, which are specific to the scope of the activity being considered and regulatory requirements against which legal compliance is measured.[22] However, as not all risks can be eliminated or removed, the HSE framework on tolerability of risk provides decision-makers with a tool to decide on the acceptability of remaining and assumed risks.[23]

The overall control effectiveness was calculated by summing the pre-assigned effectiveness percentages for engineering and administrative controls, and HPDs (as shown in Table 1) into a single score, expressed as the overall control effectiveness percentage. Thereafter, the residual risk, subtracted from the overall control effectiveness score, was calculated. A single or group of reported control measures falling under each hierarchy of control element

Table 1. Effectiveness of hierarchy of control measures

Control measure	Description	Effectiveness (%)
Elimination*	Removal of noise source from facility	100
Substitution*	Substitution with quieter equipment	75
Separation*	Lagging, acoustic covers, steam silencers, enclosures, automation, silencers; measures reduce noise at the source or modify routes of noise emission	50
Administrative	Regulatory requirements, e.g. noise zoning, audiometry, training, etc.; limit number of exposed employees and duration of exposure	10–30
Hearing protection devices	Earmuffs, earplugs, etc.	5

*engineering controls

Table 2. Controls for noise exposure identified in operational facilities of participating companies

	Hierarchy of control element			
	Engineering controls	**Administrative controls**	**PPE**	**HCP formalisation**
Company A				
Facility 1	None	Hearing conservation training	Non-specific earmuffs or earplugs or customised HPDs	Formalised
Facility 2	None	• Hearing conservation awareness • Noise survey • Audio medical surveillance	Non-specific hearing protection	Formalised
Facility 3	None	• Zoned noise areas • Noise survey • Training/awareness • Medical surveillance	Non-specific hearing protection	Not formalised
Facility 4	None	• Noise survey	None mentioned	Not formalised
Facility 5	None	• Periodic (and refresher) training on safe work procedures and PPE • Annual audiometric testing	Personnel make use of ear plugs and earmuffs	Not formalised
Facility 6	Maintenance and lubrication of plant machinery	• Audiometric testing • Site-specific training and education on safe work procedures and control measures • Reduction of exposure time	HPDs with noise reduction rating ranging from 24 to 30 dB	Not formalised
Facility 7	None	• Noise zones identified and conspicuously demarcated by using required pictogram • Periodic (and refresher) training on safe work procedures and PPE • Annual audiometric testing	Personnel make use of ear plugs and earmuffs	Not formalised
Facility 8	None	• Audiometric testing • Noise survey • Awareness sessions	Use of HPDs	Not formalised
Facility 9	Non-specific engineering controls reported	• Noise zone demarcation • Audiometric testing • Noise survey	Non-specific PPE reported	Formalised
Facility 10	None	• None	HPDs	Not formalised
Facility 11	• Cabin and spreader enclosures lined with acoustic absorptive material • Fly ash conveyor automation • Regular maintenance of conveyor belt and motors	• Employees occupancy in noisy areas reduced • Medical examinations • Training and education • Noise zone demarcation	Disposable coded earplugs with NRR of 34 dB	Not formalised
Company B				
Facility 1	• Lagging • Acoustic cover • Steam silencer • Enclosures	• Noise zone demarcation • Noise survey • Audiometric testing	Non-specific earmuffs	Formalised
Facility 2	• Most compressors and boilers have silencers • Compressor acoustic housing	• Noise zone demarcation • Training on NIHL • Signposting noise areas • Audiometric testing	Non-specific hearing protectors	Formalised
Company C				
Facility 1	None	• Registered noise workers • Annual medical surveillance	Howard Leight earplugs with NRR of 29 dB	Not formalised
Facility 2	None	• Annual audiometric testing • Noise worker training • Equipment used for short periods	Non-specific hearing protectors used in demarcated areas	Not formalised
Facility 3	Regular service and maintenance on electric motors. Noise < 85 dBA	• None	None	Not formalised
Facility 4	None	• Noise zone demarcation	Howard Leight Bilsom 304 L earplugs with NRR of 29 dB	Not formalised
Facility 5*	None required	• None required	None required	None required
Facility 6	None	• Noise zone demarcation	MSA earmuffs and Howard Leight ear plugs provided	Not formalised
Company D				
Facility 1	None	None	None	Not formalised
Facility 2	None	None	None	Not formalised

dB: decibel, dBA: A-weighted decibel, PPE: personal protective equipment, HCP: hearing conservation programme, HPD: hearing protection device, NRR: noise reduction rating, NIHL: noise-induced hearing loss

* Company C Facility 5 required no further abatement measures as the reviewed risk assessment report indicated that noise sources were eliminated

was assigned a single or a combined effectiveness percentage. The maximum allocation of the effectiveness percentage for engineering controls, administrative controls, and HPDs are based on the legal prescripts defined in Regulation 10(2) of the NIHL Regulations.

The assigned effectiveness percentages for each control indicate that elimination is the most effective measure for noise control. Residual risk percentages > 0% indicate the implemented measures' inabilities to eliminate the noise, hence the need for implementation of the continuous HCPs. Continuous HCPs require employers to conduct noise monitoring, audiometric testing, noise zoning, and noise monitoring at prescribed frequencies.

This study formed part of a larger study for which ethical clearance was obtained from the Tshwane University of Technology (TUT) Ethics Committee: FCRE 2020/10/015 (FCPS 02) (SCI).

RESULTS

Identified noise control measures

The noise risk assessment records showed that the risk assessors recorded current controls in use at the different companies to demonstrate measures implemented to minimise noise exposure. Table 2 shows the specific hierarchy of control elements and the extent of formalisation of the HCP. The most common abatement measure across the enrolled companies was

Table 3. Control effectiveness statement and resultant risk classification for each operational facility of the participating companies

	Hierarchy of control element			Effectiveness of current controls statement	Risk classification	Further proposed abatement measures
	Engineering controls	Administrative controls	PPE			
Company A						
Facility 1	-	✓	✓	✓	Medium	Assessment will be done as per the NIHL Regulations
Facility 2	-	✓	✓	×	High	No additional controls identified in report
Facility 3	-	✓	✓	✓	High	No additional controls identified in report
Facility 4	-	✓	×	×	Low	No additional abatement recommendations made
Facility 5	-	✓	✓	×	Medium	• Explore viability of installing engineering control measures as required by Regulation 10 of the NIHL Regulations • Loose, vibrating components on equipment generate rattling noise and should be repaired to reduce exposure to noise
Facility 6	✓	✓	✓	✓	Low	No additional abatement recommendations made
Facility 7	-	✓	✓	✓	Medium	• Explore viability of installing engineering control measures as required by Regulation 10 of the NIHL Regulations • Loose, vibrating components on equipment generate rattling noise and should be repaired to reduce exposure to noise
Facility 8	-	✓	✓	×	Medium	Develop and maintain an occupational hygiene programme
Facility 9	✓	✓	✓	×	Medium – high	No additional abatement recommendations made
Facility 10	-	-	✓	✓	Acceptable	Audiometric testing
Facility 11	✓	✓	✓	✓	Medium – high	Stop intermittent steam leaks by means of proper cladding or fastening of the cladding
Company B						
Facility 1	✓	✓	✓	✓	Not stated	HCP
Facility 2	✓	✓	✓	✓	Not stated	Noise reduction plan proposed
Company C						
Facility 1	-	✓	✓	✓	Medium	Occupational hygiene monitoring programme
Facility 2	-	✓	✓	✓	Low	Maintain controls in place for compliance
Facility 3	✓	-	-	✓	Negligible	No further action required
Facility 4	-	✓	✓	✓	Low	No additional abatement recommendations made
Facility 5	-	-	-	✓	Negligible	No further action required
Facility 6	-	✓	✓	✓	Low	No additional abatement recommendations made
Company D						
Facility 1	-	-	-	×	-	None proposed
Facility 2	-	-	-	×	-	None proposed

PPE: protective personal equipment
- not implemented, ✓ present, × absent

HPDs, followed by a range of administrative measures. Engineering controls as a first consideration within the hierarchy of control principle was the least utilised measure across all companies. Both the administrative controls and HPDs are basic controls catered for within the NIHL Regulations and the SANS 10083 (2013) requirements. The HCP formalisation in some of the companies' operational facilities' reports had little information about the programme elements. The HCP formalisation in the context of this study means that the risk assessors explicitly mentioned the HCP in the risk assessment report, with corresponding verifiable programme elements listed. The HCP, itself, is a risk management tool for the reduction of NIHL.

Identified noise controls and risk characterisation

The effectiveness of implemented abatement measures should be considered during the risk evaluation and included in the analysis processes of a risk assessment. Table 3 shows the consideration of the effectiveness of abatement measures, as a whole, on the overall outcome of the risk assessment process, and proposed additional abatement measures. Certain operational facilities of Companies A, C and D had no proposed abatement measures in spite of the noise risks being rated as high. The risk assessment report of noise at Company D had no risk conclusion statement, unlike those of Companies A, B and C, adding ambiguity as to what the next risk management steps for eliminating noise at this company might be.

Management decisions about future expenditures are grounded on outcomes that consider the effectiveness of current controls. Thus, if the conclusion of the risk evaluation step is incorrect, it has a detrimental effect on the allocation of financial resources for future exposure abatement.

Effectiveness of controls and tolerability of risk

The recorded existing noise controls were assigned corresponding effectiveness percentage scores, derived from Table 1, and an overall control effectiveness score, from which residual risk percentages were calculated, as shown in Table 4. The residual risk percentages were assigned to the corresponding risk level, derived from the HSE framework on tolerability of risk[20] (broadly acceptable, tolerable, and unacceptable).

The tolerability of the residual noise risks for Companies A, C and D were classified as unacceptable, which reflects an over-reliance on administrative controls and HPDs as the controls of choice. The noise risk of Company B was 'tolerable', reflecting the effectiveness of engineering controls compared to that of administrative controls and HPDs. In assigning final risk scores, certain operational facilities of Company B used both qualitative (controls and likelihood) and quantitative (noise levels) variables to allocate risk rating. Companies A, C and D relied on only qualitative variables for assigning final risk ratings.

Table 4. Control effectiveness and residual risk percentages of existing abatement measures

	Risk control hierarchy percentage (%)			Overall risk control effectiveness (%)	Residual risk (%)	Tolerability of residual risk*
	Engineering controls	Administrative controls	PPE			
Company A						
Facility 1	0	10	5	15	85	Unacceptable
Facility 2	0	20	5	25	75	Unacceptable
Facility 3	0	30	5	35	65	Unacceptable
Facility 4	0	10	0	10	90	Unacceptable
Facility 5	0	15	5	20	80	Unacceptable
Facility 6	50	20	5	75	25	Tolerable
Facility 7	0	20	5	25	75	Unacceptable
Facility 8	0	15	5	20	80	Unacceptable
Facility 9	0	15	5	20	80	Unacceptable
Facility 10	0	0	5	5	95	Unacceptable
Facility 11	50	30	5	85	15	Tolerable
Company B						
Facility 1	50	20	5	75	25	Tolerable
Facility 2	50	30	5	85	15	Tolerable
Company C						
Facility 1	0	15	5	20	80	Unacceptable
Facility 2	0	20	5	25	75	Unacceptable
Facility 3	50	0	0	50	50	Unacceptable
Facility 4	0	10	5	15	85	Unacceptable
Facility 5	100	0	0	100	0	Broadly acceptable
Facility 6	0	10	5	15	85	Unacceptable
Company D						
Facility 1	0	0	0	0	100	Unacceptable
Facility 2	0	0	0	0	100	Unacceptable

PPE: protective personal equipment
*using HSE-defined tolerability of risk framework

Assigning the control effectiveness percentages to current control and risk conclusions, based on the HSE framework on tolerability of risk, confirmed that noise was a high risk in all four companies. However, divergences in risk conclusions from the use of the control effectiveness percentages and the companies' own final risk ratings (assigned as acceptable, i.e. low to medium) were noted in nine of the 11 operational facilities of Company A and in five of six operational facilities of Company C.

DISCUSSION

The findings of the study revealed that current exposure abatement measures were recorded in the risk assessments conducted at the four companies – a requirement of the NIHL Regulations. The recording of these abatement measures fulfills a critical objective of the risk assessment process.[24] These abatement measures, together with the consequences of exposure and exposure probability,[10, 22, 25, 26] when interpreted as a whole during the risk evaluation phase of the risk assessment, influence subsequent risk scoring, risk prioritisation, and decision making for additional risk treatment – a process undertaken for risk modification through risk avoidance, risk removal from the source, and changing the likelihood of exposure.[9]

Risk assessors have a professional duty to ensure that abatement measures do not exaggerate the control effectiveness potential of these measures. The risk assessment results should be reproducible.[27] In addition to being a legal requirement to record existing abatement measures, such information also informs additional measures that should be considered to further reduce residual risks.[28]

Similar to not adhering to the requirement that a statement be made about the effectiveness of implemented abatement measures during the risk evaluation phase, the qualified use of HPDs by the respective companies was not clearly stated. Regulation 9(d) of the NIHL Regulations requires the identification of reasons for the noise level being at or above the noise rating limit, but it was not clear if this was done.[6] On this point, the nonprescriptive nature of the risk assessment process in its current form, as described in Regulation 6 of the NIHL Regulations, complicates the risk assessment process for South African industry.

Another objective of a risk assessment is to recommend further exposure abatement measures for reducing identified hazards to levels that are considered tolerable.[24] The effectiveness of implemented abatement measures should be expressed during the risk assessment process. Assigning noise as a low risk prevents it from being prioritised for further risk treatment – a possible reason for the poor or sporadic implementation of engineering controls.[29] If a risk assessment outcome ranks noise as a low risk, then the employers would be justified in not taking action to further reduce the risk.[30]

None of the evaluated risk assessments recorded the reasons for the persistence of noise exposure, although this is required in the NIHL Regulations. In such cases, the risk should be assessed as not adequately controlled. The risk assessment should assist employers to identify and institute immediate control measures to prevent exposure.[30, 31] Worldwide, noise regulations require that exposure be adequately controlled, a practice not observed in some of the operational units of the participating companies.[30]

Hearing conservation programme implementation versus engineering control

Risk assessment reports, from the companies' operational facilities that did not mention HCP formalisation, indicated a deviation of the risk management process from the legal criteria used in South Africa. Risk assessment should comply with legal requirements and national standards.[30] The administrative controls and the use of different HPDs that were extensively relied upon by the four companies did not eliminate noise from the source. Hearing protection shifts the responsibility of exposure control to the workers rather than being used to supplement engineering and administrative controls. Risk management must focus primarily on risk elimination, substitution and engineering controls as these measures lead to a substantial reduction in NIHL.[19]

The reported control measures that had not entirely eliminated noise from the workplace were being used for risk reduction rather than risk avoidance. The technical nature of noise in these companies has remained unchanged throughout the life cycle of these installations.[27] It was noted that the risk evaluations of noise across operational facilities of the same company, where high noise risk ratings were assigned, proposed no further abatement measures. This was noted especially in certain operational facilities of Companies A, C and D. Conversely, in some instances, where noise risk was assigned as low or medium, further abatement measures were proposed. This highlights the need to conduct quality risk assessments that involve trained, highly motivated and experienced teams.[32]

The recommendation of abatement measures, following risk evaluation, is undoubtedly arduous in the absence of national risk acceptability guidelines. For example, using the HSE framework on tolerability of risk,[20] noise risks assigned as tolerable will not incur prohibitive costs as the risk would have been reduced to as low as reasonably practicable, whereas risks assigned as acceptable will need continuous attention for improvement.[33] Undoubtedly, a suitably and appropriately completed risk assessment is a useful decision-making tool for the risk management team.[32]

Uncertainty of risk assessment outcomes and ensuing proposed controls

The noise risk assessment and risk management landscape in South African general industry is fraught with uncertainties, brought about by the non-prescriptive risk assessment procedures and the largely self-regulatory regime.[6, 8] Companies misinterpret the legal meaning of concepts such as 'reasonably practicable', while adopting HCPs as a default control. The non-prescriptive nature of the risk assessment procedures also leads companies to adopt unproven risk management philosophies that assign noise as an insignificant health risk, thereby not prioritising its control during risk treatment initiatives.

NIHL remains the most frequently compensated occupational disease in South Africa,[34-36] with poorly conducted risk assessments being a notable contributor. The NIHL scourge indicates the shortcomings of risk assessment in preventing ill health.[32]

Problems associated with noise risk assessments include their unreliability due to uncertainties relating to model variations, lack of industry-specific knowledge about hazards by risk assessors, including occupational hygienists, and their incompleteness.[37] These factors can lead to unrealistic and inappropriate risk assessment conclusions,[38] as observed in this study. Despite these uncertainties, employers must use risk assessment outcomes to make risk management decisions.[39] In general, companies should evaluate the overall effectiveness of adopted risk assessment practices.[27]

Only Company B used a mixture of both quantitative (noise levels) and qualitative (controls and likelihood) assessments. Using only qualitative variables to characterise risks[33] introduces subjectivity. A semi-quantitative risk evaluation, using both qualitative assessments (controls and likelihood as risk variables) and noise levels, enriches

risk characterisation decisions. The effectiveness control percentage introduces objectivity for actioning envisaged preventive or corrective abatement measures.[40] Employers are mandated to evaluate the status of existing control effectiveness and to consider new technologies that may be more effective, protective and/or reliable as part of continuous efforts for hazard prevention.[31]

The study had some limitations in that the risk assessment analysis relied on secondary data, and errors and omissions in the records could thus not be followed up with company representatives who wrote the documents. On a regulatory level, the assessed records were ambiguous about whether the recorded engineering controls were implemented as part of a separate risk treatment process. Added to that, the records were ambiguous as to whether the recorded engineering controls were an outcome of a requirement for employers to identify the reasons that the noise levels exceeded the noise rating limit, without the use of the HPDs.

More studies evaluating the effectiveness of existing control measures should be conducted in South African industry. Prospectively, companies reliant on qualitative risk assessments should consider conducting quantitative assessments to quantify noise risks accurately.

CONCLUSION

The recording of risk control measures in risk assessments, which is a legal requirement, and the evaluation of effectiveness, are established company practices, in general. These control measures undoubtedly influence risk evaluation and risk prioritisation in the risk assessment process. Administrative controls and HPDs (elements of HCPs) were the commonly recorded control measures in the four companies, in preference to engineering controls. The noise risk assessment process is fraught with uncertainties with regard to risk conclusion statements and risk prioritisation for further risk treatment, with minimal guidance for employer action to reduce or prevent residual risks. The over-reliance on HCPs is problematic, as some operational facilities had fragmented programmes that did not include all HCP elements. The quantification of the effectiveness of recorded controls yielded unacceptable noise risks, diverging from the actual risk conclusions made in the company representatives' risk assessment reports.

Unacceptable noise risks are indicative of the fact that administrative controls and HPDs do not eliminate or reduce the noise from the source. Studies such as this, which analyse real field data, assist in the search for better approaches in preventing industrial health risks.

KEY MESSAGES

1. The formalisation of hearing conservation programmes is lacking in industry.
2. Administrative controls and HPDs are commonly implemented as noise abatement measures.
3. Occupational health risk assessments conducted in industry need improved recording of information, such as implemented abatement measures, which influence risk ranking during the risk evaluation phase.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design of the study: OR, TJM, DMM
Data acquisition: OR
Data analysis: OR
Interpretation of the data: OR
Drafting of the paper: OR
Critical revision of the paper: TJM, DMM, OR

REFERENCES

1. Geldart S. 8.10 – Health and safety in today's manufacturing industry. In: Comprehensive Materials Processing. Hashmi S, Batalha GF, Van Tyne CJ, Yilbas B, editors. Ontario: Elsevier; 2014. p 177-197. Available from: https://doi.org/10.1016/B978-0-08-096532-1.00816-5 (accessed 13 Jun 2022).
2. Haefeli K, Haslam C, Haslam R. Perceptions of the cost implications of health and safety failures. Research report 403. Colegate: Health and Safety Executive; 2005. Available from: https://www.hse.gov.uk/research/rrpdf/rr403.pdf (accessed 7 May 2021).
3. Rout BK, Sikdar BK. Hazard identification, risk assessment, and control measures as an effective tool of occupational health assessment of hazardous process in an iron ore pelletizing industry. Indian J Occup Environ Med. 2017; 21(2):56-76. doi:10.4103/ijoem.IJOEM_19_16.
4. United States. Department of Labor. Occupational Safety and Health Administration. OSHA Technical Manual. Section III: Chapter 5. Washington, D.C.: OSHA; 2016. Available from: https://www.osha.gov/otm/section-3-health-hazards/chapter-5#table2.5 (accessed 22 Feb 2022).
5. United States. Department of Labor. Standard number 1910.95 – Occupational noise exposure. Washington, D.C.: Occupational Safety and Health Administration; 1995. Available from: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.95 (accessed 30 Jul 2021).
6. South Africa. Occupational Health and Safety Act, 1993 (Act No. 85 of 1993). Noise-Induced Hearing Loss Regulations. Government Gazette No. 24967:R307; 2003 Mar 7. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/24967b0.pdf (accessed 10 Aug 2021).
7. United Kingdom. The Control of Noise at Work Regulations 2005. UK Statutory Instruments 2005. No. 1643. Available from: https://www.legislation.gov.uk/uksi/2005/1643/contents/made (accessed 10 Aug 2021).
8. South Africa. Occupational Health and Safety Act (Act No. 85 of 1993). Government Gazette No. 14918:1158; 1993 Jul 2. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/act85of1993.pdf (accessed 26 Nov 2018).
9. The South African Bureau of Standards. South African National Standard. Recommended practice. Risk management – vocabulary. ARP 070:2009.
10. The South African Bureau of Standards. South African National Standard. Occupational Health and Safety Management Systems – Requirements with guidance for use. ISO 45001:2018.
11. The South African Bureau of Standards. South African National Standard. The measurement and assessment of occupational noise for hearing conservation purposes. SANS 10083:2013.
12. Carter M, Claydon M, Giacopetti D, Money C, Pizzella G, Margary A, et al. A survey of European gasoline exposures for the period 1999–2001. Report No. 9/02. Brussels: Concawe; 2002. Available from: https://www.concawe.eu/publication/report-no-902/ (accessed 26 Jun 2022).
13. Hobson HL. Petroleum refinery. In: Cralley LV, Cralley LJ, editors. In-plant practices for job related health hazards control; Production Processes. New York: John Wiley & Sons; 1989.

14. Miller RK. Noise control solutions for power plants. Atlanta, Georgia: Fairmont Press, Inc; 1984.
15. United States. National Institute for Occupational Safety and Health. Health hazard evaluation determination. The Union 76 Oil company. Report No. 77-47-427. Nederland: US Department of Health and Human Services, Centers for Disease Control and Prevention, NIOSH; 1977.
16. United States. National Institute for Occupational Safety and Health. HHE Report No. HETA-93-0498-2409, Mercury Marine, Fond du Lac, Wisconsin. Cincinnati, Ohio: US Department of Health and Human Services, Centers for Disease Control and Prevention, NIOSH; 1994.
17. Kayesa NK, Shung-King M. The role of document analysis in health policy analysis studies in low and middle-income countries: lessons for HPA researchers from a qualitative systematic review. Health Policy Open. 2021; 2:100024. doi:10.1016/j.hpopen.2020.100024.
18. Dalglish SL, Khalid H, McMahon SA. Document analysis in health policy research: the READ approach. Health Policy Plan. 2020; 35(10):1424-1431. doi.10.1093/heapol/czaa064.
19. Iqbal MI, Isaac O, IA Rajawy I, Khuthbuddin S, Ameen A. Hazard identification and risk assessment with controls (Hirac) in oil industry – A proposed approach. Mater Today Proc. 2021; 44:4898-4902. doi:10.1016/j.matpr.2020.11.800.
20. Rick J, Evans C, Barkworth R. Evaluation of reducing risks, protecting people. Research report 279. Colegate: Health and Safety Executive; 2004. Available from: https://www.hse.gov.uk/research/rrpdf/rr279.pdf https://www.hse.gov.uk/research/rrhtm/rr279.htm(accessed 26 Jun 2022).
21. Pitblado R, Turney R. Risk assessment in the process industries. 2nd ed. Warwickshire, UK: Institution of Chemical Engineers; 1996.
22. The South African Bureau of Standards. South African National Standard. Risk management – Guidelines. ISO 31000:2019.
23. Rodriques MA, Azeres P, Leão CP. Risk criteria in occupational environments: critical overview and discussion. Procedia Soc Behav Sci. 2014; 109:257-262. doi:10.1016/j.sbspro.2013.12.455.
24. Kour R, Singh A, Ahire N. An implementation study on hazard identification and assessment (HIRA) technique in the critical care unit of a tertiary care hospital. Indian J Forensic Med Toxicol. 2020; 14(4):4018-4026. doi:10.37506/ijfmt.v14i4.12270.
25. United Kingdom. Health and Safety Executive. Risk ranking. Contract research report 131/1997. Colegate: Health and Safety Execute; 1997. Available from: https://www.hse.gov.uk/research/crr_pdf/1997/crr97131.pdf (accessed 07 May 2021)
26. The South African Bureau of Standards. South African National Standard. Risk management – risk assessment techniques. ISO 31010:2010.
27. Hope S, Eddershaw BW, Joanny L, Bjordal N, Diack HM, Ortone G, et al. Methodologies for hazard analysis and risk assessment in the petroleum refining and storage industry. Report No. 10/82. Den Haag: Concawe; 1982.
28. Dehdashti A, Fatemi F, Jannati M, Asadi F, Kangarloo MB. Applying health, safety, and environmental risk assessment at academic settings. BMC Public Health. 2020; 20(1):1328. doi:10.1186/s12889-020-09419-5.
29. Gan SK. Importance of hazard identification in risk management (editorial). Ind Health. 2019; 57(3):281-282. doi: 10.2486/indhealth.57_300.
30. European Commission. Directorate-General for Employment, Social Affairs and Inclusion. Guidance on risk assessment at work. Publications Office; 1996. Available from: https://op.europa.eu/en/publication-detail/-/publication/1a3462b0-728c-4a2b-88f0-6c641b91a86f (accessed 26 Jun 2022).
31. United States. Occupational Safety and Health Administration. Recommended practices for safety and health programs. OSHA; 2016. Available from: https://www.osha.gov/sites/default/files/publications/OSHA3885.pdf (accessed 26 Jun 2022).
32. Lele DV. Risk assessment: a neglected tool for health, safety, and environment management. Indian J Occup Environ Med. 2012; 16(2):57-58. doi: 10.4103/0019-5278.107064.
33. Hadef H, Negrou B, Ayuso TG, Djebabra M, Ramadan M. Preliminary hazard identification for risk assessment on a complex system for hydrogen production. Int J Hydrogen Energy. 2020; 45(20):11855-11865. doi:10.1016/j.ijhydene.2019.10.162.
34. South Africa. Department of Labour. Annual report of the compensation fund. Pretoria; 2002. Available from: https://www.labour.gov.za/DocumentCenter/Reports/Annual%20Reports/Compensation%20for%20Occupational%20Injuries%20and%20Diseases/2002/part2.pdf (accessed 16 Jun 2021).
35. South Africa. Department of Labour. Annual report 1 April 2005 to 31 March 2006. Pretoria: Dept. of Labour; 2005. Available from: https://www.gov.za/sites/default/files/gcis_document/201409/annualreportlabour20052006.pdf (accessed 16 Jun 2021).
36. South Africa. Department of Labour. Compensation fund annual report 2006/2007, 2007. Chapter six: Medical services and occupational diseases. Available from: https://www.labour.gov.za/DocumentCenter/Reports/Annual%20Reports/Compensation%20for%20Occupational%20Injuries%20and%20Diseases/2006/Annual%20Report%20-%20Compensation%20Fund%202006%20-%20Chpt%206.pdf (accessed 16 Jun 2021).
37. Aven T. Risk assessment and risk management: review of recent advances on their foundation. Eur J Oper Res. 2016; 253:1-13. doi:10.1016/j.ejor.2015.12.023.
38. Gadd S, Keeley D, Balmforth H. Good practice and pitfalls in risk assessment. Research report 151. Colegate: Health and Safety Executive. 2003. Available from: https://www.hse.gov.uk/research/rrpdf/rr151.pdf (accessed 26 Jun 2022).
39. United States. National Academy of Engineering. Hazards: Technology and Fairness. Washington, D.C.: National Academies Press; 1986. Available from: http://www.nap.edu/catalog/650.html (accessed 19 Oct 2019).
40. Hafida K, Rachid C, Ahmed S. Hazard identification and risk analysis for a reinforced concrete rolling mill. World J Eng. 2017; 14(1):1-6. doi:10.1108/WJE-11-2016-0123.