International Journal of Occupational Safety and Ergonomics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tose20

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To cite this article: Nomfundo F. Moroe (2020) Occupational noise-induced hearing loss in South African large-scale mines: exploring hearing conservation programmes as complex interventions embedded in a realist approach, International Journal of Occupational Safety and Ergonomics, 26:4, 753-761, DOI: 10.1080/10803548.2018.1498183

To link to this article: https://doi.org/10.1080/10803548.2018.1498183

International Journal of Occupational Safety and Ergonomics (JOSE), 2020
Vol. 26, No. 4, 753–761, https://doi.org/10.1080/10803548.2018.1498183

Occupational noise-induced hearing loss in South African large-scale mines: exploring hearing conservation programmes as complex interventions embedded in a realist approach

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Background. Complex interventions have been conducted in the field of public health to improve health at the individual, organizational policy or population level. In occupational audiology, hearing conservation programmes (HCPs), which are interventions to minimize or eliminate occupational noise-induced hearing loss, are currently not defined as complex interventions, despite them fitting the definition and features of complex interventions. Therefore, this study aimed to explore whether HCPs are a complex intervention, fitting the predefined criteria for complex interventions. *Method*. A qualitative, descriptive research design was conducted using three sources of data – document analysis, interviews and systematic review – to allow for triangulation. Data were collected through purposive sampling and qualitative content analysis was used. *Results*. This study confirmed that HCPs are a complex intervention founded on solid and consolidated theories. Therefore, these results paved the way for realist reviews to be conducted in the mining sector in South Africa in order to understand the mechanisms influencing the success or failure of HCPs locally. *Conclusion*. The success of HCPs in the mining sector depends on conducting contextually evidence-based evaluations such as realist reviews which can provide policy-makers with contextual evidence for why certain programmes do or do not work in certain settings.

Keywords: Hearing conservation programmes; complex intervention; realist reviews; occupational noise exposure; mining industry; South Africa

1. Background

In South Africa, hearing conservation programmes (HCPs) have been formally in existence for over two decades, since the declaration of the 1996 Mine Health and Safety Act [1]. In 2003, the Mine Health and Safety Council (MHSC), comprising state, employer and labour representatives, circulated the 2003 MHSC milestones on the elimination of occupational noise-induced hearing loss (ONIHL) in the mining industry with an aim to achieve these targets by 2014. These 2003 MHSC milestones [2] had two targets. The first target stated that by December 2008, HCPs implemented by the industry must ensure that there is no deterioration in hearing greater than 10% amongst occupationally exposed individuals. The second target focused on the noise source, and stated that by December 2013, the total noise emitted by all equipment installed in any workplace must not exceed a sound pressure level of 110 dB(A) at any location in that workplace (including individual pieces of equipment) [2].

When the aforementioned milestones were evaluated at the end of 2013, it became apparent that the mining industry had not met all of the targets. Therefore, the 2003 milestones were revised. The revision of the 2003 milestones saw refinement and more specificity in the targets, which made the milestones seem more measurable. Firstly, as far as deterioration in hearing is concerned, the new target specifies that by December 2016, no employee's standard threshold shift (STS) will exceed 25 dB from baseline when averaged at 2000, 3000 and 4000 Hz in one or both ears. Secondly, regarding the noise source, the revised milestones state that by December 2024, the total operational or process noise emitted by any equipment must not exceed a milestone sound pressure level of 107 dB(A) [3].

A close look into these milestones revealed that a significant flaw is evident in them. This flaw could arguably be the key reason for the failure of the South African mining industry to meet the targets. Firstly, the targets focus on only two aspects of noise conservation; hearing deterioration and noise source. These two aspects are the responsibility of mine management. A key stakeholder, the mineworker, has not been included in the targets at all. One could argue that education of and buy-in from the mineworkers with regards to hearing conservation is key to the success of any intervention involving the miners. Therefore, careful deliberation should occur around the role of mineworkers in the setting of targets, if HCPs are to succeed. Secondly, the sequencing of the two targets (hearing deterioration and noise source) appears incongruent to the goal. Reduction of noise from the noise source

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should come prior to the expectation of reducing the deterioration of hearing loss. These milestones, as currently stated, appear to expect the opposite. That is, there must be a reduction in deterioration of hearing loss in miners at least 5–8 years before the reduction in the level of intensity of the noise source causing the hearing loss. Lastly, the 2014 milestone revisions, which acknowledged the failure to meet the 2003 milestones, increased the time frame of reducing noise from the noise source from 5 to 8 years. This seems to indicate serious challenges with this target, which the current author believes is key towards eliminating ONIHL.

Challenges in meeting milestones have implications for ONIHL within the South African mining industry. For instance, in 2013, statistics on ONIHL as recorded by the Department of Mineral Resources indicated that, on average, 1600 cases of NIHL are reported each year [4]. An unpublished study aimed to understand stakeholders' perceptions of the HCPs implemented in the South African mining industry. This study sought to understand the reasons leading to the revision of the 2003 MHSC milestones. Findings of this study highlighted challenges with the implementation of the 2003 MHSC milestones. These challenges included poorly defined action plans, lack of cohesive engagement and collaboration with all stakeholders; with exclusion of some stakeholders, from formulation to implementation of these milestones. These challenges raise important implications for the success of any intervention programme.

Current evidence suggests that HCPs implemented in the South African mining industry are currently not achieving the desired results. It is the author's belief that studies conducted on the presence and management of ONIHL in the mining sector will continue to yield the same unsatisfactory results if careful strategic and contextually relevant changes that adopt realist reviews within a complex intervention position are not considered.

There are therefore calls for new, innovative and evidence-based ways of managing excessive exposure to hazardous noise in the mining industry. There is a need for approaches that will focus on holistically understanding why HCPs are not successful in the South African mining industry, while their counterparts in developed countries have reported success. One such approach is a realistic review of the HCPs currently implemented in the South African mining industry.

Realist reviews are fundamentally concerned with 'understanding and unpacking the mechanisms by which an intervention works (or fails to work)' [5,p.1]. Realist approaches focus on theory development while taking into consideration the context when methodically and transparently synthesizing results [6–8]. A realist review, although a relatively new methodological strategy [7], can assist in explaining why HCPs implemented locally are currently failing to achieve the set targets. Benefits of conducting realist reviews include, firstly, providing stakeholders and policy-makers with enlightenment and empirical evidence on the nature of the programme or intervention implemented in a given setting [7]. Secondly, realist reviews assist policy-makers to interpret and clearly understand why a programme worked better in one context than another, e.g., international vs local context. Thirdly, realist reviews provide policy-makers with a justification for taking one course of action over another. Lastly, realist reviews alert policy-makers to potential problems and specific measures that can be applied to mitigate potential problems. Moreover, realist reviews provide explanations rather than judgements around interventions [7].

Realist reviews are conducted to review complex interventions [9–13]. Complex interventions are defined as interventions built from multiple interacting components, which may act both independently and interdependently [14,15]. These components may include behaviours, behaviour parameters and methods of organizing those behaviours, and they may have an effect at an individual level, organizational level or population level [16]. Complex interventions are generally conducted to improve health either at the individual, organizational policy or population level in different fields such as public health research, medical research [14] and any public services dealing with complex social interventions such as performance measures, regulations and inspection or funding reforms [7].

In the field of occupational audiology, complex interventions have not been conducted even though research widely demonstrates both the auditory and non-auditory health impacts of excessive exposure to occupational noise in the workplace [17–20]. Furthermore, the fact that HCPs are 'built from multiple interacting components, which act both independently and interdependently' [21,p.1281] from each other makes, them well suited to complex interventions. Hence, the current study aimed to explore whether HCPs are a complex intervention, fitting the predefined criteria for complex interventions described by Pawson et al. [7] as follows:

- Complex interventions are theories.
- Complex interventions are active and able to achieve their effect through the active involvement and engagement of individuals.
- Complex interventions are comprised of long journeys.
- Complex interventions are non-linear in their implementation chains, and can even go into reverse.
- Complex interventions are fragile and embedded in multiple social systems.
- Complex interventions are prone to be borrowed.
- Complex interventions are open systems that feed back on themselves.

2. Methodology

2.1. Research strategy

A qualitative, descriptive research design was adopted as this study used existing data to explore the complexity of HCPs. A qualitative descriptive approach was selected because of its cardinal features. Firstly, it allows the use of a range of theoretical orientations. Secondly, it allows the use of any purposive sampling technique. Thirdly, it allows the use of document reviews and semi-structured interviews to collect data. Fourthly, it allows the use of content analysis as an analysis technique. Lastly, it allows the provision of a descriptive summary organized in a way that best fits the data [22,23]. All of these aforementioned features were adopted in the current study.

2.2. Sampling strategy

Purposive sampling was utilized in this study as it allowed the researcher to use the data previously collected and readily available to the researcher. Data were obtained from three sources: (a) interviews with stakeholders in the South African mining sector; (b) document analysis of the regulations on ONIHL in South African mines; (c) a literature review of original research on the management of ONIHL in the mining sector. Therefore, the use of purposive sampling was ideal in that it allowed the research, according to Etikan et al. [24], to identify and select individuals and groups of individuals who have experience and are knowledgeable on the management of ONIHL in the mining industry. Furthermore, the researcher sought to recruit participants who are available and willing to participate in the current study. Also, the researcher used documents that are readily available online.

2.3. Sources of data

2.3.1. Interviews with various stakeholders

The first source of data was obtained from interviews conducted with 15 stakeholders who are involved in the management of ONIHL in the South African mining sector. These participants consisted of audiologists, ventilation and occupational health engineers, occupational hygienists and representatives of the state, labour and employer. These participants were identified from the websites of the companies affiliated with the mining industry. Participants were contacted by telephone and via email to request them to participate in the study. The interviews were conducted both face to face and by telephone, depending on the availability of participants. Interview questions were formulated by the researcher and focused on the specific roles of the participants, the objectives of the mining industry with regard to the management of ONIHL and the challenges and progress since the formulation to the evaluation of the HCPs in the mining sector.

2.3.2. Document analysis

The second set of data was obtained through the document analysis of the Acts, regulations, policies and guidelines on the management of ONIHL in the South African mining sector since 1994. Websites of the companies affiliated to the mining industry were searched for the aforementioned documents. The search yielded eight documents (Table 1) which accurately focused on the complexity of HCPs in the mining sector. Documents included and analysed in this study were from 1994 to date with a focus on occupational health and safety in the mining industry in South Africa.

2.3.3. Systematic review

The last set of data emerged from a systematic review of literature on the management of ONIHL in the African mining industry. The literature search yielded nine articles that met the inclusion criteria. Of the nine articles, seven were conducted in South Africa while, of the remaining two, one was conducted in Ghana and the other in Zimbabwe. Therefore, seven articles (Table 2) from the South African mining sector were included in the final sample.

Table 1. Document analysis data.

Document number	Name of document	Year promulgated	Reference
1	Report of the Commission of Inquiry into Safety and Health in the Mining Industry	1994	[25]
2	Mine Health and Safety Act, 1996: No. 29 of 1996.	1996	[1]
3	South African Mining Industry Journey to Zero Harm 2003–2013	2014	[26]
4	Audiometry in the Work Place	2011	[27]
5	Noise-induced Hearing Loss Regulations	2003	[28]
6	Guideline for the Compilation of a Mandatory Code of Practice for an Occupational Health Programme (Occupational Hygiene and Medical Surveillance) for Noise	2003	[29]
7	Guidelines for Hearing Conservation Programmes	2003	[30]
8	(2014 mine Occupational Health and Safety Summit) Every Mine Worker Returning from Work Unharmed Every Day: Striving for Zero Harm	2014	[31]

Table 2. Systematic review articles.

Author(s) (year)	Research title	Reference
Edwards et al. (2015)	Evaluation of the Current Practices of Noise-induced Hearing Loss (NIHL) Awareness Training in the South African Mining Industry	[32]
Gumede et al. (2014)	Strategy Towards a Mining Industry-wide Buy-and-Maintain Quiet Initiative to Reduce Noise Induced Hearing Loss	[33]
Ntlhakana et al. (2015)	The Use of Hearing Protection Devices in South Africa: Exploring the Current Status in a Gold and a Non-ferrous Mine	[34]
Steenkamp (2008)	A Personal Approach to Hearing Conservation: The Key to Effective Second-level Noise Control	[35]
Amedofu (2007)	Effectiveness of Hearing Conservation Programme at a Large Surface Gold Mining Company in Ghana	[36]
Mutara and Mutanana (2015)	An Analysis of a Hearing Conservation Programme (HCP) at a Mining Company in Zimbabwe	[37]
Steenkamp (nd)	A Six Sigma-based Management Model to Eliminate the Noise-induced Hearing Loss Pandemic in South African Mines	[38]
Rashaad Hansia and Dickinson (2010)	Hearing Protection Device Usage at a South African Gold Mine	[39]
Burger et al. (2004)	Design and Development of a Low Noise Rockdrill	[40]

These articles were from 1994 and had a focus on the management of ONIHL in the mining industry.

2.4. Ethical considerations

The author declares that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guidelines on human experimentation. Ethical approval was obtained from the University's Medical Ethics Committee (Protocol number M160264). Participants were informed regarding confidentiality, anonymity and the right to withdraw from the study without any negative consequences to the participants.

2.5. Trustworthiness

Trustworthiness and credibility of the findings were achieved through triangulation as three sets of data were used in this study. Triangulation allowed for the collaboration of findings across different sets of data, thereby reducing the impact of potential biases that can exist in a single study [41]. Furthermore, since the researcher is an audiologist, to guard against any bias towards the findings of the study, the researcher used a peer reviewer.

2.6. Data analysis

A qualitative content analysis approach was adopted as it allowed for a systematic and objective means to make valid inferences from verbal, visual or written data in order to describe and quantify specific phenomena [42]. Deductive content analysis is used in cases where the researcher seeks to retest existing data in a new context in order to test categories, concepts, models or hypotheses [43]. Therefore, this study adopted a deductive content analysis method recommended by Elo and Kyngäs [43], namely developing a structured analysis matrix, data coding according to categories and hypothesis testing and correspondence comparison to earlier studies. Results were then presented in line with the features of complex interventions as described by Pawson et al. [7].

3. Findings and discussion

Typically, in qualitative content analysis, supporting evidence is presented in the form of quotations, excerpts, quotation and passages as recommended by Labuschagne [44]. However, in this current study, the findings are summarized as some of the excerpts are lengthy, Readers will be directed to where they can find the full document should they require the original full text.

3.1. Feature 1: complex interventions are theories

According to Pawson et al. [7], complex interventions are based on hypotheses that are causal in nature. This statement implies that, e.g., if a certain evidence-based programme is implemented, specific results are expected. According to Document 1, entitled 'Report of the Commission of Inquiry into Safety and Health in the Mining Industry' [25] (Table 1), HCPs were implemented in the South African mining industry post a lengthy deliberation among various stakeholders who were tasked with addressing the challenge of poor occupational health and safety in the workplace. Consequently, the 2003 MHSC milestones and the revised 2014 milestones were implemented to eliminate occupational noise in the mining industry as detailed in Documents 1 and 2 [25,1] (Table 1). It is therefore clear that implementing the MHSC milestones was a move towards the elimination of ONIHL. It can therefore be argued that the implementation of MHSC milestones

was informed by the hypothesis that if HCPs, through the milestones, are implemented, then elimination of ONIHL can be achieved. Therefore, this assertion serves as the causal hypothesis or theory supporting the implementation of HCPs in the South African mining industry in order to protect the health and safety of persons at the mines. This finding is in line with that of Pawson et al. [7], who concluded that interventions are theories based on a hypothesis which postulates that if one delivers a programme in this way or one manages services in this manner, then this will bring about some improved outcome. Therefore, this postulation is in line with the premise that if the mining industry implements HCPs taking into account the context of the mine, it is possible to eliminate excessive noise exposure in the mines and thereby achieve the desired outcome. Furthermore, findings from the systematic review also support the importance of having a solid and consolidated theoretical plan when implementing HCPs as a failure to have a solid and consolidated foundation can negatively influence the success of HCPs.

3.2. *Feature 2: complex interventions are active*

Complex interventions are active, meaning that they achieve their effects through active participation and input from various stakeholders involved in that particular programme. Authors such as Craig et al. [45], Brown et al. [46] and Hawe [47] view complex interventions in terms of how interventions work, meaning what are the active ingredients components of the programme and how these ingredients exert their effect. Brown et al. [46] list three important ingredients or components of active complex interventions: (a) active components assist in raising awareness of the key issues in the choice of intervention preferred; (b) active components improve the knowledge pertinent to decision-making; (c) active components provide preparation for the involvement of various stakeholders in the consultation.

To highlight these components, the same document [25] (Table 1) reveals that the mining industry is aware of the consequences of unmanaged excessive noise in the workplace, hence the implementation of HCPs through the 2003 and 2014 MHSC milestones as the intervention of choice. The following statement supports these findings: ‘the mining industry is not making the desired progress with noise-induced hearing loss, which is a major occupational health concern. As an industry, we have committed to the massive reduction and elimination of occupational noise induced hearing loss’ [4,p.1]. With regard to improving the knowledge pertinent to decision-making and involvement of stakeholders in consultations, Document 3 [48] entitled ‘South African Mining Industry Journey to Zero Harm from 2003–2013’ (Table 1) reveals that ‘The road to attaining Zero Harm is a long, winding and bumpy one. However, it is a road that is walked alongside diverse people collaborating, executing plans and strongly rallying around a common objective’ [26,p.9]. From this excerpt, arguably, the stakeholders involved in the formulation and implementation of HCPs in the mining sector have engaged and collaborated with different stakeholders in order to select the best and evidence-based intervention to eliminate noise in the mining industry. Data obtained from various stakeholders also confirmed continual collaboration and consultation of different stakeholders depending on the task at hand.

3.3. *Feature 3: complex interventions are comprised of long journeys*

Complex interventions have long journeys, meaning they begin in the heads of policy architects, pass into the hands of practitioners and managers, and (sometimes) into the hearts and minds of the end users [7]. As alluded to in the previous section, this feature speaks to the effect that interventions are typically a long process from conceptualization to evaluation. Holmboe [49,p.351] states ‘the journey to change takes time’. This was evident in this study as findings from Document1 [25] (Table 1) revealed that before the formalization of HCPs in South Africa, the then President of the country appointed a task team, referred to as the Leon Commission, to address health and safety concerns in the mining industry. Through deliberations of this committee, a Mine Health and Safety Act 29 of 1996 [1] was established to provide a comprehensive legal framework for creating a healthy and safe working environment. Subsequently, in 1997, the MHSC was established and led the development of the 2003 MHSC milestones on eliminating ONIHL. These milestones underwent the Presidential health and safety audit in 2008 and were ultimately revised in 2014.

The findings presented clearly illustrate the journey and process that was undertaken to formally implement HCPs in the mining sector. In addition, it is clear that the idea of introducing HCPs in the mining sector started with the President, and this idea was passed on to various stakeholders and, eventually, the stakeholders who implemented the milestones were not necessarily the individuals who developed the milestones themselves. Furthermore, data obtained from the interviews also highlighted the same sentiments reported in Document 3, entitled ‘South African Mining Industry Journey To Zero Harm 2003–2013’ [26] (Table 1), and indicate that the process was in progress when these stakeholders were roped in and that the process is still continuing, hence the latest milestones will be evaluated in 2024. The length of time it has taken for the conceptualization, implementation, evaluation and revision of milestones appears to be significantly long. The process from formulating to evaluating the HCP journey in the South African mining industry has taken a long journey, whose end may not be near. However, it is hoped that this journey brings out the desired outcome.

3.4. Feature 4: complex interventions are non-linear in their implementation chains

According to Pawson et al. [7], complex interventions are non-linear and can even go into reverse. Complex interventions are built from multiple interacting components, which may act both independently and interdependently, and include behaviours, behaviour parameters and methods of organizing those behaviours, and they may have an effect at an individual level, organizational level or population (local society) level [16,17]. It is therefore no wonder that complex interventions are non-linear and they may even go into reverse. This was evident in this current study as data obtained from Document 2, entitled 'Mine Health and Safety Act, 1996: No. 29 of 1996. Mine and Health Safety' [1] (Table 1), revealed that, initially, the 2003 MHSC milestones were concerned with the eliminating ONIHL by focusing on monitoring the percentage of hearing loss (PHL). However, with further consultation and involvement of other stakeholders along the way, the focus council changed from using PHL to monitoring the STS. Hence, the milestones were revised to incorporate the changes identified by the stakeholders. Furthermore, the initial milestones also targeted limiting total noise emitted by all equipment installed in any workplace not to exceed a sound pressure level of 110 dB(A) at any location in that workplace (including individual pieces of equipment). Through consultations and studying the progress from developed countries such as Canada, noise emission was then reduced further to 107 dB(A). These findings attest to the importance and the impact of continual engagement among stakeholders in order to improve HCPs in the mining sector.

3.5. Feature 5: complex interventions are fragile

Complex interventions are fragile creatures, and are often embedded in multiple social systems. Furthermore, complex interventions are rarely, if ever, equally effective in all circumstances because of the influence of context [7]. The observation that complex interventions are rarely equally effective in all situations due to contextual factors was evident in this study. For instance, in this current study, interviews with stakeholders revealed that some mines were able to meet the targets while others were unable to meet these milestones. The scales (large vs small) of the mines, the culture of the mines and the active involvement of stakeholders were cited as some of the factors that influence the success of the milestones. Therefore, the size of the mine and the availability of resources and level of support and commitment from all stakeholders may contribute to the fragility of the implemented programmes. Furthermore, social systems have an impact on the success of programmes, therefore having a buy-in from all departments and systems is crucial in the success of HCPs. As already mentioned, social systems may influence the outcome of implemented interventions. Therefore, it is important to consider social systems and their impact on the programme. For instance, from the interviews conducted and systematic review results, the role of mineworkers in the management of ONIHL was not overtly communicated. It is important to include mineworkers as they are directly exposed to the noise, and their participation and buy-in may be a critical step in achieving the desired outcomes.

3.6. Feature 6: complex interventions are prone to be borrowed

Complex interventions are leaky and prone to be borrowed. Pawson et al. [7] state that, when it comes to putting flesh on the bones of an intervention strategy, practitioners will consult with colleagues and cross-fertilize ideas. In engaging with various stakeholders, it is important to acknowledge that 'transparent and meaningful consultation with key stakeholders is a cornerstone of informed decision-making and good governance' [50,p.1]. Consultation allows for cross-fertilization of ideas and knowledge which influences stakeholders on communal decision-making by allowing stakeholders to communicate their individual knowledge to other stakeholders in order to reach a mutual decision to execute the cross-fertilized idea that is best suited in accomplishing a given task [51]. In the current study, the consultation and the cross-fertilization of ideas was evidenced by engaging various stakeholders with an aim of implementing evidence-based interventions. Therefore, in this study, the initial MHSC milestones were focused on and concerned with PLH shifts as opposed to the STS. Through consultation and further engagements with other stakeholders, the milestones were revised to focus on the STS as it was rationalized that this was the best strategy to monitor and thereby eliminate ONIHL in the mining sector. The following quotation from one of the stakeholders who participated in the interview summarizes the process:

> For instance, when we were working towards the 2014 milestones, the new milestones, then we got in an audiologist you know because we were debating for instance, should we use the PLH (percentage of hearing loss) shift or should we use the STS (standard threshold shift) as a way of early detection of noise. So an audiologist from an academic institution was invited and she went through the cons and the pros and in the end, we are agreed as the industry that we will shift from PHL shift to STS. So that's what the new milestones are based on STS.

This quote highlights the importance of consultation and cross-fertilization of ideas. Through the engagement of stakeholders, opportunities to improve the quality of HCPs in the mining industry were realised. Document 3 also supports the importance of collaboration: 'The following aspects are critically important to reach the target of Zero Harm: the right mind set, correct action and strong support from stakeholder. Working together, the South African mining industry has achieved major successes' [26p.5]. Having a common goal and allowing for consultations

and interrogation of ideas will indeed yield favourable outcomes.

3.7. *Feature 7: complex interventions are open systems that feed back on themselves*

The final feature of complex service interventions is that they are open systems that feed back on themselves. As interventions are implemented, they change the conditions that made them work in the first place [7]. According to Cooper et al. [9], complex interventions do not act as independent agents for change; rather, they operate within open systems, interacting with personal, interpersonal and environmental factors outside of the programme. Complex interventions are multifactorial systems which are interconnected, changes in one part of the system feed through other parts of the system and feed back on themselves [21]. Therefore, learning occurs that alters subsequent receptivity to interventions, which ultimately leads to unintended effects in the longer term [7]. Data from the current study indicated that HCPs are manipulated or affected by factors outside the programme itself. For instance, due to poor socio-economic status and low wages for mines, some stakeholders revealed that some workers expose themselves to excessive noise in the workplace in order to be compensated for incurring a hearing loss in the workplace. Other stakeholders expressed that most mines use production incentives for production, therefore, some workers may expose themselves to excessive noise in order to meet the production targets and get a bonus. This revelation by stakeholders also highlighted the importance of educating the workers about the long-term effects of exposure to excessive noise in the workplace.

4. Conclusion

The aim of this study was to explore whether HCPs are a complex intervention, fitting the predefined criteria for complex interventions described by Pawson et al. [7]. The analysis of documents, systematic reviews and interviews from stakeholders provides evidence for the complexity of HCPs currently implemented in the South African mining industry.

The findings revealed that HCPs are, firstly, based on a theoretical premise which states that implementation of HCPs will bring about the elimination of ONIHL in the mining industry. Secondly, formulating, implementing monitoring and evaluating HCPs involved participation of various stakeholders, thus making them active complex interventions. Thirdly, HCPs were formulated in 1994 and are still ongoing, thereby making them complex interventions with long journeys. Fourthly, HCPs comprised multiple pillars, which act both independently and interdependently; hence, making them non-linear complex interventions. Fifthly, HCPs are influenced by the context, such as the size of the mine, the resources available and the culture of the mine, thereby making them fragile complex interventions. Sixthly, the implementation of HCPs has been influenced by continual consultation and cross-fertilization of ideas, therefore making them complex interventions prone to being borrowed and refined. Lastly, HCPs are affected by personal, interpersonal and environmental factors outside of the programme, thereby making them open systems that feed back on themselves.

Much energy and dedication has been fuelled towards achieving the best outcomes; however, the outcomes are still not satisfactory. It is clear that the journey towards elimination of ONIHL in the mining sector is still far from being over. There is therefore a need for the mining industry to focus its energies on new and innovative ways of understanding why some aspects of the HCPs currently implemented yield desired outcomes while some do not. There is therefore a need to implement studies focusing on the context of each mine so as to improve HCPs in individual mines as opposed to implementing a HCP for all mines as a blanket approach.

Failure to recognize HCPs as complex interventions has implications, not only for the individuals exposed to noise, but for their colleagues, families, companies and the state at large. Arguably, exposure to excessive noise is not life threatening; it is, however, health threatening. Therefore, there is an urgent need to recognize HCPs as a complex intervention in order to conduct a realist review on the status quo of noise management in South Africa as a developing country.

In conclusion, the findings of this study have shown the complexity of HCPs, which was a necessary step in moving towards embarking on conducting realist reviews in local mines to understand what works for which mine under what conditions. Therefore, current findings pave the way for mines to conduct realist reviews, now that it has been confirmed that HCPs are complex interventions needing realist reviews to understand their mechanisms.

Acknowledgement

The author acknowledges the excellent supervision and guidance of Professor Katijah Khoza-Shangase during the writing process of the current paper.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This research was supported by the Consortium for Advanced Research Training in Africa (CARTA). CARTA is jointly led by the African Population and Health Research Center and the University of the Witwatersrand and funded by the Carnegie Corporation of New York [grant number B 8606.R02]; Sida [grant number 54100029]; DELTAS Africa Initiative [grant number 107768/Z/15/Z]. The DELTAS Africa Initiative is an independent funding scheme of the African Academy of Sciences

(AAS) Alliance for Accelerating Excellence in Science in Africa (AESA) and supported by the New Partnership for Africa's Development Planning and Coordinating Agency (NEPAD Agency) with funding from the Wellcome Trust (UK) [grant number 107768/Z/15/Z]; UK government. The statements made and views expressed are solely the responsibility of the author.

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References

[1] Mine Health and Safety Act (No. 29 of 1996). Government Gazette. 1996;372(17242).
[2] Edwards AL, Kritzinger D. Noise-induced hearing loss milestones: past and future. J South Afr Inst Min Metall. 2012;112:865–869.
[3] Mine Health and Safety Council (MHSC). The road to zero harm – new milestones. In: Proceedings of the 10th Anniversary of the 2003 Occupational Health and Safety; 2014 Nov 19–20; Midrand, South Africa. Woodmead: MHSC; 2014.
[4] Booyens Y. Noise induced hearing loss worrying – CoM. Creamer Media: Mining Weekly [Internet]. 2013, May 17 [cited 2016 Apr 29]. Available from: http://www.miningweekly.com/article/noise-induced-hearing-loss-worrying-com-2013-05-20.
[5] Rycroft-Malone J, McCormack B, Hutchinson A, et al. Realist synthesis: illustrating the method for implementation research. Implement Sci. 2012;7(33):1–10. doi:10.1186/1748-5908-7-33
[6] Rycroft-Malone J, McCormack B, DeCorby K, et al. Realist synthesis: method and examples. In: Gerrish K and Lacey A, editors. The research process in nursing. Oxford: Wiley Blackwell; 2010. p. 1–10.
[7] Pawson R, Greenhalgh T, Harvey G, et al. Realist review – a new method of systematic review designed for complex policy interventions. J Health Serv Res Policy. 2005;10(1):21–34. doi:10.1258/1355819054308530
[8] Pawson R. Evidence-based policy. A realist perspective. London (UK): SAGE; 2006.
[9] Cooper C, Lhussier M, Shucksmith J, et al. Protocol for a realist review of complex interventions to prevent adolescents from engaging in multiple risk behaviours. BMJ Open. 2017;7:e015477.
[10] Fletcher A, Jamal F, Moore G, et al. Realist complex intervention science: applying realist principles across all phases of the Medical Research Council framework for developing and evaluating complex interventions. Evaluation (Lond). 2016;22(3):286–303.
[11] Willis CD, Riley BL, Stockton L, et al. Scaling up complex interventions: insights from a realist synthesis. Health Res Policy Syst. 2016;14(88):1–16.
[12] Berg RC, Nanavati J. Realist review: current practice and future prospects. J Res Pract. 2016;12(1):1–28.
[13] Kirst M, O'Campo P. Realist review methods for complex health problems. In: O'Campo P, Dunn J, editors. Rethinking social epidemiology. Cham: Springer; 2012. p. 231–245.
[14] Moore GF, Audrey S, Barker M, et al. Process evaluation of complex interventions: Medical Research Council guidance. BMJ. 2015;350:h1258.
[15] Medical Research Council (MRC). A framework for development and evaluation of RCTs for complex interventions to improve health. London (UK): MRC; 2000.
[16] Datta J, Petticrew M. Challenges to evaluating complex interventions: a content analysis of published papers. BMC Public Health. 2013;13(568):1–18.
[17] Shendell DG, Barnett C, Boese S. Science-based recommendations to prevent or reduce potential exposure to biological, chemical, and physical agents in schools. J Sch Health. 2004;74(10):390–396. doi:10.1111/j.1746-1561.2004.tb06603.x
[18] Delecrode CR, et al. Prevalence of tinnitus in workers exposed to noise and organophosphates. Int Arch Otorhinolaryngol. 2012;16(3):328–334.
[19] Omer Ahmed H. Noise exposure, awareness, practice and noise annoyance among steel workers in United Arab Emirates. Open Public Health J. 2012;5:28–35. doi:10.2174/1874944501205010028
[20] Basner M, Babisch W, Davis A, et al. Auditory and non-auditory effects of noise on health. Lancet. 2014;383(9925):1325–1332. doi:10.1016/S0140-6736(13)61613-X
[21] Shiell A, Hawe P, Gold L. Complex interventions or complex systems? Implications for health economic evaluation. BMJ. 2008;336(7656):1281–1283. doi:10.1136/bmj.39569.510521.AD
[22] Colorafi KJ, Evans B. Qualitative descriptive methods in health science research. Health Environ Res Des J. 2016;9(4):16–25. doi:10.1177/1937586715614171
[23] Sandelowski M. What's in a name? Qualitative description revisited. Res Nurs Health. 2010;33:77–84.
[24] Etikan I, Musa SA, Alkassim RS. Comparison of convenience sampling and purposive sampling. Am J Theor Appl Stat. 2016;5(1):1–4. doi:10.11648/j.ajtas.20160501.11
[25] Stanton DW. Report of the Commission of Inquiry into Safety and Health in the Mining Industry. South Afr OHS Comm. 2003;1(1):1–192.
[26] Mine Health and Safety Council (MHSC). South African mining industry journey to zero harm 2003–2013. Woodmead: Mine Health and Safety Council; 2014.
[27] South African Society of Occupational Medicine (SASOM). Audiometry in the work place. Pretoria: SASOM; 2011. (SASOM guideline; 29).
[28] Occupational health and safety act, 1993. Noise induced hearing loss regulations. Government Gazette. 2003; (24967):318–327.
[29] Mine Health and Safety Inspectorate. Guideline for the compilation of a mandatory code of practice for an occupational health programme (occupational hygiene and medical surveillance) for noise. Pretoria: Department of Minerals and Energy; 2003. (DME 16/3/2/4-A3).
[30] de W Oosthuizen S. Guidelines for hearing conservation programmes. Bloemfontein: Provincial Occupational Health Unit; 2006. p. 1–27.
[31] Mine Health and Safety Council (MHSC). Every mine worker returning from work unharmed every day: striving for zero harm. In: Proceedings of the 10th anniversary of the 2003 Occupational Health and Safety milestones; 2014 Nov 19–20; Midrand, South Africa. Woodmead: MHSC; 2014.
[32] Edwards AL, Milanzi LA, Khoza NN, et al. Evaluation of the current practices of noise-induced hearing loss (NIHL) awareness training in the South African mining industry. Occup Health South Afr. 2015;21(1):11–17.
[33] Gumede H, Blomerus K, Coutts D, et al. Strategy towards a mining industry-wide buy-and-maintain quiet initiative to reduce noise induced hearing loss. J South Afr Inst Min Metallurgy. 2014;114:923–928.
[34] Ntlhakana L, Kanji A, Khoza-Shangase K. The use of hearing protection devices in South Africa: exploring the current

status in a gold and a non-ferrous mine. Occup Health South Afr. 2015;21(2):10–15.
[35] Steenkamp RJ. A personal approach to hearing conservation: the key to effective second-level noise control. South Afr J Ind Eng. 2008;19(1):215–229.
[36] Amedofu GK. Effectiveness of hearing conservation program at a large surface gold mining company in Ghana. Afr J Health Sci. 2007;14:49–53.
[37] Mutara G, Mutanana N. An analysis of a hearing conservation programme (HCP) at a mining company in Zimbabwe. J Biol Agric Healthcare. 2015;5(12);51–58.
[38] Steenkamp RJ. A six sigma-based management model to eliminate the noise-induced hearing loss pandemic in South African mines. South Afr Bus Rev. 2007;11:104–124.
[39] Rashaad Hansia M, Dickinson D. Hearing protection device usage at a South African gold mine. Occup Med (Lond). 2010;60(1):72–74. doi:10.1093/occmed/kqp114
[40] Burger NDL, von Wielligh AJ, de Wet PR, et al. Design and development of a low noise rockdrill. J South Afr Inst Min Metall. 2004;104(7):403–410.
[41] Bowen GA. Document analysis as a qualitative research method. Qual Res J. 2009;9(2):27–40. doi:10.3316/QRJ0902027
[42] Bengtsson M. How to plan and perform a qualitative study using content analysis. NursingPlus Open. 2016;2:8–14. doi:10.1016/j.npls.2016.01.001
[43] Elo S, Kyngäs H. The qualitative content analysis process. J Adv Nurs. 2008;62(1):107–115. doi:10.1111/j.1365-2648.2007.04569.x
[44] Labuschagne A. Qualitative research: airy fairy or fundamental? Qual Rep. 2003;8(1):100–103.
[45] Craig P, Dieppe P, Macintyre S, et al. Developing and evaluating complex interventions: the new Medical Research Council guidance. BMJ. 2008;337:a1655.
[46] Brown I, Bradley A, Ng CJ, et al. Investigating active ingredients in a complex intervention: a nested study within the Patient and Decision Aids (PANDAs) randomised controlled trial for people with type 2 diabetes. BMC Res Notes. 2014;7:347.
[47] Hawe P. Lessons from complex interventions to improve health. Annu Rev Public Health. 2015;36(1):307–323. doi:10.1146/annurev-publhealth-031912-114421
[48] Mine Health and Safety Council (MHSC). The health and safety summit: the road to zero harm – new milestones. Johannesburg: MHSC; 2014. p. 1–92.
[49] Holmboe ES. Competency-based medical education and the ghost of Kuhn: reflections on the messy and meaningful work of transformation. Acad Med. 2018;93(3):350–353. doi:10.1097/ACM.0000000000001866
[50] Kvam R. Meaningful stakeholder consultation. Washington (DC): Inter-American Development Bank (IDB); 2017. (IDB monograph; 545)
[51] Gunasekaran SS, Ahmad MS, Mostafa S, et al. Cross-fertilization of ideas in collective intelligence model (CIM). In: 2nd International Symposium on Agent, Multi-Agent Systems and Robotics (ISAMSR); 2016 Aug 23–24; Bangi, Malaysia. Piscataway (NJ): Institute of Electrical and Electronics Engineers; 2017. p. 27–33.