

**Supplementary Table 1. Comprehensive evidence synthesis of ONIHL, gaps in hearing conservation, and roles of worker unions in the African context**

#	Authors(s), year	Study location and population	Key findings on ONIHL prevalence	Hearing conservation programmes	Role of worker unions	Policy and regulatory frameworks
1	Abdalla et al. (2017)*	Global/DCP3 chapter – multi-sector review (LMIC and HIC evidence synthesis)	Noise identified as a major preventable occupational risk; sector-specific prevalence varies widely (often high in mining/manufacturing), but chapter provides no single pooled prevalence	Recommends hierarchy-of-control approaches (engineering, administration, PPE)	Notes stronger union engagement in HICs; limited union capacity in many LMICs	Discusses international OHS norms and ILO guidance; frames ILO Conventions as benchmarks
2	Abdelrahim et al. (2023)	Sudan – scoping review of OHS governance	Prevalence data for ONIHL scarce; evidence indicates hazardous noise exposure in mining, construction, and agriculture	Weak or inconsistent implementation of HCPs reported	Limited evidence of union-led hearing advocacy for hearing conservation; labour movement exists, but constrained	Calls for stronger harmonisation of Sudanese OHS law with ILO instruments and stronger enforcement
3	Abera Kumie et al. (2016)	Ethiopia – situational analysis/review of OHS	No robust national ONIHL prevalence estimate; small studies indicate occupational noise exposure and early hearing changes among workers (some studies report ~10–20% with early threshold shifts)	HCPs are fragmented and often ad hoc; audiometry not widely available	Minimal influence of trade unions on advocacy and OHS due to structural/political constraints	Identifies policy and implementation gaps in Ethiopian OHS frameworks; limited enforcement capacity
4	Anino et al. (2010)	Kenya – Jomo Kenyatta Int'l Airport ground staff; cross-sectional (n = 116)	High prevalence of ONIHL due to aircraft noise: article reports 34.8% of ground-handling staff with NIHL (audiometric evidence)	Limited organised HCPs; workers rely on personal protection; intermittent training	No significant union involvement in the airport cohort reported	Notes weak enforcement of noise controls; need for stronger regulatory monitoring
5	Bentil (2018)	Ghana – AngloGold Ashanti Iduapriem mineworkers (Tarkwa)	Audiometry and workplace data indicate notable ONIHL cases; dissertation reports > 25% with threshold shifts in sampled workers (varies by job class)	Partial HCP presence (screening and HPDs), but inconsistent follow-up and engineering controls limited	Unions (miner unions) participate in safety meetings and training campaigns; documented advocacy for PPE and screening	Calls for stronger enforcement of mining OHS regulations and better employer accountability
6	Chendume (2021)	South Africa – active mine in Rustenburg; underground workers (case study)	High ONIHL prevalence among underground miners; study reports 40%+ with measurable hearing loss in sampled cohort	HCP elements present, but uneven (HPD use inconsistent; noisy tasks remain)	Unions actively advocate for improved PPE and monitoring; engaged in worker training in this site	Highlights gaps in regulatory compliance, despite existing mine health legislation
7	Coulson (2018)	South Africa – qualitative study of workplace health and safety representatives on mines	Qualitative evidence: ONIHL persistently reported as a serious hazard by reps; no prevalence numbers	HCPs described as employer-led and constrained; representatives report 'creeping responsabilisation' (shift of burden onto workers)	Strong union/rep. advocacy for OHS reforms exists, but constrained by employer dominance and legal/practical limits	Notes legislative complexity: existing Acts, but implementation/enforcement problems
8	Coulson et al. (2019)	South Africa – mineworkers' perspectives (qualitative)	Workers aware of hearing risks, perceived high incidence, but study offers qualitative insights more than prevalence figures	Some HCP compliance (HPD availability), but monitoring and enforcement weak	Union training programmes exist, but limited by employer hegemony; workers feel constrained to refuse unsafe work	Policy exists, but enforcement is inconsistent; worker protections unevenly applied
9	Coulson and Christofides (2020)	South Africa – study on worker health and safety representatives	Confirms ONIHL as an ongoing workplace hazard in mines (qualitative evidence)	Critiques employer-led HCPs as insufficiently participatory	Unions and reps push for stronger representation and co-regulation, but face institutional limits	Highlights tensions between tripartite governance ideals and practice; enforcement gaps

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10	Cronjé and Chenga (2007)	South Africa – mining community health issues	Community- and worker-level noise concerns reported; study not a prevalence survey, but documents noise exposure and hearing risk around mines	No structured HCPs in adjacent communities; workplace HCPs vary	Unions involved in broader occupational health advocacy (not specifically ONIHL-centric in this paper)	Argues for stronger regulation of OHS in community health/regulatory frameworks
11	Gumede et al. (2014)	South Africa – mining industry policy/strategy piece	Notes persistent ONIHL in mining despite interventions; prevalence remains significant	Promotes 'Buy-and-Maintain Quiet' engineering initiative to reduce equipment noise	Unions lobbying for industry-wide noise control strategies; engagement reported in policy discussions	Recommends regulatory updates and industry-wide engineering solutions
12	Harmse et al. (2019)	South Africa – chemical plant process operators (training evaluation)	Training improved knowledge, but did not immediately reduce measured exposure; prevalence not primary outcome	Emphasises need for structured, ongoing HCP training and monitoring	Authors suggest unions could enforce training uptake; no active union programme described	Calls for better monitoring and integration of training into policy
13	Hermanus et al. (2015)	South Africa – MOSH initiative evaluation (mining sector)	Review finds ONIHL persists; evaluation of MOSH shows mixed outcomes (no clean prevalence estimate)	MOSH was employer/industry-led HCP attempt with variable uptake and impact	Unions called for greater involvement in programme implementation; critique of employer-led approaches	Highlights limitations of employer-driven initiatives without stronger legislative enforcement
14	Kanji et al. (2019)	South Africa – mineworkers (survey)	Findings show low levels of ONIHL knowledge and practices; prevalence not universally reported, but risk high	HCP compliance inconsistent; gaps in training and audiometric follow-up	Unions do offer education, but enforcement power limited	Recommends strengthened policy implementation and union-employer collaboration
15	Keefe et al. (2020)	Global – scoping review of strategies to prevent occupational diseases	Identifies effective strategies to prevent occupational diseases, including ONIHL; not a prevalence source	Advocates multi-level evidence-based HCPs (engineering first, surveillance, training)	Unions recognised as crucial stakeholders in prevention efforts	Calls for policy harmonisation across regions and uptake of best-practice standards
16	Khoza-Shangase et al. (2020)	South Africa – platinum mines (review/analysis)	Estimate of miners at risk is high; authors synthesise data showing substantial proportions of miners exceed risk thresholds (varies by dataset)	HCPs insufficiently protective in many worksites; coverage and quality gaps reported	Unions have advocated for stricter controls and monitoring; documented union engagement in some operations	Recommend improved regulation and monitoring aligned with ILO norms
17	Khoza-Shangase and Moroe (2020 <sup>a</sup> )	South Africa – discussion on audiology in mining	Argues that audiologists' role in ONIHL management is underutilised; prevalence cited from sectoral studies	Limited implementation of effective screening within HCPs; screening programmes exist, but are not always clinically or legally optimised	Unions support mandatory screening where present, but obstacles to implementation persist	Advocates for regulatory improvements to standardise audiology practice in HCPs
18	Khoza-Shangase and Moroe (2020 <sup>b</sup> )	South Africa – a scoping review of tele-audiology in HCPs	Explores potential of tele-audiology as a tool for early identification in HCPs; prevalence context from South African mining and industry literature	Suggests tele-audiology to expand audiometric reach in remote worksites	No substantial evidence yet of union involvement in tele-audiology initiatives	Highlights need to address telehealth regulatory frameworks for integration
19	Khoza-Shangase et al. (2020)	Africa-wide – editorial/overview	Interdisciplinary analysis: ONIHL is underreported across Africa; prevalence varies, but is significant in mining and manufacturing	HCPs show systemic weaknesses across contexts	Argues unions could play stronger roles in advocacy across Africa	Calls for policy improvement and context-specific HCP adaptations
20	Khoza-Shangase and Moroe (2022)	Africa-wide – policy/position chapter	Calls for paradigm shift in HCPs, given persistent ONIHL; prevalence data from regional reviews	Emphasises employer accountability and systemic change beyond PPE	Recommends unions push for stricter compliance and worker representation	Highlights enforcement deficits across national regulatory frameworks

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21	Khoza-Shangase (2022)	South Africa – book chapter on HCP realities in mines	Critical account of persistent ONIHL in mines, despite regulations; prevalence varies by dataset	Documents shortcomings of current HCPs in South African mining	Advocates for stronger union engagement to hold employers to account	Calls for enhanced government oversight and policy enforcement
22	Kilonzo (2022)	Kenya – Jua Kali metal workers	Reports elevated ONIHL risk among informal metal workers; prevalence estimates vary by workshop, but many workers show early hearing threshold shifts (~10–30% depending on job and exposure)	Little formal HCP infrastructure in informal sector; mitigation strategies ad hoc	Unions largely absent in informal Jua Kali settings; collective representation weak	Urges development of sector-specific regulations and outreach to informal workers' organisations
23	Kubheka (2021)	South Africa – power plant construction site workers	Confirms clear link between occupational noise exposure and ONIHL in construction cohort; prevalence not pooled, but significant STS rates recorded in sample	HCPs present, but inconsistently applied during construction phases	Unions engaged in campaigning for better compliance monitoring	Calls for regulatory oversight of construction-related noise exposures
24	Madahana et al. (2020)	Global review – engineering noise control for mines	Summarises international evidence showing engineering controls reduce ONIHL prevalence in mining	Strong case for engineering controls and industry-wide strategies in HCPs	Unions largely absent from technical interventions, but can advocate for engineering investment	Recommends adoption of global best practice standards in regulation
25	McBride (2004)*	Global – mining sector review	ONIHL remains a major mining hazard historically; prevalence data vary by location	Documents evolution of hearing conservation in mining (surveillance, engineering)	Notes unions' key role historically in securing legislative and workplace changes	Highlights policy improvements over time in many jurisdictions; context matters
26	Moroe (2018)	South Africa – doctoral thesis (large-scale mines)	Finds high ONIHL burden in large-scale mines; prevalence derived from company datasets and audiometry (varies by mine and job)	Examples of HCPs exist, but policy-to-practice gaps are widespread	Unions face practical challenges to enforcement, despite having bargaining power in some sites	Suggests stricter regulatory accountability and monitoring mechanisms
27	Moroe et al. (2018)	Africa – systematic review (1994–2016)	Concludes ONIHL widely underreported across Africa; prevalence estimates heterogeneous, but consistently present in mining and industry	HCP implementation is inconsistent; many studies report reliance on PPE	Call for increased union advocacy and involvement	Identifies need for standardised policies and surveillance systems
28	Moroe and Khoza-Shangase (2018)	South Africa – mining industry; where are the audiologists? (journal article)	Audiologists largely absent from ONIHL prevention; documents gaps in audiology integration into workplace HCPs; prevalence context from South African mines	Recommends integration of clinical audiology into HCPs for early detection	Unions not strongly engaged in pushing for audiologist integration in all contexts	Urges better alignment with legal frameworks; argues for policy mechanisms to mandate audiology in workplace HCPs
29	Moroe and Khoza-Shangase (2020)	Global – systematic review on recent advances in HCPs	Survey of recent innovations and evidence; prevalence data summarised by sector	Notes improved HCPs in some settings, but inconsistent global uptake	Suggests unions should lead worker training and programme monitoring	Advocates policy strengthening to support HCP innovation
30	Moroe and Khoza-Shangase (2022 <sup>a</sup> )	Sub-Saharan Africa – exploration of complexities in mining	Identifies layers of complexity in ONIHL management in in sub-Saharan Africa mines; prevalence high, but data patchy	Employer-driven HCPs often inadequate; need for multi-stakeholder approaches	Unions can play larger monitoring/advocacy roles, if empowered	Suggests comprehensive regulatory overhauls and better implementation
31	Moroe and Khoza-Shangase (2022 <sup>b</sup> )	South Africa – mining industry; complex interventions theory applied to HCPs	Uses theory to explain inconsistent HCP outcomes; prevalence contextualised via case studies	Identifies challenges in enforcement; proposes complex systems approaches to HCP improvements (beyond single interventions)	Unions part of the proposed multi-actor solutions, but currently underutilised	Policy must support integrated, system-level interventions

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32	Mothiba et al. (2019)	South Africa – platinum mineworkers (qualitative)	Workers perceive high noise exposure and risk of ONIHL; no numeric prevalence provided in the paper	Training gaps and inconsistent HCP implementation reported	Unions suggested as potential channels for improved education and enforcement	Notes mismatches between policy expectations and workplace practice
33	Naicker (2024)	South Africa – coal mineworkers attitudes study (article)	Finds resistance to HPD use among some workers; prevalence not primary endpoint, but hearing risk remains	Finds resistance to PPE usage; HCPs present, but compliance challenges documented	Unions engaged in advocating for better PPE adherence and worker protection	Suggests updated policies for hearing protection and enforcement
34	Ntlhakana et al. (2015)	South Africa – gold and non-ferrous mines study (survey)	Reports inconsistent HPD usage; authors report risk indicators rather than national prevalence	HCPs vary across mines; device provision does not always translate to correct use	Unions pushing for stricter PPE provision and enforcement	Policy enforcement gaps identified; monitoring needs strengthening
35	Ntlhakana (2021)	South Africa – doctoral thesis, platinum mine risk assessment	Risk assessment indicates widespread risk of ONIHL within studied cohort; threshold exceedances common	Suggests improved noise monitoring and engineering controls	Unions actively lobbying for better worker protections in the studied mine	Recommends policy updates and stricter enforcement in line with ILO guidance
36	Ntlhakana et al. (2021)	South Africa – large-scale platinum mines (predictive analytics study)	Predictive models indicate many workers at risk for STSs; prevalence/STS rates reported per cohort in paper	Highlights need for targeted HCP action plans informed by predictive data	Unions encouraged to use predictive data in bargaining and surveillance	Advocates for policy action thresholds for STSs and mandated employer response
37	Ntlhakana and Khoza-Shangase (2022)	South Africa – mining industry; machine learning models chapter	Presents machine learning models for predicting ONIHL risk; not a prevalence study, but uses historical audiometry datasets	Suggests AI-driven prevention tools as adjuncts to HCPs	No evidence yet of union involvement in AI initiatives; potential for data-sharing with unions noted	Points to need for regulatory adaptation to technological innovations
38	Onyango et al. (2021)	East Africa (regional review) – legislative analysis	Finds uneven legislation across east Africa; direct prevalence figures variable and patchy	HCP legislative coverage inconsistent; implementation weak in many jurisdictions	Identifies unions as crucial for policy reform, but notes capacity constraints	Calls for harmonised regional regulations and stronger national enforcement
39	Pillay (2020)	South Africa – industrial workforce; mapping study chemical/noise co-exposure	Highlights combined risks of ototoxic chemicals with noise; prevalence of ONIHL likely underestimated due to co-exposures	Recommends integrated HCPs that consider chemical and noise exposures	Unions reported limited awareness of combined exposures in some settings	Suggests policy updates to monitor ototoxicants within workplace surveillance
40	Pillay and Manning (2020)	South Africa – critical legal analysis	Analyses current law; not an epidemiologic prevalence study	Finds weak enforcement mechanisms; gaps in legal framework for comprehensive ONIHL prevention	Notes unions often lack legal leverage in disputes over HCP implementation	Calls for stronger legislative backing and clarity on employer obligations
41	Radebe (2021)	South Africa – economic costs in mining (Master's thesis)	Calculates economic burden of ONIHL where data available; indicates significant costs to workers/industry	Argues for investment in HCPs as cost-saving in the long term	Recommends unions use economic data to support bargaining for HCP investment	Suggests financial penalties/incentives could strengthen compliance
42	Sekhon et al. (2020)*	USA/global – services sector prevalence review (2006–2015)	Shows hearing loss prevalence among noise-exposed workers in service sectors; useful comparator, but not African data	Presents evidence supporting comprehensive HCPs across sectors	Notes unions' role in implementation in some settings	Calls for evidence-based policymaking

\* global studies (Abdalla et al. (2017), McBride (2004), and Sekhonet et al. (2020)) were included – not as African evidence, but as comparative benchmarks to frame best practices, especially regarding ILO Conventions, union roles, and HCP models. Although these studies are global in scope, they include African examples (Keefe, 2020), and are authored by African scholars applying global lessons to Africa (Madahana et al., 2020; Moroe and Khoza-Shangase 2020), and were, therefore, considered relevant to this review.

AI: artificial intelligence, DCP3: Disease Control Priorities, Third Edition, HCP: hearing conservation programme, HIC: high-income country, HPD: hearing protection device, ILO: International Labour Organization, LMIC: low- and middle-income country, MOSH: Mining Industry Occupational Safety and Health, NIHL: noise-induced hearing loss, OHS: occupational health and safety, ONIHL: occupational noise-induced hearing loss, PPE: personal protective equipment, STS: standard threshold shift, USA: United States of America