

Transporting Occupational Hearing Nomograms between Factories

Abstract

In occupational hearing-risk assessment, a convincing output can still be invalid when a score calibrated in one workforce applied unchanged elsewhere. This literature-based conceptual analysis does not report a new experiment. The focal evidence concerns whether baseline hearing measurements can predict subsequent speech-frequency hearing loss in noise-exposed industrial workers. Transportability concerns the changes between a development setting and an intended use setting. Population composition, measurement, practice, and resource availability may all change. Describe the target setting before importing a model. Compare calibration, error types, and downstream decisions, including subgroups whose meaning differs between settings. The proposed comparison concerns industrial cohorts, job tasks, audiometry protocols; it would test whether the specific failure scenario is detected without erasing legitimate uncertainty. An integrated account should preserve the distinction between noise-exposed workers and clinical follow-up and any stronger downstream decision.

The decision and its evidence contract

An evidence workflow can be fast, reproducible, and still answer the wrong question. In this review, industrial cohorts provides the entry point for testing that possibility against audiometry protocols. Consider the possibility of a score calibrated in one workforce applied unchanged elsewhere. This is a proposed stress scenario, not an observed event reported by the cited studies. Its purpose is to expose which evidence contract would be violated even if the final output looked plausible. For noise-exposed workers and clinical follow-up, the relevant claim must identify its population or artifact class, its time window, and the action it is supposed to support. A failure at any of these levels may persist even after a local technical improvement. The analysis therefore treats published methods as bounded evidence and asks how their limitations interact with this particular decision. An operational analogy is useful only if it keeps those limitations visible.

Transportability concerns the changes between a development setting and an intended use setting. Population composition, measurement, practice, and resource availability may all change. External validation at one site tests only part of that space. In this article, the relevant contrast is industrial cohorts, job tasks, audiometry protocols. The proposed counterexample of a score calibrated in one workforce applied unchanged elsewhere puts that contrast under pressure. Describe the target setting before importing a model. Compare calibration, error types, and downstream decisions, including subgroups whose meaning differs between settings. A favorable finding would show that the intended interpretation of audiometry protocols remains defensible when industrial cohorts is perturbed under the specified conditions. An unfavorable finding should narrow the claim rather than be discarded as an inconvenient case.

The strongest comparison would isolate the disputed transition in industrial cohorts, job tasks, audiometry protocols. The proposed counterexample, a score calibrated in one workforce applied unchanged elsewhere, identifies what should not be accepted as equivalent evidence. The input record should retain enough information to decide which part of that scenario violates the intended contract. That includes the original source type, measurement or artifact status, and the reason the proposed interpretation exceeds its support. The evaluator would compare the system's response with a qualified judgment made without seeing that response. Disagreement should be classified rather than erased by rewriting the prompt. External validation at one site tests only part of that space. A useful negative result would show that the interface

cannot preserve this distinction under realistic use; a useful positive result would demonstrate preservation on independent cases rather than merely on the example used to develop the rule. The primary source remains relevant through its particular contribution: The design distinguishes association with existing impairment from prediction of later impairment. That contribution should be retained even if the integrated workflow fails. Conversely, successful integration would not remove the source's limitations or turn a proposed extension into an already observed result. This asymmetric interpretation protects both the literature and the user from an unjustified all-or-nothing verdict.

Methodological comparisons

False-discovery control is central when many molecular features are screened (Benjamini and Hochberg 1995). Multiplicity arises from the family of questions actually searched. Controlling false discoveries within a named family does not automatically cover later tissue filters, alternative endpoints, or narrative choices. The proposed audit should retain exploratory branches so the family is visible. Independent confirmation then addresses a different question from whether a discovery threshold was correctly applied during screening. This is methodological support for examining transportability, not a claim that the source studied occupational hearing-risk assessment. A separate application-specific test is required at the interface described in this review.

Medical machine learning must fit data provenance, care pathways, and prospective evaluation (Rajkomar, Dean, and Kohane 2019). The clinical relevance of a model depends on how its output changes a care process. Development data can contain information that becomes available only after the intended decision. A review must identify that availability boundary before comparing algorithms. Prospective use also changes who is measured and who is treated, so evaluation of a frozen historical dataset cannot establish the entire future workflow. An implementation should expose this limitation to reviewers of noise-exposed workers and clinical follow-up. The result and its evidence qualification should remain recoverable even when the interface condenses them into a short report.

Responsible health AI connects prediction with workflow, monitoring, and patient impact (Wiens et al. 2019). The point at which a model reaches practice is not the end of evaluation. New populations, changing measurements, and feedback can alter failure modes. A responsible deployment needs a route for recognizing deterioration and a person authorized to respond. Monitoring should be linked to feasible corrective actions; an alert that cannot change the workflow provides accountability only in a very limited sense. For the comparison involving industrial cohorts, job tasks, audiometry protocols, the source supplies an analytical obligation. The review's proposed application remains a hypothesis, with the deliberately difficult scenario serving as a check on scope inflation.

Policy distillation connects compression with sequential decision behavior (Rusu et al. 2015). Compressing a policy concerns sequential behavior rather than one isolated prediction. A small local mismatch can compound across actions, while a locally similar policy can explore differently. Evaluation should retain trajectories and consequential state transitions. The review treats policy transfer as a potential operational tool whose task-level contract still needs checking in the destination environment. An implementation should expose this limitation to reviewers of noise-exposed workers and clinical follow-up. The result and its evidence qualification should remain recoverable even when the interface condenses them into a short report.

Proximal policy optimization offers a widely used objective for stable policy updates (Schulman et al. 2017). An optimization procedure can make policy updates tractable without deciding whether the reward represents the desired behavior. Stable training and legitimate task success are separate properties. A review

should inspect reward boundaries, information leakage, and held-out failure modes. A larger rewarded score is weak evidence if the policy can improve it by selecting easier tasks or hiding unresolved outputs. Within occupational hearing-risk assessment, this distinction is relevant to transportability. The proposed failure scenario is a score calibrated in one workforce applied unchanged elsewhere; its evaluation must preserve the original source's methodological scope.

The information bottleneck formalizes compression that retains task-relevant information (Tishby, Pereira, and Bialek 1999). Compression is useful when it retains the information needed for the intended task. That task must be specified before one can judge what information is expendable. A bottleneck can discard nuisance variation but can also discard rare distinctions important to another user. The analysis should compare retained task information with the explicit downstream requirement rather than treating brevity as self-evidently beneficial. For the comparison involving industrial cohorts, job tasks, audiometry protocols, the source supplies an analytical obligation. The review's proposed application remains a hypothesis, with the deliberately difficult scenario serving as a check on scope inflation.

Variational bottlenecks make relevance-compression tradeoffs trainable in deep networks (Alemi et al. 2017). A trainable relevance-compression tradeoff needs an operational account of relevance. If labels omit a consequential distinction, a model can satisfy the training objective by discarding it. Hyperparameter comparisons should therefore include boundary and rare cases. The review proposes interpreting a variational bottleneck as a controlled modeling choice whose benefits and losses must be measured separately. An implementation should expose this limitation to reviewers of noise-exposed workers and clinical follow-up. The result and its evidence qualification should remain recoverable even when the interface condenses them into a short report.

Replication and transparent workflows are prerequisites for reliable biomedical claims (National Academies 2019). Reproducing a calculation and independently replicating a finding are different achievements. Recoverable data and code allow one to inspect the first; independent observations and design choices inform the second. A review should avoid calling several reanalyses of one dataset separate replications. Clear reporting of analysis changes also makes a failed replication informative instead of allowing it to disappear as an implementation dispute. The connection to transporting occupational hearing nomograms between factories is a constraint on interpretation. It would be inappropriate to borrow the source's methodological authority as direct confirmation of the integrated domain claim.

FAIR principles support reusable cohorts, signals, and analysis metadata (Wilkinson et al. 2016). Reusable evidence needs more than a downloadable file. Identifiers, metadata, provenance, and meaningful access conditions help another researcher determine what an artifact contains and whether it can answer a new question. Reuse does not mean universal permission or universal scientific comparability. The information needed to judge those boundaries should travel with the artifact rather than remain in private workflow knowledge. The connection to transporting occupational hearing nomograms between factories is a constraint on interpretation. It would be inappropriate to borrow the source's methodological authority as direct confirmation of the integrated domain claim.

Causal inference requires a clearly specified intervention, time order, and exchangeability assumptions (Hernán and Robins 2020). A prediction can be accurate without identifying what an intervention would change. A useful causal analysis begins by defining the hypothetical comparison, eligibility, and time zero. Its assumptions concern the process generating exposure and observation, not merely the flexibility of a fitted model. In this review, causal vocabulary is appropriate only when that comparison can be specified and defended. An implementation should expose this limitation to reviewers of noise-exposed workers and

clinical follow-up. The result and its evidence qualification should remain recoverable even when the interface condenses them into a short report.

What the focal studies establish

The relevant question in Prediction of Risk of Hearing Loss by Industry Noise from Cross-Sectional and Longitudinal Data is whether baseline hearing measurements can predict subsequent speech-frequency hearing loss in noise-exposed industrial workers (Xiao Yu et al. 2026d). Its methodological basis is sex-stratified cross-sectional modeling, longitudinal generalized estimating equations, and Cox-model nomograms using baseline high-frequency audiometry. The accessible evidence is specific: the accessible publication describes 7139 initially recruited noise-exposed subjects and longitudinal and external evaluation; baseline 3-kHz and 3-6-kHz measures contribute prognostic information. The design distinguishes association with existing impairment from prediction of later impairment. Limited follow-up, a smaller longitudinal sample, occupational selection, and untested prospective clinical impact constrain deployment claims. The contribution becomes relevant to transportability when the workflow moves from industrial cohorts to audiometry protocols. That transition is the review's proposed analytical focus, not a new result attributed to the source.

A useful boundary case is supplied by BoostAPR: Boosting Automated Program Repair via Execution-Grounded Reinforcement Learning with Dual Reward Models, concerned with how reinforcement learning for program repair can overcome sparse execution feedback and coarse sequence-level credit (Yuanhao Li et al. 2026a). Its methodological basis is a three-stage pipeline combining execution-verified supervised traces, sequence- and line-level reward models, and PPO with reward redistribution to critical edit regions. The accessible evidence is specific: evaluation spans SWE-bench Verified, Defects4J transfer, HumanEval-Java, and QuixBugs, with reported gains in both repository repair and cross-language generalization. Line-level credit assignment makes test execution informative at the granularity where patches actually change behavior. Benchmark success does not by itself establish maintainability, specification fidelity, or robustness to incomplete and flaky tests. This source enters the present review as a methodological comparison for evidence processing, not as evidence about disease biology, patient outcomes, or clinical efficacy. The transferable question is whether industrial cohorts remains correctly interpreted after a computational choice involving audiometry protocols. Its task-specific validation cannot be borrowed to validate the clinical claim.

A useful boundary case is supplied by Interaction between Noise Exposure and Phenotypic Age Acceleration in Hearing Loss: An NHANES Study, concerned with whether occupational noise and phenotypic age acceleration interact in association with hearing loss (Junjian Dai et al. 2026). Its methodological basis is a cross-sectional NHANES 2005-2010 analysis incorporating survey weighting and interaction analysis. The accessible evidence is specific: the accessible abstract describes 2014 adults representing approximately 16.6 million individuals after weighting. It brings biological-aging measures into the analysis of heterogeneous noise-associated hearing outcomes. Cross-sectional timing, exposure measurement, survey selection, and the scale chosen for interaction prevent direct causal or longitudinal-aging conclusions. The contribution becomes relevant to transportability when the workflow moves from industrial cohorts to audiometry protocols. That transition is the review's proposed analytical focus, not a new result attributed to the source.

The sources should be compared through the roles they play, not merged into a single performance claim. Prediction of Risk of Hearing Loss by Industry Noise from Cross-Sectional and Longitudinal Data addresses whether baseline hearing measurements can predict subsequent speech-frequency hearing loss in noise-exposed industrial workers (Xiao Yu et al. 2026d). By contrast, Interaction between Noise Exposure

and Phenotypic Age Acceleration in Hearing Loss: An NHANES Study addresses whether occupational noise and phenotypic age acceleration interact in association with hearing loss (Junjian Dai et al. 2026). That difference matters for transportability: the evidence concerning industrial cohorts is not automatically evidence concerning audiometry protocols. A successful software operation, a plausible mechanistic account, and a validated outcome are different achievements. Their integration may improve traceability, but it cannot create an unmeasured link. A coherent review should identify where the sources complement one another and where their scopes remain incompatible. Here the proposed failure scenario is a score calibrated in one workforce applied unchanged elsewhere. The analytical value of that scenario is that it can occur without requiring any cited paper to be wrong: an otherwise valid local finding can be misused at a later interface. Preventing that misuse requires evidence about the interface itself, not simply a larger collection of local results.

A discriminating evaluation agenda

To make transporting occupational hearing nomograms between factories empirically criticizable, the next study could proceed as follows. Describe the target setting before importing a model. Compare calibration, error types, and downstream decisions, including subgroups whose meaning differs between settings. These procedures are proposed, not completed. The case set would include the scenario of a score calibrated in one workforce applied unchanged elsewhere, with its validity judged independently of the system's response. The relevant comparison axes are industrial cohorts, job tasks, audiometry protocols.

A discriminating protocol would specify a preferred interpretation and at least one credible alternative before choosing measurements. It would include negative controls and observations that could favor the alternative. Reviewers would classify whether disagreement concerns data quality, model structure, or the scientific question itself. The comparison should reduce uncertainty about that distinction rather than add more observations equally compatible with every account.

An occupational study would need decision-time eligibility, subsequent outcome observation, and a realistic follow-up pathway. Model comparison should account for worker turnover and baseline impairment. Calibration in a validation cohort is informative, but improved prevention or referral quality would require evaluation of the action policy and its burdens, not a higher discrimination statistic alone.

Scope and unresolved questions

The cited sources still have design-specific limits even where their abstracts and methods are accessible. This review is a bounded conceptual synthesis rather than a systematic review with an exhaustive search protocol. It cannot establish the effectiveness of the proposed integrated workflow. Its specific contribution is to articulate how transportability changes the interpretation of industrial cohorts, job tasks, audiometry protocols. Technical sources support computational comparisons only; they do not validate biological mechanisms or patient benefit. Reviews and correspondence retain their publication roles and are not counted as new experiments. Proposed stress cases are illustrative, not observed failures attributed to the papers. Future work should therefore test the weakest inference described here, preserve contrary results, and disclose the cost of checking rather than treating additional automation as intrinsically beneficial.

Conclusion

The defensible conclusion is about the boundary between industrial cohorts and audiometry protocols, not a universal ranking of the cited methods. Describe the target setting before importing a model. Compare calibration, error types, and downstream decisions, including subgroups whose meaning differs between settings. The remaining problem can be stated as a testable contrast involving industrial cohorts, job tasks, audiometry protocols, with a score calibrated in one workforce applied unchanged elsewhere as a deliberately challenging alternative. The cited studies provide useful but different forms of support. Their integration should increase traceability and expose missing links, leaving clinical, mechanistic, and operational claims at the strength justified by their own evidence.

References

1. Yu, Xiao, et al. "Prediction of Risk of Hearing Loss by Industry Noise from Cross-Sectional and Longitudinal Data." *Communications Medicine*, vol. 6, 2026, <https://doi.org/10.1038/s43856-026-01463-3>.
2. Li, Yuanhao, et al. "BoostAPR: Boosting Automated Program Repair via Execution-Grounded Reinforcement Learning with Dual Reward Models." *arXiv*, version 4, 18 Sept. 2026, <https://arxiv.org/abs/2605.09134v4>. Preprint.
3. Dai, Junjian, et al. "Interaction between Noise Exposure and Phenotypic Age Acceleration in Hearing Loss: An NHANES Study." *ENT Updates*, vol. 16, no. 3, 2026, pp. 1-12, <https://doi.org/10.54963/entu.v16i3.100576>.
4. Benjamini, Yoav, and Yosef Hochberg. "Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing." *Journal of the Royal Statistical Society: Series B*, vol. 57, no. 1, 1995, pp. 289-300.
5. Rajkomar, Alvin, Jeffrey Dean, and Isaac Kohane. "Machine Learning in Medicine." *New England Journal of Medicine*, vol. 380, 2019, pp. 1347-58.
6. Wiens, Jenna, et al. "Do No Harm: A Roadmap for Responsible Machine Learning for Health Care." *Nature Medicine*, vol. 25, 2019, pp. 1337-40.
7. Rusu, Andrei A., et al. "Policy Distillation." *arXiv*, 2015, arXiv:1511.06295.
8. Schulman, John, et al. "Proximal Policy Optimization Algorithms." *arXiv*, 2017, arXiv:1707.06347.
9. Tishby, Naftali, Fernando C. Pereira, and William Bialek. "The Information Bottleneck Method." *Proceedings of the 37th Annual Allerton Conference on Communication, Control, and Computing*, 1999, pp. 368-77.
10. Alemi, Alexander A., et al. "Deep Variational Information Bottleneck." *International Conference on Learning Representations*, 2017.
11. National Academies of Sciences, Engineering, and Medicine. *Reproducibility and Replicability in Science*. National Academies Press, 2019.
12. Wilkinson, Mark D., et al. "The FAIR Guiding Principles for Scientific Data Management and Stewardship." *Scientific Data*, vol. 3, 2016, article 160018.
13. Hernán, Miguel A., and James M. Robins. *Causal Inference: What If*. Chapman & Hall/CRC, 2020.