

Factors associated with notification of noise-induced hearing loss in Brazil, 2013-2015: an ecological study*

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Abstract

Objective: To investigate factors associated with the notification of noise-induced hearing loss (NIHL), on the Notifiable Health Conditions Information System (SINAN) in Brazil. **Methods:** This was an ecological study to estimate the proportion of municipalities that had notified NIHL. Logistic regression models were used to identify associated factors. **Results:** Between 2013-2015, 277 (5.0%) municipalities notified NIHL. Notification was more prevalent among municipalities in an Occupational Health Referral Center (CEREST) coverage area (OR=1.62 – 95%CI 1.02;2.59) or those that had a CEREST in their territory (OR=4.37 – 95%CI 2.75;6.93), those that were closer to the state capital (OR=1.43 – 95%CI 1.06;1.92) and those with a high human development index (OR=2.35 – 95%CI 1.16;4.75). Among the municipalities located in a CEREST coverage area, notification was more frequent when there was a speech-language-hearing professional in the team (OR=1.96 – 95%CI – 1.47;2.63) and when employee turnover was low (OR=1.88 – 95%CI 1.40;2.52). **Conclusion:** Contextual factors influence NIHL notification, particularly the presence of CERESTs and their qualification.

Keywords: Hearing Loss, Noise-Induced; Health Information Systems; Public Health Surveillance; Occupational Health; Ecological Studies.

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Introduction

Noise-induced hearing loss (NIHL) is one of the most widespread and prevalent occupational health problems in the world.¹⁻⁴ According to the World Health Organization (WHO), in 2000, NIHL accounted for 19.0% of the years lived with disability caused by all diseases and health conditions due to occupational factors worldwide.⁵ NIHL is listed in the International Statistical Classification of Diseases and Related Health Problems – 10th Revision (ICD-10) and is referred to by code H83.3.

Noise-induced hearing loss (NIHL) is one of the most widespread and prevalent occupational health problems in the world. According to the World Health Organization (WHO), in 2000, NIHL accounted for 19.0% of the years lived with disability caused by all diseases and health conditions due to occupational factors worldwide.

In Brazil, notification of NIHL on the Notifiable Health Conditions Information System (SINAN) is compulsory and is to be monitored by the Occupational Health Surveillance service (VISAT).⁶ In 2002 the Brazilian National Health System (SUS), responsible for VISAT, created the National Comprehensive Occupational Healthcare Network (RENAST), which includes 210 Occupational Health Referral Centers (CEREST) responsible for coordinating actions in regions, each one covering a set of municipalities.⁶ One of CEREST's duties is to act as a specialized support center for prevention, promotion and health care, ensuring the notification of work-related health problems on the information systems administered by the Informatics Department of the SUS (DATASUS), including SINAN.⁷ Despite the time that has elapsed since its inclusion in 2004, the number of NIHL cases reported on SINAN continues to be low,⁸ considering its prevalence found in studies conducted with samples or populations of specific companies.^{9,10}

No studies were found on factors associated with NIHL notification, but rather on factors that increased the notification of work injuries on SINAN (2008-2009) within the scope of CERESTs: adequate infrastructure; greater amount and supply of staff training; and meeting external demands.¹¹ In the municipality of Fortaleza, capital of the state of Ceará, the professionals' years of service at the sentinel units, participation in training courses regarding work-related injuries, knowledge of ordinances and legislation that support notification, understanding of the compulsory nature of notifications, and discussions on daily work subjects, were also identified as favorable characteristics for the notification of work-related injuries, between 2013 and 2014.¹²

Knowledge of these factors can support actions that favor the notification of NIHL on SINAN, contributing to its viability as a strategy for NIHL surveillance in the country. This study aimed to investigate contextual factors associated with the notification of NIHL in Brazil.

Methods

This was an ecological study on factors associated with the notification of NIHL in Brazil, between 2013 and 2015. According to data from the Brazilian Institute of Geography and Statistics (IBGE), the country had 202,768,562 inhabitants in 2014, and its economically active and occupied population – henceforth referred to as occupied population – corresponded to 99.4 million workers (49.0%).¹³ All 5,570 municipalities in the period, distributed over the country's 27 Federative Units, were observation units.

Once all NIHL cases reported in the study period had been identified, by municipality, the outcome variable was defined: notifying municipality – 'yes' (1) – when it presented at least one notification of NIHL; and non-notifying municipality - (0) - in the absence of notification. The 'notifying source' variable was used to indicate whether municipal notifications were recorded exclusively via CEREST, only by other routes (except CEREST), or by both sources.

The variables analyzed as potential predictors for the outcome were:

- a) CEREST coverage (yes; no);
- b) Municipality is home to a CEREST (yes; no);

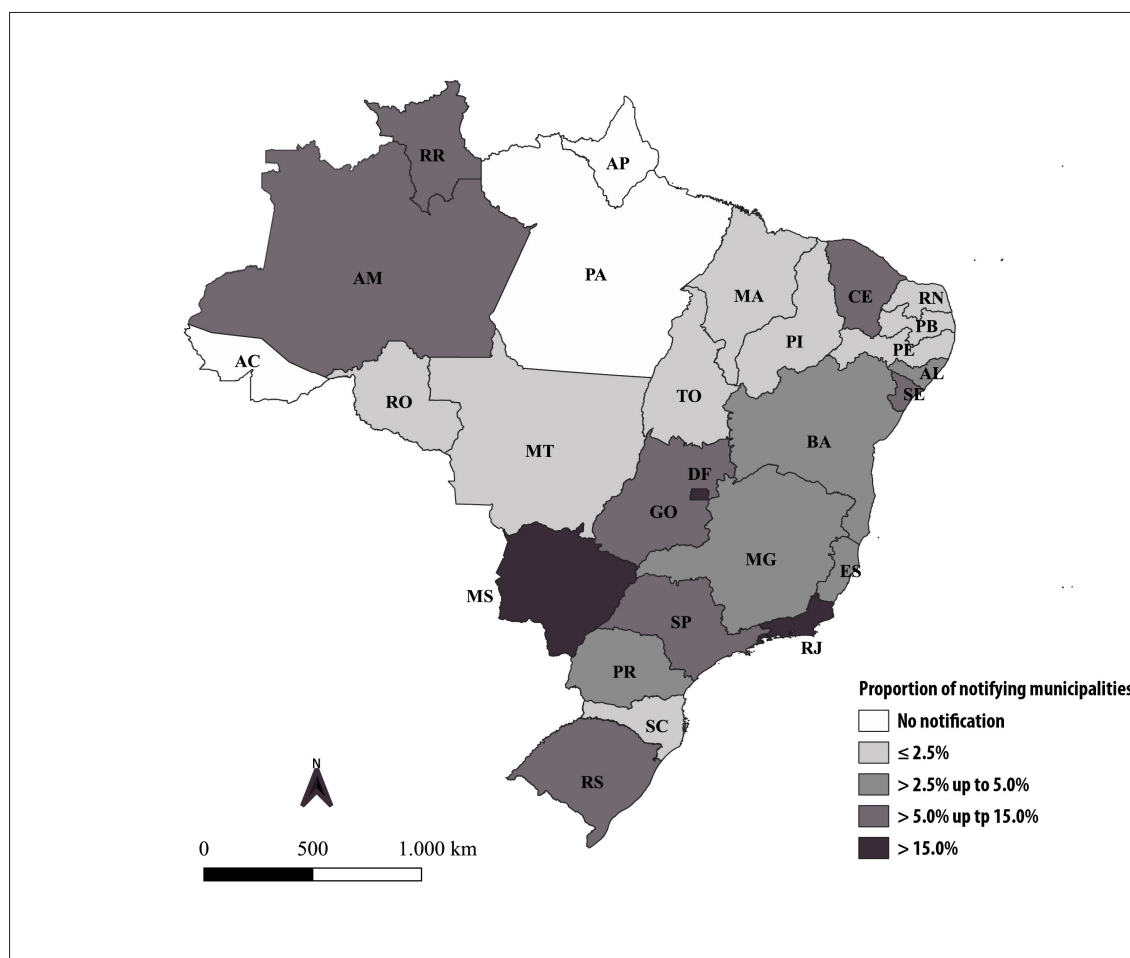
- c) Macro-region of the country (North; Northeast; Southeast; South; Midwest);
 - d) Federative Unit;
 - e) Distance from the municipality to the capital of the Federative Unit in kilometers (km), calculated by a line from the centroid of the geographic coordinates of the municipality and adjusted with the Euclidean factor, categorized by the median as (0) ≥ 275 or (1) < 275 ;
 - f) Territorial extension in square kilometers (km²) categorized based on median as (0) ≤ 418 and (1) > 418 ;
 - g) Occupied population, based on the 2010 census ($\leq 5,000$; > 5 to 20,000; > 20 to 50,000; > 50 to 100,000; $> 100,000$);
 - h) Workers in the manufacturing/mining/construction industries, which represent the proportion of workers in the municipality in these branches of activity, categorized as $< 15.0\%$ or $\geq 15.0\%$;
 - i) Workers in the manufacturing industry, categorized by the proportion $\leq 6.4\%$ or $> 6.4\%$, based on the median;
 - j) Workers in the mining industry, categorized as $\leq 0.1\%$ or $> 0.1\%$, based on the median;
 - k) Construction workers, categorized as $\leq 6.0\%$ or $> 6.0\%$, based on the median;
 - l) Workers with formal employment, categorized on the basis of the median, as $\leq 34.1\%$ or $> 34.1\%$, considering formal employment to be workers with a formal contract, military, statutory civil servants and employers, and taking informal employment to be self-employed people, production for self-consumption, unpaid and employees working off the books;
 - m) Municipal human development index (HDI-M), based on the 2010 census, categorized as low/very low (0.000 to 0.599), medium (0.600 to 0.699) or high/very high (0.700 to 1.000), based on the classification proposed by the *Atlas of Human Development in Brazil*.¹⁴
- For the municipalities with coverage, that is, belonging to the area covered by a given CEREST, the following variables were also analyzed:
- a) Year that the CEREST started operating, categorized by median, ≤ 2005 or > 2005 ;
 - b) Average number of CEREST team employees, calculated by the average National Health Establishment Registry (CNES) employee records for 2013 and 2015, categorized as < 10 or ≥ 10 , based on the legislation in force at the time, which established the minimum human resources for regional CERESTs;
 - c) Proportion of the team with statutory employment relationship, categorized as $\leq 50\%$ or $> 50\%$;
 - d) Average number of speech-language-hearing professionals in the CEREST team, calculated by the average number of speech-language-hearing professionals recorded on the CNES in 2013 and 2015, categorized as < 1 or ≥ 1 ;
 - f) Turnover in the team composition between 2013-2015, defined from the CNES nominal data, considering 'higher turnover' when more than one third of the professionals that made up the CEREST team in 2013 were not included on the list of the team professionals in 2015, and 'lower turnover' when this occurred for a maximum of one third of the professionals;
- The study's data sources included:
- a) Brazilian Institute of Geography and Statistics¹⁵ data for the year 2018, to obtain the list and codes of Brazilian municipalities and their territorial extension; and data for the year 2010, to obtain the size of the employed population, the proportion of workers with formal employment, the size and proportion of workers in the manufacturing/mining/construction industry and the HDI-M;
 - b) Google Maps,¹⁶ for the year 2018, to obtain the geographical coordinates of the municipalities;
 - c) NIHL notification database on SINAN (updated in August 2018), provided by the General Coordination of Occupational Health/Ministry of Health (CGSAT/MS) to the Collaborating Center for Occupational Health Conditions Surveillance/Integrated Environmental and Occupational Health Program, Institute of Public Health, Federal University of Bahia,¹⁷ to obtain the list of reported cases of NIHL, the calendar year of the notification, the notifying source and the municipality of residence;
 - d) Document on CEREST historical activities, provided by CGSAT/MS in January 2018, to access the calendar year of accreditation and cancelled accreditation of each CEREST;
 - e) RENAST Online Website¹⁸ (2014) and complementary document (October 2017),

provided by CGSAT/MS, to identify the municipalities in the area covered by each CEREST; f) National Health Establishment Registry (CNES)¹⁹ between 2013-2015, to obtain the composition of the CEREST teams.

In order to verify whether the variables were associated with the occurrence of NIHL notification in the municipalities, the number and proportion of notifying municipalities per calendar year and for the entire period 2013-2015 were described, according to the predictor variables; the measures of association between each of the outcome variables (notifying municipality) were estimated, using logistic regression to obtain the crude and adjusted odds ratio (OR) from the size of the occupied population (ORadj), and

respective 95% confidence intervals (95%CI); and multivariate analysis was conducted (iii) separately for the variable sets related to the municipalities and CERESTs. In the modeling, in addition to the occupied population, variables that presented p-value <0.20 were kept in the model, and those variables associated with the outcome considering an alpha ≤0.05 were kept in the respective final models of each dimension.

The database was organized from Excel spreadsheets® and the analyses were conducted using Stata statistical software, version 12.0. The QGIS version 2.6 georeferencing tool was used to build maps. The study project was approved by the Research Ethics Committee of the Institute of Public Health of the Federal University of Bahia (CEP/ISC/UFBA):



Legend: AC: Acre; AL: Alagoas; AM: Amazonas; AP: Amapá; BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espírito Santo; GO: Goiás; MA: Maranhão; MG: Minas Gerais; MS: Mato Grosso do Sul; MT: Mato Grosso; PA: Pará; PB: Paraíba; PE: Pernambuco; PI: Piauí; PR: Paraná; RJ: Rio de Janeiro; RN: Rio Grande do Norte; RO: Rondônia; RR: Roraima; RS: Rio Grande do Sul; SC: Santa Catarina; SE: Sergipe; SP: São Paulo; TO: Tocantins.

Figure 1 – Proportion of municipalities (N=5,570) notifying at least one case of noise-induced hearing loss on the Notifiable Health Conditions Information System, by Federative Unit, Brazil, 2013-2015

Certificate of Submission for Ethical Appraisal (CAAE) No. 93708218.0.0000.5030, opinion No. 2,799,319, issued on August 3, 2018. Free and Informed Consent was not required due to the public, aggregate and anonymous nature of the data.

Results

Of the 5,570 Brazilian municipalities, 277 (5.0%) reported cases of NIHL on SINAN in the period, expanding from 113 (2.0%) in 2013 to 164 municipalities (2.9%) in 2015, representing an increase of 45.1%. Among the Federative Units, Mato Grosso do Sul had the highest proportion of notifying municipalities (25.3%), followed by Rio de Janeiro (18.5%) and São Paulo (10.1%), while in Acre, Amapá and Pará, none of the municipalities notified NIHL in the period (Figure 1). Among the notifying municipalities, 42.0% notified NIHL only via CEREST, 52.8% only from other notification sources, and 5.2% notified it both via CEREST and other sources.

Considering all municipalities, 4,400 (79.0%) belonged to areas covered by CERESTs, with 3.2% of municipalities being home to a CEREST; most municipalities had up to 5,000 workers as their occupied population; and less than 15.0% of the workers were in the manufacturing, mining or construction industry. A quarter of the municipalities were classified as having very low/low HDI-M, among other characteristics (Table 1). Of the 4,400 municipalities located in the area covered by a CEREST, most of them had this unit in operation by 2005, on average teams had at least ten professionals, more than half of the team comprised of statutory employees and average number of speech-language-hearing professionals lower than one professional, in the period; and with team turnover greater than 33.3% (Table 2).

The proportion of municipalities notifying NIHL on SINAN increased with the increase in the size of the occupied population, from 1.4% in the group of municipalities with an occupied population $\leq 5,000$ inhabitants, to 4.0%, 11.0%, 33.3% and 56.0%, respectively to the occupied population $>5,000$ to 20,000, $>20,000$ to 50,000, $>50,000$ to 100,000 and $>100,000$ inhabitants. This variable was used to adjust the ORs in all analyses.

In the bivariate analysis, all variables related to the municipalities were associated with the outcome (Table 3). In the modeling for this dimension, two models were conducted separately: one including only 'workers in the manufacturing/mining/construction industries' variable, and another with each of the three worker variables of these industries, given that it was same-origin data, inducing collinearity. In both models, a higher proportion of the occupied population in these branches of activity was not a factor associated with the notification of NIHL by the municipalities. In the final model, they remained positively associated with the outcome: having CEREST coverage; being home to a CEREST; belonging to the Midwest region; being closer to the state capital; and having high/very high HDI-M (Table 3). Belonging to the Northern region was negatively associated with the outcome.

All variables related to CERESTs were associated with the outcome in the bivariate analysis, except for the proportion of team members with a statutory employment relationship (Table 4). In the final model, they remained positively associated with the outcome: having at least one speech-language-hearing professional in the CEREST team; and the team having lower staff turnover (Table 4).

Discussion

In Brazil, between 2013 and 2015, few municipalities notified NIHL on SINAN. The factors that were positively associated with being a notifying municipality were: being a municipality that was home to a CEREST or having CEREST coverage, being close to the state capital and having high HDI-M. While municipalities located in the Midwest region notified NIHL more often, in comparison with other regions, the opposite was observed in the Northern region. Among the municipalities with coverage, that is, located in an area covered by a CEREST, the factors that positively influenced the notification of NIHL were low staff turnover and the presence of a speech-language-hearing professional in the CEREST team.

Although only one out of 20 municipalities notified NIHL during the study period, the increase of notifying municipalities between 2013 and 2015 was significant. This increase is compatible with the implementation and expansion of CERESTs in Brazil. There has been an increase in the number of CERESTs since 2002,

Table 1 – Distribution of municipalities (N=5,570) according to contextual variables related to the municipality, Brazil, 2013-2015

Variables	N	%
Cerest^a Coverage		
No	1,170	21.0
Yes	4,400	79.0
Municipality home to a Cerest^a		
No	5,392	96.8
Yes	178	3.2
Macro-region		
North	450	8.1
Northeast	1,794	32.2
Southeast	1,668	29.9
South	1,191	21.4
Midwest	467	8.4
Distance to the capital (km)		
≥275.0	2,781	49.9
<275.0	2,789	50.1
Territorial extension (km²)		
≤418	2,785	50.0
>418	2,785	50.0
Occupied population (workers)^b		
≤5,000	2,942	52.9
5,001 - 20,000	1,973	35.4
20,001 - 50,000	399	7.2
50,001 - 100,000	126	2.3
>100,000	125	2.2
Workers in manufacturing/mining/construction industries (%)		
<15.0	2,974	53.4
≥15.0	2,596	46.6
Workers in manufacturing industry (%)		
≤6,4	2,785	50.0
>6,4	2,785	50.0
Workers in mining industry (%)		
≤0.1	2,871	51.5
>0.1	2,699	48.5
Construction workers (%)		
≤6.0	2,796	50.2
>6.0	2,774	49.8
Workers with formal employment (%)		
≤34.1	2,780	50.0
>34.1	2,785	50.0

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Continuation

Table 1 – Distribution of municipalities (N=5,570) according to contextual variables related to the municipality, Brazil, 2013-2015

Variables	N	%
Municipal human development index (HDI-M)^b		
Low/very low	1,399	25.1
Medium	2,263	40.7
High/very high	1,903	34.2

a) CEREST: Occupational Health Referral Center; b) Five missing data because the municipalities were created after the 2010 census.

Table 2 – Distribution of municipalities covered by CERESTs^a (N=4,400) according to contextual variables related to CERESTs^a and their teams, Brazil, 2013-2015

Variable	N	%
Year Reference Cerest^a accredited		
>2005	2,158	49.1
≤2005	2,242	50.9
Average number of team members (2013–2015)		
<10	1,557	35.4
≥10	2,843	64.6
Team members with statutory employment relationship (%)		
≤50.0	1,926	43.8
>50.0	2,474	56.2
Average number of speech-language-hearing professionals (2013-2015)		
<1	2,837	64.5
≥1	1,563	35.5
Team^b turnover		
Higher turnover (>33,3%)	2,261	52.8
Lower turnover (≤33,3%)	2,020	47.2

a) CEREST: Occupational Health Referral Center; b) 119 missing data due to the absence of records for the years 2013 and 2015, both data necessary for the calculation.

when the first 17 in the country were accredited.^{6,20} However, even reaching 210 units in 2011,²¹ 1,170 Brazilian municipalities had still not been covered by CEREST during this study.

In three states, Acre, Amapá and Pará, there were no NIHL notifying municipalities between 2013 and 2015, in contrast to Mato Grosso do Sul, Rio de Janeiro and São Paulo, which had the highest proportions of notifying municipalities. It can be seen that between 2007-2009, NIHL notifications were absent (n=8) or fewer than ten reported cases (n=12) in 20 of the 27 Federative Units.⁸ It can be inferred that there has been an evolution, although it has shown quite different

situations in the national territory. In the Southeast region, where there is important industrial activity, it is possible to see the development of systematic occupational health programs and actions,²⁰ significant scientific production in the area²² and an earlier history of CERESTs being accredited.²³ São Paulo was the first state to have a regional network of CERESTs in operation,²³ and six (35.3%) of the first 17 CERESTs implemented in 2002, were located in the state of São Paulo and the remainder in Minas Gerais, Rio Grande do Sul and Bahia.⁶ In the regions with higher density of workers – Southeast, South and Northeast – there is a higher concentration of

Table 3 – Proportion of municipalities (N=5,570) that reported noise-induced hearing loss (NIHL) on the Notifiable Health Conditions Information System, odds ratio and multivariate analysis, according to contextual variables related to the municipality, Brazil, 2013-2015

Variables	N	Reported NIHL		Measures of association				Final model ^a	
				Crude		Adjusted by occupied population ^a			
		N	%	OR ^b	95%CI ^c	OR ^b	95%CI ^c	OR ^b	95%CI ^c
Brazil	5,570	277	5.0						
Cerest^d Coverage									
No	1,170	23	2.0	1.00		1.00		1.00	
Yes	4,400	254	5.8	3.06	1.98;4.70	1.81	1.15;2.83	1.62	1.02;2.59
Municipality home to a Cerest^d									
No	5,392	186	3.4	1.00		1.00		1.00	
Yes	178	91	51.1	29.28	21.08;40.65	3.90	2.52;6.05	4.37	2.75;6.93
Macro-region									
North	450	7	1.6	0.47	0.21;1.04	0.35	0.15;0.81	0.32	0.13;0.79
Northeast	1,794	58	3.2	1.00		1.00		1.00	
Southeast	1,668	124	7.4	2.40	1.75;3.31	1.64	1.16;2.34	1.39	0.87;2.23
South	1,191	46	3.9	1.20	0.81;1.78	1.07	0.70;1.65	0.85	0.50;1.46
Midwest	467	42	9.0	2.96	1.96;4.46	3.49	2.22-5.46	2.84	1.65;4.90
Distance to the capital (km)									
≥275.0	2,781	89	3.2	1.00		1.00		1.00	
<275.0	2,789	188	6.7	2.19	1.69;2.83	1.34	1.01;1.78	1.43	1.06;1.92
Territorial Extension (km²)									
≤418	2,785	115	4.1	1.00		1.00			
>418	2,785	162	5.8	1.43	1.12;1.83	0.95	0.72;1.26		
Workers in manufacturing/mining/construction industries (%)									
<15.0	2,974	70	2.4	1.00		1.00			
≥15.0	2,596	207	8.0	3.59	2.73;4.74	1.64	1.20;2.25		
Workers in manufacturing industry (%)									
≤6.4	2,785	65	2.3	1.00		1.00			
>6.4	2,785	212	7.6	3.45	2.60;4.58	1.72	1.26;2.35		
Workers in mining industry (%)									
≤0.1	2,871	114	4.0	1.00		1.00			
>0.1	2,699	163	6.0	1.55	1.22;1.99	1.18	0.90;1.55		
Construction workers (%)									
≤6.0	2,796	67	2.4	1.00		1.00			
>6.0	2,774	210	7.6	3.34	2.52;4.42	1.42	1.03;1.95		
Workers with formal employment (%)^e									
≤34.1	2,780	50	1.8	1.00		1.00			
>34.1	2,785	227	8.2	4.85	3.55;6.61	2.00	1.41;2.83		

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Continuation

Table 3 – Proportion of municipalities (N=5,570) that reported noise-induced hearing loss (NIHL) on the Notifiable Health Conditions Information System, odds ratio and multivariate analysis, according to contextual variables related to the municipality, Brazil, 2013-2015

Variables	N	Reported NIHL		Measures of association				Final model ^a	
				Crude		Adjusted by occupied population ^a			
		N	%	OR ^b	95%CI ^c	OR ^b	95%CI ^c	OR ^b	95%CI ^c
Municipal human development index (IDH-M)^{e,f}									
Low/very low	1,399	16	1.1	1.00		1.00		1.00	
Medium	2,263	74	3.3	2.92	1.70;5.04	2.37	1.36;4.11	1.81	0.98;3.32
High/very high	1,903	187	9.8	9.42	5.63;15.77	3.44	1.99;5.94	2.35	1.16;4.75

a) Adjustment by the occupied population size (2010 Census) in five categories; b) OR: odds ratio; c) 95%CI: 95% confidence interval; d) CEREST: Occupational Health Referral Center; e) Five missing data because the municipalities were created after the 2010 census; f) P-trend = 0.0175.

Table 4 – Proportion of municipalities covered by CERESTs^a (N=4,400) that reported noise-induced hearing loss (NIHL) on the Notifiable Health Conditions Information System, odds ratio and multivariate analysis, according to contextual variables related to CERESTs^a and their teams, Brazil, 2013-2015

Variables	N	Reported NIHL		Measures of association				Final model ^b	
				Crude		Adjusted by occupied population ^b			
		N	%	OR ^c	95%CI ^d	OR ^c	95%CI ^d	OR ^c	95%CI ^d
Municipalities covered by Cerests^a	4,400	254	5.8						
Year Cerests accredited									
>2005	2,158	103	4.8	1.00		1.00			
≤2005	2,242	151	6.7	1.44	1.11;1.86	1.19	0.90;1.59		
Average number of team members (2013-2015)									
<10	1,557	70	4.5	1.00		1.00			
≥10	2,843	184	6.5	1.47	1.11;1.95	1.30	0.95;1.77		
Team members with statutory employment relationship (%)									
≤50.0	1,926	108	5.6	1.00		1.00			
>50.0	2,474	146	5.9	1.06	0.82;1.36	1.02	0.77;1.36		
Average number of speech-language-hearing professionals (2013-2015)									
<1	2,837	135	4.8	1.00		1.00		1.00	
≥1	1,563	119	7.6	1.65	1.28;2.13	1.96	1.47;2.61	1.96	1.47;2.63
Team turnover^e									
Higher turnover (>33,3%)	2,261	96	4.2	1.00		1.00		1.00	
Lower turnover (≤33,3%)	2,020	157	7.8	1.90	1.46;2.47	1.85	1.38;2.47	1.88	1.40;2.52

a) CEREST: Occupational Health Referral Center; b) Adjustment by occupied population size (2010 Census) in five categories; c) OR: odds ratio; d) 95%CI: 95% confidence interval; e) 119 missing data due to the absence of records for 2013 and 2015, both necessary for the calculation.

CERESTs, while in the North and Midwest regions there is a limited number of units.²⁰ Nevertheless, the Midwest stood out with the highest proportion of NIHL notifying municipalities, a possible consequence of well-structured implementation of surveillance and well-structured flow of case notification in the areas covered by CERESTs. Consistently with this, a study conducted in Brazil on the evolution of notification of serious work injuries on SINAN, between 2007 and 2011, showed the Midwest region as having the highest proportion of notifying municipalities (9.7%) among the macro-regions in 2007, reaching 31.1% in 2011, representing significant growth.²⁴

In this study, the municipalities closest to the state capitals notified a greater proportion of cases, compared to those farthest from the capitals. This finding may be related to the presence of a stronger health system, greater access of professionals to continuing education, presence of an occupational health reference technician, actions implemented for health promotion and disease prevention, greater supervision of work environments, and other contributory factors. The proposal for a new model of CEREST organization²⁵ considers different levels of technical reference on occupational health, and the functioning of the network should be planned according to municipal population size. This reorganization may minimize difficulties generated by municipalities being distant from large centers, with greater service capillarization, contributing to the increase of occupational health notifications on SINAN. Notifications can also be enhanced in municipalities through implementation of decentralized Intersectoral Occupational Health Commissions.²⁵

High HDI-M was also a factor associated with NIHL notification by the municipalities, with an increase in gradient. The higher the HDI-M, the better the living conditions, the greater the access to knowledge and the better the standard of living measured by municipal *per capita* income.¹⁴ These qualities can contribute to good organization of health surveillance information in the territories. In contrast, although low HDI generally reflects the worst morbidity and mortality estimates, notification of NIHL was less frequent in these municipalities, which may suggest a hypothesis that case underreporting is more prevalent in municipalities that offer a poor quality of life to their citizens.

Among the municipalities covered by CERESTs, having at least one speech-language-hearing professional in the team was a factor associated with NIHL notification. Consistently with this, health surveillance actions directed towards NIHL and work-related voice disorders were reported by the General Coordination of the CERESTs as habitual in the daily work of these professionals (73.7%).²⁶ The speech-language-hearing professional, a professional with technical knowledge and experience in the management of NIHL cases, is able to identify the type of hearing loss and discuss with the team its possible relationship with work. Although the number of these professionals in the teams has been increasing since 2002, the majority of CEREST units (51.9%) did not have a speech-language-hearing professional in 2014.²⁶

With regard to the factors related to CEREST coverage in the municipalities, the factor most strongly associated with NIHL notification was lower CEREST work team turnover. That is, higher team turnover seems to impair surveillance actions. Health professional turnover is one of the problems faced by the CERESTs because it interferes with team integration and with worker's healthcare.²⁷ A study conducted in Minas Gerais,²⁸ from 2002 to 2007, focusing on regional CEREST performance, found that almost three quarters of the workers who made up the CEREST team had a permanent employment relationship, that being a proportion higher than that identified in this study. RENAST's new reorganization proposal indicates the need for a mostly multi-professional team to be hired through a public competitive selection process and to have a fixed employment relationship.²⁵ The measure may contribute to a lower turnover in the CERESTs' technical and managerial teams and, as a result, better development of surveillance actions, including notifications of diseases and health conditions on SINAN. It is worth noting, however, that although a permanent employment relationship favors a certain stability in the teams' composition, it does not guarantee low staff turnover, given that there may be employee allocation mobility.

Achieving 100% of health regions with at least one CEREST operating by 2019, was a goal established in 2015 by the Ministry of Health Multiannual Plan and National Health Plan (2016-2019).²⁹ Although this goal had not been achieved, Resolution No. 603 was

published on November 8, 2018,²⁵ containing a proposal to reorganize Comprehensive Occupational Health in the SUS, the objective of which was to develop a new organizational model for the CERESTs. In this model, each Health Region would have at least one regional CEREST as a technical support for its municipalities. Considering the relevance of CERESTs for occupational health surveillance ratified by this study, its expansion is one of the strategies for ensuring institutional, technical and pedagogical support for occupational health in the territory in which it provides coverage. However, it is worth mentioning that there are factors that impact the functioning of the CERESTs, and that only having one unit operating neither guarantees working to full potential capacity, nor provision of services to the population with the equity, quality and efficiency that is expected.²⁰

Among the limitations of this study, data quality may have been affected by incompleteness and inconsistency, as it is secondary data from information systems. Moreover, the absence of notification in very small municipalities, as opposed to potential underreporting, could simply mean non-occurrence of NIHL cases during the study period. As such, the model was adjusted according to occupied population size, as a strategy to minimize possible bias in the results. It is noteworthy that this is the first epidemiological study dedicated to investigating contextual factors associated

with NIHL notification in Brazil and to adopt the strategy of using of several public data sources.

Contextual factors influence NIHL notification the municipalities. It is worth noting that most of these factors refer to the existence and qualification of occupational health care services. The study provides evidence that can contribute to strategy planning for strengthening NIHL notification, and therefore, reduce the underreporting of this health condition on SINAN. Possible recommendations include the expansion of the number of CERESTs, greater service capillarization, training courses for notification that reach the entire national territory, greater investment in surveillance in municipalities with low human development index, presence of speech-language-hearing professionals and measures to reduce team turnover in Occupational Health Referral Centers.

Authors' contributions

Gusmão AC and Ferrite S collaborated with the concept and design of the study, data analysis and interpretation, and drafting the first version of the manuscript. Meira TC collaborated with data analysis and interpretation, and critical reviewing of the manuscript. All authors have approved the final version of the manuscript and have declared themselves to be responsible for all aspects of the work, including ensuring its accuracy and integrity.

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