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► **To cite this version:**

Sofia Temam, Nathalie Billaudeau, Sofiane Kab, Marie Zins, Marie-Noël Vercambre. Occupational noise, work-related stress, and teachers' health in the French CONSTANCES study. *Noise and Health*, 2024, 26 (123), pp.523-534. 10.4103/nah.nah_10_24 . hal-04953571

HAL Id: hal-04953571

<https://hal.science/hal-04953571v1>

Submitted on 18 Feb 2025

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Occupational noise, work-related stress, and teachers' health in the French CONSTANCES study

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Abstract

Objective: Besides psychosocial stressors, teachers are exposed to disturbing noise at work, such as students' irrelevant speech. Few studies have focused on this issue and its health consequences. We explored occupational noise exposure among teachers within the French workforce and analyzed how noise and work-related stress are related to their health. **Materials and Methods:** The prevalence of perceived noise exposure, evaluated through the question "Do you work in an environment where you sometimes have to raise your voice to talk to people 2 to 3 m away?" was compared between teachers ($n = 13,843$) and various occupational groups ($n = 34,338$) using inclusion data (2012–2020) from the ongoing French population-based CONSTANCES cohort (>217,000 participants). Additionally, the relationships between perceived noise and two health dimensions, perceived health (poor vs. good) and depressive symptoms (Centre for Epidemiologic Studies-Depression Scale, high vs. low/moderate), among teachers were alternately investigated using logistic regressions. Moreover, how perceived noise may interact with work-related stress (effort–reward imbalance/strained relationships) was explored. **Results:** Thirty-two percent of teachers reported working in a noisy environment, compared with 14% of noneducation employees ($P < 0.001$). Primary school teachers were the most likely to report noise exposure (43%). Independent of stress, teachers exposed to noise had poorer perceived health and higher odds of depressive symptoms than nonexposed teachers, with odds ratios (95% confidence interval) of 1.21 (1.07; 1.37) and 1.14 (1.01; 1.28), respectively. Evidence of an interaction between perceived noise and strained relationships was observed on perceived health ($P = 0.05$). **Conclusion:** French teachers commonly reported disturbing noise at work, and those exposed showed poorer health indicators, particularly when facing strained relationships. The findings call for further studies on noise in schools, especially longitudinal studies, to ascertain its long-term effect on teachers' health and its potential interaction with the psychosocial environment.

Keywords: Occupational noise, Work-related stress, Health status, Mental health, Teachers

KEY MESSAGES

- (1) In this nationwide study of French employees, exposure to occupational noise, assessed as an interference with speech communication, was more than twice as likely among teachers than non-education employees, and especially common among primary school teachers.
- (2) Occupational noise was associated with poorer perceived health and higher odds of depressive symptoms among teachers, particularly when also exposed to strained interpersonal relationships.
- (3) Further studies, particularly longitudinal, are warranted, to better document occupational noise and its health consequences, direct or through interaction, from the teachers' perspective.
- (4) Developing preventative actions at school against both strained relationship and noise would contribute to promote the quality of life of both teachers and the youth.

INTRODUCTION

Noise is one of the most common exposures at work,^[1] and it has been linked with a range of not only negative health effects, including physical outcomes, especially auditory impairment,^[2] but also psychological effects such as sleep disturbance.^[3] Even at a lower noise level of 85 decibels (dB) over 8 hours, which is the European criterion of occupational noise harmfulness for hearing impairment,^[1] auditory and nonauditory health effects were found,^[1,3] including tinnitus,

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Received: 16 January 2024 **Revised:** 25 April 2024
Accepted: 1 July 2024 **Published:** 30 December 2024

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How to cite this article: Temam S, Billaudeau N, Kab S, Zins M, Vercambre M-N. Occupational noise, work-related stress, and teachers' health in the French CONSTANCES study. *Noise Health* 2024;26:523–34.

Access this article online

Quick Response Code:



Website:
www.noiseandhealth.org

DOI:
10.4103/nah.nah_10_24

hyperacusis,^[4] voice disorders, annoyance, stress,^[1] and increased risk of long-term sickness absence.^[5]

As an intellectual profession exposed to a large number of young people, teachers are among the nonindustrial occupational groups that could be particularly exposed to disturbing noise at work.^[6] The different types of noise to which they are exposed, mainly from students, including inappropriate chatter, classroom hubbub, shouts, and noisy games in the playground, are rather specific and may considerably interfere with the teaching task.^[7] In the Danish Work Environment Cohort Study, 64% of teachers reported to be exposed to loud noise for at least one-fourth of the working hours compared with 32% of Danish employees.^[8] Consistently, studies with objective noise measurements found that classroom noise, mainly in primary schools, can exceed 85 dB.^[9-12] Excessive noise in classrooms could create inappropriate conditions for learning and teaching.^[13] While extensive data support the negative effect of noise at school on the wellbeing of young people,^[12,13] the potential consequences on teachers' health and wellbeing have received limited attention.^[14] Nonindustrial and mainly female-dominated work environments, such as education, are largely overlooked in terms of noise research, even though this nuisance may interfere with well-being and performance.^[14] Existing studies have mainly focused on the association between occupational noise and voice disorders,^[6,15,16] with the latter being highly prevalent and disabling among teachers. In terms of other auditory and nonauditory health symptoms, one study in Sweden suggested that preschool female teachers had a higher prevalence of hearing-related symptoms, including auditory fatigue, tinnitus, and hyperacusis, than women in the general population.^[14] Lindblad *et al.*,^[11] who compared the prevalence of auditory dysfunctions in different occupational groups, found that teachers had auditory dysfunctions to the same extent as manual workers exposed to industrial noise. However, data concerning the potential effects of noise on teacher's general health and mental well-being are scarce.^[6]

Some data pointed to an interaction effect of occupational noise exposure and work-related stress on health.^[17] Teaching, as a human service profession, involves many sources of stress that pertains to emotional job demands, exposure to threats and violence, high responsibility, and job complexity.^[18-20] Hence, as a psychosocial stressor,^[21] noise exposure could exacerbate the well-documented deleterious effect of work-related stress on teachers' health.^[22,23] However, this issue has been seldom studied specifically.^[14]

To the authors' knowledge, no epidemiological study has investigated the extent to which teachers are disturbed by noise at work in France and what the consequences could be for their health and well-being. Studies comparing teachers' noise exposure to that of other occupations are lacking. The French CONSTANCES cohort for occupational and environmental epidemiology provides an original

nationwide perspective,^[24] and the inclusion data from this large cohort were used to test the authors' hypotheses: firstly, teachers are more likely to report disturbing noise at work than nonteachers; secondly, perceived noise exposure is associated with worsened general and mental health among teachers, and work-related stress exacerbates this deleterious effect.

METHODS

CONSTANCES Cohort

Data from the French CONSTANCES study, a large population-based cohort whose aim is to contribute to the development of epidemiologic research, were used in this study. Details about the study design and methods have been extensively discussed.^[24] In brief, CONSTANCES (www.constances.fr) is an ongoing prospective population-based cohort of more than 217,000 participants aged 18 to 69 years at inclusion, randomly selected from the National Health Insurance Fund (*CNAM: Caisse Nationale d'Assurance Maladie*). This cohort covers professionally active or retired employees and their families, i.e., almost 85% of the French population (agricultural and self-employed workers, who are covered by another fund, are not included).^[24] Baseline data were collected between 2012 and 2020 through extensive medical examinations and several self-administered questionnaires covering personal, environmental, behavioral, occupational, social, and medical factors.

ESTER Study

This analysis is part of the ESTER study (*Étude Santé-Travail dans l'Enseignement et la Recherche*; "occupational health study in education and research"), a subproject of the CONSTANCES cohort. ESTER, which focuses on a CONSTANCES subpopulation, was specifically designed to investigate the occupational risks and work-related health determinants of education and research professionals *per se* and in comparison with other occupational groups.^[25] As part of the ESTER study, all education and research professionals actively employed ($n=19,219$) were comprehensively identified among participants who were actively employed and enrolled in CONSTANCES until June 2020, by using the French nomenclature of occupations and socioprofessional categories (PCS2003) from the National Institute of Statistics and Economic Studies and the classification used by the French Ministry of Education and Research. The a priori targeted professions included teachers, school managers, school health staff, school technical staff, researchers, research assistants and research support staff. Twice as many active employees involved in sectors other than education and research ($n=38,775$) were randomly selected from the remaining CONSTANCES participants and added to the exhaustive sample of education and research professionals for comparison purposes [Figure 1].

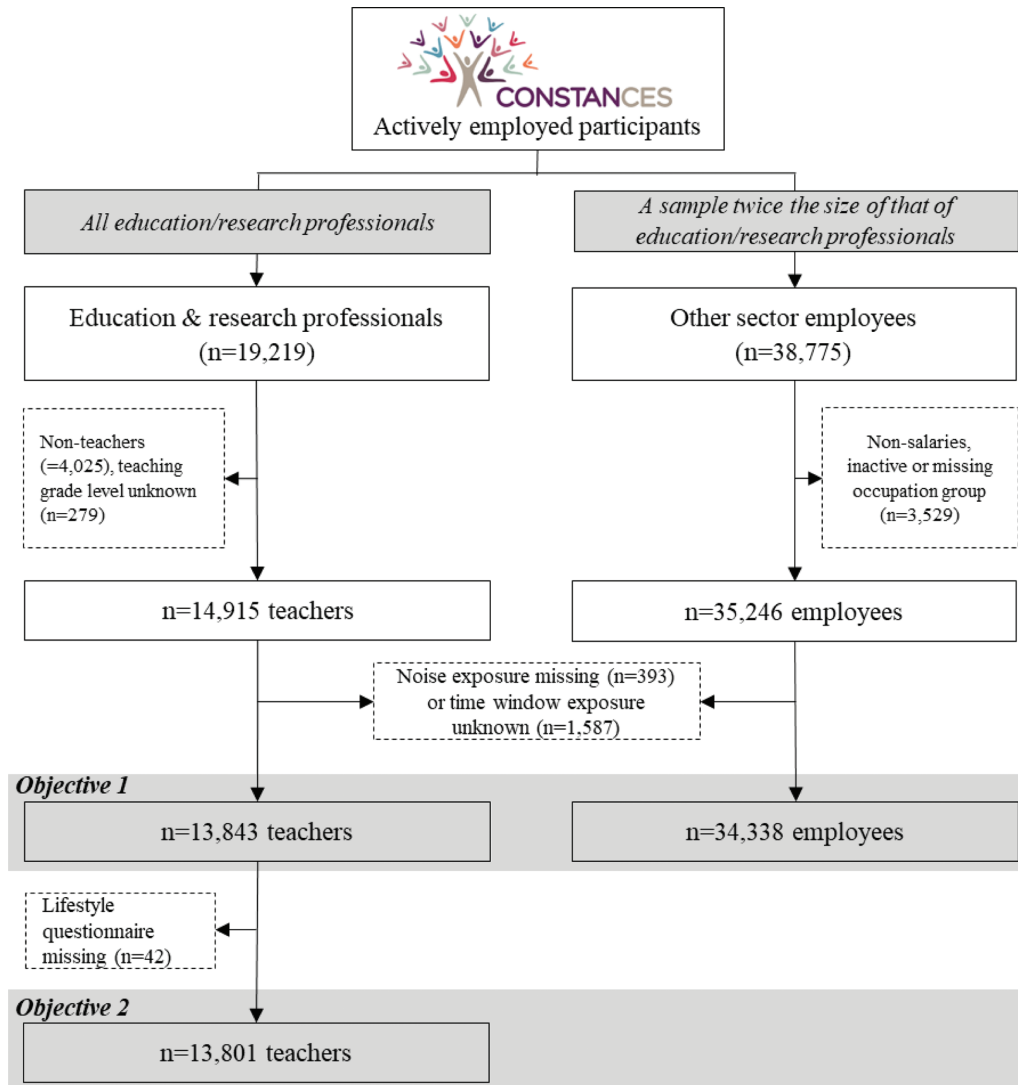


Figure 1: Flowchart of the study population (dashed boxes refer to excluded participants).

Participants

The first objective was to assess how French teachers are exposed to disturbing noise at work compared with other French employees. The study included 13,843 teachers and 34,338 noneducation employees, and the latter group was secondarily categorized by socioprofessional groups, including executives and higher intellectual professions, intermediate professions, clerks, and manual workers. The second objective was to investigate the extent to which disturbing noise at work was related to teachers' health, and to test the putative interaction effect with work-related stress. Forty-two teachers who did not complete the lifestyle questionnaire, which was used to assess health outcomes, were further excluded. Thus, 13,801 teachers were included in this second objective [Figure 1].

question “Do you work in an environment where you sometimes have to raise your voice to talk to other people within 2 or 3 meters of you?” (yes/no). This question, which captures the noise exposure by assessing interference with speech communication, has been shown to be effective in estimating noise levels within the workplace.^[26] Participants who answered “yes” were asked to specify the exposure period. For evaluating current job exposure, participants were considered “exposed” if (1) they answered “yes” to the question on noise exposure and (2) the exposure period declared was concomitant with the current job period. Participants were considered “unexposed” if they answered “no”, or “yes” but with an exposure period prior to the current job [Figure 2].

Perceived Occupational Noise Exposure

Perceived occupational noise exposure was defined by asking about noise exposure at work through the

Health-related Outcomes

For health outcomes, perceived health status was firstly considered on the basis of the question “How would you

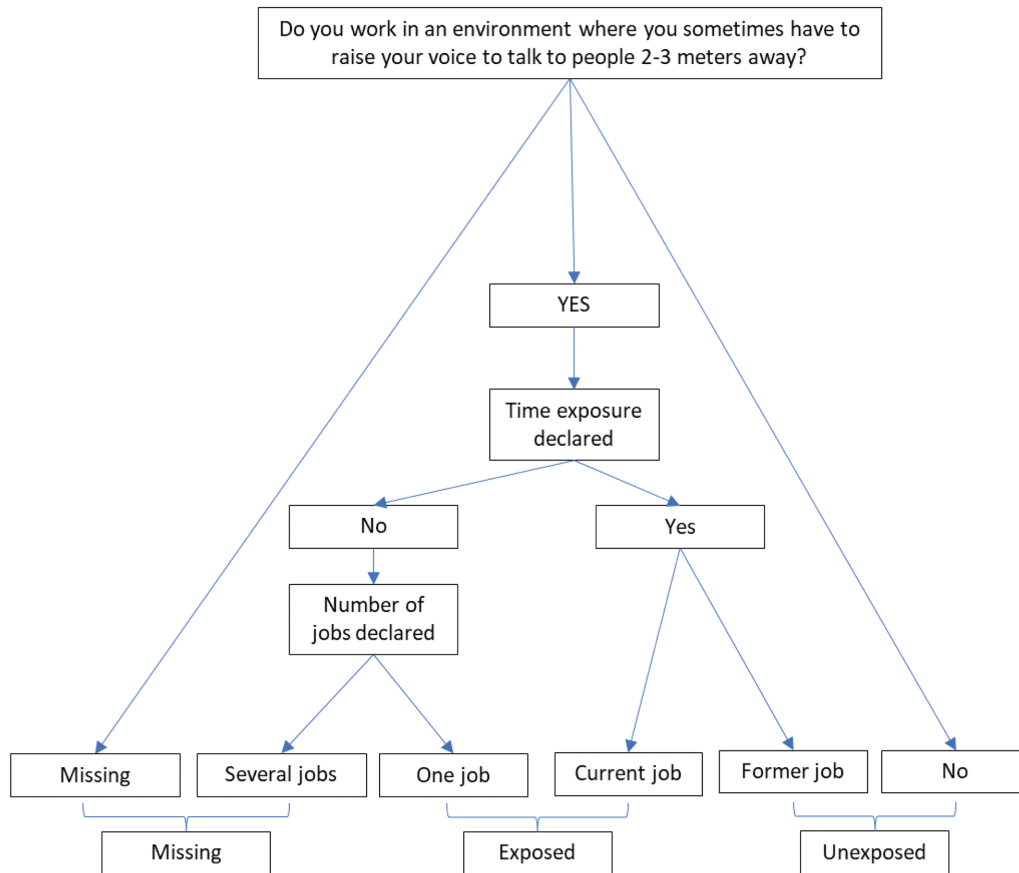


Figure 2: “Decision tree” to define the perceived occupational noise exposure status of respondents, ESTER-CONSTANCES study, baseline data.

rate your general health?” Responses were graded on an eight-point Likert scale ranging from “A-very good” to “H-very poor” and dichotomized as “good” (A–C) and “poor” (D–H). Secondly, given that noise acts as a psychosocial stress factor likely to affect the psychological dimension of health,^[27] the mental health status was assessed using the French version of the Centre for Epidemiologic Studies-Depression scale.^[28] This psychometric questionnaire evaluates the frequency of depressive symptoms during the previous week (20 items, score range: 0–60), and it has shown good internal consistency in the CONSTANCES setting.^[29] A higher score indicated a higher risk of clinical depression. Individuals with a score of ≥ 16 for men and 20 for women were classified as being at high risk of depression.^[28]

Work-related Stress

Two complementary work-related stress indicators available in the CONSTANCES setting were considered to investigate the potential interaction effect between noise and stress. Firstly, the effort–reward ratio, derived from the effort–reward imbalance (ERI) model^[30] and validated in the CONSTANCES cohort,^[31] was considered. As recommended, respondents with an effort–reward ratio > 1 (i.e., inadequate rewards relative to efforts) were considered exposed to work-related stress.^[31,32] Secondly, a variable evaluating “strained relationships with the public” was

considered. This psychosocial risk factor, which induces work-related stress,^[33] is particularly encountered by teachers in contact with students and their families. A binary variable was defined based on two questions: “Are you in contact with the public (users, patients, travelers, clients, etc.) every day or almost every day, directly or by phone?” (yes/no) and “If yes, do you experience stressful situations in your relations with this public?” (no or almost never, rarely, often, always, or almost). A variable in three classes (“no or almost never”/“rarely”/“often, always or almost”) was created to have balanced proportions in each category, hereinafter called “strained relationships.”

Additional Variables

In addition to work-related stress indicators, several factors were considered as potential confounders in the association between noise and health to estimate how noise affects health independent of sociodemographic characteristics and occupational environment: (1) sociodemographic factors: age, sex, relationship status (yes/no), living with children (yes/no), financial difficulties (never, in the past, and currently), and urbanicity of residence (city center, suburbs, and rural/remote municipalities); (2) occupational-related factors: teaching level (primary, i.e., pre-school/elementary, secondary, and higher education) and company size (< 50 and ≥ 50 employees), as a proxy for school size.

Statistical Analysis

Firstly, a logistic regression model adjusted for sex and age was used, with noise exposure (yes/no) as the outcome, to formally assess the statistical differences between the proportions of participants exposed to noise according to their occupational group, overall (teachers vs. other occupational groups), and then across occupational groups (with the “manual workers” group as the reference). Secondly, among the sample of teachers, a mutually adjusted logistic regression model was used, with noise exposure (yes/no) as the outcome, to investigate how sociodemographic and occupational factors available in the CONSTANCES context were associated with perceived occupational noise. Finally, logistic regressions were used for the two health indicators, adjusting for the ERI ratio, strained relationships, sex, age category (<35, 35–49, and ≥50 years old) and teaching level (model 1) and then additionally for all other potential confounders previously outlined (model 2), to evaluate the potential health effect of noise independent of potential confounders. The hypothesis of an interaction between noise and each indicator of work-related stress was formally tested using an interaction term between the two parameters.

Missing Values

The rates of missing values were ≤3% for health outcomes and work-related stress indicators. Participants with missing values were alternately excluded, resulting in a slightly different sample size each time in the descriptive analysis. No missing values for age, sex, and teaching level (among teachers) were found. For the other covariates, the rates of missing values were consistently <5%. These covariates were imputed by turn, to limit sample attrition, with the

most common value of the covariate observed in the entire sample, or specifically for the company size, in accordance with the teaching level.

Sensitivity Analyses

Several sensitivity analyses were performed to check the robustness of the results. Analyses were conducted to test potential exposure misclassification by alternately excluding from among the 13,801 teachers the following: (1) teachers who reported no contact with the public (*n* = 1374) to focus only on teachers who reported being in contact with the public; (2) teachers who reported past noise exposure (*n* = 560) to examine the difference between currently exposed teachers and those who were never exposed. Moreover, the main models were run without imputing missing values (“complete case analysis”) to assess potential bias due to imputation choices, and the resulting coefficients were compared with those from the imputed dataset. The same sensitivity analyses were conducted in models with the interaction term. All analyses were conducted using Stata 17 (Stata Statistical Software: Release 17., Stata Corp, College Station, TX).

RESULTS

Compared with the national statistics, the study population was comparable in terms of sex ratio across different socioprofessional groups, but overall, the intermediate age category was slightly over-represented [Table 1]. Compared with the other socioprofessional groups included in this study, teachers were highly feminized, especially in pre-school/elementary school (“primary school teachers”). Regarding noise exposure, 32% of teachers reported working in a noisy environment compared with 14%

Table 1: Distribution of Key Characteristics of the ESTER-CONSTANCES Study Participants Included in This Study and Comparison with National Statistics.*

	Teachers			Other occupational groups			
	Primary School	Secondary School	Higher Education	Executives and Higher Intellectual Professions	Intermediate Professions	Clerks	Manual Workers
Percentage of women							
Study population	83	60	42	41	56	72	18
National statistics*	84	60	39	42	54	75	20
Percentage by age category							
Study population							
<35	18	12	13	26	23	28	23
35–49	60	54	56	46	45	42	43
≥50	22	34	31	28	32	30	34
National statistics*							
<35	22	18	6	27	31	33	35
35–49	51	44	48	40	41	34	35
≥50	27	38	46	33	28	33	30

*National statistics are extracted from the reference book annually published by the French Ministry of Education (2019) for the teachers and from the national survey *Enquête Emploi 2019*, INSEE, for the other occupational groups.

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Table 2: Comparison of Perceived Occupational Noise* by Occupational Groups, Baseline Data of ESTER-CONSTANCES Study.

	Teachers			Other Occupational Groups					
	All 13,843	Primary School Teachers (n = 5159)	Secondary School Teachers (n = 6956)	Higher Education Teachers (n = 1728)	All 34,338	Executives and Higher Intellectual Professions (n = 12,411)	Intermediate Professions (n = 8752)	Clerks (n = 9927)	Manual Workers (n = 3248)
Perceived occupational noise, [†] n (%)									
No	9371 (68)	2964 (57)	4808 (69)	1599 (93)	29,657 (86)	11,719 (94)	7468 (85)	8629 (87)	1841 (57)
Yes	4472 (32)	2195 (43)	2148 (31)	129 (7)	4681 (14)	692 (6)	1284 (15)	1298 (13)	1407 (43)
Difference across the seven occupational groups [‡]		0.11	<0.001	<0.001		<0.001	<0.001	<0.001	Ref.
Difference between "Teachers" and "Other occupational groups" [‡]	<0.001				Ref.				

*Defined as "working in an environment where you sometimes have to raise your voice to talk to people 2 to 3 m away." † "Manual workers" as the reference group, *P*-value from age- and sex-adjusted logistic regression with perceived occupational noise (yes/no) as a dependent variable, and the six other occupational groups (dummy variables) as independent variables. ‡ "Other occupational groups" as the reference group, *P*-value from age- and sex-adjusted logistic regression with perceived occupational noise (yes/no) as a dependent variable, and the "teachers" dummy variable as an independent variable.

overall for other socioprofessional groups ($P < 0.001$, Table 2). Significant heterogeneity was found between occupational groups, with proportions of 'exposed' participants ranging from 6 to 43%. "Manual workers" (43%), "primary school teachers" (43%), and "secondary school teachers" (31%) were those who reported being exposed the most. Even after controlling for sex and age, primary school teachers reported disturbing occupational noise to the same extent as manual workers ($P = 0.11$). Teachers who reported working in a noisy environment were younger, more often female, and more often primary school teachers than teachers who did not [Table 3]. They were also more likely to have had financial difficulties in the past and to experience work-related stress, whether evaluated through the ERI ratio or the strained relationship indicator.

Perceived noise exposure was significantly associated with worse health indicators among teachers. Fourteen percent of the teachers who reported being exposed to noise had poor health compared with 10% of those who did not, and the difference remained significant independent of stress and other covariates considered in the models [model 2: adjusted odds ratio = 1.21 and 95% confident interval (1.07;1.37)] [Table 4]. Likewise, 15% of the teachers who reported being exposed to noise had depressive symptoms compared with 11% of those who did not [1.14 (1.01;1.28)]. For both health outcomes, the effects associated with work-related stress were of higher magnitude than those associated with noise. An interaction effect was suggested between noise and strained relationships, especially on perceived health (P for interaction = 0.05). In the results stratified by the level of strained relationships at work [Table 5], noise was not significantly associated with health outcomes among teachers who do not or rarely experience strained relationships, whereas significant risks of poor perceived health [1.32 (1.11; 1.58)] and at the limit of significance

for depressive symptoms [1.17 (0.99; 1.39)] were observed among teachers regularly experiencing strained relationships. In the sensitivity analyses, the results were virtually unchanged when excluding teachers who reported not being "in contact with public" or those who reported noise exposure in former job. The analyses conducted on the sample without any missing values [Table 6] showed similar results. Stronger evidence was found in favor of an interaction effect between noise and strained relationships on both health outcomes in most sensitivity models (i.e., P for interaction < 0.10, Table 7).

DISCUSSION

In this nationwide study of French employees, teachers were more than twice as likely to work in a noisy environment compared to noneducation employees. Among teachers, noise exposure was most frequently reported by those in preschool/elementary school, female teachers and younger teachers. Noise was also significantly associated with poorer general and mental health, independent of work-related stress. Some evidence was observed in favor of an interaction effect between noise and strained relationships on poorer perceived health and higher depressive symptoms, suggesting that a certain kind of work-related stress could exacerbate the negative effect of noise on teachers' health, particularly strained interpersonal relationships.

To the authors' knowledge, this study is the first to investigate the issue of occupational noise among French teachers. The main strength lies in its sample size including a large sample of teachers quite representative in terms of age, gender, and teaching degree, as well as a large and varied sample of employees from other sectors than education for comparison. Most previous studies on teacher noise exposure included relatively few teachers, and they were not able to compare them to other occupational groups.^[14] The intermediate age

Table 3: Teachers' Characteristics According to Perceived Occupational Noise,* Baseline Data of ESTER-CONSTANCES Study.

	Perceived Occupational Noise*		OR (95% CI)
	No <i>n</i> (%) [†]	Yes <i>n</i> (%) [†]	
<i>Sociodemographic factors</i>			
<i>Age category</i>			
<35 years old (ref)	1243 (13)	706 (16)	1
35–49 years old	5149 (55)	2626 (59)	0.96 (0.85; 1.08)
≥50 years old	2955 (32)	1122 (25)	0.78 (0.68; 0.88)***
<i>Sex</i>			
Men (ref)	3491 (37)	1150 (26)	1
Women	5856 (63)	3304 (74)	1.12 (1.03; 1.23)*
<i>Relationship status</i>			
In a relationship (ref)	7405 (80)	3516 (80)	1
Single	1836 (20)	889 (20)	1.03 (0.93; 1.15)
<i>Living with children</i>			
No (ref)	2839 (31)	1238 (29)	1
Yes	6218 (69)	3090 (71)	1.01 (0.92; 1.12)
<i>Financial difficulties</i>			
Never (ref)	7047 (76)	3064 (70)	1
In the past	1705 (18)	1030 (23)	1.23 (1.12; 1.36)***
Currently	509 (6)	321 (7)	1.14 (0.97; 1.34)
<i>Degree of urbanicity</i>			
City center (ref)	4093 (44)	1726 (39)	1
Suburbs	2971 (32)	1557 (35)	1.08 (0.99; 1.19)
Rural/remote municipalities	2282 (24)	1170 (26)	0.93 (0.84; 1.03)
<i>Occupational-related factors</i>			
<i>Teaching level[‡]</i>			
Preschool/elementary (ref)	2956 (32)	2189 (49)	1
Secondary	4796 (51)	2136 (48)	0.81 (0.73; 0.91)***
Higher education	1595 (17)	129 (3)	0.23 (0.19; 0.29)***
<i>Company size</i>			
<50 employees (ref)	3633 (40)	2632 (61)	1
≥50 employees	5374 (60)	1711 (39)	0.67 (0.60; 0.75)***
<i>Effort–reward imbalance ratio</i>			
≤1 (ref)	5192 (57)	1791 (41)	1
>1	3870 (43)	2576 (59)	1.53 (1.41; 1.65)***
<i>Strained relationships</i>			
No or not in contact with the public (ref)	2798 (31)	523 (12)	1
Yes: rarely	4056 (45)	1773 (41)	1.71 (1.53; 1.92)***
Yes: often, always, or almost	2219 (24)	2049 (47)	3.24 (2.88; 3.66)***

Odds ratio (OR) with 95% confidence interval (CI) adjusted for all variables mentioned in the left column. *Defined as “working in an environment where you sometimes have to raise your voice to talk to people 2 to 3m away.”[‡]Participants with missing values were alternately excluded, resulting in a slightly different sample size each time. [†]At the national level, the distribution of teachers by level of teaching was 40% primary, 52% secondary, and 7% higher education (French Ministry of National Education 2019). * $P < 0.05$, and *** $P < 0.001$.

category in the present study was slightly over-represented. If it may have slightly biased the estimation of noise exposure in absolute terms, it would not have an effect on the statistical differences between occupational groups, because it appears to be rather nondifferential across them. The large sample size allowed for the assessment of potential interactions between noise and work-related stress, which are prevalent occupational risks among teachers.^[34] While this study provides valuable insights on a subject that has been rarely documented elsewhere, some limitations must be acknowledged. The cross-sectional design of this study

makes it not possible to rule out reverse causation bias and longitudinal studies are crucial to determine whether it is perceived noise exposure that is inducing or amplifying health problems or existing health problems that are increasing noise perception. No information on noise sensitivity or noise annoyance was available. Such information could have been important to disentangle the mechanisms underlying the statistical associations observed between perceived noise exposure and poorer health indicators. Indeed, noise sensitivity could moderate the association between perceived noise exposure and poorer

Table 4: Multiadjusted Odd Ratios of the Associations of Perceived Occupational Noise* and Work-related Stress with Health Outcomes among Teachers, Baseline Data of ESTER-CONSTANCES Study.

	Health Outcomes					
	Poor Perceived Health (vs. Good) <i>n</i> /All=1441/12,685			Depressive Symptoms (vs. Low to Moderate) <i>n</i> /All=1587/12,726		
	Percentage of Cases	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Percentage of Cases	Model 1 OR (95%CI)	Model 2 OR (95%CI)
Perceived occupational noise*						
No (ref.)	10	1	1	11	1	1
Yes	14	1.23 (1.09; 1.39)**	1.21 (1.07; 1.37)**	15	1.16 (1.03; 1.31)*	1.14 (1.01; 1.28)*
ERI †						
No (ref.)	9	1	1	7	1	1
Yes	15	1.71 (1.52; 1.93)***	1.61 (1.43; 1.81)***	18	2.56 (2.28; 2.89)***	2.42 (2.15; 2.73)***
Strained relationships‡						
No (ref.)	9	1	1	9	1	1
Rarely	10	0.99 (0.85; 1.16)	0.98 (0.84; 1.15)	10	1.02 (0.87; 1.20)	1.02 (0.87; 1.20)
Often, always, or almost	15	1.45 (1.23; 1.71)***	1.40 (1.18; 1.65)***	19	1.79 (1.52; 2.11)***	1.75 (1.48; 2.06)***
Teaching level						
Primary (ref.)	11	1	1	12	1	1
Secondary	12	1.05 (0.93; 1.19)	0.97 (0.82; 1.15)	13	1.13 (0.99; 1.27)	1.08 (0.91; 1.27)
Higher education	10	1.02 (0.83; 1.26)	0.95 (0.74; 1.22)	12	1.28 (1.06; 1.56)*	1.26 (0.99; 1.61)
Age category (years old)						
<35 (ref.)	7	1	1	12	1	1
35–49	10	1.47 (1.21; 1.78)***	1.56 (1.28; 1.91)***	12	0.96 (0.82; 1.12)	1.08 (0.91; 1.30)
≥50	15	2.46 (2.01; 3.01)***	2.48 (2.02; 3.03)***	14	1.16 (0.97; 1.38)	1.18 (0.99; 1.42)
Sex						
Male (ref.)	11	1	1	13	1	1
Female	12	1.02 (0.90; 1.16)	1.01 (0.89; 1.14)	13	0.88 (0.78; 0.99)*	0.85 (0.75; 0.96)*
Relationship status						
In a relationship (ref.)	11		1	11		1
Single	15		1.23 (1.07; 1.42)**	20		1.73 (1.51; 1.97)***
Living with children						
No (ref.)	13		1	15		1
Yes	11		0.90 (0.79; 1.03)	11		0.84 (0.74; 0.96)**
Financial difficulties						
Never (ref.)	9		1	10		1
In the past	16		1.61 (1.41; 1.83)***	16		1.41 (1.24; 1.61)***
Currently	22		2.31 (1.90; 2.81)***	32		3.18 (2.66; 3.79)***
Degree of urbanicity						
City center (ref.)	11		1	13		1
Suburbs	11		0.99 (0.87; 1.13)	12		0.95 (0.83; 1.08)
Rural/remote areas	12		1.07 (0.93; 1.24)	12		1.01 (0.87; 1.16)
Company size						
<50 Employees (ref.)	11		1	12		1
≥50 Employees	12		1.11 (0.94; 1.31)	13		1.01 (0.86; 1.19)

Odds ratios (ORs) and 95% confidence intervals (95% CIs) of the association between exposures and health-related outcomes. Participants with missing values on health outcomes and work-related indicators were alternately excluded from the corresponding model, resulting in a slightly different sample size each time. Model 1: adjusted for sex, age category (< 35, 35–49, and ≥50 years old), teaching level and stress indicators (ERI ratio and strained relationships). Model 2: Model 1 + relationship status, living with children, financial difficulties, degree of urbanicity, and company size. ERI = effort–reward imbalance. *Defined as “working in an environment where you sometimes have to raise your voice to talk to people 2 to 3 m away.” † Effort–reward imbalance (ERI), defined as an effort–reward ratio >1, indicates inadequate rewards in relation to the efforts. ‡ Defined as “do you experience tension in your relations with the public?” (“no or almost never”/“rarely”/“often, always or almost”). **P* < 0.05, ** *P* < 0.01, and ****P* < 0.001.

health (i.e., noise-sensitive individuals are potentially more affected by noise)^[35] and noise annoyance (i.e., person’s individual adverse reaction to noise) was likely to mediate this association.^[36] In fact, noise exposure was estimated through perceived noise disturbance using a single-item question that could introduce reporting bias.

In this regard, future studies should conduct a more detailed assessment of the types and sources of noise to which teachers are exposed. Ideally, the assessment should combine objective (metrological) and subjective (perceived) perspectives. However, studies have shown that speech communication effort in a noisy

Table 5: Association between Perceived Occupational Noise* and Health Outcomes Stratified by Level of Strained Relationships† among Teachers, Baseline Data of ESTER-CONSTANCES Study.

	Health Outcomes			
	Poor Perceived Health (vs. Good)		Depressive Symptoms (vs. Low to Moderate)	
	n/all	OR (95% CI)	n/all	OR (95% CI)
Strata by level of strained relationships†				
Strata 1: no	294/3153	1.06 (0.76; 1.48)	298/3170	1.00 (0.71; 1.43)
Strata 2: rarely	528/5505	1.17 (0.95; 1.43)	542/5547	1.14 (0.93; 1.39)
Strata 3: often, always or almost	619/4027	1.32 (1.11; 1.58)**	747/4009	1.17 (0.99; 1.39)
P-value for interaction‡		0.05		0.11

Odds ratios (ORs) and 95% confidence intervals (95% CIs) of the relationship between self-reported noise exposure (yes vs. no) and health-related outcomes, stratified by strained relationships. The model was adjusted for sex, age category (< 35, 35–49, and ≥50 years old), teaching level, relationship status, living with children, financial difficulties, degree of urbanicity, company size, and ERI ratio. Participants with missing values on health outcomes and work-related indicators were alternately excluded from the corresponding model, resulting in a slightly different sample size each time. *Defined as “working in an environment where you sometimes have to raise your voice to talk to people 2 to 3 m away.” †Defined as “do you experience tension in your relations with the public?” (“no, or almost never”/“rarely”/“often, always or almost”). ‡Test for interaction was computed by considering noise as dichotomous and strained relationships as ordinal variables. ** P < 0.01.

environment is an effective method of estimating noise levels within the workplace and a valid exposure metric if the exposure concerns the last or the longest-held job,^[26] which was the case in the present study. Moreover, data on working conditions were lacking to understand more precisely the factors associated with perceived occupational noise amongst teachers (i.e., student’s age,

class size, age of school building and background noise) and their potential mutual interaction on health. Information on environmental exposure at the residential address was not available either. However, when adjusting for urbanicity of residence as a rough proxy of environmental noise exposure, the results were unchanged.

Table 6: Association of Perceived Occupational Noise* and Work-related Stress with Health Outcomes among Teachers, Baseline Data of ESTER-CONSTANCES Study—sensitivity Analyses.

	Sensitivity Analysis 1 Exclusion of Teachers who Reported Not being in Contact with Public†		Sensitivity Analysis 2 Exclusion of Teachers Who Reported Noise Exposure in Former Job‡		Sensitivity Analysis 3 Complete Case Analysis (for Both Outcomes)	
	Poor Perceived Health (vs. Good)	Depressive Symptoms (vs. Low to Moderate)	Poor Perceived Health (vs. Good)	Depressive Symptoms (vs. Low to Moderate)	Poor Perceived Health (vs. Good)	Depressive Symptoms (vs. Low to Moderate)
n/All	1322/11,538	1458/11,573	1367/12,201	1512/12,240	1302/11,666	1436/11,666
Perceived occupational noise*						
No (ref.)	1	1	1	1	1	1
Yes	1.23 (1.09; 1.40)	1.14 (1.01; 1.29)	1.24 (1.09; 1.41)	1.15 (1.02; 1.30)	1.23 (1.08; 1.40)	1.15 (1.02; 1.29)
ERI‡						
No (ref.)	1	1	1	1	1	1
Yes	1.63 (1.43; 1.85)	2.44 (2.15; 2.77)	1.61 (1.43; 1.83)	2.48 (2.20; 2.81)	1.63 (1.44; 1.85)	2.43 (2.14; 2.76)
Strained relationships#						
No (ref.)	1	1	1	1	1	1
Rarely	1.03 (0.85; 1.24)	1.11 (0.92; 1.34)	0.96 (0.82; 1.13)	1.03 (0.87; 1.21)	0.98 (0.82; 1.15)	1.02 (0.86; 1.21)
Often, always or almost	1.46 (1.21; 1.77)	1.89 (1.56; 2.31)	1.39 (1.17; 1.65)	1.72 (1.45; 2.04)	1.38 (1.16; 1.64)	1.72 (1.44; 2.05)

Odds ratios (ORs) and 95% confidence intervals (95% CIs) of the association between exposure and health outcomes, adjusted for sex, age category (<35, 35–49, and ≥50 years old), teaching level, relationship status, living with children, financial difficulties, degree of urbanicity, company size, and stress indicators (ERI ratio and strained relationships). Participants with missing values on health outcomes and work-related indicators were alternately excluded from the corresponding model, resulting in a slightly different sample size each time. ERI = effort–reward imbalance. *Defined as “working in an environment where you sometimes have to raise your voice to talk to people 2 to 3m away.” † Instead of considering them as unexposed. ‡ Effort–reward imbalance (ERI), defined as effort–reward ratio > 1, indicates inadequate rewards in relation to the efforts. # Defined as “do you experience tension in your relations with the public?” (“no or almost never”/“rarely”/“often, always or almost”).

Table 7: Association of Perceived Occupational Noise* with Health Outcomes Stratified by Strained Relationships† among Teachers, Baseline Data of ESTER-CONSTANCES Study–Sensitivity Analyses.

Health Outcome	n All	Strata Defined by Level of Strained Relationships†			P-value for Interaction‡
		No	Rarely	Often, Always, or Almost	
Poor perceived health (vs. good)					
<i>Main analysis</i>	12,683	1.06 (0.76; 1.48)	1.17 (0.95; 1.43)	1.32 (1.11; 1.58)**	0.05
SA 1	11,538	1.14 (0.75; 1.74)	1.17 (0.95; 1.43)	1.32 (1.11; 1.58)**	0.11
SA 2	12,201	1.06 (0.76; 1.49)	1.21 (0.98; 1.48)	1.35 (1.12; 1.62)**	0.05
SA 3	11,666	1.05 (0.74; 1.50)	1.15 (0.94; 1.42)	1.37 (1.14; 1.66)**	0.03
Depressive symptoms(vs. low to moderate)					
<i>Main analysis</i>	12,724	1.00 (0.71; 1.43)	1.14 (0.93; 1.39)	1.17 (0.99; 1.39)	0.11
SA 1	11,573	0.94 (0.59; 1.49)	1.13 (0.93; 1.39)	1.18 (1.00; 1.39)*	0.12
SA 2	12,240	1.00 (0.70; 1.42)	1.13 (0.93; 1.39)	1.21 (1.01; 1.44)*	0.09
SA 3	11,666	1.03 (0.71; 1.49)	1.10 (0.89; 1.36)	1.23 (1.03; 1.47)*	0.07

Odds ratios (ORs) and 95% confidence intervals (95% CIs) of the association between self-reported noise exposure and health-related outcomes, stratified by strained relationships. The model was adjusted for sex, age category (<35, 35–49, and ≥50 years old), teaching level, relationship status, living with children, financial difficulties, degree of urbanicity, company size, and ERI ratio. Sensitivity Analysis (SA) 1: Exclusion of teachers who reported not being in contact with the public, instead of considering them as unexposed, SA 2: Exclusion of teachers who reported noise exposure in a former job, instead of considering them as unexposed, SA 3: Complete case analysis (for both outcomes). *Defined as “working in an environment where you sometimes have to raise your voice to talk to people 2 to 3 m away.” † Defined as “do you experience tension in your relations with the public?” (“no or almost never”/ “rarely”/“often, always, or almost”). ‡ Test for interaction was computed by considering noise as dichotomous and strained relationships as ordinal variables. * $P < 0.05$, ** $P < 0.01$ and *** $P < 0.001$.

Consistently with the literature, the descriptive results showed important heterogeneity in exposure to disturbing occupational noise among teachers, with a clear trend of decreasing exposure with increasing teaching level.^[37] Primary school teachers reported being exposed in the same proportion as manual workers included in this study. Other studies consistently showed that in the nonindustrial sectors, teachers in lower grades are among the most exposed to noise at work,^[11] yet at lower sound levels than those found in industrial sectors.^[11] However, this issue could not be addressed because sound level data were not available in the CONSTANCES setting. Nonetheless, several studies supported that teachers are at increased risk of auditory and nonauditory disorders compared with unexposed employees,^[11,14,38] advocating for further investigation into the characteristics and global effects of noise at school, especially from the teacher's perspective. Indeed, the present study found that perceived occupational noise was associated with poorer perceived health and higher depressive symptoms, which is consistent with the findings of few other cross-sectional studies available among teachers or other occupational settings. For example, a study in a sample of preschool employees found that higher perceived sound fluctuation was related to higher levels of depression.^[34] Furthermore, in the present study, women were more likely to report noise exposure than male teachers. This finding is consistent with another study that found women reported significantly higher levels of annoyance from noise exposure than men.^[39] However, no sex difference was found in the health effects of noise exposure (not shown). The results were also consistent with the widely documented

deleterious impact of work-related stress on health.^[33] The corresponding associations estimated in the models were consistently of higher magnitude than those observed between noise and health indicators, highlighting the critical weight of work stress on health, independent of noise exposure. Thus, if a comprehensive approach to teachers' health promotion could benefit from the consideration of noise, it must firstly be a stress prevention approach. The results were also consistent with the well-known associations between demographic/socioeconomic factors (e.g., being single and financial difficulties) and a higher risk for mental health issues.^[40]

The results further suggested evidence of an interaction effect of noise with strained relationships on poor perceived health and depressive symptoms, thus supporting the hypothesis that while the physical characteristics of an environment may not be harmful *per se*, they may act to exacerbate the negative impact of co-occurring psychosocial stress.^[17] This interaction effect between noise and stress was only observed with the strained relationships indicator, but not with the ERI. Unlike the ERI, which refers more to a mismatch between high efforts spent and low rewards experienced by individual teachers, exposure to noise and strained relationships contribute in their own manner through classroom disruptions to create inappropriate conditions for learning and teaching, which is a context that has been identified as an important cause of job strain among teachers.^[13] Another interpretation could be that noise has no or slight effect on teacher's health unless it is part of a strained interpersonal context; in which case, noise could

amplify the deleterious effect of the latter. In other words, chatter in the background of the classroom could be harmless as long as it is not experienced as aggression. This hypothesis, which remains to be tested, points to the critical role of how noise is perceived rather than its objective sound level. As perception is closely linked with psychosocial context, further studies are needed to improve understanding of the mechanisms involved. In this regard, longitudinal studies combining assessments of classroom noise and the psychosocial environment could be particularly informative.

CONCLUSION

In this nationwide study of French employees, a high proportion of teachers reported working in a noisy environment. Among teachers, such occupational exposure was associated with poorer general and mental health, particularly when combined with a strained interpersonal context. The results argue in favor of taking better account of noise at school from the point of view of teachers as a daily and long-term occupational exposure with potential adverse effects on their health. Firstly, given the paucity of the literature, developing epidemiological studies, particularly longitudinal ones, is necessary to further document noise in schools and its consequences on teachers' health and the long-term impacts such as early retirement or long-term sickness absence. Secondly, in view of the results in line with the broader body of knowledge on their negative health effects, preventive actions targeting noise and work-related stress, which could interact negatively on teachers' health, are recommended.

Acknowledgments

The authors thank the team of the "Population-based Cohorts Unit" (Cohortes en population) that designed and manages the CONSTANCES Cohort Study. They also thank the French National Health Insurance Fund ("Caisse nationale d'assurance maladie", CNAM) and its Health Screening Centers ("Centres d'examen de santé"), which are collecting a large part of the data, as well as the French National Old-Age Insurance Fund ("Caisse nationale d'assurance vieillesse", Cnav) for its contribution to the constitution of the cohort, and ClinSearch, Asqualab, and Eurocell, which are conducting the data quality control.

Sources of Support and Funding

The authors did not receive support from any organization for the submitted work. The CONSTANCES Cohort Study was supported and funded by the French National Health Insurance Fund ("Caisse nationale d'assurance maladie", CNAM). The CONSTANCES Cohort Study is an "Infrastructure nationale en Biologie et Santé" and benefits from a grant from the French National Agency for Research ("Agence Nationale de la Recherche", grant number: ANR-11-INBS-0002). CONSTANCES is also partly funded by Merck Sharp & Dohme (MSD), AstraZeneca, Lundbeck,

and L'Oréal. None of these funding sources had any role in the design of the study, collection and analysis of data, or decision to publish.

Ethical Approval

The CONSTANCES Cohort Study was approved by the Institutional Review Board of the National Institute for Medical Research – INSERM (no. 01-011) and obtained the authorization of the National Data Protection Authority (Commission Nationale de l'Informatique et des Libertés – CNIL, no. 910486).

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials

The data underlying this article were provided by the CONSTANCES cohort under permission and are not publicly available, to ensure the confidentiality of study participants. However, the CONSTANCES cohort is "an open epidemiological laboratory" and access to study protocols and data is available on request. See for more details: <https://www.constances.fr/espace-scientifique/acces-a-constances/> (accessed on February 6, 2024).

Conflicts of interest

There are no conflicts of interest.

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