Association of Occupational Stress With Tinnitus Among Career Firefighters in the United States

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Objective: This study explores the relationship between occupational stress and tinnitus among firefighters, a group often exposed to two tinnitus risk factors: high stress and noise. **Methods:** This cross-sectional study includes 240 firefighters in the United States. Data describing demographic characteristics, occupational stress, noise exposure, and tinnitus were collected by survey. Occupational stress was measured using the short version of the Effort-Reward Imbalance Questionnaire. **Results:** Forty-three percent of participants reported experiencing tinnitus within the past month. For occupational stress, higher effort (odds ratio, 1.25; 95% confidence interval, 1.05 to 1.49) and higher effort-reward ratio (odds ratio, 12.28; 95% confidence interval, 3.08 to 48.86) were associated with increased odds of tinnitus, after adjustment for demographic characteristics and noise exposure. **Conclusions:** Occupational stress may increase the likelihood of tinnitus for firefighters, an already at-risk group of workers. Health providers should incorporate stress assessment into tinnitus management programs.

Keywords: effort-reward imbalance, firefighter, hearing loss, occupational stress, tinnitus

LEARNING OUTCOMES

(1) Describe the relationship between occupational stress as measured by the Effort-Reward Imbalance Questionnaire and tinnitus among firefighters
(2) Understand the importance of detecting and preventing occupational stress to maintain physiological health and well-being among workers

Tinnitus is defined as the perception of sound in the absence of an external source and is most commonly described as a continuous buzzing, hissing, or ringing sound. This bothersome and at times debilitating condition has been estimated to afflict approximately 10% to 20% of the total adult population,[1,2] although estimates vary because this subjective experience can be difficult to consistently diagnose. Using national survey data, researchers found that respondents reporting tinnitus also endorsed more than double the prevalence of depression and anxiety when compared with those without tinnitus. Further, those who reported the most bothersome tinnitus experienced a fourfold to sixfold increase in the odds of concurrent depression or anxiety symptoms during the prior year when compared with those without tinnitus.[3] Frequently, sleep duration and quality are also compromised for those experiencing tinnitus, a challenge that can impact overall quality of life and global functioning.[1,3,4] In addition, global psychological functioning impairment is often associated with chronic tinnitus, which can lead to a vicious circle of worsening tinnitus and mental health.[5]

Researchers have also found that severe tinnitus is associated with reduced health-related quality of life.[6] Tinnitus tends to be more common[2] and more problematic for older individuals,[7] as other functional declines may compound the tinnitus-related problems and negatively impact social functioning. Although there are promising psychotherapeutic approaches, including cognitive-behavioral therapy (CBT) and other types of therapy such as Gamma Knife® radiosurgery,[8] to managing tinnitus, there is currently no cure for the condition.[9] A recent systematic review including 28 studies found that CBT may help those with tinnitus reduce depressive symptoms and negative interpretations of tinnitus, but the evidence base for these findings, and other outcomes of interest including anxiety reduction and health-related quality of life, was mixed.[10]

Although the specific pathophysiologic mechanism of tinnitus is not fully understood, there are several hypotheses to explain the relationship between stress and tinnitus. One is that increased production of cortisol, a known response to stress, affects gene expression and heightens reactivity throughout the neurological system, potentially leading to or worsening tinnitus.[11] In addition, researchers have investigated the possible impact of glutamate-related neuroplasticity on the auditory system, finding that chronic stress may create the conditions for epigenetic changes responsible for disease.[11] Although there is no conclusive evidence for how stress causes or worsens tinnitus, there are multiple known risk factors that have been shown to increase its likelihood. Physical trauma, particularly involving the head; certain neurological conditions; ototoxic medications; hypertension; and diabetes have all been linked to reports of the condition.[12]

For those engaged in occupational health promotion, there are several specific tinnitus risk factors to consider because they map to actionable health protection strategies. The first risk is prolonged exposure to loud noise, a hazard that has been shown to be strongly linked to both tinnitus and hearing loss.[1] Importantly, the most significant risk factor for tinnitus is hearing loss,[13,14] so hearing protection is of primary importance in the occupational health context. However, tinnitus is more common than hearing loss and is thought to be caused by some additional or varying factors, so it bears independent investigation. Also of relevance to occupational health practitioners is the finding that chronic stress exposure has shown strong links to tinnitus.[4,9] Although there are challenges in determining the causal direction of the experiences of stress and reported tinnitus—more severe cases of tinnitus can undoubtedly increase stress—it is clear that managing both of these chronic conditions is essential to increasing workers' well-being.

Firefighters experience many occupational health conditions, including musculoskeletal injury, respiratory illness, cardiovascular disease, and hearing loss,[15] as well as multiple types of cancer due to occupational exposure to carcinogens.[16] In addition to the multiple physical hazards, firefighters also face some unique psychosocial

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stressors, frequently working 24- or 48-hour shifts during which they remain and away from their homes and on-call for unpredictable events.[17,18] Taken together, these occupational health risks reflect a significant burden, and although the individual risks have been well-described, the ways some of these factors interact have yet to be fully explored.

A recent investigation into changes in military firefighters' reported medical and mental health conditions over time found significant increases in both tinnitus and mental health conditions between 2001 and 2015.[19] Importantly, researchers found that incidence rate of tinnitus more than quadrupled during the study period (reaching 60 cases per 10,000 individuals in 2015) and that the incidence rates of mental health conditions including depression, generalized anxiety disorder, insomnia, and adjustment disorder also saw moderate to significant growth.[19] For this at-risk group, exploring how job stress may heighten the risk for adverse health outcomes such as tinnitus might offer insight into what mitigation strategies will be the highest yield for occupational health providers and other advocates.

The objective of this study was to explore the links between occupational stress and tinnitus for firefighters. By including measured audiometry in addition to self-reported tinnitus and experiences of occupational stress, this investigation looks at tinnitus independently of hearing loss, helping to clearly assess the potential associations.

METHODS

Study Design and Participants

A cross-sectional study using convenience sampling was conducted with career firefighters from six fire departments (size varied from 71 to 1129 members) in Central Texas and Northern California. Study participants were recruited in several ways: at two occupational health clinics during their annual physical examination, through study flyers posted and distributed at fire stations and at fire training educational programs, and through fire department e-mail announcements. Depending on the method of recruitment, the response rate varied from 3% to 39%. Recruitment materials stated that the researchers were doing an online survey to learn more about firefighters' work-related injuries, occupational stress, noise exposure, and hearing ability; the specific focus on tinnitus was not identified. A total of 301 firefighters were screened between March 2015 and March 2016, and 249 completed the online survey. Of them, audiogram records were accessible for 240 of the participants. The final sample size for analysis was 240. The Human Research Protection Program of the University of California San Francisco approved all study procedures. Participation was voluntary, and informed consent was obtained from firefighter participants before completing the online survey.

Study Variables and Measures

Demographic characteristics included age, gender, race/ethnicity, and years in fire services. Race/ethnicity was categorized as White non-Hispanic, Hispanic, Black or African American, Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or other.

Occupational stress was measured using the short version of the Effort-Reward Imbalance Questionnaire (S-ERI). The S-ERI instrument consists of 16 items and contains three psychometric subscales: effort (three items), reward (seven items), and overcommitment (six items). In addition, there are three subscales of the reward scale: esteem (two items), job security (two items), and job promotion (three items). All components are measured on a four-point Likert scale (1 = strongly disagree, 2-disagree, 3 = agree, 4 = strongly agree).[20] In our sample, all Cronbach α coefficients for subscales were higher than 0.80, indicating high internal consistency. More detailed information on the reliability of the subscales had been reported elsewhere.[21]

In the ERI model, occupational stress is defined as the imbalance between high efforts (ie, overtime at work) and low rewards received in terms of the fewer salary, esteem, job security, and promotions. Overcommitment, an intrinsic personal characteristic of coping with job demands, is also related to increasing work-related stress. The effort-reward ratio was calculated from two subscales (effort and reward), dividing effort by reward multiplied by the ratio of the number of items in two scales (three items in effort/7items in reward) to correct for the item number difference in the two scales.[20]

Occupational exposure to loud noise was assessed by asking, "What percent of time were you exposed to each of the following noise levels at work?" The following scenarios were given (totaling 100%): normal speaking voice or quieter, as loud as a vacuum, as loud as a gas lawnmower, as loud as a chainsaw, and as loud or louder than a siren, and then dichotomized for the analyses as normal speaking voice or quieter or as loud or louder than a vacuum due to small numbers of responses.

Hearing-Related Characteristics

Measured hearing was assessed using standard pure-tone audiometry. The audiometers were calibrated according to the American National Standards Institute S3.6-1969-2004 standard.[22] The audiometric tests were administered in the occupational health clinic by trained audiometric technicians, using a microprocessor audiometer with frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kHz in both ears. The participants receive hearing tests annually; the participant's most recent (within the past 12 months) hearing test results were obtained for this study.

Hearing threshold levels (HTLs) were measured in 5-dB increments from 0 to 95, with a higher HTL indicating poorer hearing ability. Hearing loss was defined as an HTL of 25 dB or greater based on HTLs in the worst ear (World Health Organization, 1986). In this study, firefighters' hearing status at noise-sensitive frequencies (4 and 6 kHz) was calculated.

Perceived hearing was assessed by the question: "In general, would you say your hearing is excellent, very good, good, fair, or poor?" and then was dichotomized as good and bad.

Use of hearing protective devices (HPDs) was assessed using the following question: "When exposed to loud noise at work, what percentage of the time do you wear your hearing protective device? Please provide a number between 0 and 100."

Tinnitus status was assessed by asking, "Within the past 12 months, have you experienced tinnitus? Tinnitus is defined as recurring or persistent ringing, hissing, roaring, pulsing, whooshing, chirping, whistling, or clicking in the ears." The above question was modified from the American Speech-Language-Hearing Association's[23] definition of tinnitus. If a participant answered "yes," they were asked questions from the Tinnitus Functional Index (TFI), which is a valid and reliable instrument (Cronbach $\alpha = 0.97$, test-retest reliability = 0.78, convergent validity $r = 0.86$ with the Tinnitus Handicap Inventory for scaling the severity of tinnitus and $r = 0.75$ with the visual analog scale).[24] The TFI consists of a 25-question survey. However, to reduce subject burden due to the length of the online survey, the following three TFI questions were used after the consultation with the tinnitus expert to assess tinnitus severity and the effect of tinnitus on performing firefighter duties: (*a*) "How strong or loud is your tinnitus?" Response options ranged from 0 to 10 (0 = not at all strong or loud, 10 = extremely strong or loud); (*b*) "Over the past week, how often did your tinnitus cause you to have difficulty performing your work as a firefighter?" Response options ranged from 0 to 10 (0 = never had difficulty, 10 = always had difficulty); (*c*) "Over the past week, how much has your tinnitus interfered with your ability to concentrate?" Response options ranged from 0 to 10 (0 = did not interfere, 10 = completely interfered). Although objective tinnitus, a phenomenon where the noise perceived is also perceptible to other people, does occur, it accounts for only 1% of total cases, making self-report the only realistic approach to measurement.[25]

Data Analyses

Statistical analysis was conducted using SPSS 28 (IBM Corp, Armonk, NY). Descriptive statistics were analyzed for all study variables. Means and SDs were presented for continuous variables. Categorical variables were summarized by frequencies and percentages. Bivariate analysis was performed to examine differences in tinnitus, using χ^2 tests for categorical variables and t tests for continuous variables.

After bivariate analysis, multivariable logistic regression analysis was used to examine the relationship of occupational stress with tinnitus. Before conducting the multivariable analysis, multicollinearity was assessed to check for high correlations among the independent variables. Because age and years in fire services ($r = 0.8$, $P < 0.001$) and perceived hearing and measured hearing were highly correlated ($r = 0.5$, $P < 0.001$), only years in fire services and measured hearing at 4k and 6k were included in the multivariable models. Of occupational stress, each ERI subscales and effort-reward ratio were separately chosen as the indicator of the participant's tinnitus symptoms in each multivariable model. Odds ratios (ORs) with 95% confidence intervals (CIs) and P values were calculated to analyze the association of occupational stress and tinnitus, using logistic regression analyses. The level of statistical significance was set at $P < 0.05$.

RESULTS

Characteristics of the Participants

Table 1 summarizes the demographic and work-related characteristics of the career firefighters. The participants were middle-aged (41.5 years) White non-Hispanic (76.8%) men (92.9%) who worked in the fire service for an average of 15 years. Participants represented a range of job classifications within their departments, with 35% reporting their job positions as firefighter paramedics and 30% describing themselves as officers. The mean scores for S-ERI subscales were 8.56 for effort, 22.15 for reward, 12.88 for overcommitment, and 0.92 for the effort-reward ratio. Firefighters reported being exposed to noise as loud or louder than a vacuum 44% of the time while at work.

TABLE 1. Demographic and Work-Related Characteristics of the Study Participants (N = 240)

Characteristics	Mean ± SD (Range) or n (%)
Age, y	41.52 ± 8.25 (24–62)
Gender (male)	223 (92.9)
Race/ethnicity	
White, non-Hispanic	179 (76.8)
Hispanic	27 (11.6)
Black or African American	11 (4.7)
Asian	10 (4.3)
Other*	6 (2.6)
Job position	
Firefighter	30 (12.5)
Firefighter paramedic	85 (35.4)
Apparatus operator/engineer/driver	49 (20.4)
Company officer (lieutenant, captain)	73 (30.4)
Battalion chief	3 (1.3)
Occupational stress	
Effort	8.56 ± 1.77 (3–12)
Reward	22.15 ± 3.09 (13–28)
Esteem	6.20 ± 1.16 (2–8)
Job security	6.71 ± 1.10 (2–8)
Job promotion	9.24 ± 1.53 (4–12)
Overcommitment	12.88 ± 3.00 (6–24)
Effort-reward ratio	0.92 ± 0.26 (0.32–1.97)
Years in the fire service	15.04 ± 8.87 (1–37)
Occupational exposure to loud noise†	44.12 ± 19.46 (5–100)

Totals may differ because of missing data.

*Other: American Indian, Alaska Native, Native Hawaiian, and other Pacific Islander, and other.

†Percent of time (totaling 100%).

TABLE 2. Hearing Ability and Hearing-Related Characteristics of the Study Participants (N = 240)

Characteristics	Mean ± SD (Range) or n (%)
Perceived hearing	
Excellent	8 (3.3)
Very good	64 (26.7)
Good	108 (45.0)
Fair	52 (21.7)
Poor	8 (3.3)
Use of HPDs*	54.59 ± 28.11 (0–100)
Measured hearing† at 4k and 6k	20.20 ± 14.78 (0–77.50)
Normal (<25 dB)	172 (71.7)
Hearing loss (≥25 dB)‡	68 (28.3)
Tinnitus (yes)	103 (43.1)
Severity (n = 103) (0–10)	3.73 ± 2.26 (0–9)
Difficulty performing work (n = 103) (0–10)	0.53 ± 1.30 (0–8)
Interfered with ability to concentrate (n = 103) (0–10)	1.05 ± 1.65 (0–8)

Totals may differ because of missing data.

*Measured by percentage (0%–100%) of the time.

†Average of hearing threshold levels in the worse ear.

‡Hearing loss was determined based on hearing threshold levels in the worst ear between left and right ears with the cutoff of 25 dB.

HPD, hearing protective device.

Hearing Ability and Hearing-Related Characteristics

Table 2 presents the summary of hearing ability and hearing-related characteristics of the study participants. Approximately 25% of career firefighters perceived their hearing to be fair or poor. However, when exposed to loud noise at work, only 55% of the time did they use HPDs. The means of HTLs at noise-sensitive frequencies (4 and 6 kHz) were 20.2 dB, and 28% of firefighters demonstrated high-frequency hearing loss. Approximately 43% of the participants reported experiencing tinnitus within the past month. Firefighters with tinnitus (n = 103) rated their tinnitus severity as low (mean, 3.73), and they perceived that their tinnitus did not impact their ability to concentrate (mean, 1.05) or perform their work (mean, 0.53).

Comparison of Characteristics Between Firefighters With and Without Tinnitus

Table 3 presents the comparison of characteristics of firefighters with and without tinnitus. We did not find that firefighters' rank or job position was associated with significant differences in reported tinnitus ($P = 0.808$). For occupational stress, firefighters with tinnitus reported lower reward (21.5 vs 22.62, $P = 0.005$) with lower job promotion (8.82 vs 9.55, $P < 0.001$), higher overcommitment (13.34 vs 12.58, $P = 0.05$), and higher effort-reward ratio (0.99 vs 0.88, $P = 0.001$), compared with those without tinnitus. Firefighters with tinnitus tend to report poor hearing status (30.1% vs 20.6%, $P = 0.091$) and less likely to report use of HPDs (49.11% vs 59.14%, $P = 0.006$). Furthermore, firefighters with tinnitus had poorer hearing ability, as indicated by higher mean HTLs at noise-sensitive frequencies (23.23 vs 17.78 dB, $P = 0.007$) and a higher percentage of hearing loss at high frequencies (35% vs 22.8%, $P = 0.038$) than those who did not experience tinnitus.

TABLE 3. Comparison of Characteristics Between Firefighters With and Without Tinnitus

	With Tinnitus (n = 103)	Without Tinnitus (n = 136)	
	Mean ± SD or n (%)	Mean ± SD or n (%)	*P*
Age	41.75 ± 8.43	41.32 ± 8.17	0.695
Gender (male)	94 (91.3)	128 (94.1)	0.395
Race (White)	74 (75.5)	104 (77.6)	0.708
Job position			
Firefighter	14 (13.6)	16 (11.8)	0.808
Firefighter paramedic	38 (36.9)	47 (34.6)	
Apparatus operator/engineer/driver	21 (20.4)	27 (19.9)	
Company officer (lieutenant, captain)	28 (27.2)	45 (33.1)	
Battalion chief	2 (1.9)	1 (0.7)	
Occupational stress			
Effort	8.80 ± 1.76	8.39 ± 1.75	0.076
Reward	21.50 ± 3.34	22.62 ± 2.80	0.005
Esteem	6.08 ± 1.26	6.27 ± 1.06	0.198
Job security	6.59 ± 1.14	6.79 ± 1.07	0.162
Job promotion	8.82 ± 1.62	9.55 ± 1.39	<0.001
Overcommitment	13.34 ± 2.55	12.58 ± 3.24	0.050
Effort-reward ratio	0.99 ± 0.28	0.88 ± 0.22	0.001
Years in working services	15.25 ± 9.31	14.89 ± 8.58	0.764
Occupational exposure to loud noise*	44.84 ± 18.79	43.60 ± 20.08	0.628
Perceived hearing†			
Bad	31 (30.1)	28 (20.6)	0.091
Good	72 (69.9)	108 (79.4)	
Use of HPDs‡	49.11 ± 28.41	59.14 ± 26.90	0.006
Measured hearing§ at 4k and 6k	23.23 ± 17.38	17.78 ± 11.97	0.007
Normal (<25 dB)	67 (65.0)	105 (77.2)	0.038
Hearing loss (≥25 dB)‖	36 (35.0)	31 (22.8)	

Totals may differ because of missing data.
*Percent of time (totaling 100%).
†Bad: poor, fair; good: good, very good, and excellent.
‡Measured by percentage (0%–100%) of the time.
§Average of hearing threshold levels in the worse ear.
‖Hearing loss was determined based on hearing threshold levels in the worst ear between left and right ears with the cutoff of 25 dB.
HPD, hearing protective device.

Association Between Occupational Stress and Tinnitus

Table 4 presents multivariable association of firefighters' occupational stress with tinnitus. Higher effort (OR = 1.25; 95% CI, 1.05 to 1.49), lower reward (OR, 0.85; 95% CI, 0.76 to 0.94) with lower job promotion (OR, 0.66; 95% CI, 0.52 to 0.83), higher overcommitment (OR, 1.16; 95% CI, 1.04 to 1.30), and higher effort-reward ratio (OR, 12.28; 95% CI, 3.08 to 48.86) were significantly associated with increased likelihood of tinnitus.

DISCUSSION

This study explored the link between occupational stress as measured by the S-ERI and tinnitus among firefighters. The key S-ERI constructs of a higher effort, lower reward (particularly reduced access to job promotion), and overcommitment were all associated with increased reports of tinnitus. In addition, the relationship between occupational stress and tinnitus remained significant after adjustment for years of services, self-reported noise exposure, use of HPDs, and measured hearing.

The findings of the current study are largely consistent with those reported by investigations of the link between stress at work and tinnitus among other occupational groups. In Denmark, researchers conducted a large cohort study comparing hearing-related symptoms among preschool providers with those reported by a control group. Researchers concluded that preschool workers' exposure to both noise and high occupational stress (also as measured by the S-ERI) were significantly associated with experiences of hearing-related symptoms including tinnitus.[26] However, it is worth noting that the authors' previous study of preschool workers and manufacturing workers in Denmark failed to find a link between hearing-related symptoms, noise exposure, and occupational stress.[27] This previous investigation used the demand-control model to capture other psychosocial factors in terms of high psychological demands of work, a difference that makes its results less comparable to the approach used here.

In a study exploring the links between occupational stress and tinnitus among workers in Asia, researchers examined reported tinnitus for healthcare workers in China and bus drivers in Thailand.[28] For the workers in China, researchers used the ERI questionnaire to capture occupational stress, and in Thailand, they used the demand-control model to calculate a demand-control ratio for the study participants. For

TABLE 4. Multivariable Association of Occupational Stress With Tinnitus

Characteristics	OR* (95% CI)	*P*
Effort	1.25 (1.05–1.49)	0.014
Reward	0.85 (0.76–0.94)	0.002
Esteem	0.79 (0.60–1.04)	0.095
Job security	0.78 (0.59–1.02)	0.074
Job promotion	0.66 (0.52–0.83)	<0.001
Overcommitment	1.16 (1.04–1.30)	0.008
Effort-reward ratio	12.28 (3.08–48.86)	<0.001

*Adjusted for gender, race, years of services, job position, noise exposure, use of HPDs, and measured hearing at 4 k & 6 k.
CI, confidence interval; OR, odds ratio.

both groups of workers, researchers found significant associations between occupational stress and tinnitus, after adjusting for respondent age, noise exposure, and other demographic variables. Similar to the current study, this investigation was cross-sectional, and capture of potentially relevant covariates was limited, so researchers were unable to postulate a causal direction of these findings.[28] Nonetheless, the linkages between occupational stress and tinnitus appeared to be significant for these diverse occupational groups, even when using multiple approaches to measuring stress exposure at work.

In an interesting variation on these approaches to measuring the links between occupational stress and tinnitus, Herr and colleagues[29] used the concept of organizational justice, an idea reflecting perceived fairness at the workplace, as a potential predictor for tinnitus among a sample of pharmaceutical company workers in Germany. These researchers found that lack of perceived organizational justice at work was associated with increased reports of tinnitus, a finding they account for in part by demonstrating that both burnout and depression act as mediators in the relationship.[29] The authors' discussion, in which they emphasize the complex interrelationship between experiences of stress at work (which can lead to burnout) and more global experiences of depression (which can be worsened by burnout or can cause it), provides an important extension to the findings of this study and points to the need to evaluate firefighters' direct work stressors and the impact these experiences have on their lives as a whole.

In Sweden, researchers used a population-based approach to explore the relationship between noise exposure, stress, and tinnitus.[30] Using a national health survey with more than 12,000 participants, researchers found that occupational stress perception was a key factor in the transition from mild to severe experiences of tinnitus. Researchers reported that whereas noise exposure and occupational stress were each independently associated with tinnitus, together they had an additive effect. In other words, a higher than expected number of respondents exposed to both noise and stress at work reported tinnitus.[30] These findings have not been reported elsewhere, but this approach to capturing the impact of several known risk factors for tinnitus seems important to consider. For worker populations like firefighters who are known to face multiple occupational health risks simultaneously, the potentially additive nature of these exposures can help guide health promotion practices. In addition, using quantitative measures of increased tinnitus may illuminate the causal pathways between stress and tinnitus and reduce the likelihood of confounding by age or job position.

Prior research has explored the links between occupational stress and adverse health outcomes in firefighters. Researchers focused on cardiovascular risk factors used the ERI questionnaire to investigate the links between job demands and hypertension.[17] Although they found that increased ERI was not correlated to higher blood pressure among firefighters, they did determine that excess 24-hour shifts were linked to higher blood pressure.[17] This finding points to the complexity of measuring occupational stress in a group that faces a range of working conditions that may contribute to the overall experience of stress. In addition, the risk factors for cardiovascular disease are broad and are likely to be more evenly distributed among multiple occupational groups. Although studying a different population of firefighters, the military firefighters researchers also found that, from 2001 to 2015, incident rates of alcohol use disorder, hypertension, and tobacco use all declined.[19] These findings are likely due to improved treatment and screening procedures, as well as larger shifts in social attitudes. At the same time, greater understanding of the mental health consequences for working in an environment characterized by extreme stress and repeated exposure to trauma[31] has taken on new urgency.[32]

Recognizing the specific types of occupational stress that firefighters encounter, including the long shifts, unpredictable patterns of work requiring the need for constant readiness, and emotional trauma due to experiencing death and disaster, researchers have begun exploring unique approaches to stress management, leveraging the essential social connections that are forged between coworkers.[33] Based on the findings that occupational stress may heighten the risk for conditions such as tinnitus, it will be important for health providers and other advocates to consider all possible options to encourage stress management and positive coping among this population of workers. Assessment of work-related stress and other mental health conditions in frontline essential workers such as firefighters has taken on new prominence in occupational health since the onset of the coronavirus pandemic, and the services communities rely on for functioning were tested in new ways. Although there is not a single prescription to measure and manage stress, incorporating responsiveness and openness to discussion of mental health challenges is a necessary starting point.[34] Qualitative researchers have identified the importance of culturally responsive approaches to identifying and treating mental health issues among firefighters, recognizing the unique attributes of the workforce that have historically impeded access to care.[35]

In addition, as researchers approaching occupational stress through the lens of organizational justice point out, aspects of work design, demanding workplace cultures, and lack of fairness are an important contributor to increased stress and resulting health concerns.[29] Those committed to workers' health and safety should support critical appraisal of the working conditions firefighters face, recognizing that stress management has limitations under circumstances where expectations of self-sacrifice are strongly embedded in the explicit and implicit demands of the job. Further, it is notable that the element of the reward construct most strongly associated with odds of tinnitus was reduced job promotion, demonstrating the role access to career advancement plays in overall occupational stress. In evaluating the relationship between workers and their environments, workers' perception of fairness in performance assessment and promotion can play an important role and can provide an additional focal point for needed change.

Firefighters face a multitude of physical hazards on the job, but the impact of occupational stress on their long-term well-being and continued ability to perform their work role should not be neglected. Current National Fire Protection Agency guidelines specify that hearing tests should be performed annually on all fire department personnel who are exposed to noise. In addition, guidelines state that both behavioral health screening for suicidality/depression and occupational stress consultation should be provided during annual health assessments.[36] In the course of conducting these assessments, clinicians can discuss the potential relationship between what might appear to be unrelated sets of symptoms, helping firefighters understand the risks of unmanaged work stress. For firefighters experiencing tinnitus in addition to mental health conditions such as anxiety or depression, clinical intervention is warranted, particularly as these conditions combine to worsen both sets of symptoms. While evidence of long-term efficacy is needed, findings from the recent Cochrane systematic review indicate that CBT or audiological treatments may be worthwhile treatments to pursue for individuals experiencing tinnitus in addition to mental health conditions.[10] The International Association of Firefighters and other advocacy groups have developed trainings to incorporate peer support and increase resilience among firefighters, helping improve access to needed mental health services.[37]

Strengths and Limitations

This study used a validated occupational stress measure to investigate the links between occupational stress and tinnitus. It is a meaningful contribution to the emerging discussion of how occupational health risks may combine to lead to worse health outcomes. Based on our literature review, this study may be one of the first investigating the association of work stress with tinnitus in the United States, with earlier reported studies describing findings from Europe and Asia. In addition, this study took noise exposure and measured hearing into account to better describe the links between tinnitus and stress. The study also has several limitations. First, the cross-sectional approach necessarily limits the ability to demonstrate causality between the variables

of interest, and potentially meaningful information about exposure to tinnitus risk factors during leisure time was not available. Further, the survey response rate was highly variable, depending on recruitment method, although we do not have reason to believe the responder/nonresponder population was different with respect to our variables of interest. In addition, the sample was limited geographically and was not diverse with respect to gender or race/ethnicity. This may impact some of the generalizability of the above findings; however, the sample composition is not dissimilar from other fire departments in the United States.

Conclusion

Firefighters face multiple occupational hazards and perform a socially essential role that often involves personal sacrifice. Although tinnitus and stress may not be the first hazards that come to mind when enumerating these risks, the potential for stress to worsen what can be a debilitating hearing-related condition bears further consideration. As occupational health providers and public health advocates work toward mitigating other types of risk for firefighters, the role of stress and tinnitus should be part of an effective health promotion plan.

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