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Noise and neurotoxic chemical exposure relationship to workplace traumatic injuries: A review☆

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ABSTRACT

Introduction: More than 5,000 fatalities and eight million injuries occurred in the workplace in 2007 at a cost of $6 billion and $186 billion, respectively. Neurotoxic chemicals are known to affect central nervous system functions among workers, which include balance and hearing disorders. However, it is not known if there is an association between exposure to noise and solvents and acute injuries. *Method*: A thorough review was conducted of the literature on the relationship between noise or solvent exposures and hearing loss with various health outcomes. *Results*: The search resulted in 41 studies. Health outcomes included: hearing loss, workplace injuries, absence from work due to sickness, fatalities, hospital admissions due to workplace accidents, traffic accidents, hypertension, balance, slip, trips, or falls, cognitive measures, or disability retirement. Important covariates in these studies were age of employee, type of industry or occupation, or length of employment. *Discussion*: Most authors that evaluated noise exposure concluded that higher exposure to noise resulted in more of the chosen health effect but the relationship is not well understood. Studies that evaluated hearing loss found that hearing loss was related to occupational injury, disability retirement, or traffic accidents. Studies that assessed both noise exposure and hearing loss as risk factors for occupational injuries reported that hearing loss was related to occupational injuries as much or more than noise exposure. Evidence suggests that solvent exposure is likely to be related to accidents or other health consequences such balance disorders. *Conclusions*: Many authors reported that noise exposures and hearing loss, respectively, are likely to be related to occupational accidents. *Practical applications*: The potential significance of the study is that findings could be used by managers to reduce injuries and the costs associated with those injures.

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1. Problem

More than 5,000 fatalities and eight million injuries occurred in the workplace in 2007 at a cost of $6 billion and $186 billion, respectively (Leigh, 2011). Approximately 22 million workers are exposed to hazardous noise in the United States (Tak, Davis, & Calvert, 2009). *Healthy People 2020* objectives include a 10% reduction in occupational injuries to 380 per 10,000 workers (HHS, 2010). One potential contributor to occupational injury is noise exposure (Girard et al., 2009; Kling, Demers, Alamgir, & Davies, 2012). Cohen (1973a) reported a higher number of accidents per worker among younger workers in high noise jobs (≥95 dBA) but he did not control for inherent risk of injury in jobs. Girard et al., (2009) reported that noise exposure (>90 dBA) increased the risk of workplace accidents (RR = 1.1 to 1.3) as did hearing loss (RR = 1.1 to 2.3) and both factors (RR = 1.2 to 2.8). Girard et al., (2009) recruited participants from six manufacturing industries, somewhat controlling for workplace risk. Workers were shown to have higher injuries among those newly exposed to noise and those with high job complexity (Melamed, Fried, & Froom, 2004). These significant associations may be due to hearing loss (Park, Bushnell, Bailer, Collins, & Stayner, 2009; Zwerling et al., 1996), high job complexity (Melamed et al., 2004), or communication abilities (Kling et al., 2012).

Solvents are commonly used in many industries and processes including: vapor degreasing, dry cleaning, painting, adhesives, dyes, agricultural products, aviation, and shoes and other textiles (Kelafant, Berg, & Schleenbaker, 1994; NIOSH, 1987). Over 30 million American workers are exposed to hazardous chemicals in their workplaces, and several of these can represent a risk to the hearing of the exposed worker (OSHA, 2004). An outdated, but best estimate is that there are as many as 9.8 million workers exposed to organic solvents (NIOSH, 1987). Organic solvents are volatile, relatively stable, liquid (at room temperature) mixtures or compounds in the following general classes: aliphatic hydrocarbons, cyclic hydrocarbons, aromatic hydrocarbons, halogenated hydrocarbons, ketones, amines, esters, alcohols, aldehydes, and ethers (NIOSH, 1987). Many industries with solvent exposures also have workers exposed to hazardous noise levels. Masterson et al.

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Table 1
Studies on noise exposure and risk of occupational injury, absence, or symptom.
Table adapted from (Palmer et al., 2008).

Design first author	Definition of exposure*	Injury or health measure	Sample size	Effect measure**	Point estimate (CI)†	Factors considered‡
Amjad-Sardrudi et al. (2012)	≥85 dBA	Workplace injuries	1062	OR	1.52(1.10,2.11)	a, y
Barreto et al. (1997)	High ≥95 dBA	Fatality	177	OR	2.19(0.60, 8.04)	e
	Moderate				5.72 (1.63, 20.1)	
	Low <90 dBA				3.05(0.80,11.7)	
(Cohen, 1973b)	High >95 dBA	% with 15 accidents in	903	%	35%	a, o, e,
Boiler plant only	Low <80 dBA	5 year period			5%	
Cantley et al. (2015)	>88 dB	All injuries	9,220 workers	RR	1.61 (1.13–2.30)	a, li, o, ra, s, y
	85–87.9 dB				1.34 (1.07–1.70)	
	82–84.9 dB				1.15 (0.94–1.41)	
	<82 dB					
	>88 dB	Serious Injuries			2.29 (1.52–3.47)	
	85–87.9 dB				1.39 (1.05–1.85)	
	82–84.9 dB				1.26 (0.96–1.64)	
	<82 dB					
Clausen et al. (2009)	Self-report noise	Sickness absence	5186	HR		a, e, c, ch, b, al, sm, r
	exposure — men > ¾ time				0.87 (0.61, 1.23)	
	1/2 time				1.43 (1.10, 1.85)	
	Rarely				1.37 (1.07, 1.76)	
d'Errico and Costa (2012)	Noise & vibration, men	Sickness absence	60,000	OR	1.36 (1.05, 1.77)	r, a, e
Dias and Cordeiro (2007)	Workplace noise: High	Hospital admission for	600	OR	2.294(1.513, 3.479)	e, a, o
	Medium	work-related injury			1.630(1.172, 2.268)	
	Low				1.331(0.938, 1.887)	
	All			AF	30.4%	
Dias and Cordeiro (2008)	Noise:	Work-related accident	432	RR		e, w, o, co, sh, ov
	Always	in past 90 d			4.955(2.817, 8.716)	
	Sometimes				3.660 (1.817–7.370)	
Girard, Leroux, Verreault, et al. (2015)	Year of noise exposure	Death from CVD	5,524 workers	OR		a, o, n
	≥37 y		over 55 years		1.70 (1.10–2.62)	
	27–36.4 y				0.76 (0.47–1.22)	
	<27 y				1.00	
Girard, Leroux, Courteau, et al. (2015)	Noise ≥100 dBA	Work-related hospital	46,550	HR	2.36 (2.01 to 2.77)	a, y
	Noise 80–89 dBA	admission				
Girard et al. (2009)	Noise ≥90 dBA	Acute accident #	52,982	RR		a
		1			1.08 (1.02, 1.14)	
		2			1.21 (1.12, 1.31)	
		3			1.15 (1.03, 1.28)	
		4			1.28 (1.15, 1.43)	
Kling et al. (2012)	Noise >85 dBA, duration:	Hospitalized for	5000	RR		a, ra, yr
	5+ y	workplace injury			1.27 (0.58, 2.55)	
	2–5 y				1.75 (0.90, 3.12)	
	1–2 y				1.82 (0.94, 3.56)	
	91 d– 1 y				2.01 (1.06, 3.78)	
	2–90 d				1.58 (0.74, 3.38)	
Lees et al. (1980)	Noise exposure	Medical events	140		$p = 0.702$	a, y, sh
	≥90 dBA ≤85 dBA	Head-aches			$p = 0.714$	
		Accidents			$p = 0.954$	
Melamed et al. (1992)	Noise exposure	Accidents:	2368	X^2		
	high (≥85 dBA),	M			7.9 ($p = 0.02$)	
	moderate (75–84 dBA)	F			2.8 (n.s.)	
	low (<75 dBA)	Sickness: absence				
		M			35.9 ($p < 0.005$)	
		F			8.0 ($p < 0.005$)	
		Job satisfaction:				
		M			6.8 ($p < 0.001$)	
		F			17.3 ($p < 0.001$)	
Melamed et al. (2004)	Noise exposure >80 dBA	Accident with 1 lost work day	6014	OR	5.96 (0.99–15.67)	r, a, b, y, e, o
Moll van Charante and Mulder (1990)	>82 dBA	Recordable injuries	600	OR	1.83 (1.17, 2.88)	al
Picard, Girard, Simard, et al. (2008)	Noise >90 dBA	WC accidents	52,900	AF	6.2%	a, n
Picard, Girard, Courteau, et al. (2008)	Noise ≥100 dBA	Traffic accident	46,030	PR	1.07 (1.01,1.15)	a, y
Sbihi et al. (2008)	Noise (dBA) >115	Hypertension,		RR	1.3 (0.9, 1.7)	a, yr, ra
	110–115	3 doctor visits, death,			1.3 (0.9, 1.6)	
	105–110	or hospital visit			1.1 (0.8, 1.5)	
	100–105				1.1 (0.8, 1.5)	
	95–99				0.8 (0.6, 1.2)	
	Cumulative exposure				32%	
	>95, >19 y				1.3 (1.05, 1.6)	
	>90, >19 y				1.3. (1.0, 1.5)	
	>85, >29 y				1.5 (1.1, 2.0)	
Yoon et al. (2015)	≥90 dB	Injury claims by company	1,790 companies	OR	3.68 (2.35–5.78)	sh
	80–89 dB				1.72 (1.25–2.37)	
	<80 dB				1	