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Does Occupation Explain Gender and Other Differences in Work-Related Eye Injury Hospitalization Rates?

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Abstract

Objective— We sought to determine whether demographic differences in eye injury rates persist after adjusting for occupational exposure.

Methods— On-duty eye injury hospitalizations were linked to occupation among active-duty US Army personnel.

Results— Eye injury rates were higher for white solidiers, men, and for younger soldiers, even after adjusting for occupational group and specific job titles using multivariate models.

Conclusions— This finding contrasts with studies of other injuries, suggesting that occupation does not fully account for variations in eye injury risk. Because protective eyewear can prevent most serious eye injuries, we hypothesize that differences in protective eyewear use between men and women may contribute to differences in eye injury rates, although follow-up studies are needed to confirm this. Prevention efforts should consider targeting high-risk demographic groups in addition to high-risk occupations.

Occupational injuries are important causes of preventable morbidity and long-term disabilities in working adults in the United States. Studies of occupational injuries have shown wide variations in injury rates by type of occupation, gender, and other demographic factors. Excess injury rates typically are seen in men, younger individuals, and certain racial groups.^{1–6} Although it is assumed that differences in occupational exposures may explain in part these disparities, it is not clear the extent to which these variations are caused by differences in behavior (eg, men take greater risks) or caused by differences in exposure to hazardous conditions and occupations (eg, men are more likely to work in “high-risk” occupations). Thus, the extent to which specific occupational exposure is a confounder of the demographic patterns of trauma has not been adequately addressed. Understanding these factors will aid in more effective and targeted injury prevention strategies for those in high-risk occupations.

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However, a major challenge facing researchers is how to separate out the influence of risk behaviors from the effects of occupational exposures because accurate information on work exposures is difficult to obtain. Studies that examine work injury risks in broad occupational groups (eg, metal industry or automotive industry) often do not have enough specific information on work tasks and occupational risk. As a result, residual confounding may limit the inferences that can be made about demographic and behavioral risk factors. In fact, some studies that were able to adjust for occupational exposure have shown that demographic risk patterns apparent in unadjusted models may even be reversed once work exposure is adequately controlled. For example, men may initially appear to be at greater risk for some types of work-related injuries. However, once exposure is controlled, in some cases women may actually have higher rates of some injuries than men, possibly because of differences in training, physical capacity, or inherent biological differences between men and women.^{6–16}

In an earlier study of eye injuries in the US Army, we found large differences in hospitalization rates for eye injury by gender, age, and race/ethnicity groups, with young, white males generally experiencing greatest risk of ocular trauma.¹⁷ Because reliable occupational exposure data were not available, we were unable to control for occupational exposure. Recent advances in data linkage capabilities now allow us to examine risk by specific occupational subtypes doing the same job. This study examines whether the demographic differences in serious eye injuries among military personnel identified in our earlier study¹⁷ may be explained by differences in occupational exposure, or if the higher risks among the young, male, and white soldiers persist even after we control for occupational exposure.

Materials and Methods

Study Population and Case Definition

The study population consisted of all US Army personnel on active duty during the period 1980 to 1997. Denominator data were obtained from mid-year personnel files from the Defense Manpower Data Center (DMDC), which include information on subjects' demographic characteristics, including race and ethnicity, and current occupational specialty. Eye injury cases were identified from the Patient Administration Systems and Biostatistics Activity (PASBA) hospitalization database, which records all hospitalizations for active-duty personnel and includes principal and secondary diagnoses (nature of injury), and military STANAG codes that describe the cause of injury (including trauma codes that denote duty status).^{18–21} Serious eye injury cases were defined as any injury or foreign body affecting the eye or adnexa requiring hospitalization as either a principal or secondary diagnosis. Cases were selected using ICD-9-CM diagnostic codes used in our earlier study:¹⁷ ICD 802.6 – 802.7, 871.0 – 871.9, 918.0–918.9, 921.0–921.9, 930.0–930.9, 940.0–940.9, 941.02–941.52, 948, 950.0–950.9, 951.0, 951.1, and 951.3. STANAG (military cause) codes associated with these hospitalizations provide information on the circumstances or conditions under which an injury occurred as well as intentionality (unintentional versus assault) and duty status (on-duty, off-duty).^{18–20}

For this analysis investigating workplace exposure, only those cases that were coded as occurring on-duty (ie, at work) were included. Of the 8537 total eye injury hospitalizations, 38% were classified as on-duty, 37% were off-duty, and 26% had unknown duty status. Examination of the causes of injuries for the unknown duty status cases showed that they more closely resembled soldiers injured while off-duty than those with known on-duty injury. An earlier validation study reviewing a sample of all hospitalized injuries found that less than 20% of the unknown duty status cases could be attributed to on-duty injuries, whereas all cases coded as on-duty did occur at work.¹⁹ Thus, although our rates may slightly underestimate the true incidence of on-duty injuries, the exclusion of unknown cases is unlikely to influence the generalizability of our findings.

Data Linkage

Linkage of hospitalization and personnel records was accomplished using encrypted social security numbers and procedures developed for the Total Army Injury and Health Outcomes Database (TAIHOD).²¹ No individual identifiers are in the working database and the study was approved by the Human Use Review Committee of the US Army Research Institute of Environmental Medicine and the Committee on Human Research at the Johns Hopkins School of Public Health. Because occupational coding and reporting of race/ethnicity is not reliable in the hospital database, cases were linked with personnel files to record occupational assignment at the time of the injury as well as race/ethnicity, age and gender. Race/ethnicity categories are based on soldier responses on enlistment and categories routinely used in the services.

Military Occupations

Military personnel are assigned a primary military occupational specialty (MOS) based on their training and a more specific duty MOS for their actual job, which may change depending on new assignments.⁴ Current occupation was obtained from the personnel file as defined by the “duty MOS” variable. If “duty MOS” was not available then we used “primary MOS.”

Broad Occupational Group

We first grouped the study population into broader occupational groups for analysis using the Department of Defense (DoD) service wide classification system which allows collapsing of the specific MOS categories from each service into more general groupings (ie, medical, admin/support, infantry etc.) that are comparable with civilian occupations.²²

Specific Occupation

To investigate occupational exposures in more detail, we then examined a sample of eye injuries at the very specific MOS level. Of the 237 possible codes for enlisted personnel, we selected all MOSs with five or more on-duty eye injury hospitalizations among women to permit meaningful comparisons within MOSs that include male and female workers. These included light-wheeled vehicle mechanic, motor transport operator, unit supply specialist, food service specialist, and military police. Person-time exposure data were derived from personnel files for subjects specifically assigned to those MOSs based on the mid-year population for each of the 18-year study period and then compiled to obtain summaries of demographic and occupational person-time.

Statistical Analysis

Service-wide gender-, race-, and age group-specific rates of work-related ocular injury were calculated using hospital admission data ($n = 3690$) and personnel files and presented as rates per 100,000 person-years (PY) with 95% confidence intervals (95% CI) obtained using the Cornfield approximation. Analyses were performed using Stata 6.0 software (Stata Corporation, College Station, TX). Incident rate ratios (IRRs) and corresponding 95% confidence intervals (95% CI) were constructed using Poisson techniques²³ to represent the risk of hospitalized ocular injury relative to the strata with either the lowest incidence or largest denominator. Poisson regression models were created to compare rates among the demographic strata and occupational group while adjusting for other factors. The first model assessed the roles of gender, race/ethnicity, age group, and broad occupational group using all enlisted personnel. The second model was limited to enlisted personnel in the five MOSs previously mentioned and replaced the broad occupational group factor with specific occupation (MOS).

Results

The total study population comprised 13,372,000 person years during the period 1980 to 1997. The overall rate for hospitalized eye injuries for all persons in the military was 27.6 per 100,000 PY (Table 1). The crude rate for men was significantly higher than for women (IRR = 3.2, 95% CI = 2.7–3.8). Among different racial and ethnic groups, whites had significantly higher rates than blacks did (IRR = 1.2, 95% CI = 1.2–1.4). After 20 years of age, age-specific rates consistently declined from the youngest group to the oldest group.

Occupation

Broad Occupational Group—There was wide variation in eye injury hospitalization rates by broad occupational groups, ranging from 13.6 per 100,000 PY (support/admin) to 50.5 per 100,000 PY (infantry/gun crews) (Table 2). Infantry/gun crews and electrical/mechanical equipment repair groups accounted for the largest proportions of cases (40% and 16%, respectively) and had the highest rates; however, crafts workers also experienced high rates (39.2 per 100,000 PY). Enlisted personnel accounted for 94% of all hospitalized eye injuries and had dramatically higher rates than officers. Because of the low rates and small numbers of injuries to officers and warrant officers, they were grouped as “officers” for determination of rates but excluded from subsequent analyses because of insufficient cell-sizes.

Specific Occupation—Within the five enlisted MOSs selected for study there was also considerable variation in serious eye injury hospitalization rates (Fig. 1). Three MOSs had higher rates than that observed for the overall service and all showed higher rates than the rate for all officer MOSs combined. Motor transport operators had the highest rates of on-duty hospitalized eye injuries (46.9 per 100,000 PY), and the lowest rates were for unit supply specialists (21.6 per 100,000 PY) and military police (22.0 per 100,000 PY).

Demographics

Gender—The increased risk for on-duty eye injury was consistently higher among male soldiers across the broad occupational groups (Fig. 2A), although the confidence intervals overlapped for five of the nine groups. Similarly men had higher rates than women for each specific MOSs (Fig. 2b), although none of the differences were statistically significant. In subsequent pooled multivariate analyses the overall differences by gender were significant (Table 3).

Race/Ethnicity—White soldiers had significantly higher rates than black soldiers for on-duty injuries (Table 1; 29.6 per 100,000 PY versus 23.5 per 100,000 PY). Comparison of on-duty eye injuries by race/ethnicity and occupational groups showed that white soldiers had consistently higher rates than black soldiers across all occupational groups although the differences were not significant (data not shown). When the specific occupations were examined, white soldiers continued to have higher rates than black soldiers across all MOSs examined, but because of small numbers were not significant.

Age—Crude injury rates by age group showed that the rates were much higher in the younger age groups, particularly 21 to 24 year olds (39.5 per 100,000 PY vs. 5.7 for those older than 40 years; Table 1). However, when individual jobs or MOS were accounted for, the age pattern was not consistent. Given this variation in risk when examining individual MOS within specific occupational specialties, we then examined the risk of serious eye injury by adjusting for occupational exposure and demographic factors using multivariate analyses.

Multivariate Analyses

Multivariate analyses of variations in on-duty eye hospitalizations adjusting for both broad occupational group and specific MOS are shown in Table 3. Compared with the crude rates for all hospitalizations, adjustment at the broad occupational group level reduced the excess rates in males from 3.2 to 2.2. Even when adjusting for the specific duty MOS with presumably similar exposures and physical demands, the male excess risk persisted (IRR = 2.2). Similarly, for race, the small but significant excess risk among whites persisted in the partial adjustment by broad occupational group and was even more prominent in the specific adjustment by MOS.

In comparing rates among age groups, the excess risks among young personnel (21–24 years old compared to personnel 41+ years old) in the crude analysis (IRR = 6.9) and declining risk with increasing age were consistent but less pronounced in the partially adjusted model by broad occupational groups (IRR = 4.0) and specific adjustment by selected occupational specialties (IRR = 3.4).

Discussion

In our current study, we found that unadjusted eye injury hospitalization rates in the US Army were higher for men than women, white soldiers than black soldiers, and younger than older soldiers. These differences persisted after partial adjustment for occupation using broad occupational groups and also when we used more specific adjustment using detailed MOS (specific occupational titles) to adjust for occupational exposure. Each MOS has detailed job descriptions that are the same regardless of gender. Thus, our differences in work-related eye injury risk may not be attributable to variations in military occupational exposures alone. Although there may well be some differences in task assignment at the local level, each MOS in the Army is likely to involve more similar exposures than job titles in the civilian sector.

The military provides a useful environment in which to examine this interrelationship between demographic profile, occupational exposure and ocular trauma for several reasons. First, hospitalization for ocular trauma in the military appears to be more frequent. Our earlier study found that the US Army had eye injury hospitalization rates almost 30 times greater than a study of hospitalized civilian work-related eye injuries in California,^{17–24} although rates are declining as admission practices are becoming more similar to civilian practices.²⁵ Second, many potential confounders, such as full employment and full access to health care, are “controlled” by the unique features of military service. Third, homogeneous work activities are more likely within a specific occupational group (eg, food service specialists typically have similar duties).

Other studies of eye injuries that do not control for exposure consistently find higher risks in males and in young adults.^{17,20} Previous studies documenting excess injury risk in men often attribute the difference to variations in occupational exposure to risk.^{1,3,6,7,13,15–17,27} Those studies of occupational injury risk that have attempted to adjust for exposure use either rather broad occupational titles to adjust for job exposure^{9,13,28,29} or examine groups of men and women doing the same task.^{7,15} However, few studies have been able to do refined adjustments in controlled occupational environments as in the military, as most studies have to rely on only job titles as a surrogate for job exposure. In the military, studies of training injuries have shown that women have higher rates of training injuries than men once exposure is controlled.^{7,8,11,12,30,31} The unique controlled environment of military basic training provides a useful laboratory in which to study gender differences in injury risk, as trainees live and work/train under the same conditions for this time period (8 weeks in the Army basic combat training course). One study by Bell et al⁷ found that when using running speeds to adjust for pre-employment fitness, the gender difference in training injuries was eliminated. Studies of other injuries have also shown that while crude injury rates are higher in men, women

often exhibit higher injury rates after adjusting for occupational exposure, especially for musculoskeletal injuries.^{9,10,13–15} These findings contrast to our study, which found that higher rates of hospitalized eye injuries persist despite adjusting for exposure, and suggest that other factors may be important in explaining lower eye-injury risk among women who perform similar occupational tasks as men.

Studies examining racial variation in eye injuries offer less consistent results, with higher risks of ocular trauma reported among non-white populations in one study³² and lower risks in another.¹⁷ In the study of training injuries by Bell et al., an excess risk among white female soldiers as compared to black female soldiers was reported (RR 1.31, 95% CI = 0.98–1.94),³³ comparable to our study of eye injuries, and this difference persisted even when adjusting for physical fitness. The rates were also higher among white male trainees than black, but did not achieve statistical significance.

Some studies have suggested that the excess female injury risk may be caused in part by their increased likelihood to seek medical attention.³⁴ To overcome this potential bias some studies restrict themselves to injuries that generally require treatment such as fractures, more severe injuries such as lost time injuries, or objectively verifiable injuries such as lacerations.^{7,9} When adjusting for injury severity, the gender differences persist, and in some cases even become more pronounced.⁷ One study, however, did find some increased reporting of more subjective injuries (ie, muscle pain) by women.⁹ Because we only examined hospitalized eye injuries we have substantially diminished potential gender-related reporting bias, as admission practices are unlikely to vary by gender.

Our study does not provide an explanation of why eye injury rates continue to be higher in young, white men. Eye injuries are very different from many other types of injuries (eg, musculoskeletal injuries) in that biological factors such as hormonal or body composition differences^{15,16} are unlikely to be important in susceptibility of the eye to acute trauma. Furthermore, there are few injuries where there exists such an effective and simple strategy as protective eyewear to prevent eye injuries.^{35–38} Although our findings suggest that occupational exposure alone cannot account for elevated injury risk among groups such as young white males, we can only speculate as to potential explanations. One hypothesis could be that they are less likely than other groups to wear adequate eye protection. This observation may be related in part to differences in perception and willingness to use protective eyewear in this demographic group. However, our study could not examine this issue, and we could find no studies documenting usage rates for eye protection by gender or other characteristics. Other studies have found that young men are less likely to perceive risk from dangerous behaviors, have lower seat belt use, use of other protective equipment or sun-screen, and overestimate their skills for driving motor vehicles and swimming.^{39–42} Previous work also indicates that the same demographic group of soldiers at highest risk for ocular trauma, enlisted white males in infantry and craftworker occupational groups, are also at greatest risk for a variety of risk-taking behaviors, including smoking, excessive alcohol consumption, driving without a seat belt, and speeding.^{43,44} White male enlisted soldiers were also at greater risk for engaging in these high-risk behaviors than were black male enlisted soldiers.⁴⁴

One implication of our study is that preventive programs may be more appropriately directed at specific demographic groups within high-risk occupations, rather than focusing only at specific occupational groups per se. This might suggest a need to not only focus on high-risk jobs but to also look for age-occupation and sex-occupation interactions. Given that effective protective eyewear is available that can prevent many eye injuries future studies should be directed at determining if usage rates do vary by gender in the same at risk groups.

One of the important strengths of this study is that accurate data are available on occupation at the time of injury for all cases and race was reported consistently in the numerator and denominator. This was only made possible by the ability to link separate databases using unique identifiers. Data linkage has been shown in other studies to greatly increase the quality of data available in individual databases and their value for epidemiologic research.^{20,45–48} This feature is one of the major strengths of using military data for epidemiologic research that has implications beyond just the military environment, especially as occupational data is not available in civilian hospital databases. Without the ability to adjust for differences in exposure on the job, analyses of hospitalized eye injuries would suggest the need to focus prevention efforts mainly on high-risk jobs. With respect to the generalizability of these results to the civilian population, it should be noted that only about a fifth of all serious eye injuries were caused by weapons and only 4% of these occurred in battle situations. Thus, the vast majority of occupational eye injuries as well as other injuries in the military occur during peacetime and when performing jobs similar to those found in the civilian world.^{17–20} One potential limitation, however, of the study is that it only examines those injuries admitted to a hospital and does not include the much larger number of eye injuries treated in outpatient clinics.²⁶ However, the injuries studied represent the more serious cases and although the criteria for admission has changed over time²⁵ it is unlikely that any demographic group within occupations would be more or less likely to be admitted at the same point in time. Over time there has been some change in the demographic composition of the army enlisted population but not enough to account for our study findings. From 1980 to 1991 the proportion of enlisted females increased slowly from 9.1% in 1980 to 11.2% in 1991, and then rose to 15.1% in 1997. Blacks comprised 32.9% of the enlisted force in 1980 and 29.7% in 1997, whereas Hispanics rose from 4.4% to 7.0% over the same time.⁴⁹

Occupation-related ocular trauma is an important cause of preventable morbidity and long-term disability in both civilian and military populations despite the availability of highly effective protective equipment that can even prevent small caliber high velocity eye injuries.^{24,36,37,50–66} Barriers to protective eyewear use include comfort, visibility, ability to rapidly clean lenses when splattered by substances, previous history of eye or other injury, cost, group norms, and attitudes and perception of risk.^{34,35,56,67–69} Policy changes mandating eyewear use have been shown to be effective, especially in unstructured work environments where engineering solutions are more difficult to implement³⁶ as have a work environment with safety climates that are supportive of the use of safety equipment and make it available.⁷⁰ More studies are needed to determine how usage rates for eye protection actually vary among demographic subgroups within high-risk occupational groups and how to improve usage rates as compliance is often low despite availability of good equipment.^{36,55–57,62} It is also important to collect information on usage of eye-wear at the time of the injury and to evaluate if current standards for eye protection are appropriate for the tasks involved, including those for off-the-job activities such as sports. Preventive measures should be directed at both high-risk activities and at specific demographic groups, including factors influencing the use of protective eye-wear in these groups and mandating use when indicated.

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Fig. 1. Occupational specialties with highest rates of serious on-duty eye injuries, US Army, 1980 to 1997.

Fig. 2.

(A) On-duty enlisted serious eye injury rates (95% CI) by sex and broad occupational groups, US Army, 1980 to 1997. (B) On-duty enlisted serious eye injury rates (95% CI) by sex and occupational specialties, US Army, 1980 to 1997.

Variation in On-Duty Eye Injury Hospitalization Rates per Person Year Among Active Duty US Army Soldiers by Gender, Race/Ethnicity, and Age Group, 1980–1997

TABLE 1

Category	Strata	Hospital Discharges		Person-Years	Hospitalization Rate per 100,000 (95% CI)
		N	(%)		
Total		3690	(100)	13,372,656	27.6 (26.7–28.5)
Gender	Female	139	(3.8)	1,495,287	9.3 (7.9–11.0)
	Male	3551	(96.2)	11,877,369	29.9 (28.9–30.9)
Race/ethnicity	White	2514	(68.1)	8,507,099	29.6 (28.4–30.7)
	Black	875	(23.7)	3,717,514	23.5 (22.0–25.1)
	Hispanic	145	(3.9)	557,296	26.0 (22.1–30.6)
	Other	156	(4.2)	590,747	26.4 (22.6–30.9)
Age group *	17–20	896	(24.3)	2,348,582	38.2 (35.7–40.7)
	21–24	1503	(40.7)	3,804,740	39.5 (37.6–41.6)
	25–30	828	(22.4)	3,378,082	24.5 (22.9–26.2)
	31–35	290	(7.9)	1,799,700	16.1 (14.4–18.1)
	36–40	127	(3.4)	1,237,732	10.3 (8.6–12.2)
	41+	46	(1.2)	803,763	5.7 (4.3–7.6)

* Age groups based on demographic data routinely used by US Army.

TABLE 2
On-Duty Eye Injury Hospitalization Rates by Broad Occupational Group, US Army, 1980–1997

Personnel Category	Occupational Groups	Hospital Discharges			Rate per 100,000
		N	(%)	Person-Years	
Total Enlisted	Infantry/gun crews	3690	(100)	13,372,656	27.6
	Electronic equipment repair	1473	(40)	2,917,407	50.5
	Communications/intelligence	95	(3)	600,326	15.8
	Health care	372	(10)	1,452,813	25.6
	Technical/allied special	118	(3)	841,210	14.0
	Support/admin	81	(2)	318,074	25.5
	Elect/mechanical equipment repair	262	(7)	1,920,473	13.6
	Craftsworkers	573	(16)	1,785,002	32.1
	Service/supply	103	(3)	262,532	39.2
	Nonoccupational	379	(10)	1,350,199	28.1
	Other	0	(0)	38,833	0.0
	All enlisted	6	(0)	26,931	22.3
		3462	(94)	11,513,800	30.1
		49	(1)	265,194	18.5
Warrant officers		179	(5)	1,594,978	11.2
Officers					

TABLE 3

Crude and Adjusted Rate-Ratio Estimates by Demographic and Occupational Group for On-Duty Eye Injury Hospitalizations Among Enlisted Soldiers in the US Army, 1980–1997

Category	Strata	Incidence Rate Ratio (95% CI), Crude Analysis*	Incidence Rate Ratio (95% CI), Multivariate Poisson Regression by Broad Occupational Group†	Incidence Rate Ratio (95% CI), Multivariate Poisson Regression by Specific Occupational Specialty‡
Gender	Female	Referent	Referent	Referent
	Male	3.22 (2.71–3.84)	2.19 (1.99–2.43)	2.23 (1.52–3.28)
Race/ethnicity	White	Referent	Referent	Referent
	Black	0.80 (0.74–0.86)	0.89 (0.85–0.93)	0.67 (0.54–0.84)
	Hispanic	0.88 (0.74–1.04)	0.80 (0.71–0.89)	0.92 (0.56–1.50)
	Other	0.89 (0.76–1.05)	1.03 (0.93–1.14)	0.98 (0.61–1.56)
Age group	17–20	6.67 (4.96–9.17)	3.25 (2.68–3.95)	3.52 (1.44–8.63)
	21–24	6.90 (5.15–9.47)	4.02 (3.32–4.87)	3.37 (1.38–8.20)
	25–30	4.28 (3.18–5.90)	2.83 (2.33–3.44)	2.82 (1.15–6.93)
	31–35	2.82 (2.06–3.93)	1.91 (1.56–2.34)	1.99 (0.78–5.06)
	36–40	1.79 (1.27–2.57)	1.48 (1.19–1.84)	0.97 (0.34–2.75)
	41+	Referent	Referent	Referent

* Includes all active-duty Army personnel.

† Includes only enlisted personnel, model includes occupational group (results not shown).

‡ Includes only enlisted personnel in occupational specialties of light-wheeled vehicle mechanic, motor transport operator, unit supply specialist, food service specialist, and military police; model includes occupational specialty (results not shown).