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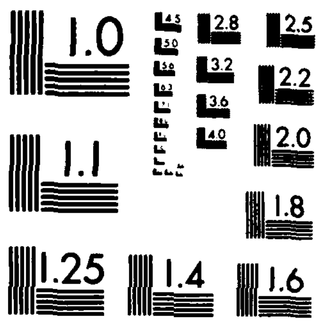

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INDIVIDUAL CHARACTERISTICS AS PREDICTORS OF ACCIDENTAL INJURIES IN NAVAL PERSONNEL

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REPORT NO. 83-10

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BETHESDA, MARYLAND

Individual Characteristics as Predictors of Accidental Injuries in Naval Personnel[1]

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Summary

Problem

Accidental injuries accounted for almost 25% of all days lost because of hospitalizations for Navy enlisted personnel in 1974. Previous studies have found that pre-enlistment individual characteristics such as age at enlistment, general aptitude, and education level predicted military performance effectiveness during and after recruit training. Because previous studies have found highest accident rates among first term enlistees, this study will determine the relationship of these pre-service characteristics, plus occupation, to accidental injuries for a cohort of naval enlistees throughout the first enlistment.

Objective

The objective of this study was to relate preenlistment and service-related characteristics to accidental injury rates for first term enlistees in order to identify high risk groups and focus preventive efforts.

Approach

The study extracted all hospital admissions and deaths due to accidental injuries for a cohort of male enlisted personnel who entered the Navy in 1974. This cohort was followed throughout the four years of the first enlistment. Age, education, and mental ability classification at enlistment were analyzed singly and jointly, as well as occupation at the time of injury, and were related to injury rate during enlistment by a modification of the life table technique. This technique takes into account varying lengths of time spent in the cohort and losses from the cohort due to discharge from the service or death.

Results

The individual characteristics of age at enlistment, educational level, and mental ability all were found to relate significantly to injury when considered singly. When considered jointly, however, only education had a major effect on injury rate. The occupational analysis indentified a number of high-risk occupational specialties (occupations with injury rates above the Navy norm). With the exception of Hospital Corpsman, all of these occupations were engineering, construction, or aviation specialties in which exposure to hazardous machinery or equipment was evident.

Conclusions/Recommendations

1. In general, the results indicated that the same individual characteristics that predict poor military performance also predict risk of accidental injury.

2. Improved safety training and closer supervision should be considered for first term enlistees, particularly non-high school graduates, who are in occupations found to be at high risk for accidents.

3. A modified life table technique was found to be appropriate for this type of longitudinal analysis where large and uneven withdrawals from the cohort occurred.

4. Further analysis of large cohorts from high-risk occupations will be needed to understand the causal factors underlying observed differences in injury rate.

Individual Characteristics as Predictors of

Accidental Injuries in Naval Personnel

Accidental injuries accounted for almost 25% of all days lost because of hospitalizations for Navy enlisted personnel, or almost one-half million noneffective days, in 1974 [Melton and Hellman, 1977]. The cost to the U.S. Government in terms of dollars and manpower losses, together with the associated human suffering, provides a strong incentive to reduce accidental injury rates. A logical approach to the reduction of accidents would be to identify personnel characteristics and occupational factors associated with risk of injury. To this end the present study investigates selected personnel and occupational factors that may contribute to accidents in naval environments.

During the 1960s studies conducted by all of the military services found that the individual characteristics of age at enlistment, educational level, and general aptitude were predictors of military effectiveness among enlisted personnel [Fisher et al., 1960; Klieger, Dubuisson and de Jung, 1961; Plag and Goffman, 1966]. These predictors have been incorporated into actuarial tables to provide assistance in recruiting and separation or retention decisions [Plag and Hardacre, 1964; Plag and Goffman, 1968]. The consistency with which these variables predicted military effectiveness in spite of differences in study design and the particular definition of effectiveness made them logical choices as possible predictors of accidental injuries. Therefore, the hypothesis addressed in this study was that the individual characteristics of age at enlistment, educational level, and aptitude will singly or in combination, predict accidental injuries among Navy enlistees during their first enlistments. In addition, occupational specialty and pay grade have been shown to influence accident rate [Brownley, 1979; Ferguson, McNally and Booth, 1981(a)] and were examined in the present study.

In studies of illness aboard ship, it was found that age and educational level were inversely related to illness rate [Gunderson, Rahe and Arthur, 1970]. However, conflicting evidence has been presented concerning the relationship of individual characteristics to accident rates among naval personnel. One study [Butler and Jones, 1979] reported that age and pay grade but not educational level were predictive of accident rate among Deck Division personnel aboard 15 destroyers. Another study [Pugh and Gunderson, 1975] of enlisted personnel aboard 20 destroyers and 2 aircraft carriers found no significant correlations between age, pay grade, and educational level and traumatic injuries. Other studies have shown that accident rates were highest early in the individual's naval careers and declined with increasing levels of seniority or experience [Fisher et al., 1960; Hoiberg, 1980; Plag et al. 1966].

Recent cross-sectional studies of accidental injuries by the authors [Ferguson et al., 1981(a)(b)] have provided preliminary incidence data on accidental injury hospitalizations among Navy enlisted personnel. The present longitudinal study examines distributions of accidental injury hospitalizations and deaths during the first enlistment. This type of cohort analysis has not been technically feasible previously. A longitudinal analysis was conducted for a cohort of naval enlistees entering service in 1960-1961 [Plag and Phelan, 1970], but differences in individual characteristics were not considered. The present analysis which relates individual and occupational characteristics to accidental injury rates should help to identify high-risk groups and to focus preventive efforts.

METHOD

The study included all hospital admissions and deaths from accidental injuries for a cohort of male enlisted personnel who entered in the Navy in 1974 (N = 87,549). This cohort was followed through four years of the first enlistment. Hospitalization and death data were obtained from computer files maintained at the Naval Medical Data Services Center, Bethesda, Maryland. These records were edited and compiled into individual medical history files maintained at the Naval Health Research Center, San Diego for all active duty naval personnel. Primary diagnosis and date of admission were extracted from each hospitalization record. Date and cause of death were extracted from death records. Hospitalizations were considered to be injury-related if the diagnoses were included in the "Accidents, Poisonings, and Violence" category of the International Classification of Disease, Adapted for Use in the United States, Eighth Revision. Injuries that resulted in deaths without associated hospitalizations also were included in the study. Self-inflicted, combat-related, or assault injuries were excluded.

The medical history files contained pertinent demographic and service history information. Age, education, and mental ability classification at the time of enlistment were extracted as well as occupational status (occupation and pay grade) at the time of injury.

In order to monitor and adjust for attrition from the cohort over time, the four-year enlistment was divided into seven intervals. Reflecting the fact that most attrition occurs early in the enlistment, the first two intervals were three months in duration, followed by three six-month intervals and two 12-month intervals. Previous experience with enlistee attrition also has shown that withdrawals do not occur evenly throughout an interval but tend to occur in large groups. Thus, attrition adjustment methods assuming uniform attrition throughout the interval could not be applied. A more precise attrition measure--the length of time actually served prior to withdrawal--was used in the study [Lee, 1980].

The follow-up life table technique, as described by Remington and Schork [1970], with the modification for attrition adjustment described above, was used to analyze the accident experience of the cohort over time in order to determine the probability of injury in the total population and in various subgroups. This technique takes into account varying lengths of time spent in the cohort and losses from the cohort due to discharge from the service or death during the term of the first enlistment.

Appendix A provides a sample modified life table and a description of calculations illustrating injury experience for one level of one variable--less than 12 years of education. Although the probability of injury was computed for each time interval, only the final cumulative probability over four years was of major interest in this study. Thus, as shown in Appendix A, individuals with less than a 12th grade education had a 10.4% probability of being injured over the first 4-year enlistment. Similar life tables were calculated for all levels of the other variables. Because previous studies had demonstrated moderate intercorrelations among the three individual characteristics of interest, a joint life table also was calculated for these three variables simultaneously.

The standard error of Px, that is, the standard error of the probability of no injury occurring to those entering any time interval x, was computed using a modification of a method described by Remington et al. [1970]. Ninety-five percent confidence intervals were computed for the cumulative rate of injury over the four-year period for each level of each variable. Non-overlapping confidence intervals between levels of each variable were used to evaluate significance of differences and to define levels for use in the three-way analysis.

RESULTS

Table 1 presents injury rate as a function of age at enlistment. The U-shaped relationship indicates that 17-year old enlistees have the highest risk of injury during a first enlistment, but enlistees who are more than 25 years old also have an elevated risk. Enlistees who are age 21-25 have the lowest probability of injury while those who are age 18-20 have an intermediate probability. Adjacent categories of age at enlistment are nonoverlapping with respect to 95% confidence intervals.

Table 1

Injury Rate by Age at Enlistment

Age at Enlistment	Number of Injuries	Injury Rate[a]	Standard Error	Confidence Interval[b]
17	1279	9.3	.26	8.8-9.8
18-20	2965	8.2	.15	7.9-8.5
21-25	545	6.5	.27	6.0-7.0
≥ 26	126	8.6	.73	7.2-10.0

[a]The number of injuries per 100 man-years calculated over the 4-year enlistment.

[b]The 95% confidence interval.

Table 2 reflects injury rate as a function of level of education. Years of education are inversely related to injury rate, and the relationship is linear. Men with less than a high school education have double the injury rate of men with more than a high school education. The 95% confidence intervals are nonoverlapping, indicating that the three education levels differ significantly in injury rate.

Table 2

Injury Rate by Education Level

Years of Eduation	Number of Injuries	Injury Rate[a]	Standard Error	Confidence Interval[b]
≤ 11	1643	10.4	.26	9.9-10.9
12	3005	7.6	.13	7.3-7.9
≥ 13	264	5.1	.30	4.5-5.7

[a]The number of injuries per 100 man-years calculated over the 4-year enlistment.

[b]The 95% confidence interval.

Table 3 presents injury rate as a function of mental ability (General Classification Test score). Categories I-V represent a normal distribution of scores from high mental group (I) to low (V). Mental group, like educational level, was inversely related to injury rate. Confidence intervals were nonoverlapping for the four mental group categories; mental groups IV and V did not differ in injury rate and were combined.

When differences in injury rate among the levels or subcategories within each variable were tested using the chi-square statistic as modified by Chan et al., [1982], the values were all significant at $p < .01$ (education, $\chi^2 = 158.9$; mental group, $\chi^2 = 58.9$; and age at enlistment, $\chi^2 = 44.3$). Thus, each of the variables considered singly correlated significantly with injury rate.

Table 3

Injury Rate by Mental Group Category

Mental Group		Number Injuries	Injury Rate[a]	Standard Error	Confidence Interval[b]
High	I	38	4.0	.64	2.75-5.25
	II	1449	7.1	.18	6.74-7.46
Average	III	1407	7.9	.21	7.49-8.31
Low	IV-V	1939	9.0	.21	8.60-9.40

[a]The number of injuires per 100 man-years calculated over the 4-year enlistment.

[b]The 95% confidence interval.

Injury rate as a joint function of the above variables analyzed simultaneously is shown in Table 4. This table shows educational level to be the only variable having a major effect on injury rate. When high school graduate and nonhigh school graduate subgroups are compared for each combination of mental group and age at enlistment, it can be seen that nonhigh school graduates consistently have higher injury rates than high school graduates. Confidence intervals are nonoverlapping for all such comparisons except the 17-year old, low mental group category. Among 17-year old high school graduates there is a trend for injury rate to vary inversely with mental group, but confidence intervals overlap among these three subcategories to some extent. With the exceptions noted, injury rates are generally uniform within educational levels, indicating that mental group and age at enlistment do not contribute in a major way to observed differences.

Table 4

Injury Rate by Education Level, Mental Group, and Age at Enlistment

		High School Graduate		Non-High School Graduate	
Mental Group	Age	Injury Rate	Confidence Interval	Injury Rate[a]	Confidence Interval[b]
I-II	17	6.6	5.6-7.6	9.7	7.9-11.5
	≥ 18	6.8	6.4-7.2	10.9	8.9-12.9
III	17	7.6	6.3-8.9	10.8	9.5-12.1
	≥ 18	7.1	6.6-7.6	10.1	8.8-11.4
IV-V	17	9.6	8.0-11.2	10.4	9.4-11.4
	≥ 18	7.9	7.4-8.4	10.2	9.2-11.2

[a]The number of injuries per 100 man-years calculated over the 4-year enlistment.

[b]The 95% confidence interval.

Table 5 lists occupational groups with injury risks above the Navy norm as reflected by the rate for the entire 1974 cohort. It would be predicted that occupational groups with less experience and with lower mental group and educational levels would have elevated injury rates; also, occupations that involved operation, maintenance, and repair of engines and machinery, would be expected to incur more injuries. Both of these hypotheses are borne out by the results in Table 5. Nondesignated personnel (men not assigned to an occupational specialty) generally are less experienced and have less favorable mental group and educational characteristics than those in designated occupations. Also, it can be seen that all of the major occupations with injury rates above the Navy norm except one (Hospital Corpsman) principally involve work with engineering tasks, machinery, or construction.

Table 5

Occupational Groups with Injury Risks above the Navy Norm[a]

Nondesignated Personnel:[b]	Number of Injuries	Injury Rate[c]
Airman	314	12.9
Fireman	402	12.0
Seaman	772	11.4
Designated Occupations:[d]		
Construction Mechanic	26	10.9
Hull Maintenance Technician	199	10.8
Equipment Operator	40	10.3
Boiler Technician	220	10.0
Aviation Boatswain's Mate	135	9.7
Aviation ASW Operator	35	9.6
Hospital Corpsman	215	9.5
Aviation Machinist's Mate	134	8.6
Engineman	111	8.6
Machinist's Mate	317	8.4
Boatswain's Mate	134	8.2
Total Cohort		8.1

[a] Includes only occupational groups with more than 25 hospitalizations for injuries.

[b] Men not selected for a designated occupation; includes men in pay grades E-2 and E-3

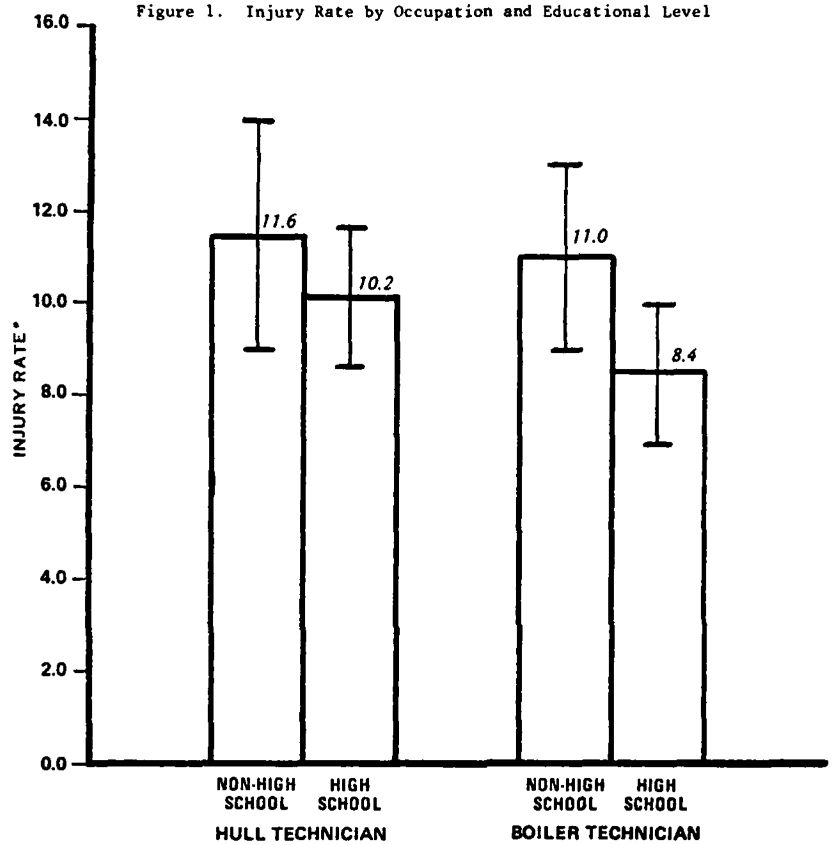
[c] The number of injuries per 100 man-years calculated over the 4-year enlistment.

[d] Men selected and trained for particular occupations; includes "strikers" (men in training status--pay grades E-2 and E-3) as well as all other pay grades.

Comparing injury rates by time intervals, it was found that there was no significant variation in injury rates over time with rates ranging narrowly from 2.0 to 2.2 percent injured per year.

Because educational level and occupational specialty both appear to influence injury rate, it is of interest to determine the relative contribution of each of these variables separately to risk of injury. Of the high risk occupations identified in this study (injury rates above the Navy norm), the Hull Technician (HT) and Boiler Technician (BT) occupational groups are among the largest and also include substantial proportions of nonhigh school graduates (more than 40%). For this reason separate analyses by educational level within occupational specialty were conducted. The results are shown in Figure 1. While there is a trend for injury rate to differ by educational level in both occupations, this effect is not pronounced. Numbers were too small for these finer analyses to be conclusive, however, and larger cohorts must be examined to obtain a definitive answer to the question posed.

Figure 1. Injury Rate by Occupation and Educational Level



**Number of injuries per 100 man-years over the 4 year enlistment*

DISCUSSION

The results have shown that individual characteristics found in previous studies to predict general military effectiveness [Fisher et al., 1960; Klieger et al., 1961; Plag, et al., 1966] and overall health [Gunderson, E.K.E., et al., 1970] also have a significant relationship with injury rates. In addition, the nature and strength of these relationships appear similar to those with military effectiveness in that education was associated most highly with accident rate as it was with military effectiveness [Plag et al., 1968].

Mental ability, as measured by the Navy General Classification Test (GCT), has an inverse relationship with injury rate. The GCT is part of a battery of aptitude tests administered upon entry into the Navy, and occupational assignment is partially determined by GCT score. Therefore, the analysis of occupational differences is confounded by such *differential assignment practices*. In any case, it seems clear from the results in Table 4 that mental group is at most a minor contributor to injury rate. Generally, previous studies [Brownley, 1979; Ferguson, et al., 1981(a)] have shown that highly technical occupations, which require high GCT scores, have lower accidental injury rates than other occupations; however, the relative importance of mental ability versus specific occupational hazards has not been determined.

With respect to age at enlistment, highest injury rates were found for youngest and oldest age groups. Age at enlistment had a similar relationship with general military effectiveness (discharge within two years) in a previous study [Plag et al., 1964]. This variable appears to reflect immaturity and unfavorable social adjustment to some degree at the time of enlistment in that many of the 17-year old enlistees are high school dropouts. It seems clear that a firm policy of requiring high school completion in order to enlist would significantly reduce not only premature attrition, disciplinary problems, and unsatsifactory performance, but serious injuries as well. It is not known why *older enlistees also have elevated injury rates*. It may be that this group differs in other personnel characteristics (e.g., education level) or that older enlistees tend to be given more hazardous job assignments than younger enlistees. In any case, this is a question for further research.

Environmental hazards such as heavy machinery, propulsion plants, construction equipment, and machine tools, usually associated with excessive noise and heat, undoubtedly play a fundamental role in risk of injury. All of the major occupations with injury rates above the Navy norm, with the exception of Hospital Corpsman, were in engineering, construction, and aviation fields. Conversely, all major clerical, administrative, and technical occupations were below the injury rate for the total cohort. The work environments then exerts a pervasive effect upon risk of injury. Coupled with this general influence, individual differences, particularly a *combination of inexperience* and unfavorable personal characteristics (immaturity, low educational attainment, and/or low mental ability) *can increase the risks inherent in the physical environment appreciably*.

The presence of the Hospital Corpsman specialty among the high-risk occupations may appear to be an anomaly; yet even superficial analysis reveals that Corpsmen are exposed to a wide variety of toxic or harmful physical and chemical agents and they serve in more diverse operational environments than any other naval occupation.

An unexpected finding in the present study was that the risk of injury was uniform over the four-year enlistment. This fact again would suggest the relative importance of the work environment which tends to remain constant over time and affords a stable exposure risk.

It must be concluded that both the occupational environment and individual differences are important in explaining differences in risk of injury. Further studies involving larger cohorts and longer periods of observation will be needed to fully explicate underlying variables and to facilitate the understanding and prevention of *accidental injuries in naval environments*.

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Appendix A. Example of Life Table: Data for Enlistees with Less than Twelfth Grade Education

Interval x	Interval (Days)	l_x [a]	W_x [b]	A_x [c]	l'_x [d]	I_x [e]	q_x [f]	p_x [g]	P_x [h]	Q_x [i]	S.E. of Q_x [j]
1	90	30,934	6,176	.45	27,530	168	.006	.994	1.000	.000	.0005
2	90	24,758	1,102	.47	24,173	167	.007	.993	.994	.006	.0007
3	185	23,656	2,748	.53	22,353	306	.014	.986	.987	.013	.0010
4	182	20,908	3,272	.49	19,245	223	.012	.988	.973	.027	.0013
5	183	17,636	2,728	.49	16,241	215	.013	.987	.962	.038	.0015
6	365	14,908	5,656	.65	12,943	336	.026	.974	.949	.051	.0020
7	365	9,252	5,274	.70	7,674	228	.030	.970	.924	.076	.0026
									.896	.104	

[a] Number of persons observed at beginning of interval.

[b] Number of persons withdrawing during the interval for any reason.

[c] Mean proportion of time spent in the interval by those who withdrew. $A_1 = \dfrac{\text{Mean no. of days in interval for those withdrawing}}{\text{Total days in interval}} = \dfrac{40.39}{90} = .45$

(If the assumption is made that withdrawals are at a uniform rate throughout an interval, this proportion can be set at .50. If this assumption does not reflect the true rate of withdrawal a more accurate estimate can be calculated from supplementary information. In this example, it was determined that the mean number of days spent in the first 90-day interval by withdrawn persons was 40.39 days.)

[d] Adjusted number of persons observed in the interval: $l'_x = l_x - (1-A_x)(W_x)$.

[e] Number of events (injuries) occurring during interval.

[f] Probability of event occurring during interval for those entering interval: $q_x = \dfrac{I_x}{l'_x}$

[g] Probability of event not occurring for those entering at beginning of interval: $p_x = 1-q_x$

[h] Cumulative probability of event not occurring by beginning of interval: $P_x = P_o p_0 p_1 p_2 \ldots p_{(x-1)}$, where $P_0 = 1.000$.

[i] Cumulative probability of event occurring by beginning of interval: $Q_x = 1-P_x$

[j] Standard Error of P (or Q) $= P_x \sqrt{\dfrac{nq_x}{l'_x}}$

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Personnel characteristics and occupational factors were investigated in order to identify groups with elevated risks of accidental injury in naval environments during first enlistments. The individual characteristics of age at enlistment, educational level, and mental ability all were found to relate significantly to injury when considered singly. When considered jointly, however, only education had a major effect on injury rate. In general, the results indicated that the same individual characteristics that predict poor military

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) performance also predict risk of accidental injury.

The occupational analysis identified a number of high-risk occupational specialties (occupations with injury rates above the Navy norm). With the exception of Hospital Corpsmen, all of these occupations were engineering, construction, or aviation specialties in which exposure to hazardous machinery or equipment was evident. Improved safety training and closer supervision should be considered for these personnel, particularly nonhigh school graduates.

A modified life table technique was found to be appropriate for this type of longitudinal analysis where large and uneven withdrawals from the cohort occurred. Further analyses of large cohorts from high-risk occupations will be needed to understand the causal factors underlying observed differences in injury rate.

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