USARIEM Technical Report T-01/1

DISABLING KNEE INJURY IN THE UNITED STATES ARMY: CLASSIFICATION OF INJURY FOR ETIOLOGIC RESEARCH

Padmaja Patnaik, MS
LTC Paul J. Amoroso, MC, USA
Ken Mundt, PhD
Carol Bigelow, PhD

Military Performance Division

October 2000

U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 2000	Technical Report

4. TITLE AND SUBTITLE
Disabling Knee Injury In The United States Army: Classification Of Injury For Etiologic Research

5. FUNDING NUMBERS

6. AUTHOR(S)
P. Patnaik, P. Amoroso, K. Mundt, C. Bigelow

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Massachusetts, Department of Epidemiology and Biostatics
Amherst, Massachusetts 01002

US Army Research Institute of Environmental Medicine
Natck, Massachusetts 01760-5007

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

US Army Medical Research and Material Command
Fort Detrick
Frederick, MD21702-5012

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Background: Musculoskeletal injuries, especially those associated with rigorous physical training or vigrous occupational activities, are common in the U.S. Army, and have substantial economic consequences in both direct and indirect costs. The lack of consistent, specific definitions of injuries results in misclassification bias and hinders etiologic research. This report compares 4 different classification systems (ICD-9-CM codes, percent disability, VASRD codes, and physical therapy parameters) as tools for etiologic research.
Methods: A case-control study design drawn from The Total Army Injury and Health Outcomes Database (TAIHOD) is used. Bivariate and multivariate logistic regression models compare the 4 systems in their ability to accurately describe and classify disabling knee injury.
Results: The VASRD and the ICD-9-CM systems were too non-specific and did not capture sufficient detail. The assessment of percentage of disability may prove useful, except that under the current coding system, it is inextricably linked to the VASRD code, and it is difficult to stratify injuries based on this measure of severity. The system that seemed most promising was the one based on physical therapy parameters.
Concl;usions: Selecting an appropriate classification system in epidemiologic research is important in order to accurately identify risk factors and design appropriate intrventions.

14. SUBJECT TERMS
disability, musculoskeletal injury, injury, Army, TAIHOD, database, epidemiology, Military personnel, case-control study, VASRD, ICD-9-CM, percent disability, physical therapy

15. NUMBER OF PAGES
48

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The authors would like to thank the following individuals for their assistance in preparing this technical report:

Sandy Sulsky, doctoral candidate, Department of Epidemiology and Biostatistics, University of Massachusetts, Amherst, for her assistance with study design, analysis and interpretation, and for critical review of the report.

Laura Senier, SSDS, Inc., for editing and formatting the report.

Shari Hallas, Geo-Centers, Inc., for editing the text.

Michelle Yore, MPH, of USARIEM, for assistance with data acquisition, data set creation, and consultation regarding various data issues during the study.

EXECUTIVE SUMMARY

The trends of increasing morbidity and mortality attributed to injury make it an important aspect of public health that deserves increased attention, including epidemiological study. Musculoskeletal injuries, especially those associated with rigorous physical training or vigorous occupational activities, are common in the U.S. Army. Knee injuries are among the most common musculoskeletal injuries in the Army. The economic impact of such injuries is substantial, in terms of direct and indirect costs associated with medical care, disability payments, time lost from training and occupational activities, and loss of an occupation for those who experience a disabling injury.

From the literature, it is clear that although epidemiologic studies have been conducted on injury and on knee injuries in particular, the lack of consistent, specific definitions for injury may lead to misclassification. Misclassification hinders etiologic research, making it difficult to ascertain the true causes of such injuries. This difficulty in pinpointing the causes of disabling knee injury further hinders efforts to design appropriate and effective interventions.

This report analyzes four injury classification systems, using disabling knee injuries in the U.S. Army as a sample injury type: VASRD codes, ICD-9-CM codes, percent disability, and parameters used in physical therapy. The systems were compared first at a univariate level, then at a bivariate level (with respect to demographic variables), and finally at a multivariate level by means of multiple logistic regressions. Understanding which classification systems best facilitate epidemiologic assessment of knee injury causes may lead to improved identification of risk factors and appropriate interventions for specific disabling knee injuries.

A case-control study design was used. Cases were defined as individuals awarded disability between 1980 and 1994 and given one of 11 primary or secondary disability codes related to impairments of the knee. Controls were soldiers who were free from knee-related disability at the time the corresponding cases received disability designation. All cases and controls were selected from the Total Army Injury and Health Outcomes Database (TAIHOD), a relational database that includes personnel, hospitalization, casualty, safety, disability, and self-reported health risk assessment data. Controls were selected in proportion to the number of cases awarded a disability in a given year, with proportions determined by gender. All enlisted personnel without a prior recorded knee disability discharge were eligible to be selected as controls in a given year.

The Veterans' Administration System for Rating Disabilities (VASRD) and the ICD-9-CM coding system were rather non-specific and too broadly inclusive to be of much use in classifying disabling knee injury with sufficient detail for etiologic research. Assessing the knee disability by the percentage of disability may prove useful, except that under the current coding system, percent disability is inextricably linked to the VASRD code, and it is difficult to stratify injuries based solely on this measure of severity. The system that seemed most promising for etiological research was the one

based on parameters used in physical therapy, because it incorporates the most detailed information about the injury and the extent of disability. However, the data present in the database disability files were not adequate to allow accurate recording using this system.

INTRODUCTION

Injury is defined as "harm or hurt; a wound or maim; usually applied to damage inflicted to the body by an external force" (1). It is projected to become one of the leading causes of disability and premature death in the developing world (2) and is currently the fourth leading cause of death in the U.S. (3). Among Americans under age 44, injury is the number one cause of death (3). This increasing trend in morbidity and mortality due to injury makes it an important aspect of public health that deserves increased attention.

Musculoskeletal injuries, or injuries "pertaining to or comprising the skeleton and the muscles" (1), are among the most common types of injuries that occur as a result of rigorous physical activity (4). Rigorous physical activity is typical of Army training and occupations, where the prevalence of injury, musculoskeletal injury in particular, is correspondingly high (3,4). Among musculoskeletal injuries in the Army, the prevalence of knee injury is high, probably due to the mechanically stressful nature of many Army jobs (5). It is especially important to study the causes of knee injury, because knee injuries often lead to disability (6).

Disability is defined as a condition in which one is "deprived of mental or physical ability" (7). Disability in the Army, however, is simply the inability of a soldier to perform his or her occupational duty (8,17,19). Although there have been modest reductions in the number of occupational injuries and illnesses, disability continues to be one of the leading causes of lost workdays (5,17). Besides lost workdays disability also leads to lost time and efficiency for the employer, and economic costs related to the treatment of disability (5,17). Disability is therefore an important public health issue that is worthy of study.

Knee injuries that lead to disability commonly result from impairment of the femur, tibia, and fibula, and other knee impairments. Problems with flexion and dislocation of the knee also often lead to disability. Some injuries that would not necessarily lead to disability among civilians would meet the Army's definition of disability if they prevented an individual from meeting the requirements of his or her occupation. These include strains, sprains, tendinitis, and shin splints. Conditions such as chondromalacia and osteoarthritis may or may not lead to disability. Although these conditions tend to be chronic and debilitating, an individual may still be ambulatory; a disabling condition is typically understood to be one in which an individual is unable to walk without physical or mechanical assistance. In the Army, many cases of chondromalacia and osteoarthritis would be classified as disabling, but it would depend upon the job of the individual.

Various studies have identified risk factors for knee injury such as occupation, demographic characteristics, history of injury, adherence to safety regulations, environmental factors, and congenital factors. However, relatively little is known about how these risk factors may be linked to specific types of knee injury. The ability to identify risk factors associated with specific subtypes of knee injury would provide the basis upon which preventive measures aimed at decreasing disability could be made.

The economic impact of this could be significant, since knee disability is associated with a wide variety of direct and indirect costs, including the cost of medical treatment, loss of training and occupational time, inability to remain occupationally qualified, and the socioeconomic burden on the disabled and their families. Part of the fiscal impact of physical disability estimated by the U.S. Army for 1994 alone was $500 million (5). Identifying the risk factors associated with particular types of knee injury open up opportunities for intervention. Preventive measures addressing the risk factors in question could be implemented and thereby prevent disability.

Despite the known social and economic burdens associated with disabling knee injury in the Army, there have been few efforts to reduce the occurrence of such injuries. Little information is available on specific types of knee injuries due to their complex nature and the use of non-specific coding systems. For example, the existing scheme for classifying disabling knee injury is based on a system created mainly for the purpose of determining compensation levels. The ability to stratify knee injuries by specific types and subtypes would minimize problems of misclassification and enhance future etiologic research.

The purpose of this report is to suggest a practical method of classifying disabling knee injury in order to improve the detection of risk factor–outcome associations in etiologic research and to illustrate the utility of a classification system that uses specific injury outcomes. The objectives for this report are as follows:

- to identify and compare the most prevalent categories of disabling knee injury within different systems of classification in a subpopulation of the U.S. Army;
- to further compare these classification systems at a more quantitative level with respect to their usefulness in etiologic research.

REVIEW OF THE LITERATURE

A number of studies have been conducted on knee injuries in occupational settings (10). Additional studies have been conducted in military settings or in the Army in particular (3,4,5,6,9,11,16).

A cohort study conducted at a military base in Alaska in 1993 investigated the incidence and types of injuries occurring in a sample of infantrymen (3). Injuries were classified for analysis as either musculoskeletal or all other types (including cold-related injuries, contusions, blisters, and abrasions/lacerations). Researchers examined the association of specific risk factors, such as physical fitness and age, with musculoskeletal injuries. The types of injuries most commonly reported were musculoskeletal pain, strains, sprains, and cold-related injuries. A trend of a higher proportion of injury in the lower age categories was found (the middle age category being 20–24 years) with more injuries occurring among those subjects who had less aerobic capacity and muscle strength. The authors hypothesized that the age trend may be explained by the fact that older men tend to be higher-ranking and have more sedentary occupations.

Ross and Woodward conducted a case-control investigation of injury during basic training at the Recruit Training Unit, Royal Australian Air Force Base, Edinburgh, South Australia (9). This study found that some of the risk factors for injury during basic military training included being female, having body mass index greater than 26.9 kg per meter squared, undergoing winter training, having a history of lower limb injury, and having lower limb deformity. No significant associations were found with other potential risk factors such as age, height, weight, and smoking. Categories of injury included stress fractures, shin splints, Achilles tendinitis, plantar fasciitis, blisters, retropatellar syndrome/chondromalacia patella, and anterior compartment syndrome.

A team of researchers led by Bruce Jones studied the risk factors for injury during basic training at a U.S. Army base and found that the most common injuries were muscle strains, sprains, and knee-overuse conditions (4). Risk factors included older age, smoking, previous injury, low levels of previous occupational or physical activity, low frequency of running prior to entry into the Army, and low physical fitness on entry. Some of these findings conflict with the findings of Ross and Woodward (9), but the differences may be attributed to differences in methods and definitions of risk factors and injury outcomes. For instance, in the Jones study (4), the risk factor, physical training, was measured in terms of physical fitness and physical training. The parameters being measured were height, weight, girth of neck, girth of waist, body mass index, muscle strength and flexibility, 2-mile run times and daily calisthenics, drills, stretches, and running. Jones defined cases of injury as subjects having received treatment for one or more lower extremity musculoskeletal injuries. Ross and Woodward, on the other hand, measured risk factors in terms of degree of activity, season of training (winter versus other), body mass index, and history of lower limb deformity (9). Injury cases were defined as subjects who had been held back in a training course due to a musculoskeletal injury and had lost 5 days of training. These

differences in definition of the risk factors and the outcomes may account for the dissimilar results

Jensen et al. (10) conducted a review of the literature on the risk of knee disorders related to kneeling or squatting and heavy physical work in an occupational setting. Subjects whose jobs required kneeling or squatting had significantly higher prevalence of knee osteoarthritis, and kneeling was seen to have a strong association with bursitis. Other types of knee injury, such as chondromalacia and meniscal lesions, were not significantly associated with occupational exposures.

One study (5) specifically investigated disability due to musculoskeletal injuries in the U.S. Army using the Army's Physical Disability Agency database. The investigators found that back-related disorders were the most prevalent type of disability, that risk of disability was related to job type, that women experienced higher risk of disability due to musculoskeletal injuries as well as injuries overall, and that specific jobs were associated with this increased risk among women compared to men in the same jobs. A descriptive analysis of the codes from the Veterans' Administration System for Rating Disability (VASRD) system revealed that knee impairment was among the top 5 diagnoses, accounting for about 6% of the top 20 disabilities. The knees and ankles were the most common sites of injury among working infantry soldiers.

A study investigating disabling knee injury in the Army with emphasis on gender is currently under way at the University of Massachusetts, under the leadership of Sandra Sulsky (11,16). This study examines the risk factors for occupational disability resulting from knee injuries in the U.S. Army, with particular emphasis on differences in gender-specific risk factors for disabling knee injury. This is one of the first epidemiological studies to utilize the Total Army Injury and Health Outcomes Database (TAIHOD) (14). The TAIHOD is a large, annually updated, relational database developed at the U.S. Army Research Institute of Environmental Medicine (USARIEM), which links demographic, occupational, hospitalization, disability, fatality, and other data sources on all active duty personnel.

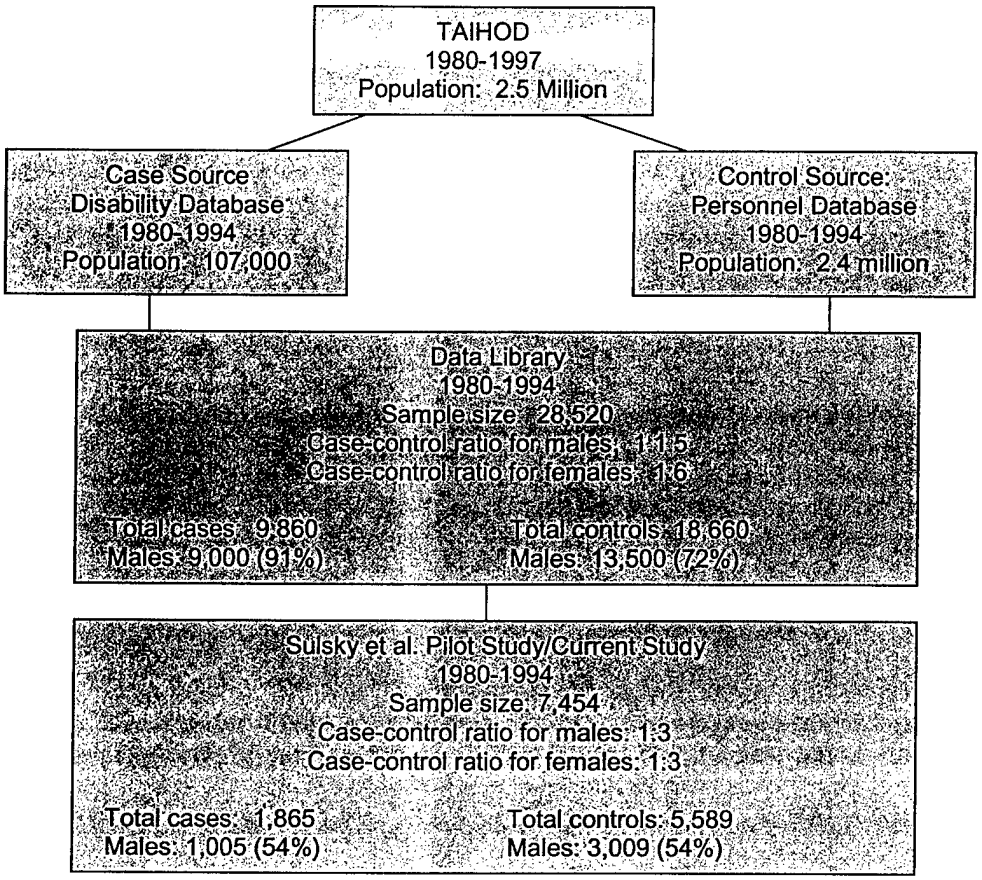
METHODS

SAMPLE SELECTION

The current report is an extension of an ongoing case-control study conducted by Sulsky et al. at the University of Massachusetts, Amherst (11,16). The study base was a population of men and women derived from the Total Army Injury and Health Outcomes Database (TAIHOD). The TAIHOD is a comprehensive database maintained by the Military Performance Division of the United States Army Research Institute of Environmental Medicine (USARIEM) which, at the time this study was initiated, included data on approximately 2.5 million soldiers who had been on active duty since 1979, 11.8% of whom were women. This database consists of 6 principal components: personnel data from the Defense Manpower Data Center (DMDC), the Individual Patient Data System, the Army Safety Management Information System, the Army Disability Data, the Army Casualty Information Processing System, and data from Health Risk Appraisal questionnaires.

In the Sulsky et al. study, cases were selected from the Army Disability Database, and controls were identified from the Personnel Database. Cases were defined as individuals first discharged for disability between 1980 and 1994 and given one of 11 primary or secondary disability codes related to impairment of the knee. Cases of disability discharge were selected rather than cases of injury because the former were easily identifiable and would have occurred only once per case. Moreover, reduction of disability has become increasingly important to the military and more information is needed on the determinants of disability. There were 8728 knee-related disability cases that occurred among men and 860 among women. Sulsky et al. used all 9588 subjects to create a study data library with 1.5 controls each for men and 6 controls each for women. Controls were selected in proportion to the number of cases awarded disability in a given year, with proportions determined by gender. All enlisted personnel without a prior knee disability discharge were eligible to be selected as controls in a given year. Subjects with missing information on gender were not included in the study. From this data library, a random sample of 1005 enlisted men and all 860 enlisted women with knee-related disability were selected for the pilot study, in order to investigate the relationship between demographic variables and risk factors for disabling knee injury. Through simple random sampling, three controls were selected, stratified by gender. Figure 1 is a schematic of the sample selection process.

Figure 1. Data Selection Process and Data Profile



The sample from the pilot study was used for the current study, which was conducted in two phases. In the first phase, four systems of classifying disabling knee injury were compared, first for all cases and controls, and then by strata of gender, race and age. In the second phase, these classification systems were evaluated with respect to their ability to improve the sensitivity with which risk factor variables could be linked to the most common injury outcomes within each classification system.

STUDY VARIABLES

Ten principal variables were used in the study. The 6 outcome variables in this study were the Veteran's Administration System for Rating Disability (VASRD) code; the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) code; percent disability; nature of injury; requirement of surgery; and affected tissue. The first three variables represented the first 3 systems of classification while the latter 3 represented the fourth system of classification, which is based on parameters used in the field of physical therapy. The exposure variable was the Primary Military Occupational Specialty (PMOS), which is the code assigned by the Army to designate

each individual's primary occupation. The three variables that were considered as potential confounders or effect modifiers were gender, race, and age. Data on VASRD and percent disability were extracted from the disability database, while ICD-9-CM codes were extracted from the hospital database. PMOS codes and demographic variables were extracted from the personnel database. A description of these 10 variables is presented in Table 1.

Table 1. Profile of Study Variables

Variable Name	Variable Type	Definition
VASRD	Outcome variable	The VASRD code is a 4-digit code describing the functional impairment. For example, VASRD code 5257 designates "other impairments of the knee".[1]
Percent disability	Outcome variable	A percentage rating of disability is assigned to each Veteran's Administration System for Rating of Disability (VASRD) code and represents average loss in earning capacity resulting from service-acquired or service-aggravated injury. Different criteria are applied to each injury type in determining the percent disability. For instance, for VASRD code 5257 ("other knee impairments"): 30% (for use of knee brace for functional purpose), 20% (for use of knee brace for protective purpose), 10% (for lateral instability of knee that has failed to improve with physical therapy). When injury that causes disability is lower than the minimum rating, a disability rating of 0% is assigned. Only overall percent rating was used in the study.[1]
MOS	Exposure variable	Military Occupation Specialty (MOS) is the variable that describes the occupation of the subject. Each subject is assigned a primary MOS (PMOS) describing the job for which he or she was trained and a duty MOS (DMOS) which describes the job he or she actually performs.
Gender	Potential confounder or effect modifier	Gender of subject was obtained from the personnel file and was one of the required variables during sample selection, (i.e., subjects were selected by gender).
Race	Potential confounder or effect modifier	Race of the subject was obtained from the personnel file. Race categories used were white, black, other/unknown. "Other" includes Asians, Native Americans, and Hispanics. Only 5 subjects are classified as "unknown".
Age	Potential confounder or effect modifier	Age was calculated by subtracting the date of birth, obtained from personnel files, from the date of discharge, obtained from the disability files. Ages ranged from 17 to 54 years and were grouped according to quintiles of age distribution in the pilot study.
ICD-9-CM	Outcome variable	International Classification of Disease codes, Ninth Revision, (ICD-9-CM) were available on many subjects. The Army hospitals create a "carded for record only (CRO)" record on a majority of disability cases. These records contain ICD-9-CM diagnostic codes. Up to 8 ICD codes are assigned per case, but only the first one, the primary diagnosis, was used in this study.
Nature of injury	Outcome variable	Conventional parameter of disease classification in medicine/ rehabilitation. Categories are based on mode of assault: traumatic versus repetitive. Categories are not mutually exclusive, since an injury may initially be traumatic, but become a chronic condition.[2]

Table 1. Profile of Study Variables (cont'd)

Variable Name	Variable Type	Definition
Requirement of surgery	Outcome variable	Conventional parameter of disease classification in medicine/rehabilitation. Categories are based on requirement of surgery. Injuries classified as non-surgical may occasionally require surgery depending on severity.[2]
Affected tissue	Outcome variable	Conventional parameter of disease classification in medicine/rehabilitation. Categories are based on type of tissue affected. Combinations of bone, ligament, muscle, tendon, or cartilage may exist.[2]

[1] Department of the Army, Headquarters. *Personnel Separations: Physical Evaluation for Retention, Retirement, or Separation.* Washington, D.C., AR 635-40, 1990.

[2] Personal communication with Bryan Heiderscheit (MSPT), Department of Exercise Science, University of Massachusetts, Amherst.

COMPARISON OF CLASSIFICATION SCHEMES BASED ON FREQUENCY DISTRIBUTIONS

The knee injury types were classified according to four different systems, three based on a single parameter, and the fourth based on three parameters. The systems were VASRD, ICD-9-CM code, percent disability (percentage of function lost due to the injury) and physical therapy classification, respectively. The parameters used in the physical therapy classification were nature of injury (traumatic versus repetitive), requirement of surgery (surgical versus non-surgical), and tissue type involved (i.e., bone, ligament, tendon, muscle, cartilage, various combinations of these tissue types).

Univariate and stratified analyses were performed for VASRD, ICD-9-CM code, and percent disability. For each parameter, we analyzed the overall frequency distribution. Because the demographic variables had been identified as effect modifiers by Sulsky et al. (11), the frequency of injury codes was generated separately for men and women, for each of the race and age categories. A different approach was used in investigating the fourth system of classification, as defined below under "Classification by Physical Therapy Parameters." All analyses employed the statistical software SAS (13).

Classification by VASRD

VASRD codes are 4-digit disability codes created by the Department of Veteran's Affairs and assigned to cases of disabling injury by the Physical Evaluation Board of the Army. Subjects are assigned either a primary VASRD alone or both a primary and a secondary VASRD in cases where there was a significant secondary condition (19). Over 99% of the cases were assigned a VASRD code for the primary disability (VASRD1), and about 74% of these individuals were also assigned a VASRD code for secondary disability (VASRD2). Since the numbers of cases within categories of VASRD2 were too small for conducting meaningful analyses, VASRD1 and VASRD2 were combined for analysis in the following manner. Cases having either VASRD1 or VASRD2 that was one of the 11 knee-related VASRD codes were subset into a single

dataset so that records for all 1865 cases and their first knee-related VASRD were present. This dataset was used for subsequent analyses.

Classification by ICD-9-CM Code

The ICD-9-CM code assigned to knee injuries that led to disability was the second method considered for classifying disabling knee injuries. This was selected because it is a more standard, internationally used method for classifying musculoskeletal disorders. Although each individual may have been assigned up to 8 different ICD-9-CM codes for subsidiary diagnoses, only the primary ICD-9-CM code was taken into consideration. We made this decision based on the premise that the primary diagnosis would be knee-related, since the sample selection for the pilot study was based on primary or secondary knee-related disability. Although one would not expect the primary diagnosis to correspond to the VASRD code in every case, the primary ICD assigned to the 10 most frequently occurring VASRD codes were found to be closely associated with knee-injury. Among those cases whose knee-related injury was represented by the secondary VASRD, the primary ICD-9-CM code would less likely be knee-related. However, this happened in only 21% of these cases.

The ICD-9-CM codes were truncated from four or five digits to the first three digits to group closely related types of injury and for ease of analysis. ICD-9-CM categories selected for analyses were the top 10 3-digit primary ICD-9-CM codes assigned to the 1865 cases. Before attempting to investigate classification of knee injury by ICD-9-CM code, however, a cross tabulation of the top 10 ICD-9-CM codes by the top 5 VASRD codes was constructed to investigate whether similarities existed between the two classification schemes. The percentage of overlap was calculated. Only the top 5 VASRD codes were used, rather than top 10, to maintain adequate sample sizes within each category.

Classification by Percent Disability

The parameter of percent disability attributed to each knee injury was considered a severity measure of disability and was therefore selected as the third method of grouping disabling knee injuries. Percent disability was also assigned by the Veteran's Administration and was based on different criteria for each type of disability. A cross-tabulation of the top 10 ICD-9-CM codes was performed first to investigate any similarities between the methods of grouping by ICD-9-CM codes and by percent disability. Deciles that were greater than 50 were collapsed into one category due to sparse numbers.

Classification by Physical Therapy Parameters

The fourth and final method of grouping disabling knee injuries was by parameters of evaluation used in the field of physical therapy. The three diagnostic parameters included nature of injury, requirement of surgery, and type of tissue affected

(12). These were selected in consultation with Bryan Heiderscheit, MSPT; Dr. Joseph Hamill, PhD (Biomechanics); and Dr. Gregory Kline, PhD (Exercise Physiology) from the Department of Exercise Science at the School of Public Health and Health Sciences, University of Massachusetts, Amherst. Physical therapists categorize injury as "traumatic" or "repetitive" based on the mode of assault. In traumatic injuries, the "hit" occurs at one point in time, whereas multiple hits are responsible for repetitive injuries. Some injuries, however, may have been initiated by a traumatic event and worsened over time due to repeated stress. At the time of diagnosis, such an injury would then be classified as "repetitive." Therefore, this parameter of classification may not necessarily produce discrete, mutually exclusive categories. Once divided into traumatic or repetitive categories, injuries are further classified into those requiring surgery and those that do not. There are some types of injury that typically do not require surgery, but may under certain circumstances. The third and final level of classifying knee injury is by the type of tissue affected. The 5 types of tissue typically considered are bone, muscle, ligament (which connects bone to bone), tendon (which connects muscle to bone), and cartilage, or various combinations of these.

The primary ICD-9-CM codes were used for classifying disabling knee injuries by physical therapy parameters. VASRD and percent disability codes do not contain sufficient information to classify injuries according to these dimensions. In attempting to group the 10 most frequently occurring ICD codes by these three physical therapy parameters, the truncated three-digit ICD codes were too broad to classify by nature of injury, requirement of surgery, and type of tissue affected. Therefore, full-length ICD-9-CM codes were used. The subset of the top 10 most frequently occurring 3-digit ICD codes was first obtained. Expanding the 10, 3-digit codes in this subset to their full length resulted in 39 codes (representing a little more than half the cases). Only those codes that occurred with a frequency of 5 or more were selected and grouped by the three physical therapy parameters.

COMPARISON OF CLASSIFICATION SCHEMES BASED ON RISK FACTOR ASSOCIATIONS

After comparisons were made based on frequency distributions, the four systems of classifying disabling knee injury were compared on the basis of the strength of their association with the four sets of predictor variables described below. The index of comparison used was odds ratios produced by multivariable logistic regression models. The odds ratios produced by models representing each system of classification were compared to those produced by a crude model that considered "any injury" as the outcome. "Any injury" included all categories of injury. The absolute difference between the two odds ratios was assessed as a measure of the potential improvement in sensitivity with which an etiologic association could be established by using the outcome specified by the classification system concerned as opposed to using the outcome "any injury."

There were four different sets of predictor variables. The first set consisted of the demographic variables: gender, race, and quintiles of age. Race was dichotomized as

white and non-white. Blacks and persons of other races were combined into one group based on the fact that their risks of discharge for disability were similar based on univariate logistic regression models (11,16). The referent group was white males in the 23–26 years age category, since the strata of men, whites, and subjects aged 23–26 years were the most stable due to a larger sample size.

The second and third sets of independent variables consisted of the demographic variables as well as terms for the interaction of gender with race and gender with age, respectively. These models were run to account for the interaction of gender with race and age, as seen in the study by Sulsky et al. (11,16).

The fourth set of independent variables consisted of a primary military occupational specialty (PMOS) variable in addition to the demographic variables and was constructed to assess potential improvement in the ability to identify military occupation as a risk factor for disabling knee injury. The distribution of the top 5 PMOS codes that were represented by both men and women was examined first (Table 2). The PMOS Military Police (95B) was chosen because it had a reasonably large population of both men and women. The same rationale was used in selecting Administrative Specialist (71L) as the referent group for PMOS.

Table 2. Distribution of the 5 Most Frequently Occurring Primary Military Occupational Specialties (PMOS) That Occur Among Both Men and Women

	PMOS	Definition	N	% Men	% Women
1	71L	Administrative specialist	434	17.65	89.95
2	95B	Military police	263	49.43	50.57
3	94B	Food service specialist	248	41.53	58.47
4	88M	Motor transport operator	101	44.55	55.45
5	63B	Light-wheel vehicle mechanic	221	64.25	35.75

There were 13 dependent variables. All 13 dependent variables defined outcome and were dichotomized as case or control. The first included all cases and all controls and served as the "any injury" outcome. The other 12 dependent variables were case-control status, where cases met a specific outcome definition, and all controls constituted the controls. The 12 different conditions specified for cases were the top three VASRD categories of 5257, 5255, and 5262; the top four ICD-9-CM categories of 717, 718, 719, and 733; the top three percent disability categories of 10%, 20%, and 30%; and the first two physical therapy parameters, traumatic vs. repetitive. These categories were chosen to represent each classification system based on the fact that they were highly representative of each system, respectively.

Each of the 6 sets of independent variables was modeled against each of the 13 outcome variables resulting in a total of 52 different models.

RESULTS

COMPARISON OF CLASSIFICATION SCHEMES BASED ON FREQUENCY DISTRIBUTIONS

A frequency distribution of the 1865 cases by demographic characteristics (gender, race, and age) revealed that a large majority of the cases were white and ages 23–26 (Table 3).

Table 3. Overall Demographic Distribution of Cases

Variable		N	%
Gender			
1	Male	1005	53.9
2	Female	860	46.1
	Missing	0	0
	TOTAL	1865	100
Race			
1	White	1283	68.79
2	Black	450	24.13
3	Other	129	6.92
	Missing	3	0.16
	TOTAL	1865	100.00
Age Group			
1	17 to 20	290	15.55
2	21 to 22	311	16.68
3	23 to 26	491	26.33
4	27 to 30.35	283	15.17
5	30.36 to 54	337	18.07
	Missing	153	8.20
	TOTAL	1865	100.00

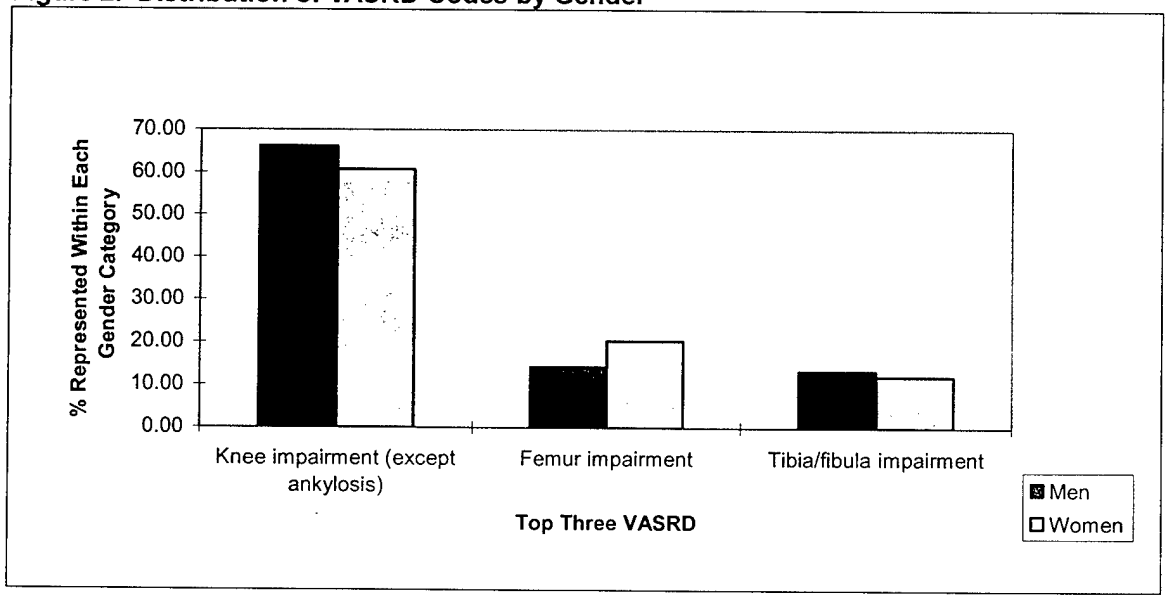
The top three categories of the VASRD, each of which represented at least 10% of the cases, together constituted 93% of all cases (Table 4). Clearly, more than half of the cases were afflicted with "impairments of knee other than ankylosis" (5257), a broad, inclusive category that revealed little information regarding the impairment. The second and third highest VASRD codes, "impairment of femur" (5255) and "impairment of tibia and fibula" (5262) were also somewhat inclusive, revealing little information other than their relation to the bones of the lower limbs.

Table 4. Overall Distribution of Knee-Related VASRD (VASRD1 and 2 Combined)

	VASRD	Definition	N	% of total (N=1865)
1	5257	Impairments of knee other than ankylosis	1187	63.65
2	5255	Impairment of femur	318	17.05
3	5262	Impairment of tibia and fibula	238	12.76
4	5259	Removal of semilunar cartilage	96	5.15
5	5258	Dislocation of semilunar cartilage	12	0.64
6	5263	Genu recurvatum	6	0.32
7	5256	Ankylosis of knee	4	0.21
8	5161	Amputation of upper third of thigh	2	0.11
9	5160	Disarticulation of thigh	1	0.05
10	5055	Knee replacement	1	0.05
	TOTAL		**1865**	**100.00**

Stratified analysis by gender showed minor differences between men and women. The top three VASRD codes, "impairments of knee other than ankylosis" (5257), "impairment of femur" (5255), and "impairment of tibia and fibula" (5262), were found in both men and women, had similar distributions, and were each represented by at least 10% of the cases in both strata (Figure 2). The proportion of men and women with any of these 3 VASRD varied by no more than 6%.

Figure 2. Distribution of VASRD Codes by Gender



For instance, the proportion of men with "impairment of knee other than ankylosis" (5257) was 66.17%, whereas this number was 60.7% for women, a between-stratum difference of about 5.5%. The rest of the knee injury categories comprised men and women in similar proportions. However, there were four additional categories of knee injury that were present among women that were not present among men. The total proportion of women represented in these four categories was very small (1.87%). At a bivariate level of analysis, gender did not appear to be a substantial determinant of knee injury outcome defined by VASRD codes. (See Appendix A1.)

Similarly, the distribution of VASRD codes by race and age did not seem to differ substantially among categories of injury outcome defined by VASRD codes. As with gender, the rest of the VASRD codes were similar between the strata, except for a few codes that were not represented by the 3 race groups and the 5 age groups. Once again, these codes constituted few subjects within each stratum (less than 1%). (See Appendixes A2 and A3.)

Figure 3. Distribution of VASRD Codes by Race

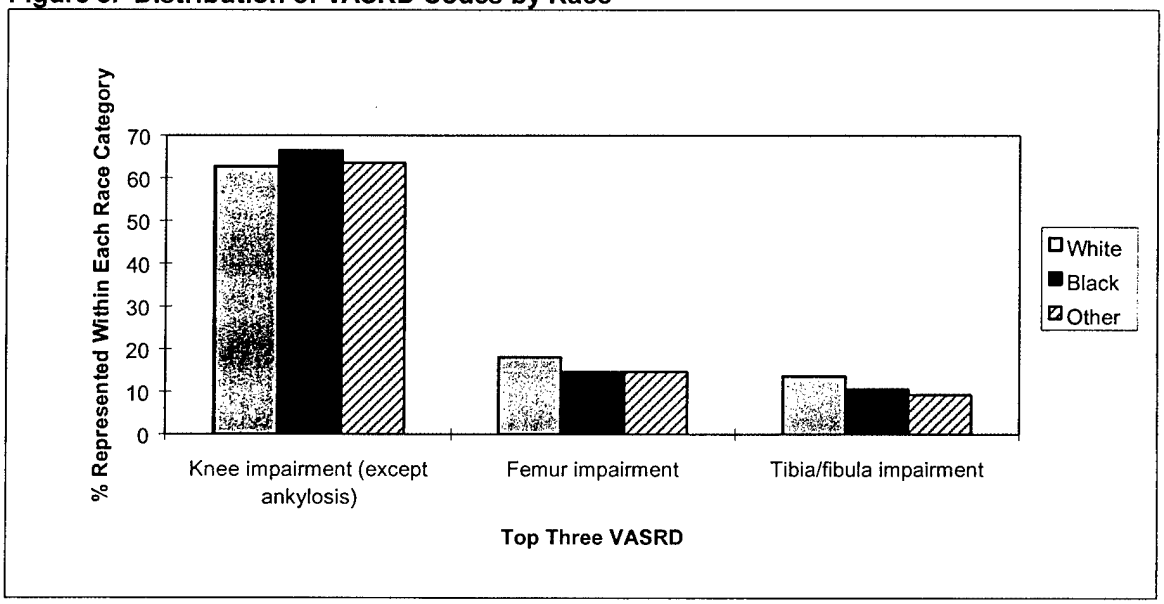
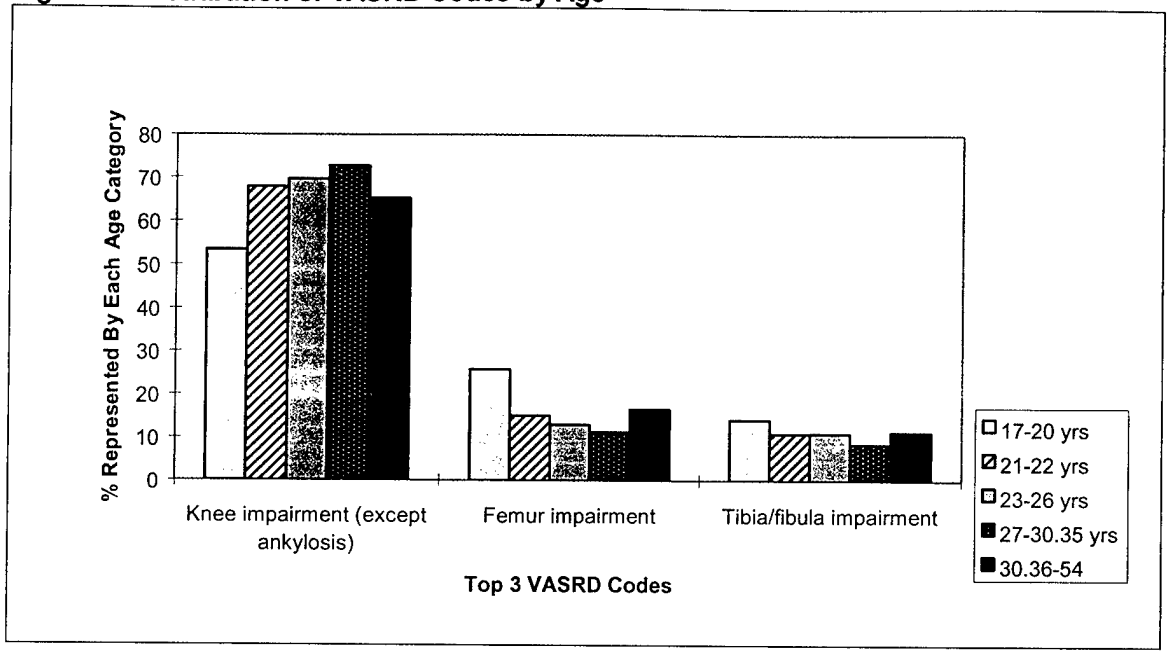


Figure 4. Distribution of VASRD Codes by Age



The cross tabulation between the top 5 VASRD codes and the top 10 ICD-9-CM codes showed that although there were one or two ICD-9-CM codes that corresponded closely with the VASRD codes, the percentage of overlap was fairly low, ranging from 0% to 55%. One exception was the overlap between "impairment of femur" (VASRD 5255) and "other bone/cartilage disorders: osteoporosis, pathological fracture" (ICD-9-CM 733), which was 67% (Table 5). These results demonstrated that, although most VASRD codes have a few ICD-9-CM codes that together constitute almost all of that VASRD code, the two classification systems are substantially different and cannot be used interchangeably.

Table 5. Percentage of Overlap of Top 10 Groupings by ICD-9-CM codes and Top 5 Groupings by VASRD Codes

VASRD Code	Definition	ICD-9-CM Code	N	% overlap
5257 (N=794)	Impairments of knee other than ankylosis			
		718	262	33.0
		717	257	32.4
		719	127	16.0
		715	40	5.0
		844	36	4.5
		716	25	3.1
		728	18	2.3
		733	17	2.1
		823	5	0.6
		821	7	0.9
			794	100.0
5255 (N=167)	Impairment of femur			
		733	112	67.1
		719	17	10.2
		718	10	6.0
		715	4	2.4
		716	2	1.2
		728	2	1.2
		823	2	1.2
		844	1	0.6
		717	0	0.0
		821	17	10.2
			167	100.0
5262 (N=134)	Impairment of tibia and fibula			
		733	75	56.0
		823	23	17.2
		821	5	3.7
		718	10	7.5
		719	10	7.5
		716	4	3.0
		728	4	3.0
		717	2	1.5
		844	1	0.7
		715	0	0.0
			134	100.0

Table 5. Percentage of Overlap of Top 10 Groupings by ICD-9-CM codes and Top 5 Groupings by VASRD Codes (cont'd)

VASRD Code	Definition	ICD-9-CM Code	N	% overlap
5259 (N=96)	Removal of semilunar cartilage			
		717	2	40.0
		719	2	40.0
		718	1	20.0
		715	0	0.0
		716	0	0.0
		728	0	0.0
		733	0	0.0
		823	0	0.0
		824	0	0.0
		844	0	0.0
			5	100.0
5258 (N=12)	Dislocation of semilunar cartilage			
		717	13	35.1
		718	8	21.6
		719	8	21.6
		715	4	10.8
		733	2	5.4
		716	1	2.7
		728	1	2.7
		823	0	0.0
		824	0	0.0
		844	0	0.0
			37	100.0

About 80% of the cases had information on ICD-9-CM codes. The 10 most frequently recorded ICD-9-CM codes covered 78.36% of these cases. As shown in Table 6, the overall distribution of the top 10 ICD-9-CM codes is concentrated in the top two, "ankylosis and joint derangement of knee" (718) and "internal derangement of knee" (717), which together represent nearly 50% of the cases. As in the case of top VASRD codes, these ICD codes are both inclusive and not very specific.

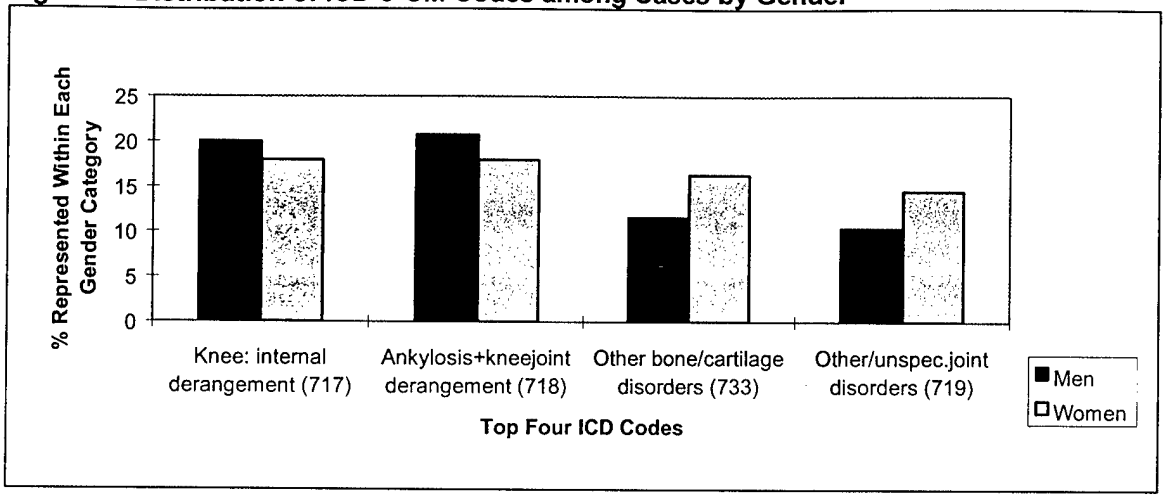
Table 6. Overall Distribution of the 10 Most Frequently Reported ICD-9-CM Codes

	ICD-9-CM Code	Definition	N	% of top 10 (N=1166)	% of total with ICD-9-CM Code (N=1488)	% of total (N=1865)
1	718	Ankylosis and joint derangement of knee	290	24.87	19.49	15.55
2	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	284	24.36	19.09	15.23
3	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	204	17.50	13.71	10.94
4	719	Other unspecified joint disorders	182	15.61	12.23	9.76
5	715	Osteoarthritis, polyarthritis	52	4.46	3.49	2.79
6	844	Sprains/strains of knee/leg	37	3.17	2.49	1.98
7	716	Other unspecified arthropathies	33	2.83	2.22	1.77
8	823	Fracture of tibia and fibula	29	2.49	1.95	1.55
9	824	Fracture of ankle	29	2.49	1.95	1.55
10	728	Disorders of muscle, ligament, fascia	26	2.23	1.75	1.39
TOTAL			**1166**	**100.00**	**78.36**	**62.52**

Results of the stratified analysis of the ICD-9-CM codes by gender, race, and age showed marginally higher differences than those produced by stratified analysis of the VASRD codes. This indicated that the demographic terms were better able to explain differences using more specific categories.

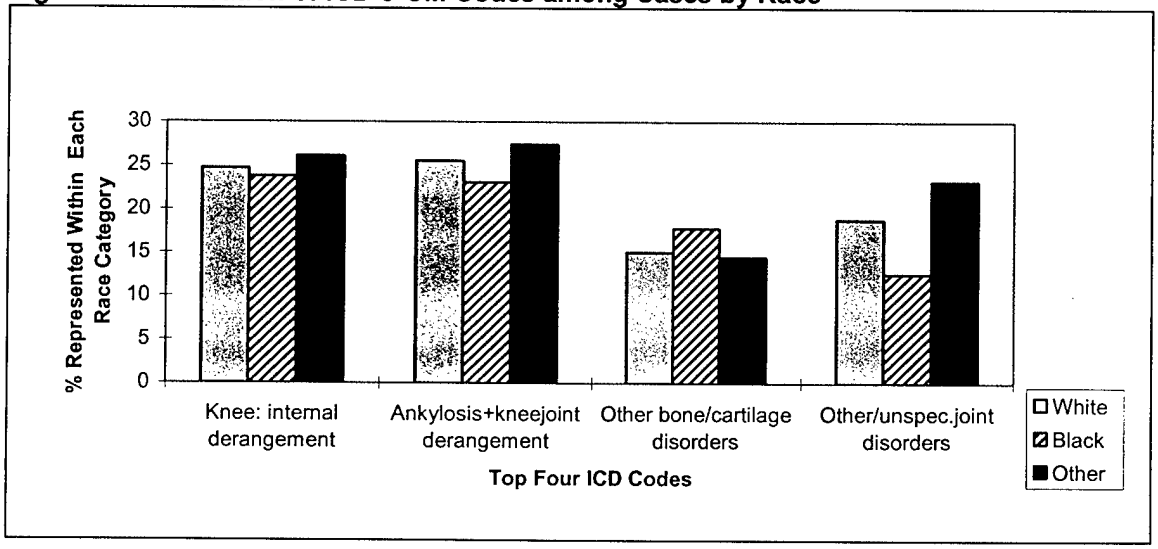
With respect to gender, the proportion of cases among the top 10 ICD-9-CM codes was 63% for both men and women. The top four ICD-9-CM codes were the same ["ankylosis and joint derangement of knee" (718), "internal derangement of knee" (717), "other unspecified joint disorders" (719), and "other bone/cartilage disorders" (733)] for both groups, but were ranked differently (Figure 5). Similar proportions of men and women were represented in each ICD-9-CM code. (See Appendixes A4 and A5.)

Figure 5. Distribution of ICD-9-CM Codes among Cases by Gender



The differences seen in the results of the stratified analyses of ICD-9-CM codes by race were marginally higher than those seen in the stratified analysis of VASRD codes. For instance, the top three ICD-9-CM codes were different between the three strata (Figure 6). While "other unspecified joint disorders" (719) ranked third among whites, "other bone/cartilage disorders" (733) was third among blacks and other races. The proportion of blacks with "other bone/cartilage disorders" (733) was also higher among blacks compared to whites, as was "osteoarthritis or polyarthritis" (715), both by 6%. Overall there were only slight differences in the ICD-9-CM codes and their ranks between strata. (See Appendixes A6-8.)

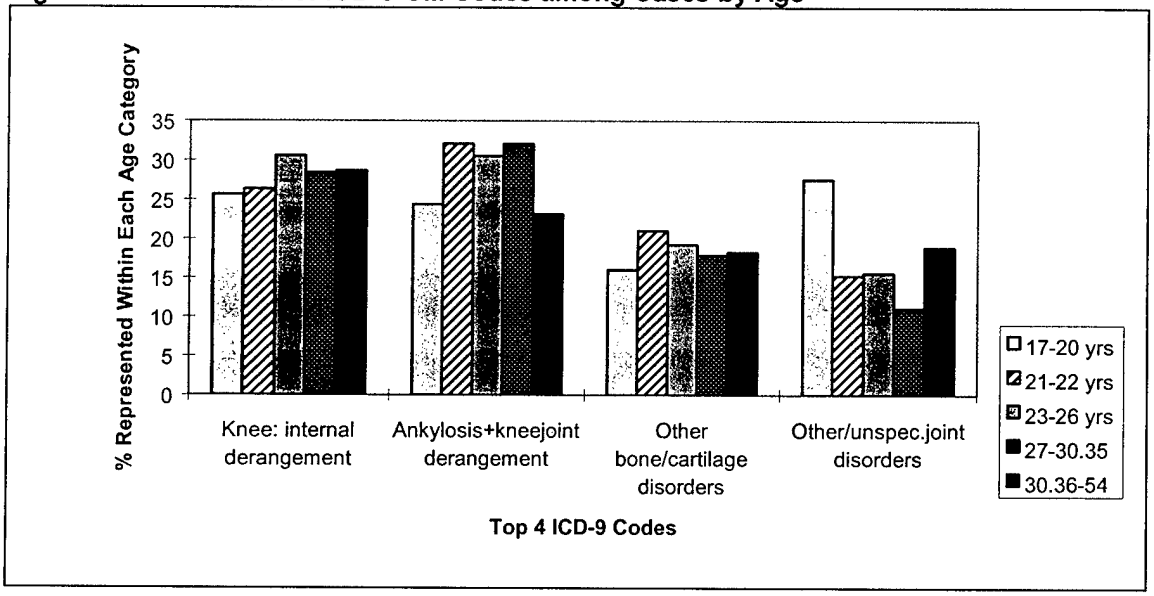
Figure 6. Distribution of ICD-9-CM Codes among Cases by Race



Stratified analysis of ICD-9-CM codes by age, once again, showed small differences (Figure 7). The top 5 ICD-9-CM codes were similar for all strata of age except for "sprain/strains of knee/leg" (844), which occurred only among those ages

17–20 and ages 21-22, and "disorders of muscle, ligament, fascia" (728), which occurred only among ages 23–26. The proportion of cases having "other bone/cartilage disorders" (733) was highest in the 17–20 years age group and "internal derangement of knee" (717) was highest in the 23–26 years age group. (See Appendix A9.) As with gender and race, age was not found to be an important factor in knee injury outcomes as defined by ICD-9-CM coding.

Figure 7. Distribution of ICD-9-CM Codes among Cases by Age



Tables representing the cross tabulation between ICD-9-CM codes and percent disability are shown below (Table 7).

Table 7. Percentage of Overlap of Top 10 ICD-9-CM Codes and Percent Disability

% Disability	ICD	n	% Overlap
0%	719	8	66.7
(N=12)	717	2	16.7
	718	2	16.7
	715	0	0.0
	844	0	0.0
	716	0	0.0
	728	0	0.0
	733	0	0.0
	823	0	0.0
	824	0	0.0
		12	100.0

Table 7. Percentage of Overlap of Top 10 ICD-9-CM Codes and Percent Disability (cont'd)

% Disability	ICD	n	% Overlap
10% (N=194)	719	70	36.1
	717	64	33.0
	718	30	15.5
	733	12	6.2
	715	8	4.1
	716	5	2.6
	728	3	1.5
	821	1	0.5
	824	1	0.5
	823	0	0.0
		194	100.0
20% (N=93)	718	27	29.0
	717	26	28.0
	719	16	17.2
	733	11	11.8
	715	7	7.5
	728	5	5.4
	823	1	1.1
	716	0	0.0
	821	0	0.0
	824	0	0.0
		93	100.0
30% (N=48)	718	14	29.2
	717	11	22.9
	733	9	18.8
	715	3	6.3
	719	3	6.3
	824	3	6.3
	728	2	4.2
	716	1	2.1
	821	1	2.1
	823	1	2.1
		48	100.0
40% (N=16)	733	8	50.0
	718	2	12.5
	719	2	12.5
	823	2	12.5
	715	1	6.3
	717	1	6.3
	716	0	0.0
	728	0	0.0
	821	0	0.0
	824	0	0.0
		16	100.0

Table 7. Percentage of Overlap of Top 10 ICD-9-CM Codes and Percent Disability (cont'd)

% Disability	ICD	n	% Overlap
50%	718	1	100.0
(N=1)	715	0	0.0
	716	0	0.0
	717	0	0.0
	719	0	0.0
	728	0	0.0
	733	0	0.0
	821	0	0.0
	823	0	0.0
	824	0	0.0
		1	100.0
>50%	733	6	54.5
(N=11)	719	2	18.2
	821	2	18.2
	718	1	9.1
	715	0	0.0
	716	0	0.0
	717	0	0.0
	718	0	0.0
	728	0	0.0
	823	0	0.0
	824	0	0.0
		11	100.0

Percent disability information was available for about 68% of the cases (Table 8). The overall frequency distribution of percent disability indicated that a majority of the cases were either 30% disabled or 20% disabled. The next 2 most common ratings of percent disability were 10% and 40%.

Table 8. Overall Distribution of the Percent Disability Values Attributed to All Cases

	% Disability	N	% (N=1272)	% of total (N=1865)
1	0	78	6.13	4.18
2	10	223	17.53	11.96
3	20	322	25.31	17.27
4	30	355	27.91	19.03
5	40	132	10.38	7.08
6	50	33	2.59	1.77
7	60	79	6.21	4.24
8	70	14	1.10	0.75
9	80	18	1.42	0.97
10	90	7	0.55	0.38
11	100	11	0.86	0.59
	TOTAL	1272	100.00	68.20

Note: Missing cases = 593; actual population = 1865.

Stratified analysis of percent disability by gender showed that the highest category remained 30% among both men and women and that the proportions of men and women within each stratum of percent disability did not show a clear pattern; however, higher percent disability (i.e., > 50%) seemed to occur more commonly among men than among women (Figure 8). Other differences due to gender were, once again, marginal. Stratified analysis by race also revealed little other than that the most commonly occurring percent disability varied from 20% to 30% (Figure 9). Unlike the overall distribution and the distribution stratified by gender and race, the distribution stratified by age showed that the most commonly occurring level of percent disability within strata of age was 10% (Figure 10). This was explained by further stratification of the cases within the age categories by gender and race.

Figure 8. Distribution of Percent Disability by Gender

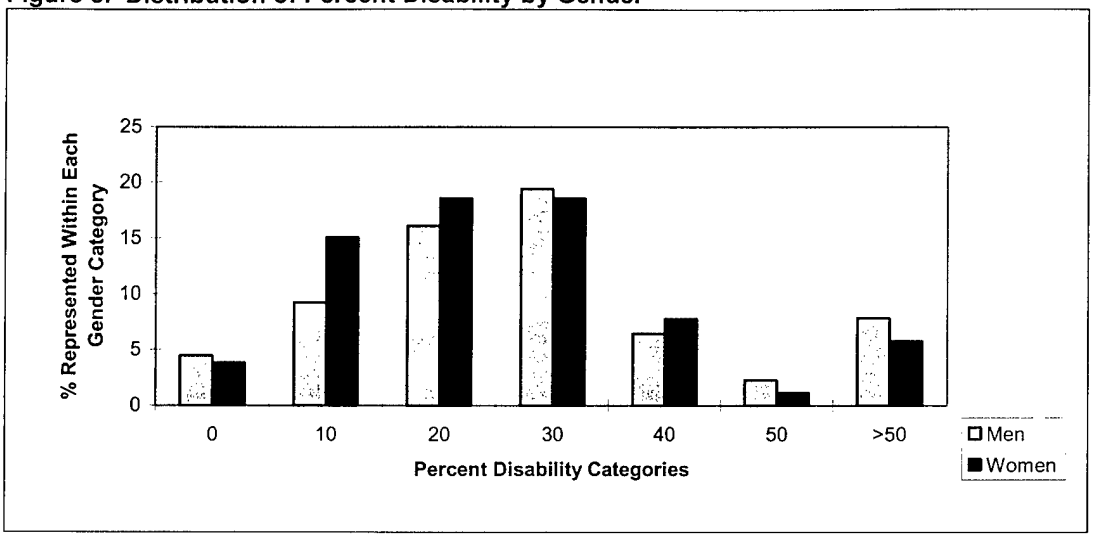


Figure 9. Distribution of Percent Disability by Race

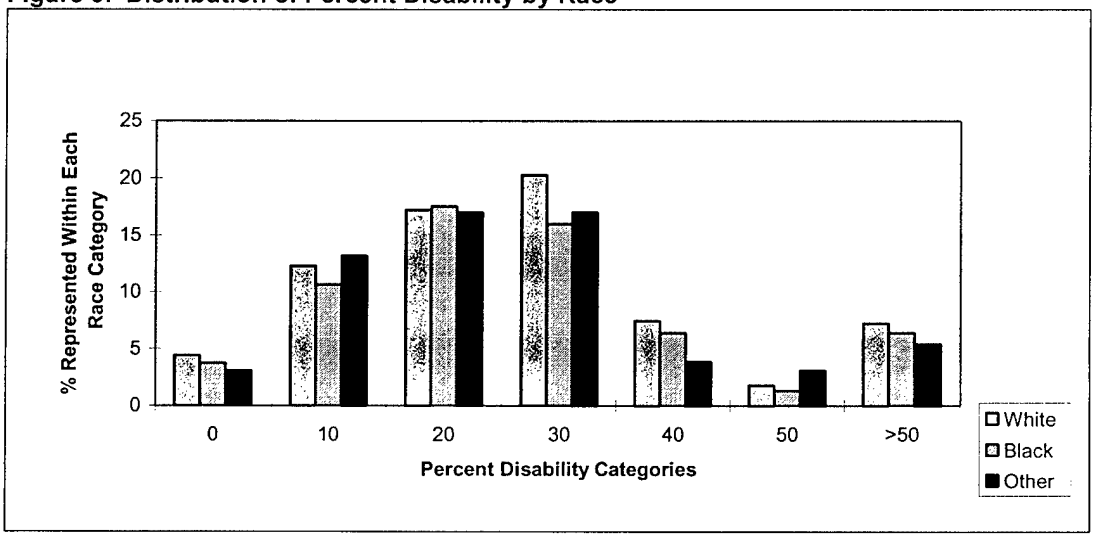
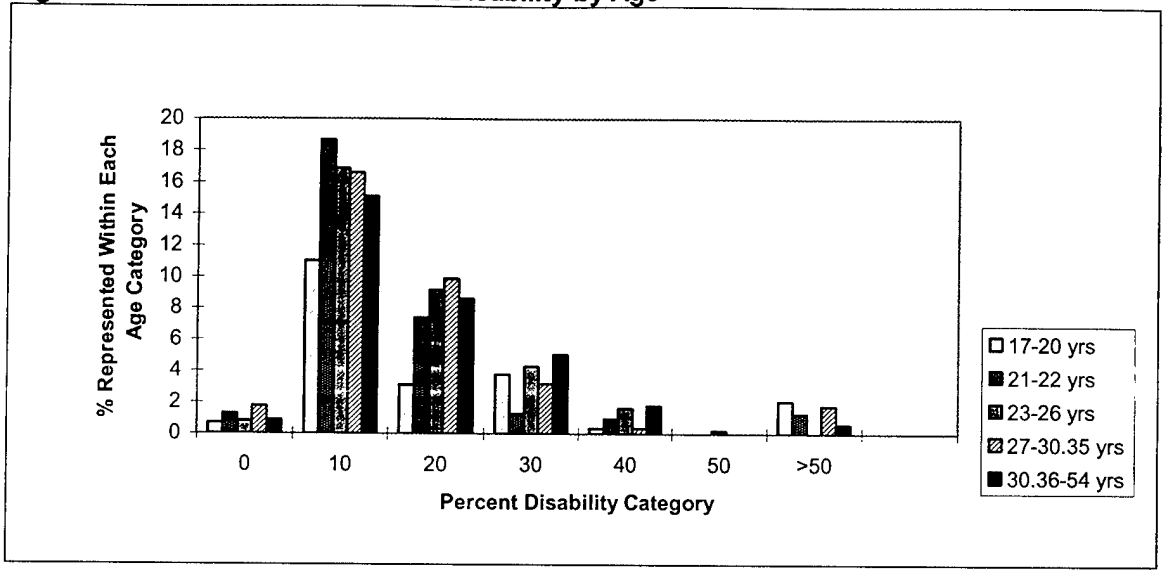
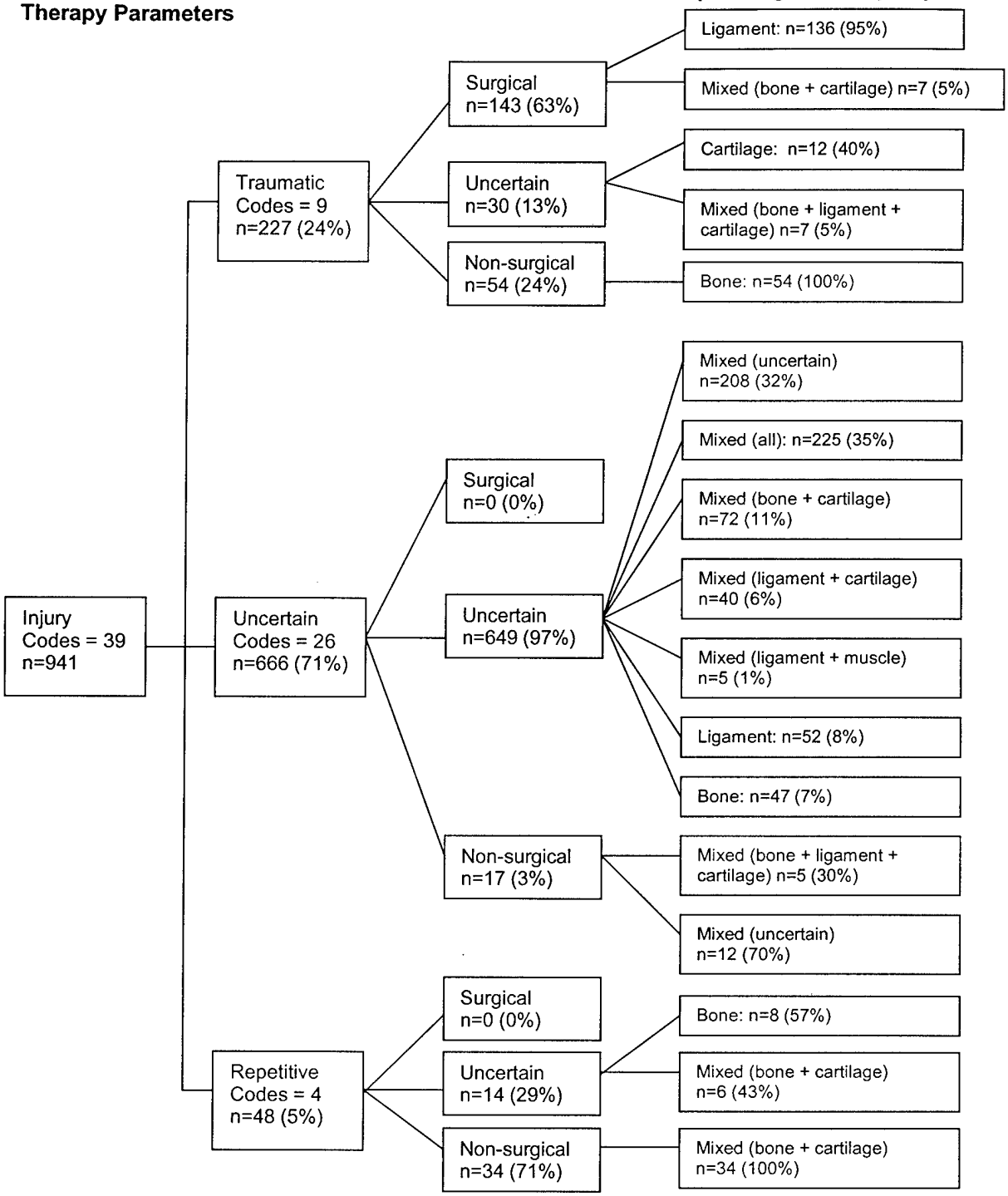


Figure 10. Distribution of Percent Disability by Age



About 50% of the cases were classified by the physical therapy parameters: nature of injury, requirement of surgery, and type of tissue affected. The results showed that although such a system would carry considerable information about each injury, it may not be useful to pursue using the current data set because a large majority of the cases were categorized as "uncertain". As shown in Figure 11, 71% of the cases fell into the "uncertain" category at the "traumatic" versus "repetitive" level. Of these "uncertain" cases, 97% fell into the "uncertain" category with regard to requirement of surgery. In the "traumatic" and "repetitive" groups, however, most cases were "surgical" and "non-surgical," respectively, as expected. At the third level, type of tissue affected, a considerable portion of the cases fell into "mixed" categories.

Figure 11. Distribution of Top 39 ICD-9-CM Codes and the Corresponding Cases by Physical Therapy Parameters



Codes=Number of ICD codes within each category
n=Total number of cases within each category
Source: Heiderscheit and Saunders, 1985

COMPARISON OF CLASSIFICATION SCHEMES BASED ON RISK FACTOR ASSOCIATIONS

The first set of logistic regression models that contained the demographic variables as risk factors showed that classifying knee injury outcomes by specific parameters did affect the strength of association between these predictor variables and the injury outcomes (Table 9). This served as evidence for potential reduction in misclassification. Specifically, the odds ratios produced for the link between each predictor variable and each of the specific outcome variables changed considerably from the "any disability" model in which the injury outcome was not classified by any specific parameter. Although the change in the odds ratio ranged from a reduction of as little as 6% (as seen in the association of being female and the risk of being disabled due to a "repetitive" knee injury) to an increase of as great as 69% (as seen in the association of being 21–22 years of age and the risk of being 30% disabled), nearly all odds ratios changed from their corresponding values in the initial model using the non-specific outcome.

COMPARISON OF CLASSIFICATION SCHEMES BASED ON RISK FACTOR ASSOCIATIONS

The first set of logistic regression models that contained the demographic variables as risk factors showed that classifying knee injury outcomes by specific parameters did affect the strength of association between these predictor variables and the injury outcomes (Table 9). This served as evidence for potential reduction in misclassification. Specifically, the odds ratios produced for the link between each predictor variable and each of the specific outcome variables changed considerably from the "any disability" model in which the injury outcome was not classified by any specific parameter. Although the change in the odds ratio ranged from a reduction of as little as 6% (as seen in the association of being female and the risk of being disabled due to a "repetitive" knee injury) to an increase of as great as 69% (as seen in the association of being 21–22 years of age and the risk of being 30% disabled), nearly all odds ratios changed from their corresponding values in the initial model using the non-specific outcome.

Table 9. Absolute Changes in Odds Ratio Estimators of Associations Between Predictor Variables and "Any Injury" Outcome Versus Specific Injury Outcomes: Model Using Demographic Variables As Predictors

			Female	Non-white	17–20 years	21–22 years	23–26 years	27–30.35 years	30.36–54 years
Any injury			**0.96**	**1.73**	**1.3**	**1.23**	**1.00**	**0.96**	**1.11**
VASRD code									
	5257	Knee impairments other than ankylosis	1.01	1.69	1.68	1.26	1.00	0.92	1.196
	5255	Impairment of femur	0.64	2.01	0.66	1.07	1.00	1.11	0.83
	5262	Impairment of tibia and fibula	1.22	2.18	1.03	1.27	1.00	1.24	1.11
ICD-9-CM code									
	717	Internal derangement of knee	1.06	1.81	1.62	1.32	1.00	1.01	1.38
	718	Ankylosis and joint derangement of knee	1.17	1.88	1.7	1.08	1.00	0.89	1.72
	719	Other unspecified joint disorders	0.7	1.66	1.61	1.03	1.00	1.02	1.29
	733	Other bone/cartilage disorders	0.67	2.05	0.77	1.17	1.00	1.33	1.01
% Disability									
		10% Disabled	1.09	1.6	1.98	1.11	1.00	0.98	1.26
		20% Disabled	1.02	1.49	3.79	1.51	1.00	0.9	1.19
		30% Disabled	1.28	1.12	1.42	3.97	1.00	1.33	0.98
Physical Therapy Parameters									
		Traumatic	1.06	2.11	1.41	1.22	1.00	1.08	1.47
		Repetitive	0.95	0.91	2.65	1.62	1.00	0.46	0.77

Referent Group: White Males 23-26 years old

Within each system of classification, the risk of one category of injury changed in one direction while that of other injury events changed in the opposite direction. For instance, using the VASRD system of classification showed that the risk of having "impairments of the knee other than ankylosis" (5257) and "impairments of tibia and fibula" (5262) increased for women as compared to men (change in OR from 0.96 to 1.01 and 1.22, respectively), while the risk of having "impairments of the femur" (5255) was reduced for women (change in OR from 0.96 to 0.64). Similarly, while being of a non-white race was protective, relative to the crude outcome, with regard to "impairments of the knee other than ankylosis" (5257) compared to being white (change in OR from 1.73 to 1.69), non-whites appeared to be at higher risk of having "impairments of tibia and fibula" (5262) and "impairments of the femur" (5255) (change in OR from 1.73 to 2.01 and 2.18, respectively). Regarding age category as a risk factor, using the VASRD system indicated that being in the age range of 17–20 was protective for the injuries coded by 5255 and 5262, but was associated with higher risk of "impairments of knee other than ankylosis" (5257).

Similar patterns were seen within the other three systems of classifying knee injury. The ICD-9-CM coding system of classification showed increases in risk of being disabled for women compared to men. Specifically, the odds ratios for disability due to "ankylosis and joint derangement of knee" (718) and "internal derangement of knee" (717) increased from 0.96 to 1.17 and 1.06, respectively, and decreased for "other unspecified joint disorders" (719) and "other bone/cartilage disorders" (733) from 0.96 to 0.70 and 0.67, respectively. Specifying the injury outcomes using percent disability indicated an increased risk of being 20% or 30% disabled, but a decreased risk of being 10% disabled among non-whites compared to whites. Classification of disabling knee injuries by physical therapy parameters showed that while the risk associated with most demographic variables was increased for "traumatic" injuries, it was decreased for "repetitive" injuries and vice versa (Table 9).

The results from the second set of models (those that also accounted for interaction of gender with race and age) further illustrated the utility of specific rather than broad outcomes of disabling knee injury. This set of models revealed interactions between the independent variables that could not be detected in the model using "any injury" as the outcome.

In the multivariate models that explored interaction of gender with race (Table 10), using the VASRD system for specifying knee injury outcome revealed changes in odds ratios that were not evident in the crude analyses. This implies that some other factor or factors other than the interaction between gender and race are influencing risk of these types of injuries. For instance, using white men as the referent group, the risk of "any injury" for white women was 52% that of white men, whereas that of "impairment of tibia/fibula" (5262) for white women was 99% that of white men. Classification of injury outcomes by ICD-9-CM codes showed similar results in that effect modification of gender on race was influenced when considering specific outcomes of "other unspecified joint disorders" (719) and "other bone/cartilage disorders" (733). The usefulness of employing specific injury outcomes in etiologic research was once again

illustrated by the changes in the magnitude of the odds ratios produced by using percent disability and physical therapy parameters as outcomes compared to "any injury" as the outcome (Table 10).

Table 10. Absolute Changes in Odds Ratio Estimators of Associations Between Predictor Variables and "Any Injury" Outcome Versus Specific Injury Outcomes: Model Using Demographic Variables and Gender-Race Interaction Terms as Predictors

			White Women	Non-White Men	Non-White Women
Any Injury			**0.52**	**0.51**	**0.88**
VASRD code					
	5257	Knee impairments other than ankylosis	0.84	1.33	1.87
	5255	Impairment of femur	0.54	1.46	1.4
	5262	Impairment of tibia/fibula	0.99	1.60	3.38
ICD-9-CM code					
	717	Internal derangement of knee	0.91	1.46	2.10
	718	Ankylosis and joint derangement of knee	1.02	1.56	2.43
	719	Other unspecified joint disorders	0.59	1.24	1.24
	733	Other bone/cartilage disorders	0.54	1.36	1.55
% Disability					
		10% Disability	1.05	1.52	1.79
		20% Disability	0.75	1.01	1.76
		30% Disability	0.86	0.78	1.70
Physical Therapy Parameter					
		Traumatic	0.97	1.83	2.41
		Repetitive	0.52	0.51	0.88

Referent Group: White Male

The results from the set of models that accounted for interaction between gender and age reinforced the findings stated above. Interaction that was apparent in the crude model was affected by the use of specific knee injury outcomes (Table 11). For instance, using 23–26 year old males as the referent group, modeling the crude outcome showed that 17–20 year old males had a 60% higher risk of "any injury" compared to 23–26 year old males. However, when "impairment of femur" (VASRD 5255) was used as the injury outcome, the risk increased by more than 200% compared to the referent group. Using other categories of VASRD or the outcomes coded as ICD 717, 718, and 719 produced similar changes in the odds ratios. Additionally, almost all of the results from the models using percent disability and physical therapy parameters

as injury outcomes revealed changes in odds ratios compared to the model using the crude outcome, indicating that using a specific outcome explained some of the interactions that existed between gender and age.

The set of models that considered military occupation as a risk factor for disabling knee injury was not robust enough to produce odds ratios that were justifiably interpretable. This happened because of the reduction in sample size that resulted from using a subset of the cases and controls (n=697) that had the PMOS Military Police (95B) (n=263), which was selected as an occupational risk factor, and the PMOS Administrative Specialist (71L) (n=434), which was selected as the referent category for occupation.

Table 11. Absolute Changes in Odds Ratio Estimators of Associations Between Predictor Variables and "Any Injury" Outcome Versus Specific Injury Outcomes: Model Using Demographic Variables and Gender-Age Interaction Terms as Predictors

			17–20 years		21–22 years		27–30.35 years		30.36–54 years	
			Men	Women	Men	Women	Men	Women	Men	Women
Any Injury			**1.6**	**1.3**	**1.35**	**1.42**	**1.04**	**1.12**	**1.54**	**0.93**
VASRD										
	5257	Knee impairments other than ankylosis	2.16	1.62	1.31	1.55	0.95	1.12	1.58	1.02
	5255	Impairment of femur	0.71	0.44	1.06	0.77	1.03	0.84	1.01	0.48
	5262	Impairment of tibia/fibula	1.24	1.85	1.86	1.69	1.57	2.00	2.14	0.98
ICD										
	717	Internal derangement of knee	3.01	1.43	1.5	1.86	1.03	1.66	2.29	1.15
	718	Ankylosis and joint derangement of knee	2.14	2.08	1.18	1.62	1.2	1.04	2.39	1.71
	719	Other unspecified joint disorders	1.75	1.09	1.01	0.77	0.86	0.88	1.62	0.74
	733	Other bone/cartilage disorders	0.82	0.73	1.55	0.89	2.05	0.94	1.66	0.62
% Disability										
		10% Disability	2.66	1.87	1.33	1.2	0.81	1.84	1.63	1.14
		20% Disability	3.45	5.56	1.87	1.46	1.09	0.91	1.29	1.32
		30% Disability	2.73	1.3	3.61	9.59	1.29	2.59	1.22	1.25
Physical Therapy Parameter										
		Traumatic	1.87	1.37	1.22	1.71	1.15	1.36	2.03	1.25
		Repetitive	high	1.97	2.28	3.13	1.68	0.48	1.09	1.67

Referent Group: Male, 23-26 years old

DISCUSSION

The objectives of this report were to compare systems of classifying disabling knee injury and attempt to identify the one that would be most suitable for etiologic research.

From the first set of findings, it is evident that the use of VASRD, ICD-9-CM, percent disability, and physical therapy parameters represent distinct systems for classifying disabling knee injury. Categories created by VASRD coding appear to be rather non-specific and inclusive, and those created by ICD-9-CM coding are only marginally more discriminating in terms of incorporating information on the details of the knee injury. Similarly, the use of percent disability involves the same problem of a lack of descriptive information. Additionally, although percent disability is indeed a viable method of stratifying and classifying disabling knee injury, in the current study, each value of percent disability is linked to a particular knee injury outcome designated by a VASRD code. Therefore, the use of percent disability as a parameter for classifying knee injury would be more useful if it were assigned without being intrinsically linked to other factors so that an overall comparison of percent disability would be possible. It was, perhaps, due to the simplistic nature of the bivariate analysis that none of the gender, race, and age effects found in the Sulsky et al. study (11) were detected at this level.

The system of classification based on parameters used in physical therapy proved to be the most specific in that it incorporated the most descriptive characteristics of the injury. Unfortunately, the data in the current study were not specific enough to illustrate the usefulness of such a classification system and, instead, led to far too many "uncertain" and "mixed" categories. Had the disability data been more amenable to classification by such specific criteria, it is plausible that this system of classification may have been identified as the most useful for etiologic research on the basis of the amount of information it carries. An injury outcome with this degree of descriptive detail would conceivably lend itself to improved etiologic research by considerably improving the precision of the definition.

Multivariate analyses using each of the four systems of classifying knee injury indicated that the use of specific injury outcomes led to heterogeneity in the odds ratios produced for etiologic research, regardless of whether the independent variables taken into consideration were simply the demographic variables or the demographic variables along with a variable accounting for interactions between them. This indicated that a specific set of predictors exists for being disabled due to a specific injury, whether the latter is identified by a VASRD code, an ICD code, a percentage of disability, or a parameter used in the field of physical therapy. An added advantage of using specific injury outcomes is that it confers the ability to further examine effect modification that would otherwise remain only somewhat understood and therefore produce limited research results.

It was difficult to select one system as the most useful, for several reasons. First, the amount of change in the odds ratios was variable, and there was no consistent

pattern in the different odds ratios under the 4 systems. Second, a gold standard for classifying disabling knee injury was not established prior to the current study, nor does one exist in the literature. This prevented ranking of the systems of classification by their performance in the multivariate analyses. Finally, it may be questionable to compare one system to the other if the population base captured in the categories of VASRD 5257, 5255, and 5262 was not the same as that of ICD 717, 718, 719, and 733, and so on for the other two classification systems.

A strength of this study is that it demonstrates the usefulness of classifying disabling knee injury for etiologic research. As an extension of this study, one could perhaps utilize the findings of the study by Williams (14) to further investigate the effect of occupation as a risk factor for knee-related disability discharge. For the specific purposes of etiologic research in the Army, a reasonable recommendation, given the findings of the current study, would be to create a more multidimensional coding system for classifying knee injury that would incorporate the parameters used in physical therapy and could perhaps be a combination of all 6 parameters investigated here. Such an outcome would presumably be highly distinctive and informative and would thereby potentially reduce misclassification by increasing the precision of the event definition. The use of alternate parameters for classifying disabling knee injuries could be examined. Cost of disability could be one such parameter, though the use of this alternative may not be appropriate if the ultimate goal is to refine the etiologic research methodology.

Nevertheless, the findings of this study and the recommendations made based on the findings are subject to a number of limitations. The absence of a gold standard in terms of classification systems for knee injury made it difficult to rank the systems that were investigated in this study. Several aspects of the study were hampered due to use of small sample sizes that led to instability. Larger sample sizes would have lent more statistical power.

There may have been alternate explanations for the heterogeneity in odds ratios, such as random error. There may be differences among the pool of cases included in each of the models that would have led to differences in odds ratios. Each model used a different subset of cases that would have led to some variability.

Another limitation to this study may have been that it was based on a fairly young and healthy population. Though this was a strength of the study itself, it may compromise the generalizability of the study. For instance, the results of the study could not be generalized to a population that is older than 54 years. The results of this study expose the inadequacy of the current classification schemes for disability, at least from an epidemiological standpoint. The VASRD coding system is rather non-specific, though the hospital-based coding of disability cases using ICD-9-CM codes might have improved classification if it were available on more than 2/3 of the cases. Evaluation of percent disability, as a method of classifying disability, did not yield encouraging results. The use of physical therapy parameters represent a promising method also; however, proper classification requires more information than was currently available in the TAIHOD. Improvements in these coding systems are needed before they can be

effectively used on a routine basis. Perhaps direct review of source hard copy records will allow additional insight into the idiosyncrasies and accuracy of these coding systems. With a clearer understanding of the determinants of knee disability, preventive measures could be implemented to reduce disability, both in the Army and among civilian populations. This, in turn, would reduce not only the pain and suffering associated with disability, but also disability-related costs in terms of treatment expenses, occupational loss, and disability payments. This would contribute to the overall effort of increasing injury prevention through training, creating a more ergonomic occupational environment, and increasing employee awareness of occupational injury, both in the U.S. Army and among civilian populations. It is important for epidemiology, as a field, to be able to make this contribution through sound research methodology.

REFERENCES

1. *The Random House Dictionary.* New York, NY: Random House, 1980.

2. Murray, C. J. L., and A. D. Lopez. *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020; Summary.* Cambridge, MA: Harvard University Press, 1996.

3. Knapik, J., P. Ang, K. Reynolds, and B. Jones. Physical fitness, age, and injury incidence in infantry soldiers. *J Occup Med,* 35(6): 598–603, 1993.

4. Jones, B. H., D. N. Cowan, J. P. Tomlinson, J. R. Robinson, D. W. Polly, and P. N. Frykman. Epidemiology of injuries associated with physical training among young men in the Army. *Med Sci Sports Exerc,* 25(2): 197–203, 1993.

5. Feuerstein, M., S. M. Berkowitz, and C. A. Peck Jr., Musculoskeletal-related disability in U.S. Army personnel: prevalence, gender, and military occupational specialties. *J Occup Environ Med,* 39(1): 68–78, 1997.

6. Tomlinson, J. P., W. M. Lednar, and J. D. Jackson. Risk of injury in soldiers. *Mil Med,* 152(2): 60–4, 1987.

7. *Dorland's Illustrated Medical Dictionary*, 25th edition. Philadelphia, PA: W. B. Saunders, 1974.

8. Department of the Army, Headquarters. *Personnel Separations: Physical Evaluation for Retention, Retirement, or Separation.* Washington, D.C., AR 635-40, 1990.

9. Ross, J., A. Woodward. Risk factors for injury during basic military training. Is there a social element to injury pathogenesis? *J Occup Med,* 36(10): 1120–1126, 1994.

10. Jensen, K. L., and W. Eenberg. Occupation as a risk factor for knee disorders. *Scand J Work Environ Health,* 22: 165–175, 1996.

11. Sulsky, S. I., K. A. Mundt, C. Bigelow, and P. J. Amoroso. Case-control study of disabling occupational knee injury in the U.S. Army: the role of gender, race, and age. *AmJ Prev Med,* 18(3S): 103-111, 2000.

12. Saunders, H. D. *Evaluation, Treatment, and Prevention of Musculoskeletal Disorders.* Minneapolis, MN: Viking Press, Inc., 1985.

13. *SAS.* [computer program] Version 6.12. Cary, NC: SAS, Institute, Inc., 1989.

14. Amoroso, P. J., M. M. Yore, B. Weyandt, and B. H. Jones. Chapter 8: Total Army Injury and Health Outcomes Database: A Model Comprehensive Research Database. *Mil Med,* 164(8 Suppl): 1-36, 1999.

15. Williams, R. E., P. J. Amoroso, K. A. Mundt, and C. Bigelow. *Physical Tasks of Military Occupational Specialties as Risk Factors for Knee-Related Disability Discharge*. Natick, MA: USARIEM. Technical Report T00-9, February 2000.

16. Sulsky, S. I., K. A. Mundt, C. Bigelow, and P. J. Amoroso. *Knee-Related Injuries and Disabilities in the U.S. Army, 1980-1997.* Natick, MA: USARIEM. Technical Report T00-24, 2000.

17. Songer, T. J., and R. E. LaPorte.Disabilities due to injury in the military. *Am J Prev Med,* 18(3S): 33-40, 2000.

18. Amoroso, P. J., M. M. Yore, G. S. Smith, and M. Lopez. *Analysis of Military Occupational Specialties and Hospitalizations Part 1: 25 Largest Army Enlisted Occupations.* Natick, MA: USARIEM. Technical Report T98-7, 1997.

19. Peck, C. A., Jr. The U.S. Army Physical Disability System. In: Belandres P. V., Dillingham T. R., Eds. Rehabilitation of the Injured Combatant. Vol 1. In: *Textbook of Military Medicine*. Washington, D.C.: Office of The Surgeon General, U.S. Department of the Army, and Borden Institute, 1999 p. 863-885.

APPENDIX A1
DISTRIBUTION OF VASRD CODES STRATIFIED BY GENDER

Gender	VASRD	Definition	N	% of Cases Within Stratum	% of All Cases (N=1865)
Male				**(N=1005)**	
	5257	Impairments of knee other than ankylosis	665	66.17	35.66
	5255	Impairment of femur	143	14.23	7.67
	5262	Impairment of tibia and fibula	134	13.33	7.18
	5259	Removal of semilunar cartilage	54	5.37	2.90
	5258	Dislocated semilunar cartilage	6	0.60	0.32
	5256	Ankylosis of knee	3	0.30	0.16
		TOTAL	**1005**	**100.00**	**53.89**
Female				**(N=860)**	
	5257	Impairments of knee other than ankylosis	522	60.70	27.99
	5255	Impairment of femur	175	20.35	9.38
	5262	Impairment of tibia and fibula	104	12.09	5.58
	5259	Removal of semilunar cartilage	42	4.88	2.25
	5258	Dislocated semilunar cartilage	6	0.70	0.32
	5263	Genu recurvatum	6	0.70	0.32
	5161	Amputation of upper third of thigh	2	0.23	0.11
	5055	Knee replacement	1	0.12	0.05
	5160	Disarticulation of thigh	1	0.12	0.05
	5256	Ankylosis of knee	1	0.12	0.05
		TOTAL	**860**	**100.00**	**46.01**

APPENDIX A2
DISTRIBUTION OF VASRD CODES STRATIFIED BY RACE

Race	VASRD	Definition	N	% of Cases Within Stratum	% of All Cases (N=1865)
White				**(N=1283)**	
	5257	Impairments of knee other than ankylosis	805	62.74	43.16
	5255	Impairment of femur	233	18.16	12.49
	5262	Impairment of tibia and fibula	176	13.72	9.44
	5259	Removal of semilunar cartilage	54	4.21	2.90
	5258	Dislocated semilunar cartilage	6	0.47	0.32
	5263	Genu recurvatum	6	0.47	0.32
	5256	Ankylosis of knee	3	0.23	0.16
		TOTAL	**1283**	**100.00**	**68.79**
Black				**(N=450)**	
	5257	Impairments of knee other than ankylosis	299	66.44	16.03
	5255	Impairment of femur	66	14.67	3.54
	5262	Impairment of tibia and fibula	48	10.67	2.57
	5259	Removal of semilunar cartilage	30	6.67	1.61
	5258	Dislocated semilunar cartilage	4	0.89	0.21
	5160	Disarticulation of thigh	1	0.22	0.05
	5161	Amputation of upper third of thigh	1	0.22	0.05
	5256	Ankylosis of knee	1	0.22	0.05
		TOTAL	**450**	**100.00**	**24.13**
Other				**(N=129)**	
	5257	Impairment of knee other than ankylosis	82	63.57	4.40
	5255	Impairment of femur	19	14.73	1.02
	5262	Impairment of tibia and fibula	12	9.30	0.64
	5259	Removal of semilunar cartilage	12	9.30	0.64
	5258	Dislocated semilunar cartilage	2	1.55	0.11
	5055	Knee replacement	1	0.78	0.05
	5161	Amputation of upper third of thigh	1	0.78	0.05
		TOTAL	**129**	**100.00**	**6.92**

Appendix A3
Distribution of VASRD Codes Stratified by Age

Age (years)	VASRD	Definition	N	% of Cases Within Stratum	% of All Cases (N=1865)
17 to 20				**(N=290)**	
	5257	Impairments of knee other than ankylosis	155	53.45	8.31
	5255	Impairment of femur	75	25.86	4.02
	5262	Impairment of tibia and fibula	41	14.14	2.20
	5259	Removal of semilunar cartilage	15	5.17	0.80
	5258	Dislocated semilunar cartilage	2	0.69	0.11
	5161	Amputation of upper third of thigh	1	0.34	0.05
	5256	Ankylosis of knee	1	0.34	0.05
		TOTAL	**290**	**100.00**	**15.55**
21-22				**(N=311)**	
	5257	Impairments of knee other than ankylosis	211	67.85	11.31
	5255	Impairment of femur	47	15.11	2.52
	5262	Impairment of tibia and fibula	34	10.93	1.82
	5259	Removal of semilunar cartilage	15	4.82	0.80
	5263	Genu recurvatum	2	0.64	0.11
	5160	Disarticulation of thigh	1	0.32	0.05
	5256	Ankylosis of knee	1	0.32	0.05
		TOTAL	**311**	**100.00**	**16.68**
23-26				**(N=491)**	
	5257	Impairment of knee other than ankylosis	342	69.65	18.34
	5255	Impairment of femur	64	13.03	3.43
	5262	Impairment of tibia and fibula	54	11.00	2.90
	5259	Removal of semilunar cartilage	25	5.09	1.34
	5258	Dislocated semilunar cartilage	4	0.81	0.21
	5161	Amputation of upper third of thigh	1	0.20	0.05
	5263	Genu recurvatum	1	0.20	0.05
		TOTAL	**6**	**1.22**	**0.32**
27-30.35				**(N=283)**	
	5257	Impairment of knee other than ankylosis	206	72.79	11.05
	5255	Impairment of femur	32	11.31	1.72
	5262	Impairment of tibia and fibula	24	8.48	1.29
	5259	Removal of semilunar cartilage	14	4.95	0.75
	5258	Dislocated semilunar cartilage	3	1.06	0.16
	5263	Genu recurvatum	3	1.06	0.16
	5256	Ankylosis of knee	1	0.35	0.05
		TOTAL	**283**	**100.00**	**15.17**
30.36-54				**(N=337)**	
	5257	Impairment of knee other than ankylosis	220	65.28	11.80
	5255	Impairment of femur	56	16.62	3.00
	5262	Impairment of tibia and fibula	38	11.28	2.04
	5259	Removal of semilunar cartilage	19	5.64	1.02
	5258	Dislocated semilunar cartilage	2	0.59	0.11
	5055	Knee replacement	1	0.30	0.05
	5256	Ankylosis of knee	1	0.30	0.05
		TOTAL	**337**	**100.00**	**18.07**

Appendix A4
Distribution of the 10 Most Frequently Occurring ICD-9-CM Codes, Men Only

ICD-9-CM Code	Definition	N	% of Top 10 (N=633)	% of Men Having ICD (N=820)	% of Male Total (N=1005)
718	Ankylosis and joint derangement of knee	170	26.86	20.73	16.92
717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	164	25.91	20.00	16.32
733	Other bone/cartilage disorders: osteoporosis, pathological fracture	95	15.01	11.59	9.45
719	Other unspecified joint disorders	85	13.43	10.37	8.46
715	Osteoarthritis, polyarthritis	29	4.58	3.54	2.89
844	Sprains/strains of knee/leg	26	4.11	3.17	2.59
716	Other unspecified arthropathies	19	3.00	2.32	1.89
823	Fracture of tibia and fibula	16	2.53	1.95	1.59
821	Other unspecified fractures of femur	15	2.37	1.83	1.49
728	Disorders of muscle, ligament, fascia	14	2.21	1.71	1.39
		633	**100.00**	**77.20**	**62.99**

Note: Male cases missing primary ICD-9-CM code: 185

Appendix A5
Distribution of the 10 Most Frequently Occurring ICD-9-CM Codes, Women Only

ICD-9-CM Code	Definition	N	% of Top 10 (N=537)	% of Women Having ICD (N=668)	% of Female Total (N=860)
717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	120	22.35	17.96	13.95
718	Ankylosis and joint derangement of knee	120	22.35	17.96	13.95
733	Other bone/cartilage disorders: osteoporosis, pathological fracture	109	20.30	16.32	12.67
719	Other unspecified joint disorders	97	18.06	14.52	11.28
715	Osteoarthritis, polyarthritis	23	4.28	3.44	2.67
824	Fracture of ankle	18	3.35	2.69	2.09
716	Other unspecified arthropathies	14	2.61	2.10	1.63
823	Fracture of tibia and fibula	13	2.42	1.95	1.51
728	Disorders of muscle, ligament, fascia	12	2.23	1.80	1.40
844	Sprains/strains of knee or leg	11	2.05	1.65	1.28
		537	**100.00**	**80.39**	**62.44**

Note: Female cases missing primary ICD-9-CM code: 192

Appendix A6
Distribution of the 10 Most Frequently Occurring ICD-9-CM Codes, Whites Only

ICD-9-CM Code	Definition	N	% of White Cases (N=802)	% of Total (N=1865)
718	Ankylosis and joint derangement of knee	205	25.56	10.99
717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	198	24.69	10.62
733	Other bone/cartilage disorders: osteoporosis, pathological fracture	151	18.83	8.10
719	Other unspecified joint disorders	121	15.09	6.49
715	Osteoarthritis, polyarthritis	25	3.12	1.34
716	Other unspecified arthropathies	24	2.99	1.29
823	Fracture of tibia and fibula	23	2.87	1.23
844	Sprains/strains of knee or leg	21	2.62	1.13
824	Fracture of ankle	19	2.37	1.02
728	Disorders of muscle, ligament, fascia	15	1.87	0.80
		802	**100.00**	**43.00**

Appendix A7
Distribution of the 10 Most Frequently Occurring ICD-9-CM Codes, Blacks Only

ICD-9-CM Code	Definition	N	% of Black Cases (N=286)	% of Total (N=1865)
717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	68	23.78	3.65
718	Ankylosis and joint derangement of knee	66	23.08	3.54
719	Other unspecified joint disorders	51	17.83	2.73
733	Other bone/cartilage disorders: osteoporosis, pathological fracture	36	12.59	1.93
715	Osteoarthritis, polyarthritis	25	8.74	1.34
844	Sprains/strains of knee or leg	10	3.50	0.54
821	Fractures of other unspecified parts of femur	9	3.15	0.48
728	Disorders of muscle, ligament, fascia	8	2.80	0.43
824	Fracture of ankle	7	2.45	0.38
716	Other unspecified arthropathies	6	2.10	0.32
		286	**100.00**	**15.34**

Appendix A8
Distribution of the 10 Most Frequently Occurring ICD-9-CM Codes, Races Other than Black and White

ICD-9-CM Code	Definition	N	% of Other Races (N=81	% of Total (N=1865)
718	Ankylosis and joint derangement of knee	19	23.46	1.02
717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	18	22.22	0.97
733	Other bone/cartilage disorders: osteoporosis, pathological fracture	16	19.75	0.86
719	Other unspecified joint disorders	10	12.35	0.54
844	Sprains/strains of knee or leg	6	7.41	0.32
716	Other unspecified arthropathies	3	3.70	0.16
824	Fracture of ankle	3	3.70	0.16
715	Osteoarthritis, polyarthritis	2	2.47	0.11
820	Fracture of neck of femur	2	2.47	0.11
821	Fractures of other unspecified parts of femur	2	2.47	0.11
		81.	**100.00**	**4.34**

Appendix A9
Distribution of the 5 Most Frequently Occurring ICD-9-CM Codes by Age Groups

Age Group (years)	Top 5 ICD-9-CM Codes	Definition	N	% within group	% overall
17-20	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	43	27.56	2.31
	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	40	25.64	2.14
	718	Ankylosis and joint derangement of knee	38	24.36	2.04
	719	Other unspecified joint disorders	25	16.03	1.34
	844	Sprains/strains of knee or leg	10	6.41	0.54
	TOTAL		**156**	**100.00**	**8.36**
21-22	718	Ankylosis and joint derangement of knee	61	32.11	3.27
	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	50	26.32	2.68
	719	Other unspecified joint disorders	40	21.05	2.14
	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	29	15.26	1.55
	844	Sprains/strains of knee or leg	10	5.26	0.54
	TOTAL		**190**	**100.00**	**10.19**
23-26	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	84	30.55	4.50
	718	Ankylosis and joint derangement of knee	84	30.55	4.50
	719	Other unspecified joint disorders	53	19.27	2.84
	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	43	15.64	2.31
	728	Disorders of muscle, ligament, fascia	11	4.00	0.59
	TOTAL		**275**	**100.00**	**14.75**
27-30.35	718	Ankylosis and joint derangement of knee	52	32.10	2.79
	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	46	28.40	2.47
	719	Other unspecified joint disorders	29	17.90	1.55
	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	18	1.11	0.97
	715	Osteoarthritis, polyarthritis	17	10.49	0.91
	TOTAL		**162**	**100.00**	**8.69**
30.36-54	717	Internal derangement of knee: degeneration, rupture, old tear, old cartilage, old meniscus	47	28.66	2.52
	718	Ankylosis and joint derangement of knee	38	23.17	2.04
	733	Other bone/cartilage disorders: osteoporosis, pathological fracture	31	18.90	1.66
	719	Other unspecified joint disorders	30	18.29	1.61
	715	Osteoarthritis, polyarthritis	18	10.98	0.97
	TOTAL		**164**	**100.00**	**8.79**