THE UNIVERSITY OF CALGARY

The Incidence of Elbow Injuries in the City of Calgary

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Incidence of Elbow Injuries in the City of Calgary" submitted by David M. Sheps in partial fulfillment of the requirements for the degree of (Name of degree in full).

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ABSTRACT

The purpose of this study was to determine the overall, age-specific, gender-specific, and age-adjusted incidence of elbow injuries in the city of Calgary over a three-year period. The study aimed to develop an approach to assessing injuries, including the potential bias that may exist during the study of injuries, and to compare the level of agreement between the authors and the database coding system from which cases are identified.

The study found an overall incidence of injuries of 6.131 per 10000 persons per year. It identified potential sources of bias, and estimated the overestimation of the incidence at 17.2% and the underestimation of the incidence at 2.5%. Finally, it determined the percent agreement between the authors and the database coding system to be 59.03%.

Future investigations may utilize this information to evaluate the outcomes and complications of elbow injuries, and to assist in the understanding of the sources of error and bias in epidemiologic studies of injuries.

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DEDICATION

This thesis is dedicated to my family who has been there for me during the ups and downs of my education – they have provided unwavering love and support along the long road from the beginning of university to the end of this degree.

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1. INTRODUCTION

1.1 The Research Problem

The study of traumatic injuries using an epidemiologic approach is an evolving process. Early studies presented data largely from an observational perspective, with little or no focus on the characteristics of the underlying population or the distribution of the injuries within that population. With the growth of epidemiology and an increasing understanding of the importance of the population-based study of disease, authors began to carry out research utilizing epidemiologic principles. More recent work has presented population-based rates of injuries. However, the study of traumatic injuries, in particular orthopaedic trauma, continues to change. There does not presently exist a study of traumatic injuries of the elbow that is population-based and addresses the issues of possible bias that may exist in the methodology. Thus, this study attempts to address the issues of population and of bias, and add to the evolutionary process.

1.2 Study Rationale

Fractures and dislocations are common orthopaedic injuries. Successful treatment of these injuries requires health care resources directed towards the care of injured patients and towards research aimed at improving outcomes. This includes both clinical and basic science research as well as medical and surgical education. The incidence of these injuries can direct the distribution of orthopaedic resources, provide a focus for orthopaedic educators related to teaching on common and potentially serious injuries, generate hypotheses for orthopaedic researchers regarding the prevention of complications and the improvement of outcomes, and allow clinicians to better communicate to patients the outcomes of injuries and their treatments.

Upper extremity function depends largely on a working elbow joint. The elbow is a link between the shoulder and the hand, functioning to position and stabilize the hand in space, as a load carrying joint, and as a fulcrum in the forearm lever.[1] Pain free mobility of the elbow joint is necessary for daily, recreational, and professional activities, and injuries of the elbow that lead to chronic pain and permanent restriction of motion limit the use of the hand in most activities.[2] The loss of mobility of the elbow secondary to chronic pain and stiffness is poorly tolerated because, unlike the other joints of the upper extremity, there is a lack of compensatory motions for the elbow in adjacent joints.[3]

Complications such as chronic pain and loss of motion are well recognized following all forms of elbow trauma, particularly after injuries that affect the joint surfaces of the elbow.[4] However, the factors that may predispose a patient to developing complications following such an injury are not well known. This is due in part to lack of accurate incidence data on injuries of the elbow. The present literature on the epidemiology of elbow injuries is based largely on a series of hospital cases in which the population base from which the patients were derived cannot be estimated. Those studies that are population-based are non-specific in the description of the elbow injuries, either referring to fractures of the entire humerus or radius and ulna, or referring generally to fractures of the distal humerus and proximal radius and ulna.

This study attempts to fill the existing knowledge gap on the incidence of specific dislocations and fractures of the elbow. The methods employed in this study provide population-based estimates of these injuries. These estimates may be used as denominators in the calculation of outcome and complication rates for specific injuries. Orthopaedic educators, researchers, clinicians, and administrators can then place greater emphasis on those injuries with poor outcomes or increased complications to better understand why such injuries do poorly and to improve the results of treatment. The study also develops a methodologic approach to assessing injuries in future studies, including an approach to assessing bias that may be present in data sources used to identify injury counts. Finally, to assess the accuracy of the coding systems used to classify the identified injuries, the level of agreement between the code given to the injury by the authors, and the code originally applied to the injury is calculated.

1.3 Study Purpose

The purpose of this study is to determine the overall, age-specific, and gender-specific incidence of elbow injuries in an urban centre in Canada. Elbow injury data from the city of Calgary from April 1, 2002 until March 31, 2005 was collected and analyzed to estimate the incidence of elbow fractures and dislocations. This provides data that may be used in education, research, patient care, and resource allocation. The study seeks to establish a methodologic approach to evaluating injury data within an urban centre using elbow injuries as a template. The study also evaluates the accuracy of the coding systems of the database utilized in the study to identify cases.

1.4 Significance

This study is the first North American study to provide a population-based estimate of the incidence of traumatic elbow injuries. These estimates may be used as denominators in the calculation of outcome and complication rates for specific injuries. With the application of this information, orthopaedic educators, researchers, clinicians, and administrators can place greater emphasis on those injuries with poor outcomes or increased complications to better understand why such injuries do poorly and to improve the results of treatment.

1.5 Study Objectives

The objectives to be achieved upon the completion of the study were as follows:

1.5.1 Primary Objective

1. To determine the overall incidence of elbow injuries in the population age of eighteen and older in the city of Calgary over a three year period from April 1, 2002 to March 31, 2005.

1.5.2 Secondary Objectives

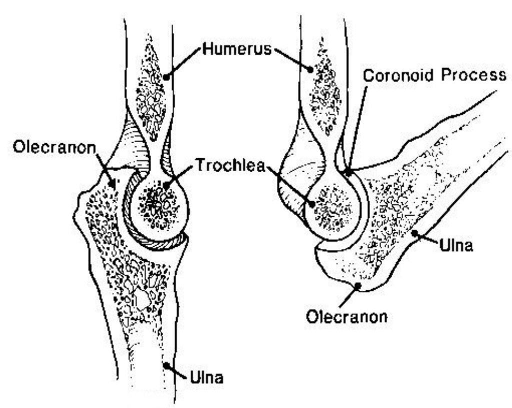
1. To determine the age-specific and sex-specific incidence of elbow injuries in the city of Calgary over a three year period from April 1, 2002 to March 31, 2005.
2. To determine the age-adjusted incidence of elbow injuries (standardized to 2001 Canadian census) to increase the generalizability of the study results so that they may be used in future studies on elbow injuries.
3. To develop a methodologic approach to assessing injuries, including an assessment of potential bias that may exist during the study of injuries, which may be used in future studies relating to the incidence of injury.
4. To compare the level of agreement between the authors classification of the identified injuries and the database coding system from which the cases are identified.

2. BACKGROUND

2.1 Boney Anatomy of the Elbow

The elbow is most simply described as a hinge joint with two principle arcs of motion – flexion-extension and pronation-supination.[1, 5, 6] It is formed by three bones, the distal humerus, the proximal radius, and the proximal ulna, and has three articulations, the ulnohumeral joint, the radiohumeral/radiocapitellar joint, and the proximal radioulnar joint.[1, 5-7] Flexion-extension occurs primarily through the ulnohumeral joint and secondarily through the radiohumeral/radiocapitellar joint, while pronation-supination occurs primarily through the proximal radioulnar joint and secondarily through the radiohumeral/radiocapitellar joint.[1]

Figure 1.1 – Boney Anatomy of the Elbow



The distal humerus begins at the diaphyseal-metaphyseal junction and extends distally to the elbow joint.[7] The distal humerus consists of two condyles, the trochlea medially and the capitellum laterally, that form the articular surface. Proximal to the trochlea is the medial epicondyle that serves as the site of attachment for the origin of the medial collateral ligament and the flexor-pronator musculature. Proximal to the capitellum is the lateral epicondyle that serves as the attachment for the origin of the lateral collateral ligament and the extensor musculature.[1, 7]

Anteriorly, the radial and coronoid fossae accommodate the radial head and coronoid during flexion. Posteriorly, the olecranon fossa receives the tip of the olecranon with extension. Separating the anterior and posterior fossae is a thin membrane of bone that is present in nearly all individuals.[1, 5] The lateral and medial columns of the distal humerus are present on either side of this membrane and form the supracondylar region of the distal humerus.[1, 5]

The proximal ulna begins at the diaphyseal-metaphyseal junction and extends proximally to the elbow joint. It provides the major articulation of the elbow that is responsible for its inherent stability. The broad, thick, proximal aspect of the ulna consists of the greater sigmoid notch that articulates with the trochlea of the humerus. The cortical surface of the coronoid process anteriorly serves as the site of attachment of the brachialis muscle. The olecranon provides the posterior articulation of the ulnohumeral joint and the site of attachment of the triceps tendon.[1]

The proximal radius includes the radial head, the radial neck, and the radial tuberosity. It also begins at the diaphyseal-metaphyseal junction and extends proximally to the elbow joint. The radial head articulates with the capitellum of the humerus and exhibits a cylindrical shape with a depression in the mid-portion to accommodate the capitellum. Distal to the radial head, the bone tapers to form the radial neck. The radial tuberosity marks the distal aspect of the neck and its rough posterior aspect forms the site of attachment of the biceps tendon.[1]

2.2 Injury Classification of the Elbow

The purpose of injury classification is to assist in communicating and recording the nature and severity of a particular injury, providing guidance for the treatment of injuries, and aiding in the comparison of similar injuries for research purposes.[8] Classification systems for injuries of the elbow have been developed, and more than one exists for certain injuries. In general, the classification systems that are most commonly used are those that are relatively simple and easy to understand.

General classification of injuries of the elbow can be divided into dislocations, fractures, and fracture dislocations. Dislocations apply to the elbow joint and involve the traumatic disarticulation of the ulnohumeral joint, radiocapitellar joint, proximal radioulnar joint, or a combination of these joints. Fractures include those of the distal humerus, the proximal ulna, and the proximal radius. These fractures may occur in isolation or in various combinations. Fracture-dislocations combine one or more fractures of the distal humerus, proximal ulna, and proximal radius, with disarticulation of one or more of the articulations of the elbow.

2.2.1 Dislocations

The classification of simple dislocations (without fracture) has evolved from the original classification by Desault in 1811.[9] It is based on the direction of the dislocation with the position of the radius and ulna described relative to the position of the humerus. Thus the direction of the dislocation dictates how the injury is classified. Types included in the classification are posterior, anterior, lateral, medial, and divergent.[9] Stimson further subdivided the original classification of Desault to include nearly every possible anatomical position.[10] Most authors have adopted the original classification of Desault, with the addition of the posterior, posterolateral, and posteromedial subdivisions of the most common posterior dislocation.[2]

2.2.2 Distal Humerus Fractures

The classification of distal humerus fractures includes fracture-specific and comprehensive classification systems for the distal humerus. The fracture-specific classification systems include those that apply to extra-articular fractures, unicondylar intra-articular fractures, bicondylar intra-articular fractures, and articular surface fractures.

Kocher, first described extra-articular fractures, or supracondylar fractures. These fractures, which occur above the epicondyles, include flexion-type, extension-type, abduction-type, and adduction-type fractures.[11] Although most applicable to pediatric fractures, this classification system has been incorporated into the comprehensive system of Jupiter and Mehne. Kocher, Ashhurst, and Chutro described the transcondylar extra-articular distal humerus fracture, distinguishing it from the supracondylar fracture.[11-13] Because this fracture occurs across the epicondyles, and is more distal than a supracondylar fracture, it has been suggested that the management of this fracture is more difficult and the outcomes are not as good.[14] However, the comprehensive classification systems for distal humerus fractures do not distinguish this as a separate type of fracture. Isolated extra-artiuclar fractures of the epicondyles occur, with medial epicondylar fractures occurring more commonly than lateral epicondylar fractures.[2] These fractures have not been subclassified, but have been included in the comprehensive classification systems of Jupiter and Mehne and the AO/OTA.

The unicondylar intra-articular classification system, described by Milch, can be applied to both the lateral and medial condyles, with two fracture types for either condyle. The fracture types for either condyle are based on the exit point of the fracture into the articular surface, and result in either a stable fracture (type I) or and unstable fracture (type II).[15] The bicondylar intra-articular classification system of Reich was the first to describe “T” and “Y” fractures of the distal humerus in 1936.[16] In 1969, Riseborough and Radin expanded upon this bicondylar classification system based on the separation, rotation, and comminution of the distal articular fragments of the humerus. This system included four types of fractures, undisplaced, displaced but not rotated, displaced and rotated, and displaced with rotation and comminuted.[17] These classification systems have been incorporated into the comprehensive classification of Jupiter and Mehne.

Articular surface fractures of the distal humerus can be separated into fractures of the capitellum and fractures of the trochlea. Isolated fractures of the trochlea are very uncommon, and therefore have not been subclassified.[2] Fractures of the capitellum were initially classified by Kocher and Lorenz. The first type, known as a Hahn-Steinthal type, generally involves a large part of the osseous capitellum. The second type, known as the Kocher-Lorenz type, involves articular cartilage with very little bone attached.[18, 19] Wilson described as third type in which the articular surface is driven proximally and impacted into the osseous portion.[20] These fractures are difficult to classify using plain radiographs, and are often based on computed tomography or operative findings. The articular surface fractures are included in both comprehensive classification systems for distal humerus fractures.

The comprehensive classification systems build upon and combine individual classification systems.[4] The comprehensive classification systems of AO/OTA (Muller et al) and Jupiter and Mehne expand upon the early systems described for the distal humerus.[21, 22] The comprehensive systems include extra-articular and intra-articular fractures, with the AO/OTA system dividing the intra-articular fractures into simple and complex. The comprehensive systems include all fracture types, including epicondylar fractures and trochlea fractures, for which fracture-specific classification systems do not exist.[21, 22] The AO/OTA system is the presently accepted system by the Orthopaedic

Trauma Association, and is the required classification system for any journal article submitted to the Journal of Orthopaedic Trauma.

2.2.3 Proximal Radius and Ulna Fractures

As with the distal humerus, the classification of proximal radius and ulna fractures includes both fracture-specific and comprehensive classification systems. The fracture-specific classification systems include those that apply to radial head fractures, olecranon fractures, coronoid fractures, and Monteggia fractures (fractures of the proximal ulna with associated a radial head dislocation). The comprehensive classification system is limited to the AO/OTA system for the proximal radius and ulna.

Fractures of the radial head have been classified by multiple authors, with the Mason system and the Hotchkiss modification of the Mason system most commonly quoted in the literature.[2, 23-30] The Mason system and the Hotchkiss modification of the Mason system include three types of radial fractures including displaced less than 2 mm. (type I), displaced greater than 2 mm. amenable to internal fixation (type II), and comminuted requiring excision or replacement (type III).[2, 23, 30] Other classification systems for fractures of the radial head include modifications of the Mason system by Johnston in 1962, Morrey in 1985, and Gutierrez in 1997, and the complex and little used classification systems of Murray, Poulsen and Tophoj, and Stankovic.[25-30]

Fractures of the olecranon are most commonly classified according the Mayo classification proposed by Morrey, which is based upon the displacement, stability, and comminution of the fracture.[31] Horne and Tanzer proposed a classification of olecranon fractures in 1981 that is based primarily on the location of the fracture relative to the articular surface of the proximal ulna.[32] Colton has also proposed a classification that takes into account the morphology of the fracture, the degree of comminution, and whether there is an associated dislocation.[33]

Regan and Morrey originally classified fractures of the coronoid in 1989. They proposed three types of fractures ranging from the tip of the coronoid to a fracture of the base of the coronoid.[34] More recently, O'Driscoll has identified medial facet fractures of the coronoid, which he has incorporated into his classification of coronoid fractures. These fractures are felt to be important as they may play a role in elbow stability. However, as this classification is quite new, its use in the literature is limited.[35]

Monteggia fracture dislocations (fracture of the proximal ulna with a dislocation of the radial head) have been classified by Bado in 1967.[36] The classification includes 4 types of injuries and their equivalents, and is based largely on the direction of the dislocation of the radial head. It has generally become the accepted classification system for these types of injuries.[36]

The comprehensive AO classification system for proximal radius and ulna fractures developed by Muller et al. is similarly structured to the system for the distal humerus. Fractures are divided into extra-articular, intra-articular simple, and intra-articular complex, and then further divided into subgroups and sub-subgroups.[22] As with fractures of the distal humerus, the AO/OTA system for fractures of the proximal radius and ulna is the accepted system by the Orthopaedic Trauma Association, and is the required classification system for any journal article submitted to the Journal of Orthopaedic Trauma.

2.2.4 Reliability of Classification Systems

Although the purpose of classification systems is to assist with the communication and treatment of injuries, many systems that are commonly used have not been evaluated for reliability and validity. Studies examining the intra-observer and inter-observer reliability of various fracture classification systems used throughput the orthopaedic literature have shown a high degree of variation.[37] Overall, there is a limited number of studies examining the reliability of the aforementioned classification systems for injuries of the elbow.

A study of the inter-observer and intra-observer reliability of the AO and Jupiter and Mehne classification systems was performed by Wainwright et al. in 2000.[38] For the AO classification system, the authors calculated a kappa of 0.343, which they classified as “fair” agreement. For the Jupiter and Mehne classification system, the authors calculated a kappa of 0.295, which they also classified as “fair” agreement.[38] No reliability studies have been performed for the Desault classification system for elbow dislocations or the AO classification systems for proximal radius and ulna fractures. For the fracture specific classification systems mentioned above, Morgan et al. found the Mason classification system to be unreliable.[39] The authors based this on a median kappa of 0.54.[39] No other inter-observer reliability studies have been performed for the aforementioned fracture classification systems. Because of the lack of reliability studies, the choice of classification systems used has been based on the frequency of use of the various systems. As well, the Journal of Orthopaedic Trauma, the Orthopaedic Trauma Association, and the AO, all use the comprehensive AO classification system as the standard classification systems for all long bone fractures.

2.3 Epidemiologic Approaches to Injury Data

2.3.1 Measures of Disease Frequency

The basic measures of disease frequency used in descriptive epidemiologic studies are incidence and prevalence. Incidence measures the occurrence of new disease over a specified period of time, while prevalence measures the existence of current disease.[40, 41] Although both measures are an important part of the natural course of disease, incidence deals with the transition from health to disease, such as occurs with an injury.[40, 41] Prevalence on the other hand focuses on the period of time that a person lives with a disease, and does not describe the occurrence of new cases.[40, 41] Thus, studies dealing with the occurrence of new injuries utilize incidence as the measure of disease frequency.

2.3.2 Types of Incidence

The calculation of incidence requires that time be part of the denominator.[41] The choice of time period is arbitrary, but it must be clearly specified as part of the incidence calculation. The two types of incidence are cumulative incidence and incidence density. Cumulative incidence is calculated using a period of time during which all individuals in the population under study are considered at risk for the outcome.[40, 41] It is commonly expressed with persons as the unit of measurement.[41] Incidence density is calculated when individuals in the population under study are at risk for different lengths of time. For this calculation, the denominator consists of the sum of the different times each individual was at risk.[40, 41] It is commonly expressed with person-time as the unit of measurement.[41]

Incidence density would be used when the onset of disease in an individual means that the individual is no longer at risk for acquiring the disease. This is not the case with traumatic injuries, as a person with an injury may still become further injured as a result of a subsequent traumatic event. Thus, the time at risk for each patient does not differ among patients and is not relevant to the calculation of incidence. The interpretation of cumulative incidence in this setting (expressed as persons per year) is easier than that of incidence density (expressed as person-time). In a study of traumatic injuries, where the purpose is to count injuries without the need to measure exposure, the use of cumulative incidence, and the expression of incidence as the number of injuries per person per year would be appropriate.

2.3.3 Standardization

Comparisons of crude rates of disease can be difficult because of the differences in the distribution of certain characteristics in the populations being compared. To overcome these differences, rates of disease in different populations can be standardized to a standard population prior to comparisons being made. In addition, standardizing to a larger or more general population increases the generalizability of the results of a particular study.[40, 41]

The two types of standardization are direct standardization, which uses the stratum-specific rates in the study population and the stratum structure (percentages) of the standard population, and indirect standardization, which uses the stratum-specific rates in the standard population and the stratum structure (percentages) of the study population.[40, 41] Direct standardization is more commonly used when converting rates in more specific populations to a standard or more generalizable population.

Calculation of the standardized summary rate requires the stratum-specific rates from the study population for the adjustment factor (such as age) and the stratum-specific counts from the standard population for the adjustment factor. The stratum-specific rates in the study population are then multiplied by the corresponding strata counts in the standard population that yields the "expected" number of cases. The "expected" number of cases are then summed and divided by the total size of the standard population to yield the standardized rate.[40, 41]

2.4 Bias

2.4.1 Types of Bias

Bias is defined as a systematic error that results in an incorrect or invalid estimate of what is being measured by the study in question.[40] The two major types of bias include selection bias and observation bias. Selection bias is an error due to systematic differences in the characteristics between those who are selected for the study and those who are not selected.[40] Observation bias is a flaw in measuring exposure or outcome data that results in different quality or accuracy of information between groups.[40] It includes misclassification bias, also called measurement error, which can apply in studies where groups are not being compared. In studies evaluating injury data, misclassification would result in an error in the classification of the injury, which may occur at different levels.

2.4.2 Measuring and Addressing Bias

When evaluating a study for the presence of bias, the steps include identifying the source of the bias, estimating the magnitude of the bias, and assessing the direction of the bias.[40] It is crucial to attempt to minimize the amount of bias within a study, as once it has occurred it can be difficult to correct.[40] Thus, the methodology employed in a given study should be carefully designed and conducted so as to avoid the presence of significant bias.

Misclassification bias can be reduced by improving the accuracy of data collection during the course of the study.[40] This is necessary so as to avoid the inclusion of inappropriate cases or the exclusion of cases that meet the study criteria. Identifying the accuracy of the data collection can be performed by sampling the data from the data source and identifying the magnitude of misclassification that has occurred.[40] The magnitude and direction of the bias can then be addressed during the course of the study.

3. CURRENT KNOWLEDGE

3.1 Incidence of Traumatic Elbow Injuries

3.1.1 Introduction

Previous studies documenting the incidence of elbow injuries can be divided into two types of studies. The first type includes population-based studies in which the incidence of a particular type of injury is calculated based on a known population, with the known population acting as the denominator and the number of injuries acting as the numerator in the incidence calculation. The second type includes non-population-based studies in which the incidence of a particular injury is calculated without a defined population. These studies include physician-specific and hospital-specific case series from which a convenience sample is drawn for study. The majority of the present literature relating to incidence rates for specific elbow injuries is non-population based, which brings into question the validity of the presently accepted rates.

3.1.2 Population-Based Studies

The population-based studies can be grouped according to the topic under study. Most of the population-based studies focus on the estimated incidence of peripheral fractures, with the estimated incidence of humerus fractures and radius and ulna fractures presented as a component of a larger study. In a portion of these studies, the estimated incidence rates are further divided into proximal, middle, and distal. Only three studies were identified during the literature review that present the estimated incidence of elbow dislocations or fractures based on an accepted classification system, where the incidence is estimated based on a known population as the denominator (Table 3.1 and 3.2).

Table 3.1 – Population-Based Studies Utilizing Accepted Classification Systems

Author	Year	Study Design	Population	Duration
Herbertsson et al.[42]	2004	Comprehensive Case Series	All Ages Malmo, Sweden	1969 to 1979
Robinson et al.[43]	2000	Observational Cohort	12 + Edinburgh, Scotland	1988 to 1997
Joseffson et al.[44]	1986	Comprehensive Case Series	All Ages Malmo, Sweden	1971 to 1982

Table 3.2 – Estimated Incidence Rates from Population-Based Studies Utilizing Accepted Classification Systems

Author	Injury Type	Classification System	Incidence (10,000 persons/year)	
Herbertsson et al.[42]	Radial Head/Neck Fracture	Mason - Broberg and Morrey Modification	Overall Type I Type II Type III Type IV	2.854 1.812 0.838 0.136 0.068
Robinson et al.[43]	Distal Humerus Fracture	AO/OTA	Overall A1 A2 A3 B1 B2 B3 C1 C2 C3	0.566 0.083 0.095 0.041 0.067 0.018 0.051 0.069 0.074 0.067
Joseffson et al.[44]	Elbow Dislocation/ Fracture-Dislocation	Desault	Overall Dislocation Fracture-Dislocation Posterior Lateral Anterior Not Specified	0.605 0.160 0.381 0.031 0.003 0.190

All three studies utilize well-defined populations as the denominator in the estimation of incidence rates, with two of the studies performed in Malmo, Sweden, and one performed in Edinburgh, Scotland. The studies by Herbertsson et al. and Robinson et al. comment on the use of a fracture registry at their respective institutions in which all fractures presenting for treatment are entered. The authors of these two studies, as well as Joseffson et al., indicate that the treating institutions are the only sites for the treatment of fractures and dislocations in their respective cities.[42-44]

Josefsson et al. comment that “the data are as complete as can possibly be attained”, and the authors of the other two studies also make reference to the completeness of their data.[44] However, the three studies have not employed methods to assess this completeness, ensuring that all appropriate cases have been captured. Although one could assume that those individuals enrolling patients into the registries are identifying and correctly labeling all cases, this cannot be assured. The presence and magnitude of potential misclassification cannot be assessed in any of the three studies.

The classification of the identified cases was performed by a single individual in the studies by Herbertsson et al. and Robinson et al., and was not described in the study by Josefsson et al.[42-44] Robinson et al. comment on the issue of the reliability of fracture classification and estimated the intra-observer reliability by reclassification of a random series of 50 radiographs on two separate occasions six weeks apart (kappa of 0.94).[43] The authors of the three studies do not comment on the possibility of misclassification of the injuries. The two studies that identify the individual classifying the injuries do not comment on a means by which the accuracy of the classification of injuries was assessed.

The incidence rates presented in the three studies do not include confidence intervals to assist the reader in assessing the accuracy of the estimated rates. Although the period of study is approximately 10 years in all three studies, which may reduce the year-to-year variation in the occurrence of injuries, the relatively small number of injuries, particularly in the study by Joseffson et al., may significantly affect the accuracy of the estimated rates.[42-44] This information can be helpful in the interpretation of the study results.

The remaining population-based studies present the estimated incidence of fractures of the humerus or distal humerus and/or the radius and ulna or proximal radius and ulna. Thirteen studies were identified during the course of the literature review that presented population-based estimates of these injuries (Tables 3.3 and 3.4). Although the information provided can be applied to numerous clinical and research applications, it is not specific enough for outcomes evaluation as discussed in section 1.2. The methods employed in these studies are somewhat varied, and a critical examination of these methods, and how they might be applied to future studies, is useful.

Table 3.3 – Population-Based Studies (Unclassified Fractures)

Author	Year	Study Design	Population	Duration
Karlsson et al.[45]	2002	Comprehensive Case Series	All Ages Malmo, Sweden	1969 to 1979
van Staa et al.[46]	2001	Descriptive Incidence Study	20 + England and Wales	1988 to 1998
Sanders et al.[47]	1999	Descriptive Incidence Study	35 + Victoria, Australia	1994 to 1996
Singer et al.[48]	1998	Prospective Incidence Study	15 to 94 Edinburgh, Scotland	1992 to 1993
Johansen et al.[49]	1997	Descriptive Incidence Study	All Ages Cardiff, Wales	1994 to 1995
Baron et al.[50]	1996	Descriptive Incidence Study	65 to 89 US Medicare	1986 to 1990
Donaldson et al.[51]	1990	Descriptive Incidence Study	All Ages Leicestershire, UK	1980 to 1982
Contreras et al.[52]	1990	Descriptive Incidence Study	All Ages Chile	1985
Sahlin[53]	1990	Comprehensive Case Series	All Ages Trondheim, Norway	1985 to 1986
Rose et al.[54]	1982	Descriptive Incidence Study	All Ages Rochester, MN	1965 to 1974
Garraway et al.[55]	1979	Descriptive Incidence Study	All Ages Rochester, MN	1969 to 1971
Wong[56]	1966	Comprehensive Case Series	15 + Singapore	1962 to 1963
Knowelden et al.[57]	1964	Comprehensive Case Series	35 + Oxford/Dundee, UK	1954 to 1958

The bulk of the studies estimated fracture incidence by attempting to identify all fractures occurring in a defined population within specified time frame. Sanders et al., Singer et al., Johansen et al., and Garraway et al. validated the coding system or fracture registry employed in their respective studies.[47-49, 55] The first three authors cross-referenced the cases identified through their primary data source with a secondary source to ensure maximum case capture.[47-49] Karlsson et al., Donaldson et al., Contreras et al., Sahlin, and Rose et al. did not discuss validation within the methods section of their studies.[45, 51-54] Only Garraway et al. sampled a portion (10%) of another group of patients (coded as non-fracture accident or injury) that may have been misclassified, and therefore missed.[55] Of all the studies reviewed, only this study attempted to assess the degree of misclassification bias. Studies by van Staa et al. and Baron et al. used a population sample to estimate the fracture incidence, and both discussed the issues related to the validity of the methods employed.[46, 50] van Staa et al. and Garraway et al., utilized age standardization to increase the generalizability of their study results.[46, 55]

Table 3.4 – Estimated Incidence Rates from Population-Based Studies (Unclassified Fractures)

Author	Injury Type	Classification System	Incidence (10,000 persons/year)	
Karlsson et al.[45]	Olecranon Fracture	Horne and Tanzer	Overall	1.08
van Staa et al.[46] (person years)	Humerus Fracture Radius/Ulna Fracture	None None	Overall Overall	7.9 22.2
Sanders et al.[47] (95% CI in brackets) (age-adjusted rates)	Humerus Fracture	None	Male Female	3 (2-4) 10 (9-12)
Singer et al.[48] (5 year age groups)	Elbow Fracture	None	Male Female	2.76-42.64 2.64-17.59
Johansen et al.[49]	Elbow Fracture	None	Overall Male Female	10.1 9.4 10.7
Baron et al.[50] (5 year age groups) (person years)	Humeral Shaft / Distal Humerus Fracture Proximal Radius and Ulna Fracture	None None	White Male White Female Black Male Black Female White Male White Female Black Male Black Female	2.2-8.1 5.7-16.0 2.1-3.0 1.7-8.5 1.8-4.7 6.1-8.6 1.5-2.0 1.9-2.6
Donaldson et al.[51]	Humeral Shaft / Distal Humerus Fracture Radial and Ulnar Shaft / Proximal Radius and Ulna Fracture	None None	Overall Overall	3.6 5.8
Contreras et al.[52]	Humerus Fracture Radius and Ulna Fracture	None None	Overall Overall	2.53 4.54
Sahlin[53]	Humerus Fracture Radius and Ulna Fracture	None None	Overall Overall	14 42
Rose et al.[54] (by level of trauma) (person years)	Distal Humerus Fracture	None	Male Moderate Male Severe Female Moderate Female Severe	1.34 3.23 1.01 1.63
Garraway et al.[55]	Humerus Fracture Radius and Ulna Fracture	None None	Male Female Male Female	11.61 12.71 42.56 41.94
Wong[56]	Supracondylar Humerus Fracture Epicondylar Humerus Fracture	None None	Overall Overall	0.18 0.22
Knowelden et al.[57] (5 year age groups)	Shaft / Distal Humerus Fracture Proximal Radius Fracture Ulna Fracture	None None None	Overall Overall Overall	0.5-5.4 0.0-4.1 0.0-3.2

3.1.3 Non-Population-Based Studies

The incidence rates from non-population-based studies are based largely upon a case series reviewed to assess the outcome of a particular injury, the treatment options for that injury, or the resulting complications associated with the injury (Table 3.5 to 3.12). The study authors review the series of cases and calculate the incidence rates of a particular injury as a percentage of the overall cases reviewed. This resulted in incidence rates that varied depending on the population seen at a particular hospital or by a particular physician, and therefore could not be generalized to any population beyond those individuals included within the case series.[17, 20, 23, 25, 26, 28, 32, 58-108]

Non-population-based studies have resulted in significant disparities in the incidence rates and percentages for various fractures and dislocations of the elbow quoted in the literature. Although these rates have been quoted throughout the orthopaedic literature, they cannot be used to accurately determine the percentage of positive and negative outcomes nor the number of complications, as they are not population-based. At best, they represent the experience of a particular institution or physician at a certain period in time. They cannot be generalized beyond that particular institution or physician, and may not even be representative if a different period of time is chosen for study.

Table 3.5 – Incidence Rates from Non-Population Studies (Fractures of the Elbow)

Author	Year	Number of Cases	Percentage of Type
Fife et al.[58]	1985	886	Distal Humerus: 1.2% Proximal Radius and Ulna: 4.5%
Ebong[59]	1978	2471	Distal Humerus: 11.9%
Jeshrani[61]	1978	224	Distal Humerus: 67.9% Proximal Radius and Ulna: 18.8% Dislocations: 8.9% Fracture Dislocations: 4.5%
Conn et al.[60]	1961	414	Supracondylar Humerus: 8.9% Medial Epicondyle: 1.9% Lateral Condyle: 1.9% Capitellum: 1.0% Radial Head and Neck: 32.4% Olecranon: 14.3% Monteggia: 1.4% Dislocation: 5.8% Fracture Dislocation: 5.6%
Wilson[20]	1933	439	Supracondylar Humerus: 18.7% Intercondylar Humerus: 3.2% Medial Epicondyle: 8.2% Lateral Epicondyle: 1.6% Medial Condyle: 3.6% Lateral Condyle: 4.6% Capitellum: 0.7% Radial Head and Neck: 17.1% Olecranon: 13.9% Coronoid: 3.4% Other Proximal Ulna: 0.7% Dislocation: 21.2%

Table 3.6 – Incidence Rates from Non-Population Studies (Elbow Dislocations)

Author	Year	Number of Cases	Classification	Percentage
Neviaser et al.[66]	1977	115	Desault	Posterior: 78.3% Posterolateral: 11% Posteromedial: 2.6% Lateral: 5.2% Anterior: 2.6%
Linscheid et al.[65]	1965	110	Desault	Posterior: 66.4% Posterolateral: 12% Lateral: 1.8% Anterior: 1.8% Medial: 3.6% Unspecified: 14.5%

Table 3.7 – Incidence Rates from Non-Population Studies (Distal Humerus Fractures)

Author	Year	Number of Cases	Classification	Percentage
Caja et al.[67]	1994	22	AO	C1: 13.6% C2: 68.2% C3: 18.1%
John et al.[68]	1994	49	AO	A: 16.3% B: 26.5% C: 57.1%
Wildburger et al.[72]	1991	72	AO	C1: 48.6% C2: 40.3% C3: 8.3%
Letsch et al.[70]	1989	104	AO	A1: 17.3% B1: 4.8% B2: 25.0% B3: 8.7% C1: 15.4% C2: 14.4% C3: 14.4%
Perry et al.[71]	1989	11	Perry et al.	A: 27.3% B: 18.2% C: 36.4% D: 18.2%
Jupiter et al.[69]	1988	22	AO	B1: 22.7% B2: 54.5% B3: 22.7%
Waddell et al.[73]	1988	48	OTA	I: 12.5% II: 45.8% III: 41.7%
Henley et al.[75]	1987	33	AO	C1: 69.7% C2: 24.2% C3: 6.1%
Aitken et al.[74]	1986	29	AO	A: 20.7% B: 20.7% C: 58.6%
Jupiter et al.[76]	1985	34	AO	C1: 38.2% C2: 5.8% C3: 55.9%
Shetty[77]	1983	19	Shetty	II: 52.6% III: 21.1% IV: 26.3%
Lansinger et al.[78]	1982	39	Riseborough and Radin	I: 2.6% II: 2.6% III: 84.6% IV: 10.3%
Suman et al.[81]	1982	22	Riseborough and Radin	I: 9.1% II: 18.2% III: 36.4% IV: 36.4%
Niemann[79]	1977	24	None	T/Y: 62.5% Lat. Condyle: 33.3% Med. Condyle: 4.2%

Table 3.7 – Incidence Rates from Non-Population Studies (Distal Humerus Fractures) (Continued)

Author	Year	Number of Cases	Classification	Percentage of Type
Sotgiu et al.[80]	1976	16	Modified Riseborough and Radin	I: 6.3% II: 18.8% III: 31.3% IV: 18.8% V: 25.0%
Bryan et al.[82]	1971	30	Riseborough and Radin	II: 20.0% III: 40.0% IV: 40.0%
Johansson et al.[83]	1971	12	Johansson and Olerud	I: 8.3% II: 33.3% III: 41.7% IV: 16.7%
Riseborough et al.[17]	1969	29	Riseborough and Radin	II: 20.7% III: 51.7% IV: 27.6%
Jones[84]	1967	27	None	Transcondylar: 67% Split: 11.1% Lat. Condyle: 11.1% Epicondyle: 7.4% Capitellum: 3.7%

Table 3.8 – Incidence Rates from Non-Population Studies (Capitellum Fractures)

Author	Year	Number of Cases	Classification	Percentage of Type
Grantham et al.[63]	1981	29	Capitellum	I: 7% II: 62% III: 28%
Collert[64]	1977	20	Capitellum	I: 35% II: 65%

Table 3.9 – Incidence Rates from Non-Population Studies (Olecranon Fractures)

Author	Year	Number of Cases	Classification	Percentage
Murphy et al.[93]	1987	45	None	Transverse: 57.8% Oblique: 26.7% Comminuted: 15.6%
Wolfgang et al.[92]	1987	45	?	B: 44.4% C: 22.2% D: 31.1% E: 2.2%
Johnson et al.[94]	1986	28	Modified Colton	A: 60.7% B: 14.3% C: 7.1% D: 17.9%
Holdsworth et al.[95]	1984	52	Colton	A: 55.8% B: 21.2% C: 19.2% D: 3.8%
Horne et al.[32]	1981	100	Horne and Tanzer	I: 11% IIa: 49% IIb: 28% III: 12%
Rettig et al.[97]	1979	52	None	Transverse: 48.1% Oblique: 30.8% Comminuted: 21.2%
Kiviluoto et al.[96]	1978	35	None	Transverse: 37.1% Oblique: 11.4% Comminuted: 51.4%

Table 3.10 – Incidence Rates from Non-Population Studies (Coronoid Fractures)

Author	Year	Number of Cases	Classification	Percentage
Regan et al.[62]	1989	35	Regan-Morrey	I: 40% II: 46% III: 14%

Table 3.11 – Incidence Rates from Non-Population Studies (Monteggia Fracture-Dislocations)

Author	Year	Number of Cases	Classification	Percentage
Llusa Perez et al.[87]	2002	54	Bado	I: 44.4% II: 37.0% III: 11.1% IV: 7.4%
Ring et al.[85]	1998	48	Bado	I: 14.6% II: 79.2% III: 2.1% IV: 4.2%
Givon et al.[86]	1997	41	Bado	I: 29.3% I equivalent: 43.9% II: 9.8% III: 4.9% IV: 12.2%
Reynders et al.[90]	1996	67	Modified Bado	I: 44.8% Ia: 20.9% II: 14.9% III: 4.5% IV: 14.9%
Hennig et al.[88]	1991	204	Bado	I: 82% II: 16% III: 2%
Reckling[91]	1982	49	Bado	I: 46.9% I equivalent: 20.4% II: 10.2% II equivalent: 4.1% III: 6.1% IV: 12.2%
Bryan[89]	1971	43	Bado	I: 58.1% II: 13.9% III: 18.6% Not Typable: 9.3%

Table 3.12 – Incidence Rates from Non-Population Studies (Radial Head Fractures)

Author	Year	Number of Cases	Classification	Percentage
Barbieri et al.[98]	1998	46	Modified Mason	I: 6.5% II: 41.3% III: 30.4% IV: 21.7%
Esser et al.[99]	1995	26	Modified Mason	II: 42.3% III: 34.6% IV: 23.1%
King et al.[101]	1991	14	Modified Mason	II: 57.1% III: 42.9%
Geel et al.[100]	1990	19	AO	B1: 36.8% B2: 26.3% B3: 21.1% C: 15.8%
Vichard et al.[102]	1988	73	Vichard et al.	A: 64.4% B: 20.5% C: 15.1%
Poulsen et al.[26]	1974	67	Poulsen and Tophoj	A: 11.9% B: 20.9% C: 37.3% D: 7.5% E: 11.9% F: 10.4%
Bakalim[103]	1970	209	Bakalim	I: 37.8% II: 41.6% III: 6.7% I (neck): 6.7% II (neck): 7.2%
Radin et al.[105]	1966	88	Mason	I: 34.1% II: 30.7% III: 35.2%
Johnston[28]	1962	100	Modified Mason	I: 55% II: 29% III: 11% IV: 5%
Arner et al.[104]	1957	310	Arner, Ekengren, and von Schreeb	Neck Fissure: 14.8% Neck Fracture: 20% Head Marginal: 61% Comminuted: 3.5%
Mason[23]	1954	100	Mason	I: 62% II: 20% III: 18%
Castberg et al.[108]	1953	41	Castberg and Thing	I: 34.1% II: 39.0% III: 19.5% IV: 7.3%

Table 3.12 – Incidence Rates from Non-Population Studies (Radial Head Fractures) (Continued)

Murray[25]	1940	459	Murray	Simple Crack: 19% Marginal: 41.8% Displaced: 13.1% Flake: 2.0% Comminuted: 10.0% Neck: 13.9%
Hein[107]	1937	52	Hein	Chip: 26.9% Comminuted: 46.2% Longitudinal: 13.5% Neck: 11.5% Oblique: 1.9%
Jones[106]	1935	32	Jones	Epiphyseal: 9.3% Fissure: 9.3% Displaced: 59.4% Comminuted: 21.9%

3.1.4 Literature Summary

The body of literature on the incidence of traumatic elbow injuries is incomplete, with the majority of studies presenting the incidence of subtypes of dislocations, distal humerus fractures, proximal radius and ulna fractures, and fracture dislocations utilizing non-population-based methods. The limited existing population-based literature utilizes varying methods to identify or capture cases and to classify injuries. There are strengths and weaknesses to the existing studies, with only a few studies addressing the validity of the methods used, and only one study addressing the issue of the misclassification of injuries. Additionally, the few studies that examine specific injuries are based on European data, with no existing studies having been performed on North American populations.

A review of the literature identifies the components that should be included in a future study of traumatic elbow injuries or injuries in general. Multiple databases should ideally be used to maximize the rate of case capture, with prior or concurrent validation of the coding systems used to identify cases. Additional codes should be sampled to assess the degree of misclassification of the injuries and magnitude of the resulting bias. More than one individual should classify the identified injuries and multiple classifications systems should be used to assess the degree of misclassification and magnitude of the resulting bias. Finally, estimated incidence rates should be presented with associated confidence intervals to allow the reader to interpret the precision, and standardization should be used to increase the generalizability.

4. METHODS

4.1 Selection of the Study Population

The study population included the population captured by the Calgary Health Region (CHR) health records database. The database included all three adult hospitals (Foothills Medical Centre, Peter Lougheed Centre, Rockyview General Hospital), the three CHR adult rehabilitation facilities (Colonel Belcher, Glenmore Park, Vernon Fanning), and both sub-acute treatment facilities (Eighth and Eighth, South Calgary) within the city of Calgary. Patients age 18 and older were included as part of the study population, and patients younger than age 18 were excluded. The paediatric population was excluded due to necessity of obtaining individual patient consent for review of the required chart information from that specific population.

During the design of the study, both the Alberta Health and Wellness billing database and Workers' Compensation Board patient database were considered as potential sources from which to identify cases to be included in the study population. With regard to the Workers' Compensation Board database, the WCB would not allow access to the information due to privacy issues. As a result, the WCB database could not be used as a source from which to identify potential cases. The Alberta Health and Wellness billing database would have allowed for the identification of all cases billed by physicians in the province. The AHW billing database utilizes the ICD 9 coding system, and the appropriate ICD 9 code must be submitted alongside the corresponding fee code.

The ICD 9 codes could have been used to identify potential cases. However, once identified, individual physician records would have to be reviewed, and this would necessitate obtaining consent to access those records from both the patient and the treating physician. The need to obtain consent in this manner, and the time and manpower required to do, was beyond the scope of this study.

4.2 Identification of Cases

The identification of cases for the study was performed with the use of the Calgary Health Region (CHR) health records database and the assistance of QIHI (Quality Improvement and Health Information). Health records data was captured for both inpatient discharges and ambulatory care visits within the city of Calgary from April 1, 2002 to March 31, 2005.

4.2.1 Calgary Health Region Health Records Database

The Calgary Health Region utilizes the International Statistical Classification of Diseases and Related Health Problems (ICD) version 10 coding system, during the years covered by the study, to record the diagnoses of patients at the aforementioned sites in the city of Calgary. Patients discharged from the hospital wards, the emergency department, day surgery, minor surgery, physiotherapy, occupational therapy, and the senior's urgent assessment clinic, are captured in the CHR health records database. Each case is given at least one discharge diagnosis by the treating physician most responsible for the patient's care. The discharge diagnosis is then converted to the appropriate ICD 10 code by the health records department, which is then associated with that health record within the CHR health records database. Patients seen in the outpatient cast clinics are captured, however, the individual injury is not specifically coded. Thus, these patients are not included in the database used for the study.

4.2.2 ICD 10 Codes

Prior to conducting the database search, ICD 10 codes for fractures and dislocations of the elbow were identified (Appendix 1). The codes included all fractures of the distal humerus, all fractures of the proximal radius and ulna, and all dislocations of the elbow and radial head. These codes were then used to search the Calgary Health Region health records database to identify all cases that contained at least one of the ICD 10 codes previously identified. Once identified, the cases from each site were cross-referenced with all other sites utilizing personal health numbers, dates of service, and type of injury to remove duplicate cases to ensure that each injury was captured only once.

4.3 Patient Demographic Data

Demographic data for each case, including the patient's sex, date of birth, and date of injury, was collected from the Calgary Health Region health records database. This information was used for the calculation of sex-specific and age-specific incidence rates, and for the standardization of incidence rates to the Canadian population from the 2001 census. Additionally, the patient's address was determined from the database to ensure the patient's residence within the city of Calgary. If a patient's residential postal code was outside of the city of Calgary, that patient was not included in the database.

4.4 Classification of Cases

Following the identification of cases, radiographs for each case were collected. Pre-treatment radiographs were compiled for all cases where these were available. For cases where pre-treatment radiographs were not available, post-treatment radiographs were compiled along with relevant patient chart documents describing the pre-treatment injury. The two principle authors (DMS and KAH) reviewed the radiographs and relevant patient chart documents for the purpose of classifying the injury.

4.4.1 Classification Systems

The choice of classification systems was based on the frequency of use of various systems within the orthopaedic literature, and included at least one comprehensive system and one fracture specific system for each type of fracture. Because studies on the reliability of classification systems for fractures and dislocations of the elbow are limited, and because those studies performed have shown only fair reliability, the choice of classification systems could be considered somewhat arbitrary. However, it was decided to choose those that would be most familiar to the readers using the classification systems for the injuries being studied. In addition, it was decided to choose a sufficient number of systems to provide a comprehensive overview of fractures and dislocations of the elbow. The systems utilized in the study on shown in table 4.1.

Table 4.1 – Classification Systems

Injury Type	**Classification System**
Elbow dislocation	Desault
Distal humerus fracture	AO Jupiter and Mehne
Proximal radius and ulna fracture	AO
Olecranon	Mayo
Coronoid	Regan and Morrey
Monteggia	Bado
Radial head/neck fracture	Hotchkiss modified Mason

The classification systems are described in greater detail in Appendix 2 to 9.

4.4.2 Case Classification

Each case identified from the database was classified as a fracture, dislocation, or fracture dislocation. The comprehensive classification systems were then used, with the Desault system used for dislocations, the AO and Jupiter and Mehne systems used for distal humerus fractures, and the AO system used for proximal radius and ulna fractures. Following this, the fracture-specific systems were used for those cases to which these systems applied. Each author classified the cases independently, and the cases were then compared to identify differences between the authors. The differences between authors were recorded for the purpose of identifying issues or problems with the classification systems being used, and as an informal assessment of the reliability of the systems. For those cases where the classification differed, the authors discussed the case and came to a consensus on the appropriate classification for that case. The final case classifications were then recorded along with the demographic data associated with that case.

4.5 Statistical Analysis

Statistical analysis was performed using STATA version 8.0 (STATA Corporation, College Park, Texas) and SPSS version 13.0 (SPSS Incorporated, Chicago, Illinois).

4.6 Calculation of Incidence Rates

Overall, age-specific, and sex-specific incidence rates were calculated utilizing the population of the city of Calgary from the 2001 Canadian national census, and presented as injuries per 10,000 persons per year. Rates of fractures, dislocations, and fracture-dislocations were calculated first, with each case included only once in these calculations. Classification-specific rates were then calculated. Cases could be included more than once in these calculations, as an injury could be classified according to more than one system. In addition, cases with a combination of injuries, such as those with a fracture of the radius and the ulna, were included more than once, as the case was included in the calculations for combined as well as separate injuries.

Age and sex-specific incidence rates were then calculated for the general categories of injuries (fractures, dislocations, and fracture-dislocations) and for the classification-specific categories of injuries. Confidence intervals were calculated for all incidence rates using a Poisson distribution. For each rate, the standard deviation of the rate was calculated and used as an estimate of the variance. The 95% confidence intervals were then calculated by multiplying the estimate of the variance by 1.96. Standardization of the results was performed using the direct form of standardization. The age-standardized rates are weighted averages of the age-specific rates, with the weights equal to the proportion of the Canadian population in each age category from the 2001 national census. Both the crude rates and the standardized rates are presented in the results section.

4.7 Assessment of Bias

The misclassification of cases results in measurement error or misclassification bias. For the purposes of this study, three sources of potential misclassification were identified. The three sources include cases incorrectly identified (as a dislocation, fracture, or fracture-dislocation), missed cases, and misclassified cases.

4.7.1 Incorrectly Identified Cases

Incorrectly identified cases are those cases that have been assigned an ICD 10 code of fracture, dislocation, or fracture-dislocation that, upon review, have been miscoded. These cases are identified during the initial review of the radiographs, and are flagged as being miscoded. The miscoding may have resulted from the injury being identified when one does not exist, or when an injury has occurred but has been incorrectly coded as elbow rather than the correct site. These cases result in an overestimation of the incidence of the injuries based on a review of the ICD 10 codes. The percentage of incorrectly identified cases is calculated by dividing the number of incorrectly identified cases by the total number of cases, and is used as an estimate of the degree of misclassification attributable to this source.

4.7.2 Missed Cases

Missed cases include those cases that have been assigned an ICD 10 code other than that of a fracture, dislocation, or fracture-dislocation when one should have been assigned. In order to estimate the number of missed cases, ICD 10 codes pertaining to injuries of the elbow other than fractures, dislocations, or fracture-dislocations were identified. In addition, ICD 10 codes for fractures of the shaft of the humerus, radius, and ulna, and unspecified or other fractures of the humerus, radius, and ulna were included. These codes are described in greater detail in Appendix 10, and include fractures of the shaft of the humerus and unspecified parts of the humerus and shoulder girdle, fractures of the shaft of the radius and ulna and other unspecified parts of the radius and ulna, crushing injuries of the elbow and forearm, traumatic amputations of the arm and forearm, contusions of the elbow and forearm, superficial injuries of the elbow and forearm, open wounds of the elbow and forearm, multiple injuries of the elbow and forearm, and sprains and strains of the elbow.

A sampling method was devised because of the anticipated large number of cases that might be potentially identified with the additional ICD 10 codes. It was determined based on a discussion amongst the authors that 10% of the total number of cases should be selected for review. This technique was based upon a similar sampling technique used by Garraway et al.[55] All cases with these ICD 10 codes not also having an ICD 10 code from the first database search were again identified with the use of the Calgary Health Region (CHR) health records database and the assistance of QIHI (Quality Improvement and Health Information). These cases were again identified from inpatient discharges and ambulatory care visits within the city of Calgary from April 1, 2002 to March 31, 2005, and included all three adult hospitals, the three CHR adult rehabilitation facilities, and both sub-acute treatment facilities within the city of Calgary. The cases were ordered sequentially according to the date and time of admission, and every tenth case was selected for review.

Relevant charts and radiographs were assembled for each selected case and reviewed to determine if the case was a fracture, dislocation, or fracture-dislocation. The number of missed cases was recorded, along with the type of injury that was missed. These cases result in an underestimation of the incidence of the injuries based on a review of the ICD 10 codes. The percentage of missed cases is calculated by dividing the number of missed cases by the total number of sampled cases, and is used as an estimate of the degree of misclassification attributable to this source.

4.7.3 Miscoded Cases

Miscoded cases include those cases that have been correctly identified as a fracture, dislocation, or fracture dislocation, but have assigned the incorrect ICD 10 code. During the classification of cases by the authors (DMS and KAH), the appropriate ICD 10 code or codes was assigned to each case. The choice of ICD 10 code was based on the type of injury identified by the authors during the classification process. The percent agreement and the kappa statistic between the original ICD 10 code or codes and the ICD 10 code or codes assigned by the authors was calculated to estimate that accuracy of the coding performed by the health records department for injuries of the elbow using the ICD 10 coding system. The percent agreement and kappa statistic is used to estimate the degree of misclassification among identified injuries attributable to the coding process performed by the health records department.

5. RESULTS

The results are presented in three sections, which correlate to the objectives outlined in section 1.5. Preceding the results is a discussion of the inter-observer reliability of the classification systems utilized in the study. Although inter-observer reliability was not formally assessed, the percent agreement outlined in this section provides for the reader an outline of how consensus was reached by the two authors for the classification of cases, and describes where disagreement occurred within the classification systems.

For the purposes of this study, a case refers to an individual patient, which may include more than one injury (fracture, dislocation, or fracture-dislocation), while a diagnosis refers to an individual injury, such as a radial head fracture or elbow dislocation. The first section outlines the number of incorrectly identified cases, and includes those cases initially classified as fractures or dislocations that have been incorrectly classified as such (section 4.6.1), and the missed cases from the 10% sample of additional ICD 10 codes (section 4.6.2). The second section includes the number of miscoded injuries represented by the percent agreement between the ICD 10 code assigned by the authors during coding of the injury, and the original ICD 10 code assigned to the injury by the health records department (section 4.6.3). The third section presents the total, age-specific, and gender-specific incidence of elbow injuries in the city of Calgary from April 1, 2002 to March 31, 2005. Also presented in this section is the age-adjusted incidence of these injuries, standardized to the 2001 Canadian population.

5.1 Inter-observer Reliability

Of the 1241 cases reviewed by the authors, there was disagreement on the classification in 374 of the cases. Thus the percent agreement between the authors was 69.9%. The disagreement on the classification was always on a type or sub-type within a classification system, rather than on the classification system itself.

For the AO classification system for both distal humerus fractures and proximal radius and ulna fractures, the authors most commonly disagreed on the sub-type, such as between C3.1 and C3.3. The exception to this was for fractures of the proximal radius where the most common disagreement occurred between A2.2 (radial neck fractures) and B2.1 (radial head fractures). Within the Jupiter and Mehne classification system for distal humerus fractures, disagreement occurred most commonly on the type, such as between H-shaped and low T-shaped. The authors agreed on the group, such as whether a fracture was extraarticular, unicondylar, bicondylar, or articular.

The type of disagreement in the fracture-specific classification systems was similar to that of the comprehensive classification systems. For the Regan and Morrey classification system, disagreement occurred between types I and II. This was also the case for the Hotchkiss modification of the Mason classification system for radial head and neck fractures. With the Mayo classification system, disagreement most commonly occurred between “a” and “b” types, which distinguish between comminuted and non-comminuted fractures. Disagreement in the Bado classification system occurred most commonly between type II and III (posterior and lateral dislocations of the radial head). There was very little disagreement for dislocations using the Desault classification system.

5.2 Number of Cases

A total of 2179 cases were initially reviewed for the purpose of the study. Of those cases, 1241 contained at least one fracture or dislocation. The additional cases represent the misclassified cases and the sampled cases, which totaled 258 and 680 respectively. The 1241 cases containing at least one fracture or dislocation were classified using the previously described classification systems. 1181 cases could be classified according to the AO classification system for fractures, with five cases containing both a fracture of the distal humerus and a fracture of the proximal radius and ulna. This resulted in a total of 1186 diagnoses classified according to the AO system. 1241 cases could be classified according to the other classification systems. Of those cases, 1089 were classified with one system, 112 were classified with two systems, 27 were classified with three systems, and 12 were classified with four systems. This resulted in a total of 1442 individually classified diagnoses using the classification systems other than the AO system previously outlined.

5.3 Misclassified Cases

A total of 1499 individual cases were identified as dislocations, fractures, or fracture-dislocations of the elbow based on the ICD 10 codes. Of these 1499 cases, 258 were incorrectly classified as a dislocation, fracture, or fracture-dislocation of the elbow. 192 of the 258 cases were found be normal, without evidence of a dislocation, fracture, or fracture-dislocation. The remaining 66 cases were found to have an injury, however the injury was in an anatomic location other than the elbow. These 66 cases were therefore also included in the total of incorrectly identified cases. This represents a 17.2% rate of incorrectly identified cases, or a 17.2% overestimation of the incidence of dislocations, fractures, and fracture-dislocations of the elbow.

To determine an estimate of the number of missed cases (dislocations, fractures, and fracture-dislocations of the elbow), 6798 cases were identified from the CHR health records database. These cases represented the additional ICD 10 codes that could be used for an injury in the region of the elbow as described in section 4.7.2. From these cases, a 10% sample was selected for review for a total of 680 cases. The radiographs and charts for these cases were compiled and reviewed as described in section 4.7.2. The total number of cases 17 cases were identified as dislocations, fractures, or fracture-dislocations of the elbow by review of the relevant radiographs and chart notes. This represents a 2.5% rate of missed cases, or a 2.5% underestimation of the incidence of dislocations, fractures, and fracture-dislocations of the elbow. Of these 17 cases, 3 were supracondylar humerus fractures, 1 was a lateral epicondyle fracture of the humerus, 1 was an olecranon fracture, and 12 were fractures of the radial head and neck.

5.4 Miscoded Cases

The 1241 (1499 – 258) cases identified as having at least one dislocation, fracture, or fracture-dislocation of the elbow, were coded using the ICD 10 codes for elbow injuries by the authors (DMS and KAH). Cases with more than one type of injury were assigned multiple ICD 10 codes. The original ICD 10 codes applied to the cases by the health records department were compared to the ICD 10 codes assigned by the reviewers. For cases with more than one ICD 10 code assigned, the cases were duplicated, and the individual ICD 10 codes were compared so that matching individual ICD 10 codes were identified. This resulted in a total of 1484 individual pairs of ICD 10 codes for the 1241 cases reviewed. The reviewers were considered the reference standard, as the choice of assigned code utilized expertise-based review of the radiographs and chart notes.

The percent agreement between the ICD 10 code assigned by the authors and the original ICD 10 code was 59.03%, with a 95% confidence interval of 56.48% to 61.55%. The kappa statistic, which provides a measure of agreement beyond chance, was 0.491, with a 95% confidence interval of 0.476 to 0.508. According to the criteria established by Landis and Koch, a kappa value ranging from 0.41 to 0.60 indicates moderate agreement.[109]

5.5 Incidence of Elbow Injuries

5.5.1 Injury Counts and Estimated Incidence rates

The counts of dislocations, fractures, and fracture-dislocations, and the counts of injuries according to the previously described classification systems, with their associated estimated incidence rates and 95% confidence intervals, are outlined in tables 5.1 to 5.10

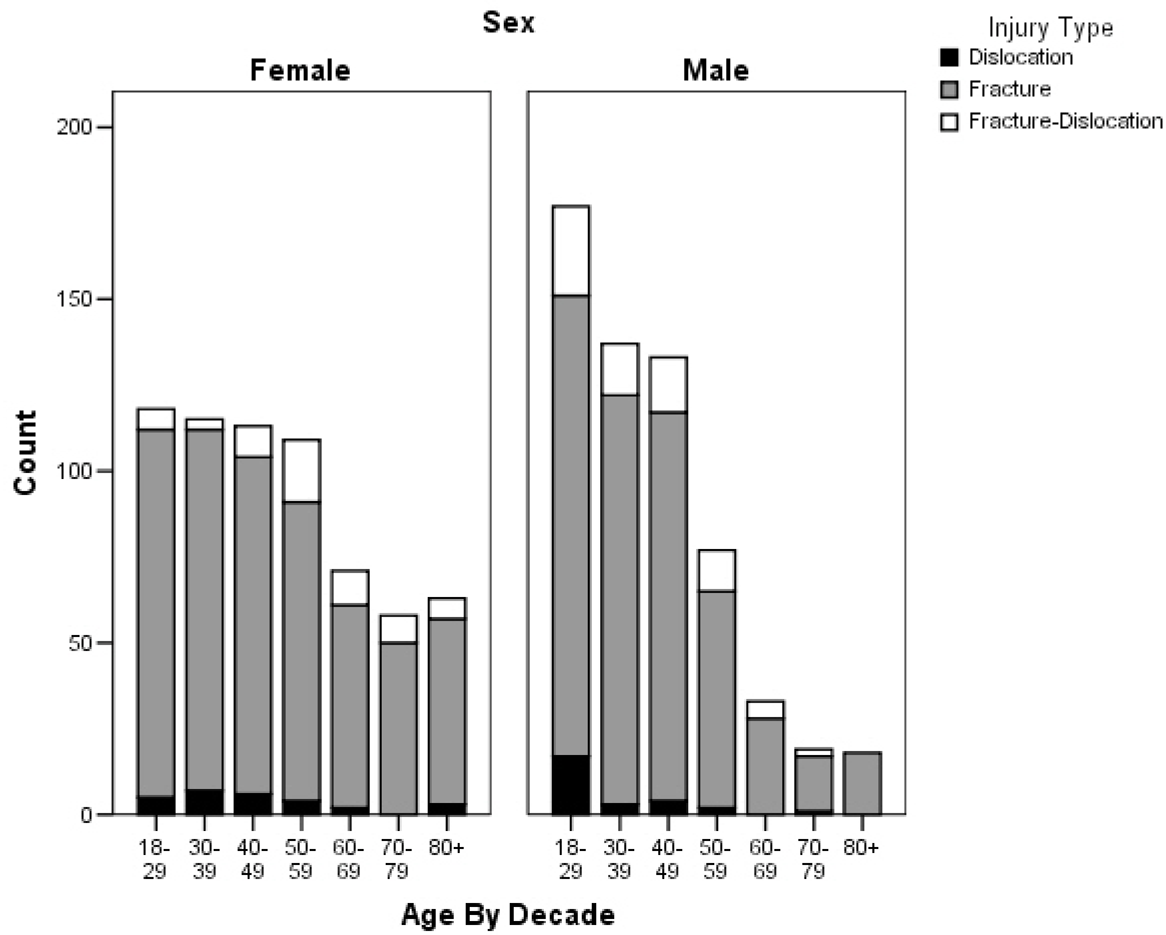
Table 5.1a – Counts of Injuries by Age

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Dislocations	22	10	10	6	2	1	3	**54**
Fractures	241	224	211	150	87	66	72	**1051**
Fracture-Dislocations	32	18	25	30	15	10	6	**136**
Total	295	252	246	186	104	77	81	**1241**

Table 5.1b – Counts of Injuries by Sex

Type	Sex		
	Female	Male	**Total**
Dislocations	27	27	**54**
Fractures	560	491	**1051**
Fracture-Dislocations	60	76	**136**
Total	647	594	**1241**

Figure 5.1 – Counts of Injuries by Type, Age, and Sex



Fractures predominate in all age groups, followed by fracture-dislocations, and dislocations. The greatest counts of injuries occur in the younger age groups, with an overall pattern of decreasing counts of injuries with increasing age. Counts of injuries were more common in males in the younger age groups, and females in the older age groups.

Table 5.1c – Age-Specific Incidence Rates – Injuries

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	6.005	5.319 – 6.691
30-39	5.461	4.787 – 6.135
40-49	5.331	4.665 – 5.997
50-59	6.595	5.646 – 7.544
60-69	6.562	5.302 – 7.822
70-79	6.740	5.235 – 8.245
80+	14.674	11.479 – 17.869
Total	6.131	5.790 – 6.472

Table 5.1d – Sex-Specific Incidence Rates – Injuries

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	6.324	5.840 – 6.808
Male	5.934	5.458 – 6.410
Total	6.131	5.790 – 6.472

Table 5.1e – Age-Adjusted Overall Incidence Rate – Injuries

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	6.314	6.212 – 6.416

The rate of injuries is relatively constant over all age groups, with the exception of individuals 80 and over, where the rate of injuries almost triples. The rate of injuries is similar in females and males.

Table 5.1f – Age-Specific Incidence Rates – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.448	0.262 – 0.634
30-39	0.217	0.082 – 0.352
40-49	0.217	0.082 – 0.352
50-59	0.213	0.042 – 0.384
60-69	0.126	0 – 0.300
70-79	0.086	0 – 0.257
80+	0.543	0 – 1.158
Total	0.267	0.196 – 0.338

Table 5.1g – Sex-Specific Incidence Rates – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.264	0.164 – 0.364
Male	0.270	0.168 – 0.372
Total	0.267	0.196 – 0.338

Table 5.1h – Age-Adjusted Overall Incidence Rate – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.256	0.234 – 0.278

The rate of dislocations gradually decreases with increasing age, with the exception of individuals 80 and older. However, there is considerable overlap of the confidence intervals, suggesting that there may more or less variation than what is seen when the rates alone are evaluated. The rate of dislocations is similar in females and males.

Table 5.1i – Age-Specific Incidence Rates – Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	4.906	4.287 – 5.525
30-39	4.854	4.011 – 5.597
40-49	4.573	3.956 – 5.190
50-59	5.319	4.468 – 6.170
60-69	5.489	4.337 – 6.641
70-79	5.777	4.383 – 7.171
80+	13.043	10.030 – 16.056
Total	5.192	4.878 – 5.506

Table 5.1j – Sex-Specific Incidence Rates – Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	5.474	5.021 – 5.927
Male	4.905	4.472 – 5.338
Total	5.192	4.878 – 5.506

Table 5.1k – Age-Adjusted Overall Incidence Rate – Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	5.370	5.276 – 5.464

The rate of fractures gradually increases with increasing age, and then jumps in individuals 80 and older. For the age groups less than 80, there is considerable overlap of the confidence intervals. The rate of fractures is slightly greater in females than males, however overlapping of the confidence intervals is seen with these two groups as well.

Table 5.1l – Age-Specific Incidence Rates – Fracture-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.651	0.426 – 0.876
30-39	0.390	0.210 – 0.570
40-49	0.542	0.330 – 0.754
50-59	1.064	0.684 – 1.444
60-69	0.946	0.486 – 1.442
70-79	0.875	0.332 – 1.418
80+	1.087	0.217 – 1.957
Total	0.672	0.558 – 0.786

Table 5.1m – Sex-Specific Incidence Rates – Fracture-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.586	0.437 – 0.735
Male	0.759	0.588 – 0.930
Total	0.672	0.558 – 0.786

Table 5.1n – Age-Adjusted Overall Incidence Rate – Fractures-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.708	0.673 – 0.743

The rate of fracture-dislocations is greater in older individuals, with a second moderate peak in individuals 18-29. Considerable overlap is seen in the confidence intervals, suggesting the possibility of more or less variation. The rate of fracture-dislocations is slightly greater in males than in females, however overlapping of the confidence intervals is also seen.

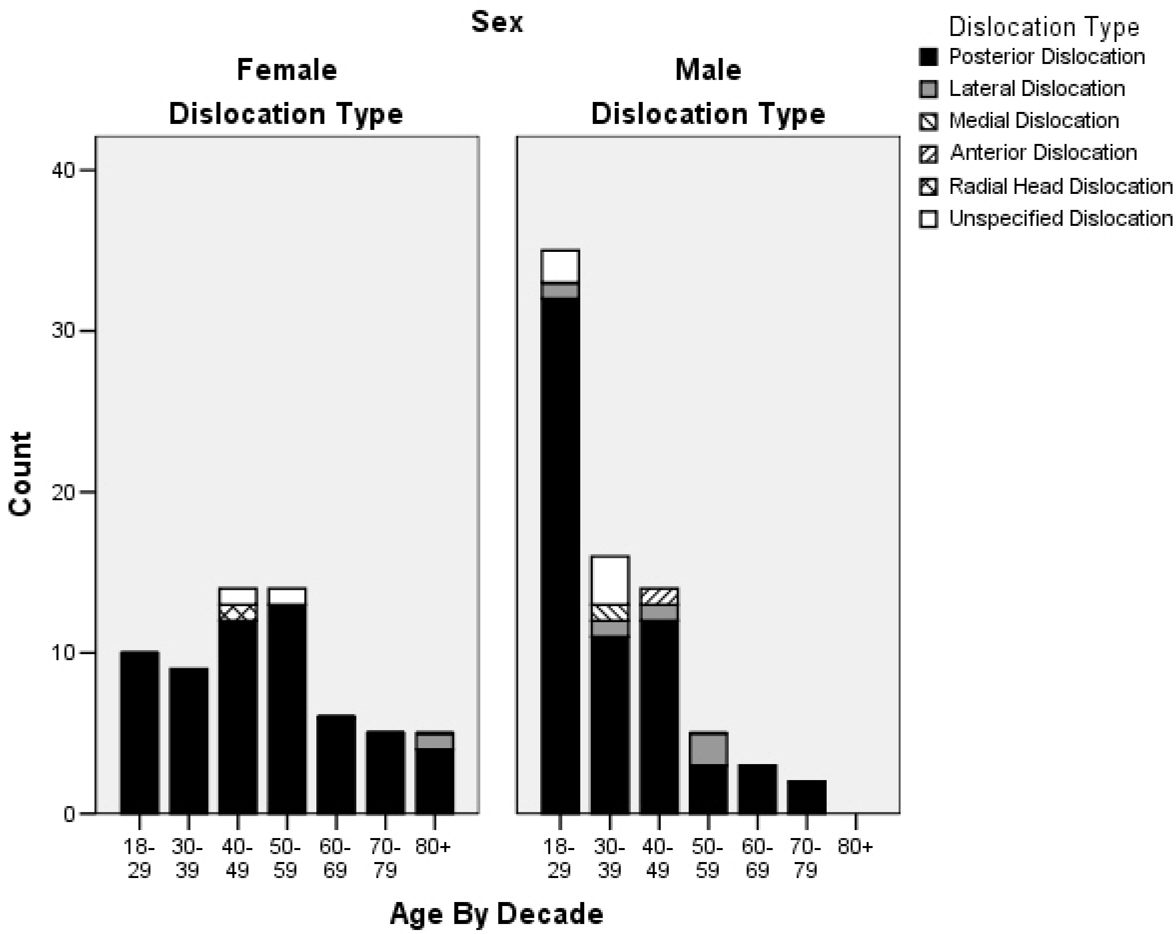
Table 5.2a – Counts of Dislocations by Age – Desault Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Posterior	42	20	24	16	9	7	4	**122**
Anterior			1					**1**
Lateral	1	1	1	2			1	**6**
Medial		1						**1**
Unspecified	2	3	1	1				**7**
Radial Head			1					**1**
Total	45	25	28	19	9	7	5	**138**

Table 5.2b – Counts of Dislocations by Sex – Desault Classification System

Type	Sex		
	Female	Male	**Total**
Posterior	59	63	**122**
Anterior		1	**1**
Lateral	1	5	**6**
Medial		1	**1**
Unspecified	2	5	**7**
Radial Head	1		**1**
Total	63	75	**138**

Figure 5.2 – Counts of Dislocations by Type, Age, and Sex



Counts of posterior dislocations occur most commonly, at a ratio of greater than 7 to 1 compared to all other dislocations. There is a general trend of decreasing counts of dislocations with increasing age. The counts of dislocations are greater in younger males then in any other group.

Table 5.2c – Age-Specific Incidence Rates – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.916	0.647 – 1.185
30-39	0.542	0.330 – 0.754
40-49	0.607	0.382 – 0.832
50-59	0.674	0.370 – 0.978
60-69	0.568	0.198 – 0.938
70-79	0.613	0.158 – 1.068
80+	0.906	0.112 – 1.700
Total	0.682	0.568 – 0.796

Table 5.2d – Sex-Specific Incidence Rates – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.616	0.463 – 0.769
Male	0.749	0.578 – 0.920
Total	0.682	0.568 – 0.796

Table 5.2e – Age-Adjusted Overall Incidence Rate – Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.675	0.642 – 0.708

The rate of dislocations classified by the Desault classification system is greatest in individuals 18 to 29 and 80 and older. However, there is considerable overlap of the confidence intervals, especially in the older age groups. The rate of dislocations is similar in females and males with overlapping of the confidence intervals.

Table 5.2f – Age-Specific Incidence Rates – Posterior Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.855	0.596 – 1.114
30-39	0.433	0.243 – 0.623
40-49	0.520	0.312 – 0.728
50-59	0.567	0.289 – 0.845
60-69	0.568	0.198 – 0.938
70-79	0.613	0.158 – 1.068
80+	0.725	0.015 – 1.435
Total	0.603	0.495 – 0.711

Table 5.2g – Sex-Specific Incidence Rates – Posterior Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.577	0.430 – 0.724
Male	0.629	0.474 – 0.784
Total	0.603	0.495 – 0.711

Table 5.2h – Age-Adjusted Overall Incidence Rate – Posterior Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.599	0.568 – 0.630

The rate of posterior dislocations gradually increases with increasing age, with the exception of individuals 18-29 where the rate of posterior dislocations is greatest. However, there is considerable overlapping of the confidence intervals. The rate of posterior dislocations is similar in females and males with overlapping of the confidence intervals.

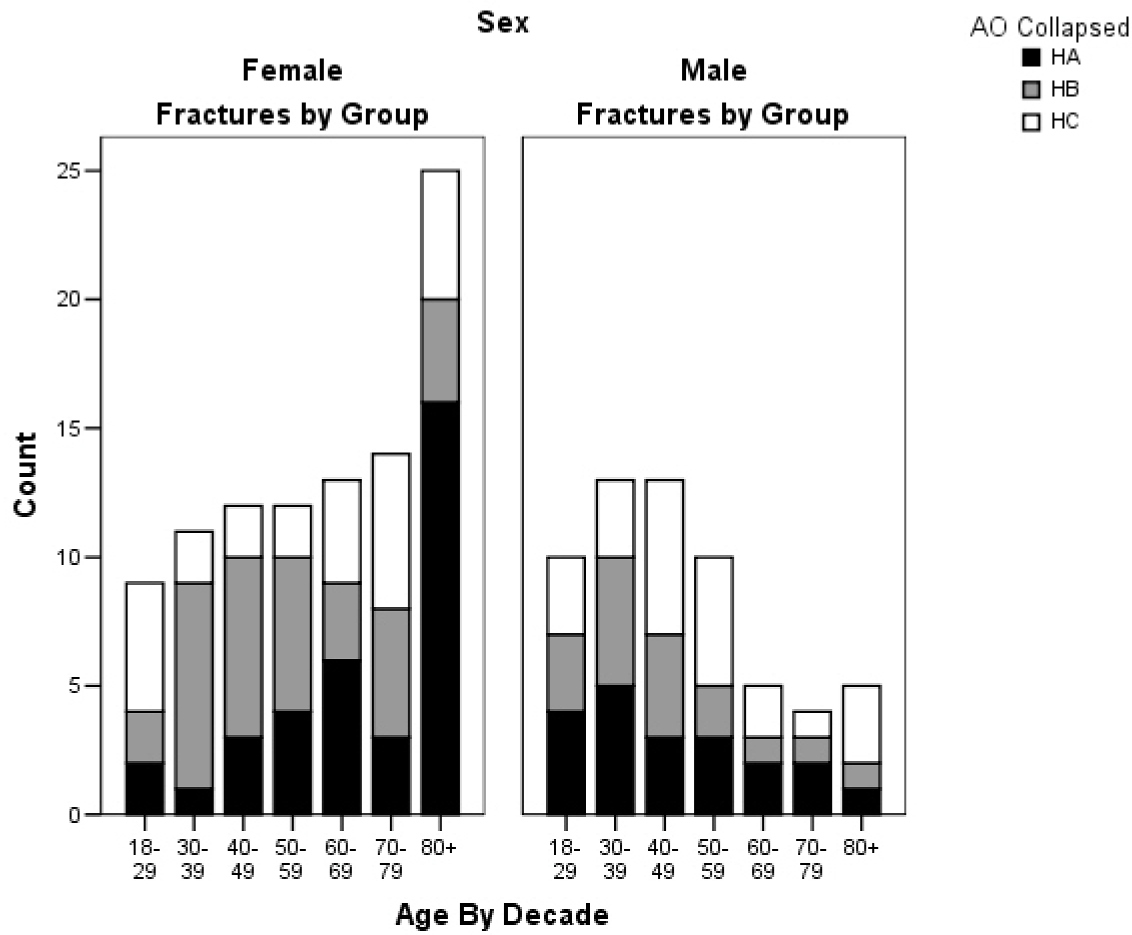
Table 5.3a – Counts of Distal Humerus Fractures by Age – AO Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
A1.1	2	2	2	1	1			**8**
A1.2	2		2	2			1	**7**
A1.3								
A2.1	1							**1**
A2.2	1	1	1		1		4	**8**
A2.3		2		2	4	4	11	**23**
A3.1		1	1	2	2			**6**
A3.2					1	1		**2**
A3.3								
B1.1	2	6	4	1	2	1		**16**
B1.2		1	2	1	1		4	**9**
B1.3								
B2.1		1		1		1		**3**
B2.2	1			1		2		**4**
B2.3						1	1	**2**
B3.1	2	5	3	3	1			**14**
B3.2				1				**1**
B3.3		1	2					**3**
C1.1	1		1	1	1	2	3	**9**
C1.2		1	1	1	1	1	2	**7**
C1.3					1		1	**2**
C2.1	3	2	1	2	2	2		**12**
C2.2		1	1	2			1	**5**
C2.3			1					**1**
C3.1	2					2		**4**
C3.2	2				1		1	**4**
C3.3		1	3	1				**5**
Total	19	24	24	24	18	17	30	**156**

Table 5.3b – Counts Distal Humerus Fractures by Sex – AO Classification System

Type	Sex		
	Female	Male	**Total**
A1.1	5	3	**8**
A1.2	5	2	**7**
A1.3			
A2.1		1	**1**
A2.2	4	4	**8**
A2.3	18	5	**23**
A3.1	3	3	**6**
A3.2	2		**2**
A3.3			
B1.1	10	6	**16**
B1.2	6	3	**9**
B1.3			
B2.1	2	1	**3**
B2.2	2	2	**4**
B2.3	1	1	**2**
B3.1	10	4	**14**
B3.2	1		**1**
B3.3	2	1	**3**
C1.1	6	3	**9**
C1.2	4	3	**7**
C1.3	2		**2**
C2.1	8	4	**12**
C2.2	2	3	**5**
C2.3		1	**1**
C3.1	2	2	**4**
C3.2	1	3	**4**
C3.3		5	**5**
Total	96	60	**156**

Figure 5.3 – Counts Distal Humerus Fractures By AO Group, Age, and Sex



Counts of distal humerus fractures, classified by the AO system, occur most commonly in older females. The trend in females is an increasing number of fractures with increasing age, while in males, there are a decreasing number of fractures with increasing age. Within group A (HA), the most common injury (by counts of injuries) is A2.3, or an extraarticular transcondylar fracture. Within group B (HB), the most common injuries (by counts of injuries) are B1.1, or a lateral condyle fracture that exits through the capitellum, and B3.1, or an articular surface fracture that involves the capitellum. Within group C (HC), the most common injury (by counts of injuries) is C2.1, or a bicondylar intraarticular fracture that has a simple articular fracture line, but comminution in the metaphyseal portion.

Table 5.3c – Age-Specific Incidence Rates – Distal Humerus Fractures (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.387	0.213 – 0.561
30-39	0.520	0.312 – 0.728
40-49	0.520	0.312 – 0.728
50-59	0.851	0.510 – 1.192
60-69	1.136	0.611 – 1.661
70-79	1.488	0.780 – 2.196
80+	5.435	3.491 – 7.379
Total	0.771	0.649 – 0.893

Table 5.3d – Sex-Specific Incidence Rates – Distal Humerus Fractures (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.938	0.750 – 1.126
Male	0.599	0.448 – 0.750
Total	0.771	0.649 – 0.893

Table 5.3e – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.885	0.846 – 0.924

Table 5.3f – Age-Specific Incidence Rates – Distal Humerus Fractures (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.122	0.024 – 0.220
30-39	0.130	0.026 – 0.234
40-49	0.130	0.026 – 0.234
50-59	0.248	0.064 – 0.432
60-69	0.568	0.198 – 0.938
70-79	0.438	0.054 – 0.822
80+	2.899	1.478 – 4.320
Total	0.272	0.199 – 0.345

Table 5.3g – Sex-Specific Incidence Rates – Distal Humerus Fractures (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.362	0.246 – 0.478
Male	0.180	0.098 – 0.262
Total	0.272	0.199 – 0.345

Table 5.3h – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.329	0.305 – 0.353

Table 5.3i – Age-Specific Incidence Rates – Distal Humerus Fractures (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.102	0.012 – 0.192
30-39	0.303	0.144 – 0.462
40-49	0.238	0.097 – 0.379
50-59	0.284	0.088 – 0.480
60-69	0.252	0.005 – 0.499
70-79	0.438	0.054 – 0.822
80+	0.906	0.112 – 1.700
Total	0.257	0.186 – 0.328

Table 5.3j – Sex-Specific Incidence Rates – Distal Humerus Fracture (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.332	0.220 – 0.444
Male	0.180	0.098 – 0.262
Total	0.257	0.186 – 0.328

Table 5.3k – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.276	0.254 – 0.298

Table 5.3l – Age-Specific Incidence Rates – Distal Humerus Fractures (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.163	0.049 – 0.277
30-39	0.108	0.014 – 0.202
40-49	0.173	0.053 – 0.293
50-59	0.248	0.064 – 0.432
60-69	0.379	0.075 – 0.683
70-79	0.613	0.158 – 1.068
80+	1.449	0.445 – 2.453
Total	0.242	0.173 – 0.311

Table 5.3m – Age-Specific Incidence Rates – Distal Humerus Fractures (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.244	0.148 – 0.340
Male	0.240	0.144 – 0.336
Total	0.242	0.173 – 0.311

Table 5.3n – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.278	0.256 – 0.300

The rate of distal humerus fractures classified according to the AO system increases with increasing age in all fractures and in groups A, B, and C. However, there is overlap of the confidence intervals suggesting the possibility of more or less variation. The rate of injuries is generally greater in females than in males, with the exception of group C, where the rates are similar. There is again overlap of the confidence intervals.

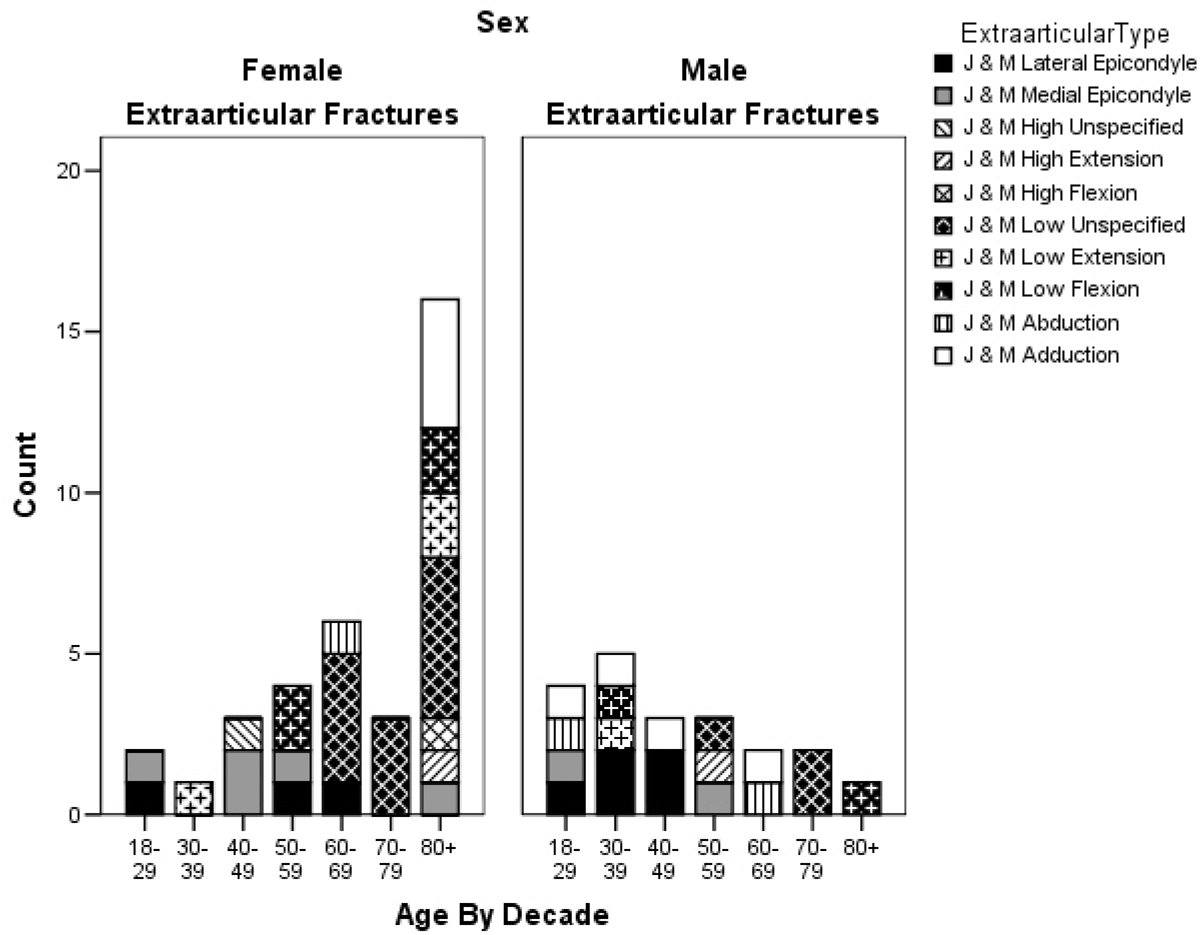
Table 5.4a – Counts of Distal Humerus Fractures by Age – Jupiter and Mehne Classification – Extraarticular

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Lateral Epicondyle	2	2	2	1	1			**8**
Medial Epicondyle	2		2	2			1	**7**
High Unspecified			1					**1**
High Extension				1			1	**2**
High Flexion							1	**1**
Low Unspecified				1	4	5	5	**15**
Low Extension		2					2	**4**
Low Flexion		1		2			3	**6**
Abduction	1				2			**3**
Adduction	1	1	1		1		4	**8**
Total	6	6	6	7	8	5	17	**55**

Table 5.4b – Counts of Distal Humerus Fracture by Sex – Jupiter and Mehne Classification – Extraarticular

Type	Sex		
	Female	Male	**Total**
Lateral Epicondyle	3	5	**8**
Medial Epicondyle	5	2	**7**
High Unspecified	1		**1**
High Extension	1	1	**2**
High Flexion	1		**1**
Low Unspecified	12	3	**15**
Low Extension	3	1	**4**
Low Flexion	4	2	**6**
Abduction	1	2	**3**
Adduction	4	4	**8**
Total	35	20	**55**

Figure 5.4 – Counts of Extraarticular Distal Humerus Fractures by Type, Age, and Sex



Extraarticular distal humerus fractures, classified by the system of Jupiter and Mehne, are most common in older females (by counts of injuries). As with distal humerus fractures classified by the AO system, there is an increasing trend with increasing age in females, and a decreasing trend with increasing age in males. The most common fracture type (by counts of injuries) is the low type, whether it is flexion, extension, or unspecified.

Table 5.4c – Age-Specific Incidence Rates – Distal Humerus Fractures (Extraarticular)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.122	0.024 – 0.220
30-39	0.130	0.026 – 0.234
40-49	0.130	0.026 – 0.234
50-59	0.248	0.064 – 0.432
60-69	0.505	0.154 – 0.856
70-79	0.438	0.054 – 0.822
80+	3.080	1.616 – 4.544
Total	0.272	0.199 – 0.345

Table 5.4d – Sex-Specific Incidence Rates – Distal Humerus Fractures (Extraarticular)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.342	0.228 – 0.456
Male	0.200	0.112 – 0.288
Total	0.272	0.199 – 0.345

Table 5.4e – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (Extraarticular)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.330	0.306 – 0.354

The rate of extraarticular distal humerus fractures increases with increasing age. However, there is considerable overlapping of the confidence intervals. The rate of fractures is 6 times greater in individuals 80 and older than in individuals 70 to 79. The rate of extraarticular distal humerus fractures is greater in females than in males. Again, overlapping of the confidence intervals is seen.

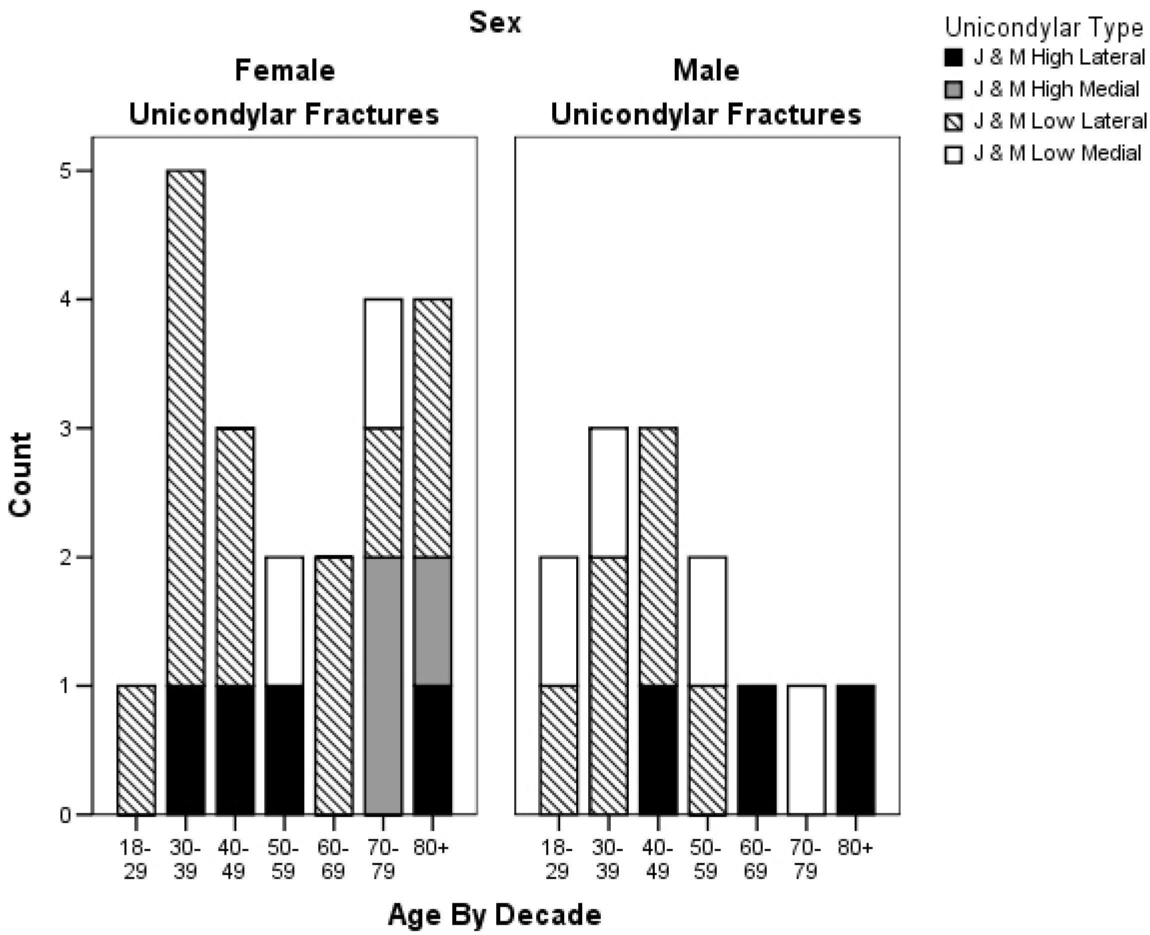
Table 5.5a – Counts of Distal Humerus Fractures by Age – Jupiter and Mehne Classification – Unicondylar

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Low Lateral	2	6	4	1	2	1	2	**18**
High Lateral		1	2	1	1		2	**7**
Low Medial	1	1		2		2		**6**
High Medial						2	1	**3**
Total	3	8	6	4	3	5	5	**34**

Table 5.5b – Counts of Distal Humerus Fractures by Sex – Jupiter and Mehne Classification – Unicondylar

Type	Sex		
	Female	Male	**Total**
Low Lateral	12	6	**18**
High Lateral	4	3	**7**
Low Medial	2	4	**6**
High Medial	3		**3**
Total	21	13	**34**

Figure 5.5 – Counts of Unicondylar Distal Humerus Fractures by Type, Age, and Sex



Unicondylar fractures, by counts of injuries, appear most commonly in the 30 to 49 year old males, with an overall decreasing trend in males, and in 30 to 39 and 70 and older females. As with distal humerus fractures classified by the AO system, lateral condyle fractures that exit through the capitellum, or low, are most common (by counts of injuries).

Table 5.5c – Age-Specific Incidence Rates – Distal Humerus Fractures (Unicondylar)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.061	0 – 0.130
30-39	0.173	0.053 – 0.293
40-49	0.130	0.026 – 0.234
50-59	0.142	0.003 – 0.281
60-69	0.189	0 – 0.403
70-79	0.438	0.054 – 0.822
80+	0.906	0.112 – 1.700
Total	0.168	0.111 – 0.225

Table 5.5d – Sex-Specific Incidence rates – Distal Humerus Fractures (Unicondylar)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.205	0.117 – 0.293
Male	0.130	0.059 – 0.201
Total	0.168	0.111 – 0.225

Table 5.5e – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (Unicondylar)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.188	0.170 – 0.206

The rate of unicondylar distal humerus fractures increases with increasing age. The rate of fractures is 2 times greater in individuals 80 and older than in individuals 70 to 79. The rate of unicondylar distal humerus fractures is greater in females than in males. In all cases, there is considerable overlap of the confidence intervals.

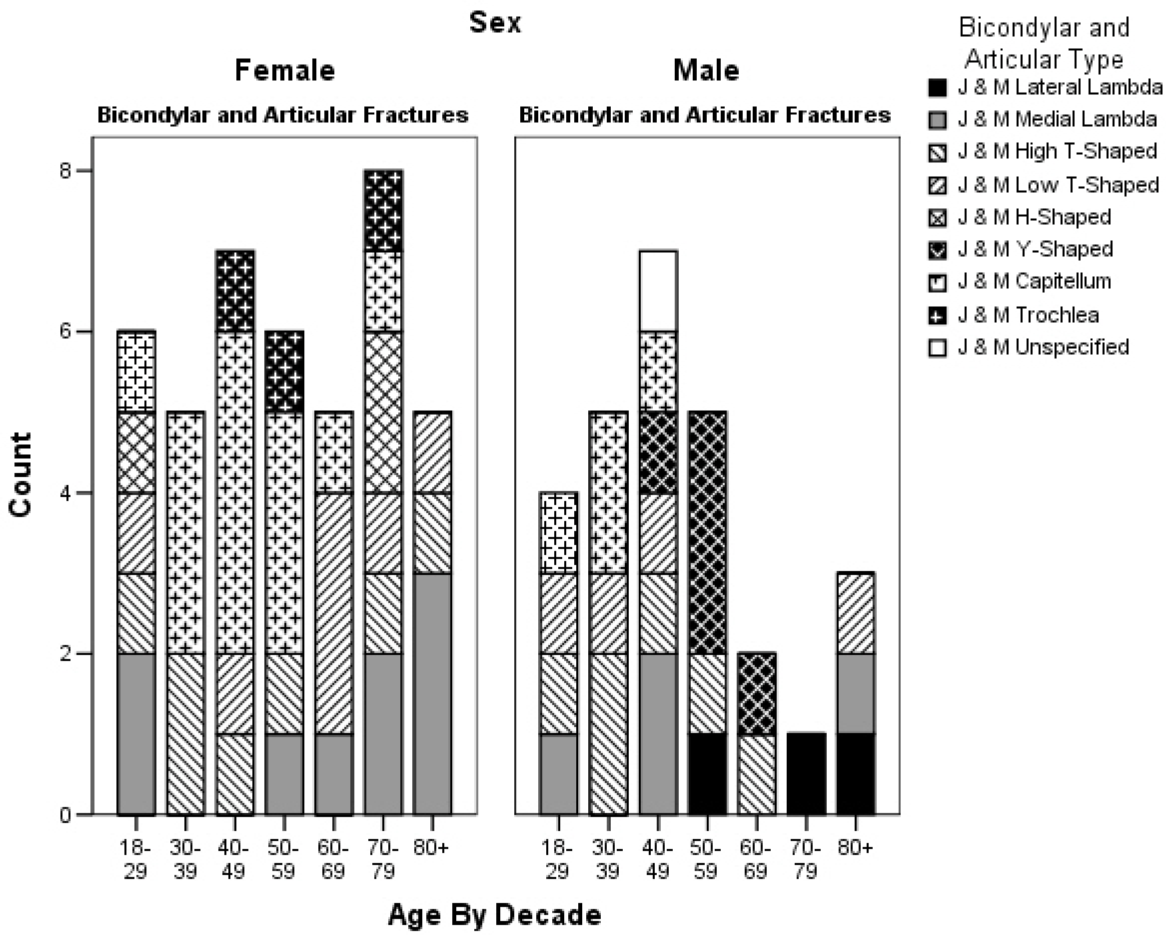
Table 5.6a – Counts of Distal Humerus Fractures by Age – Jupiter and Mehne Classification – Bicondylar, Articular Surface, and Unspecified

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Lateral Lambda				1		1	1	**3**
Medial Lambda	3		2	1	1	2	4	**13**
High T-Shaped	2	4	2	2	1	1	1	**13**
Low T-Shaped	2	1	2		3	1	2	**11**
H-Shaped	1					2		**3**
Y-Shaped			1	3	1			**5**
Capitellum	2	5	5	3	1	1		**17**
Trochlea			1	1		1		**3**
Unspecified			1					**1**
Total	10	10	14	11	7	9	8	**69**

Table 5.6b – Counts of Distal Humerus Fractures by Sex – Jupiter and Mehne Classification – Bicondylar, Articular Surface, and Unspecified

Type	Sex		
	Female	Male	**Total**
Lateral Lambda		3	**3**
Medial Lambda	9	4	**13**
High T-Shaped	7	6	**13**
Low T-Shaped	7	4	**11**
H-Shaped	3		**3**
Y-Shaped		5	**5**
Capitellum	13	4	**17**
Trochlea	3		**3**
Unspecified		1	**1**
Total	42	27	**69**

Figure 5.6 – Counts of Bicondylar, Articular Surface, and Unspecified Fractures by Type, Age, and Sex



The distribution of bicondylar and articular surface fractures in males, by counts of injuries, is greater in the younger age groups, while it is relatively evenly distributed in females. Overall, bicondylar and articular surface fractures occur twice as often in females as in males (by counts of injuries). High-T, low-T, medial lambda, and capitellum fractures occur most commonly (by counts of injuries).

Table 5.6c – Age-Specific Incidence Rates – Distal Humerus Fractures (Bicondylar, Articular Surface, and Unspecified)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.204	0.079 – 0.329
30-39	0.217	0.082 – 0.352
40-49	0.303	0.144 – 0.462
50-59	0.390	0.159 – 0.621
60-69	0.442	0.115 – 0.769
70-79	0.788	0.273 – 1.303
80+	1.449	0.445 – 2.453
Total	0.341	0.261 – 0.421

Table 5.6d – Sex-Specific Incidence Rates – Distal Humerus Fractures (Bicondylar, Articular Surface, and Unspecified)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.411	0.288 – 0.534
Male	0.270	0.168 – 0.372
Total	0.341	0.261 – 0.421

Table 5.6e – Age-Adjusted Overall Incidence Rate – Distal Humerus Fractures (Bicondylar, Articular Surface, and Unspecified)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.379	0.354 – 0.404

The rate of bicondylar and articular surface distal humerus fractures increases with increasing age. However, there is considerable overlap of the confidence intervals. The rate of fractures is 2 times greater in individuals 80 and older than in individuals 70 to 79. The rate of bicondylar and articular surface distal humerus fractures is greater in females than in males. Again, considerable overlap of the confidence intervals is noted.

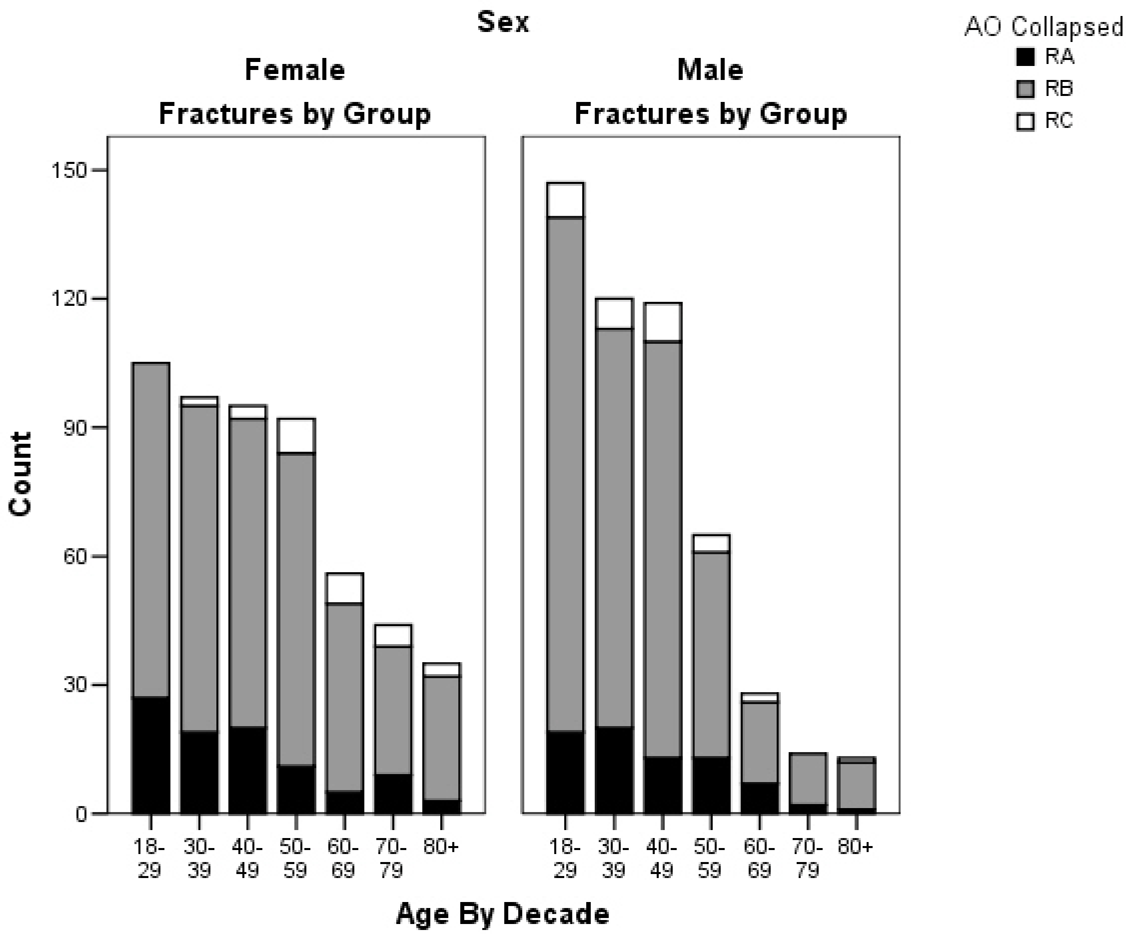
Table 5.7a – Counts of Proximal Radius and Ulna Fractures by Age – AO Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
A1.1	1	1		3	2		1	**8**
A1.2				2		1	1	**4**
A1.3	1			2	2	1	1	**7**
A2.1								
A2.2	42	38	31	16	8	9	1	**145**
A2.3	2		1	1				**4**
A3.1								
A3.2			1					**1**
A3.3								
B1.1	50	48	53	37	28	29	35	**280**
B1.2			1					**1**
B1.3	1	1	4	1				**7**
B2.1	122	87	75	54	23	8	5	**374**
B2.2	13	16	10	6	2			**47**
B2.3	12	16	23	20	8	3		**82**
B3.1		1	1		2			**4**
B3.2		1	1		2			**4**
B3.3			1	2				**3**
C1.1			1	1		1	1	**4**
C1.2	3	6	7	4		1	1	**22**
C2.1	1	1		1			1	**4**
C2.2			1		1	1		**3**
C2.3	2	2	2	2	4	2		**14**
C3.1	1			1	1			**3**
C3.2	1	1		1	2		1	**6**
C3.3				2	1			**3**
Total	252	219	213	156	86	56	48	**1030**

Table 5.7b – Counts of Proximal Radius and Ulna Fractures by Sex – AO Classification System

Type	Sex		
	Female	Male	**Total**
A1.1	4	4	**8**
A1.2	3	1	**4**
A1.3	4	3	**7**
A2.1			
A2.2	81	64	**145**
A2.3	1	3	**4**
A3.1			
A3.2		1	**1**
A3.3			
B1.1	136	144	**280**
B1.2		1	**1**
B1.3	2	5	**7**
B2.1	190	184	**374**
B2.2	19	28	**47**
B2.3	45	37	**82**
B3.1	4		**4**
B3.2	4		**4**
B3.3	2	1	**3**
C1.1	4		**4**
C1.2	6	16	**22**
C2.1	2	2	**4**
C2.2	3		**3**
C2.3	6	8	**14**
C3.1	2	1	**3**
C3.2	3	3	**6**
C3.3	2	1	**3**
Total	523	507	**1030**

Figure 5.7 – Counts of Proximal Radius and Ulna Fractures by AO Group, Age, and Sex



Proximal radius and ulna fractures, classified by the AO system, occur most commonly in the younger age groups (by counts of injuries). The fractures are more common in males then in females in the younger age groups, and more common in females then in males in the older groups (by counts of injuries). Within Group B (RB), the most common fractures are B2.1, B2.2, and B2.3, which represent radial head fractures. Of these, B2.1, or a simple fracture of the radial head, is most common. Within group A (RA), the most common fracture is A2.2, or a simple fracture of the radial neck. Although much less common, within group C (RC), combined fractures of the radial head and coronoid, or C1.2 and C2.3, occur most frequently (all by counts of injuries).

Table 5.7c – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	5.123	4.490 – 5.756
30-39	4.745	4.116 – 5.374
40-49	4.616	3.997 – 5.235
50-59	5.532	4.664 – 6.400
60-69	5.426	4.279 – 6.573
70-79	4.902	3.618 – 6.186
80+	8.696	6.236 – 11.156
Total	5.089	4.777 – 5.401

Table 5.7d – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	5.112	4.673 – 5.551
Male	5.065	4.624 – 5.506
Total	5.089	4.777 – 5.401

Table 5.7e – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	5.139	5.047 – 5.231

The rate of proximal radius and ulna fractures is similar amongst all age groups with the exception of individuals 80 and older. In this age group the rate is approximately twice that of all other age groups. The rate is similar in females and males (based on overlapping confidence intervals).

Table 5.7f – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.936	0.666 – 1.206
30-39	0.845	0.580 – 1.110
40-49	0.715	0.472 – 0.958
50-59	0.851	0.510 – 1.192
60-69	0.757	0.328 – 1.186
70-79	0.963	0.395 – 1.531
80+	0.725	0.015 – 1.435
Total	0.835	0.710 – 0.960

Table 5.7g – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.909	0.725 – 1.093
Male	0.759	0.588 – 0.930
Total	0.835	0.710 – 0.960

Table 5.7h – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO A)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.832	0.795 – 0.869

The rate of AO group A fractures is similar in all age groups and in females and males (based on overlapping confidence intervals).

Table 5.7i – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO A2.2)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.855	0.596 – 1.114
30-39	0.823	0.560 – 1.086
40-49	0.672	0.435 – 0.909
50-59	0.567	0.289 – 0.845
60-69	0.505	0.154 – 0.856
70-79	0.788	0.273 – 1.303
80+	0.181	0 – 0.536
Total	0.716	0.600 – 0.832

Table 5.7j – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO A2.2)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.792	0.620 – 0.964
Male	0.639	0.523 – 0.796
Total	0.716	0.600 – 0.832

Table 5.7k – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO A2.2)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.695	0.662 – 0.728

The rate of AO A2.2 fractures is similar in all age groups with the exception of individuals 80 and older. In the oldest age group, the rate of AO A2.2 fractures is one third to one quarter that of the other groups. However, considerable overlap of the confidence intervals is noted. The rates are similar in females and males (based on overlapping confidence intervals).

Table 5.7l – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	4.031	3.470 – 4.592
30-39	3.684	3.129 – 4.239
40-49	3.663	3.110 – 4.216
50-59	4.255	3.495 – 5.015
60-69	4.101	3.103 – 5.099
70-79	3.501	2.415 – 4.587
80+	7.246	5.000 – 9.492
Total	3.962	3.688 – 4.236

Table 5.7m – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	3.929	3.545 – 4.313
Male	3.996	3.604 – 4.388
Total	3.962	3.688 – 4.236

Table 5.7n – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO B)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	4.014	3.932 – 4.096

The rate of AO group B fractures is similar in all age groups with the exception of individuals 80 and older. The rate in the oldest age group is twice that of other age groups. The rate is similar in females and males (based on overlapping confidence intervals).

Table 5.7o – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO B1.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	1.018	0.736 – 1.300
30-39	1.040	0.746 – 1.334
40-49	1.149	0.839 – 1.459
50-59	1.312	0.889 – 1.735
60-69	1.767	0.778 – 2.088
70-79	2.539	1.616 – 3.462
80+	6.341	4.240 – 8.442
Total	1.383	1.220 – 1.546

Table 5.7p – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO B1.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	1.329	1.106 – 1.552
Male	1.439	1.204 – 1.674
Total	1.383	1.220 – 1.546

Table 5.7q – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO B1.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	1.511	1.460 – 1.562

The rate of AO B1.1 fractures is similar in all age groups with the exception of individuals 80 and older. The rate in the oldest age group is 4 to 6 times that of other age groups. The rate is similar in females and males (based on overlapping confidence intervals).

Table 5.7r – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO B2.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	2.484	2.043 – 2.925
30-39	1.885	1.489 – 2.281
40-49	1.625	1.257 – 1.993
50-59	1.831	1.331 – 2.331
60-69	1.451	0.859 – 2.043
70-79	0.700	0.214 – 1.186
80+	0.906	0.112 – 1.700
Total	1.848	1.660 – 2.036

Table 5.7s – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO B2.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	1.857	1.592 – 2.122
Male	1.838	1.571 – 2.105
Total	1.848	1.660 – 2.036

Table 5.7t – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO B2.1)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	1.763	1.708 – 1.818

The rate of AO B2.1 fractures decreases with increasing age, and are similar in females and males (based on overlapping confidence intervals).

Table 5.7u – Age-Specific Incidence Rates – Proximal Radius and Ulna (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.163	0.049 – 0.277
30-39	0.217	0.082 – 0.352
40-49	0.238	0.097 – 0.379
50-59	0.426	0.185 – 0.667
60-69	0.568	0.198 – 0.938
70-79	0.438	0.054 – 0.822
80+	0.725	0.015 – 1.435
Total	0.291	0.217 – 0.365

Table 5.7v – Sex-Specific Incidence Rates – Proximal Radius and Ulna (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.274	0.172 – 0.376
Male	0.310	0.200 – 0.420
Total	0.291	0.217 – 0.365

Table 5.7w – Age-Adjusted Overall Incidence Rate – Proximal Radius and Ulna (AO C)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.319	0.295 – 0.319

The rate of AO group C fractures increases with increasing age, however, there is considerable overlap of the confidence intervals. The rate is similar in females and males (based on overlapping confidence intervals).

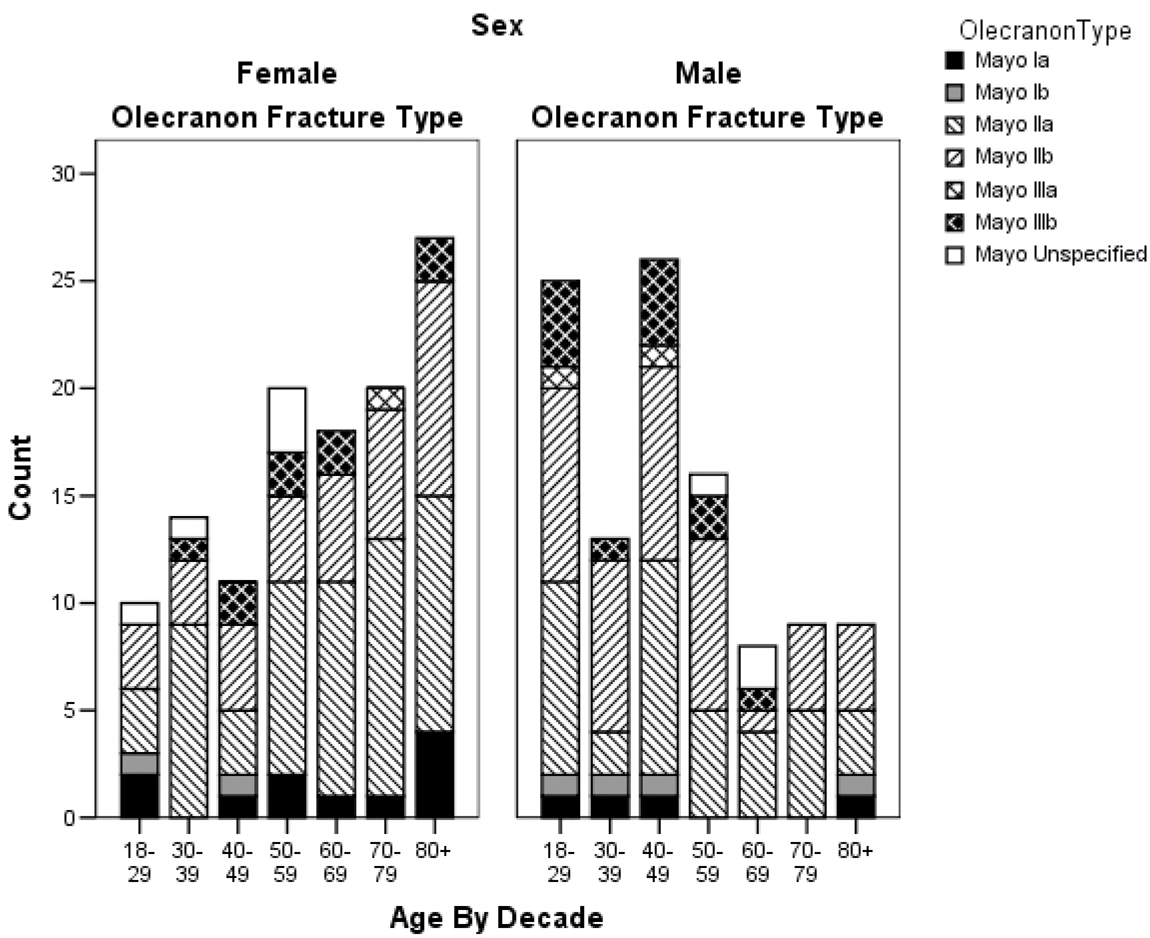
Table 5.8a – Counts of Olecranon Fractures by Age – Mayo Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
Ia	3	1	2	2	1	1	5	**15**
Ib	2	1	2				1	**6**
IIa	12	11	13	14	14	17	14	**95**
IIb	12	11	13	12	6	10	14	**78**
IIIa	1		1			1		**3**
IIIb	4	2	6	4	3		2	**21**
Unspecified	1	1		4	2			**8**
Total	35	27	37	36	26	29	36	**226**

Table 5.8b – Counts of Olecranon Fractures by Sex – Mayo Classification System

Type	Sex		
	Female	Male	**Total**
Ia	10	5	**15**
Ib	2	4	**6**
IIa	57	38	**95**
IIb	35	43	**78**
IIIa	1	2	**3**
IIIb	9	12	**21**
Unspecified	5	3	**8**
Total	119	107	**226**

Figure 5.8 – Counts of Olecranon Fractures by Type, Age, and Sex



Olecranon fractures occur most commonly in older females, with an increasing trend with increasing age, and in younger males, with a decreasing trend with increasing age (by counts of injuries). The most common types are Mayo IIa and Mayo IIb, or displaced fractures with or without comminution where the ulnohumeral joint remains reduced.

Table 5.8c – Age-Specific Incidence Rates – Olecranon Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.712	0.477 – 0.947
30-39	0.585	0.364 – 0.806
40-49	0.802	0.543 – 1.061
50-59	1.277	0.860 – 1.694
60-69	1.640	1.009 – 2.271
70-79	2.539	1.616 – 1.846
80+	6.522	4.391 – 8.653
Total	1.117	0.972 – 1.262

Table 5.8d – Sex-Specific Incidence Rates – Olecranon Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	1.163	0.953 – 1.373
Male	1.069	0.867 – 1.271
Total	1.117	0.972 – 1.262

Table 5.8e – Age-Adjusted Overall Incidence Rate – Olecranon Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	1.273	1.226 – 1.320

Table 5.8f – Age-Specific Incidence Rates – Olecranon Fractures (Mayo IIa)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.244	0.107 – 0.381
30-39	0.238	0.097 – 0.379
40-49	0.282	0.141 – 0.423
50-59	0.496	0.235 – 0.757
60-69	0.883	0.420 – 1.346
70-79	1.488	0.780 – 2.196
80+	2.536	1.207 – 3.865
Total	0.469	0.375 – 0.563

Table 5.8g – Sex-Specific Incidence Rates – Olecranon Fractures (Mayo IIa)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.557	0.412 – 0.702
Male	0.380	0.258 – 0.502

Total	0.469	0.375 – 0.563

Table 5.8h – Age-Adjusted Overall Incidence Rate – Olecranon Fractures (Mayo IIa)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.549	0.505 – 0.563

Table 5.8i – Age-Specific Incidence Rates – Olecranon Fractures (Mayo IIb)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.244	0.107 – 0.381
30-39	0.238	0.097 – 0.379
40-49	0.282	0.129 – 0.435
50-59	0.426	0.185 – 0.667
60-69	0.379	0.075 – 0.683
70-79	0.875	0.332 – 1.418
80+	2.536	1.207 – 3.865
Total	0.385	0.299 – 0.471

Table 5.8j – Age-Specific Incidence Rates – Olecranon Fractures (Mayo IIb)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.342	0.228 – 0.456
Male	0.430	0.301 – 0.559
Total	0.385	0.299 – 0.471

Table 5.8k – Age-Adjusted Overall Incidence Rate – Olecranon Fractures (Mayo IIb)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.437	0.410 – 0.464

The rate of all olecranon fractures, Mayo IIa fractures, and Mayo IIb fracture increases with increasing age. There is some overlap of the confidence intervals, particularly in the younger age groups. The rate is similar in females and males (based on overlapping confidence intervals) except for Mayo IIa fracture, which are more common in females than in males.

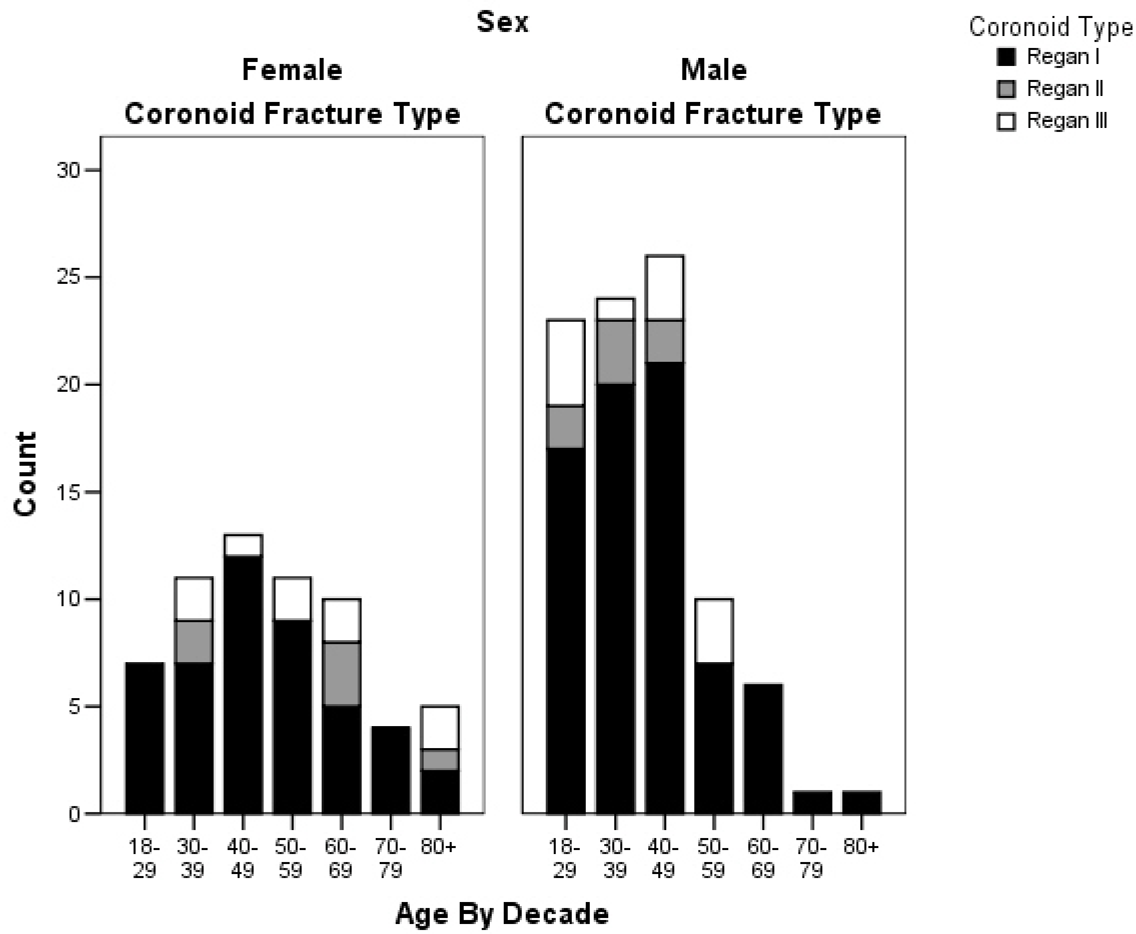
Table 5.9a – Counts of Coronoid Fractures by Age – Regan and Morrey Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
I	24	27	33	16	11	5	3	**119**
II	2	5	2		3		1	**13**
III	4	3	4	5	2		2	**20**
Total	30	35	39	21	16	5	6	**152**

Table 5.9b – Counts of Coronoid Fractures by Sex – Regan and Morrey Classification System

Type	Sex		
	Male	Female	**Total**
I	73	46	**119**
II	7	6	**13**
III	11	9	**20**
Total	91	61	**152**

Figure 5.9 – Counts of Coronoid Fractures by Type, Age, and Sex



Coronoid fractures occur most commonly in younger males (based on counts of injuries). When the sexes are combined, coronoid fractures are most common in the group age 40 to 49. Type I fractures are the most common type.

Table 5.9c – Age-Specific Incidence Rates – Coronoid Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.611	0.391 – 0.831
30-39	0.758	0.507 – 1.009
40-49	0.845	0.580 – 1.110
50-59	0.745	0.426 – 1.064
60-69	1.010	0.516 – 1.504
70-79	0.438	0.054 – 0.822
80+	1.087	0.217 – 1.957
Total	0.751	0.631 – 0.871

Table 5.9d – Sex-Specific Incidence Rates – Coronoid Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.889	0.707 – 1.071
Male	0.609	0.456 – 0.762
Total	0.751	0.631 – 0.871

Table 5.9e – Age-Adjusted Overall Incidence Rate – Coronoid Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.759	0.724 – 0.794

The rate of coronoid fractures is highest in individuals age 60 to 69 and 80 and older, and lowest in individuals age 70 to 79. However, there is overlapping of the confidence intervals. The rate is greater in females than in males.

Table 5.9f – Age-Specific Incidence Rates – Coronoid Fractures (Regan I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.489	0.293 – 0.685
30-39	0.585	0.364 – 0.806
40-49	0.715	0.472 – 0.958
50-59	0.567	0.289 – 0.845
60-69	0.694	0.284 – 1.104
70-79	0.438	0.054 – 0.822
80+	0.543	0 – 1.158
Total	0.588	0.482 – 0.694

Table 5.9g – Sex-Specific Incidence Rates – Coronoid Fractures (Regan I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.714	0.549 – 0.879
Male	0.460	0.327 – 0.593
Total	0.588	0.482 – 0.694

Table 5.9h – Age-Adjusted Overall Incidence Rate – Coronoid Fractures (Regan I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.589	0.558 – 0.620

The rate of Regan I coronoid fractures is similar in all age groups (based on overlapping confidence intervals), and is greater in females than in males.

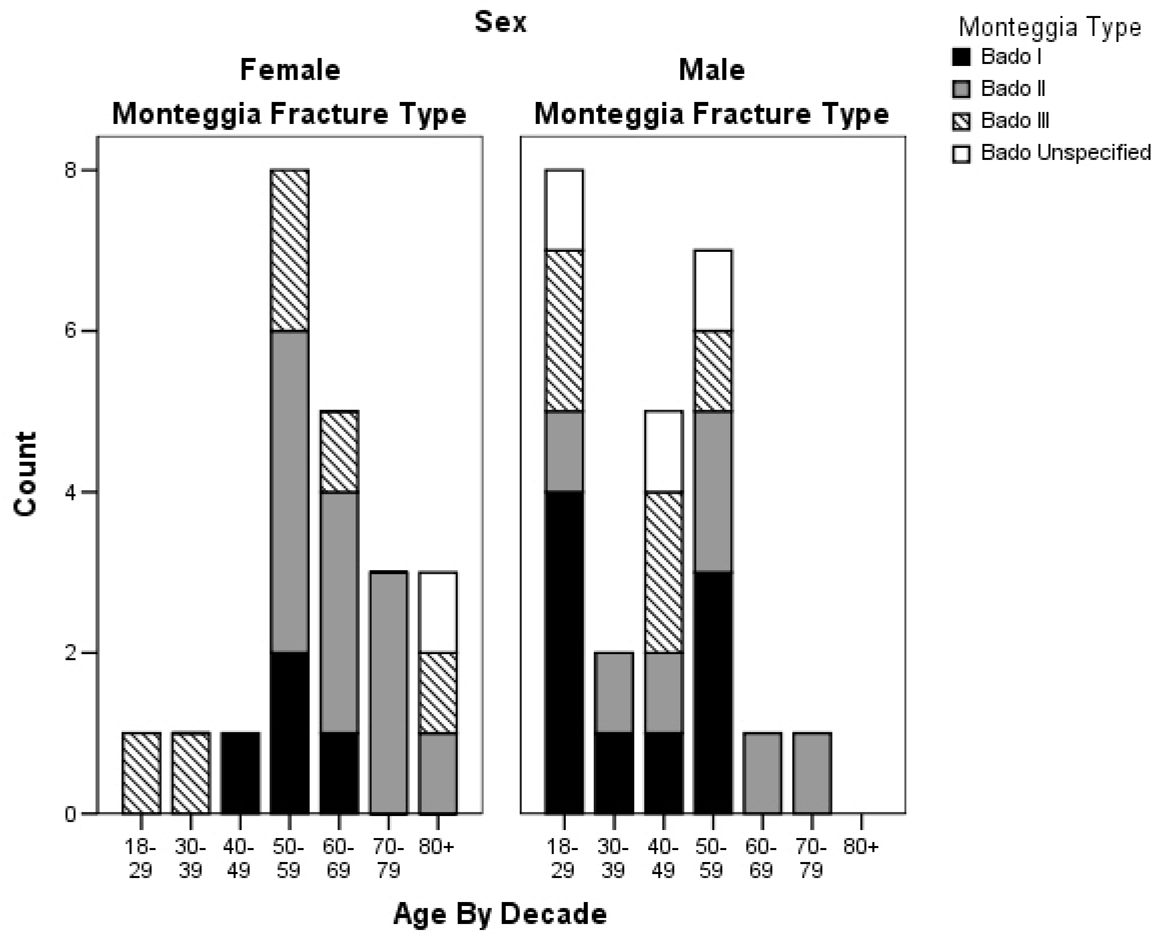
Table 5.10a – Counts of Monteggia Fracture-Dislocations by Age – Bado Classification System

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
I	4	1	2	5	1			**13**
II	1	1	1	6	4	4	1	**18**
III	3	1	2	3	1		1	**11**
IV								
Unspecified	1		1	1			1	**4**
Total	9	3	6	15	6	4	3	**46**

Table 5.10b – Counts of Monteggia Fracture-Dislocations by Sex – Bado Classification System

Type	Sex		
	Female	Male	**Total**
I	4	9	**13**
II	11	7	**18**
III	6	5	**11**
IV			
Unspecified	1	3	**4**
Total	22	24	**46**

Figure 5.10 – Counts of Monteggia Fracture-Dislocation by Type, Age, and Sex



Monteggia fracture-dislocations are more common in younger and middle-aged males and middle-aged females, based on counts of injuries. Posterior dislocations of the radial head, or type II, are slightly more common, while anterior and lateral dislocations of the radial head, type I and type III, occur with relatively similar frequency.

Table 5.10c – Age-Specific Incidence Rates – Monteggia Fracture-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.183	0.063 – 0.303
30-39	0.065	0 – 0.139
40-49	0.130	0.026 – 0.234
50-59	0.532	0.263 – 0.801
60-69	0.379	0.152 – 0.606
70-79	0.350	0.007 – 0.693
80+	0.543	0 – 1.158
Total	0.227	0.162 – 0.292

Table 5.10d – Sex-Specific Incidence Rates – Monteggia Fracture-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.215	0.125 – 0.305
Male	0.239	0.143 – 0.335
Total	0.227	0.162 – 0.292

Table 5.10e – Age-Adjusted Overall Incidence Rate – Monteggia Fracture-Dislocations

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.252	0.232 – 0.272

The rate of Monteggia fracture-dislocations is greater in middle and older age groups, however, there is overlapping of the confidence intervals. The rate is similar in females and males (based on overlapping confidence intervals).

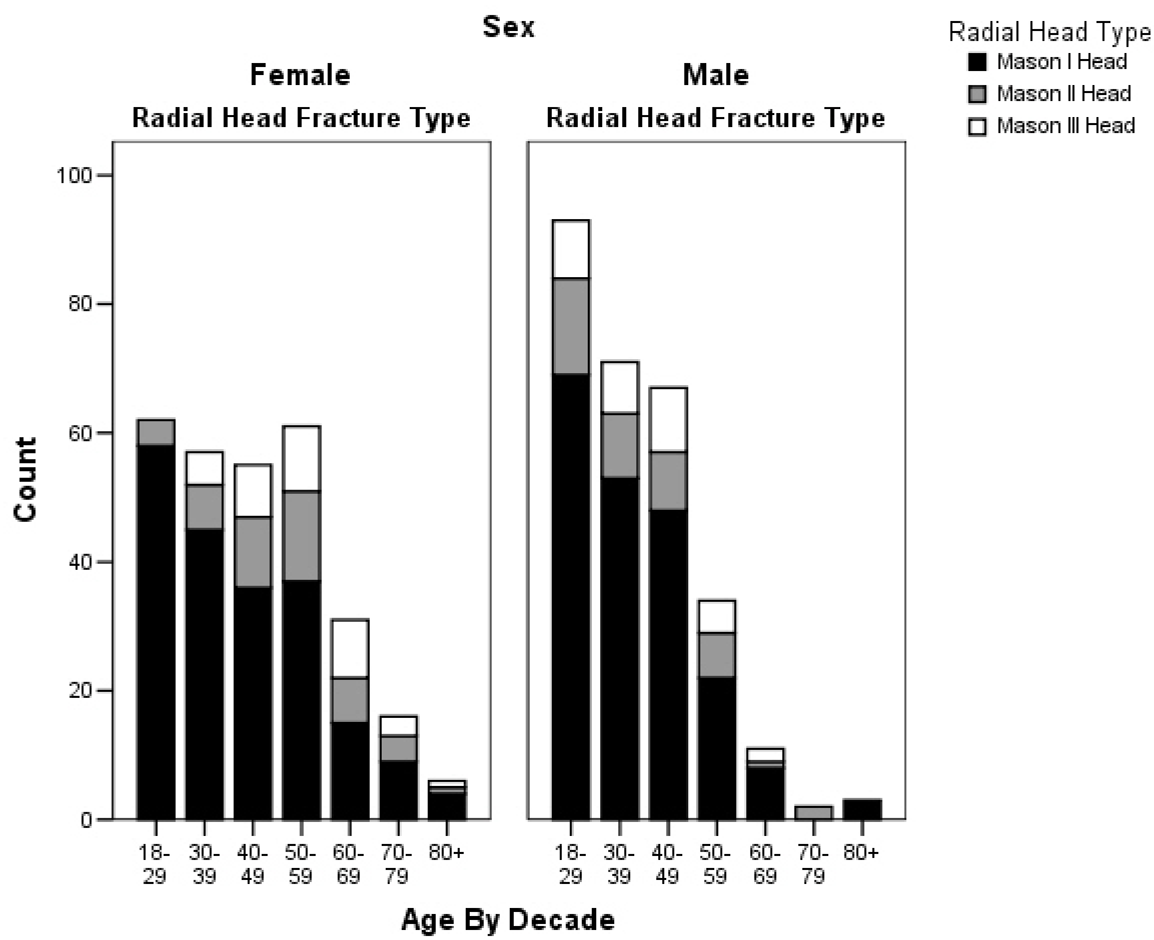
Table 5.11a – Counts of Radial Head Fractures by Age – Hotchkiss Modified Mason Classification

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
I	127	98	84	59	23	9	7	**407**
II	19	17	20	21	8	6	1	**92**
III	9	13	18	15	11	3	1	**70**
Total	155	128	122	95	42	18	9	**569**

Table 5.11b – Counts of Radial Head Fractures by Sex – Hotchkiss Modified Mason Classification

Type	Sex		
	Female	Male	**Total**
I	204	203	**407**
II	48	44	**92**
III	36	34	**70**
Total	288	281	**569**

Figure 5.11 – Counts of Radial Head Fracture by Type, Age, and Sex



Radial head fractures are more common in younger age groups, particularly in younger males. Both males and females show a decreasing trend with increasing age. Type I fractures are the most common type of radial head fractures (all based on counts of injuries).

Table 5.11c – Age-Specific Incidence Rates – Radial Head Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	3.155	2.659 – 3.651
30-39	2.774	2.294 – 3.254
40-49	2.644	2.176 – 3.112
50-59	3.369	2.691 – 4.047
60-69	2.650	1.848 – 3.452
70-79	1.576	0.849 – 2.303
80+	1.630	0.566 – 2.694
Total	2.811	2.580 – 3.042

Table 5.11d – Sex-Specific Incidence Rates – Radial Head Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	2.815	2.490 – 3.140
Male	2.807	2.480 – 3.134
Total	2.811	2.580 – 3.042

Table 5.11e – Age-Adjusted Overall Incidence Rate – Radial Head Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	2.764	2.695 – 2.833

Table 5.11f – Age-Specific Incidence Rates – Radial Head Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	2.585	2.136 – 3.034
30-39	2.124	1.703 – 2.545
40-49	1.820	1.430 – 2.210
50-59	2.092	1.559 – 2.625
60-69	1.451	0.857 – 2.045
70-79	0.788	0.273 – 1.303
80+	1.268	0.329 – 2.207
Total	2.011	1.815 – 2.207

Table 5.11g – Sex-Specific Incidence Rates – Radial Head Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	1.994	1.720 – 2.268
Male	2.028	1.750 – 2.306
Total	2.011	1.815 – 2.207

Table 5.11h – Age-Adjusted Overall Incidence Rate – Radial Head Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	1.937	1.880 – 1.994

The rate of radial head fractures and Mason I radial head fractures is greater in younger and middle age groups. However, there is some overlap of the confidence intervals. The rate is similar in females and males (based on overlapping confidence intervals).

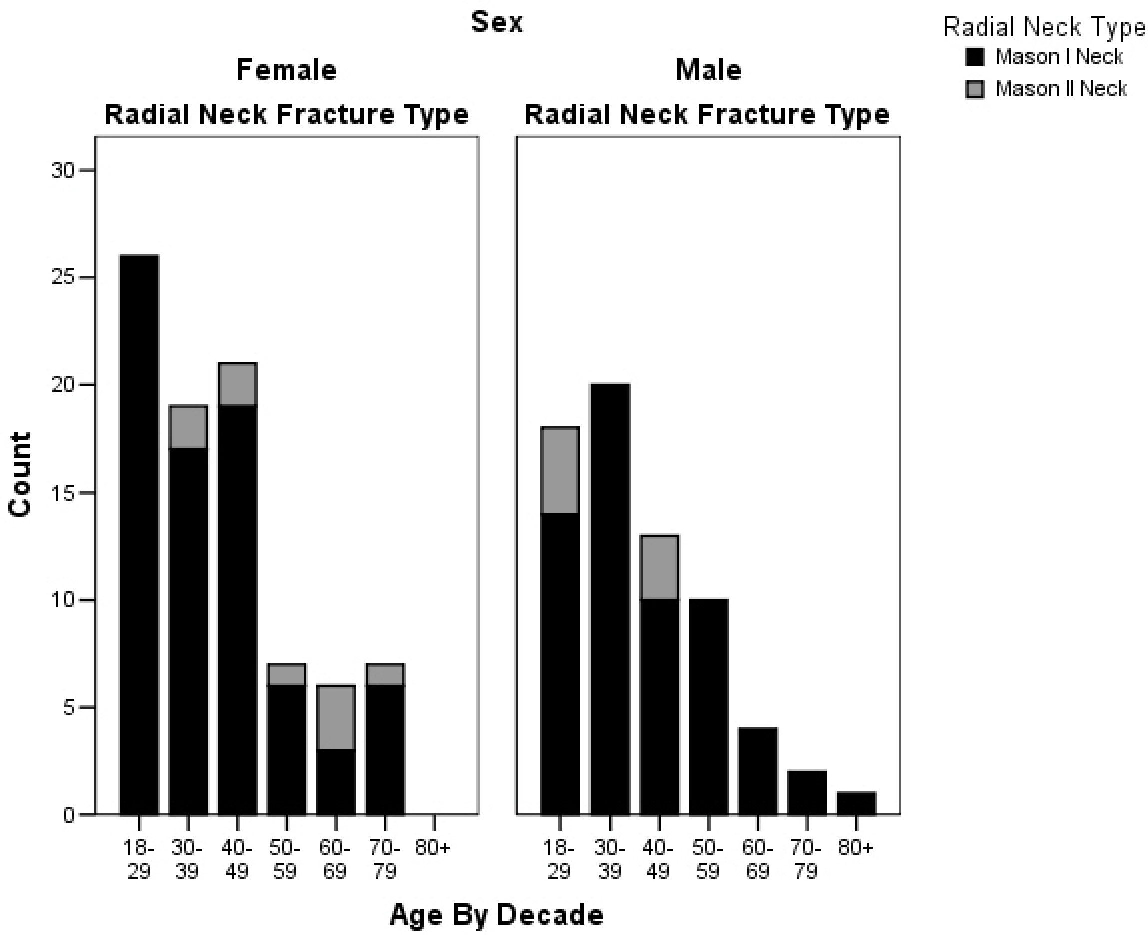
Table 5.12a – Counts of Radial Neck Fractures by Age – Hotchkiss Modified Mason Classification

Type	Age by Decade							
	18-29	30-39	40-49	50-59	60-69	70-79	80+	**Total**
I	40	37	29	16	7	8	1	**138**
II	4	2	5	1	3	1		**16**
III								
Total	44	39	34	17	10	9	1	**154**

Table 5.12b – Counts of Radial Neck Fractures by Sex – Hotchkiss Modified Mason Classification

Type	Sex		
	Female	Male	**Total**
I	77	61	**138**
II	9	7	**16**
III			
Total	86	68	**154**

Figure 5.12 – Counts of Radial Neck Fracture by Type, Age, and Sex



Radial neck fractures are more common in younger age groups, particularly in younger males. Both males and females show a decreasing trend with increasing age. Type I fractures are the most common type of radial neck fractures (all based on counts of injuries).

Table 5.12c – Age-Specific Incidence Rates – Radial Neck Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.896	0.631 – 1.161
30-39	0.845	0.580 – 1.110
40-49	0.737	0.490 – 0.984
50-59	0.603	0.317 – 0.889
60-69	0.631	0.239 – 1.023
70-79	0.788	0.273 – 1.303
80+	0.181	0 – 0.536
Total	0.761	0.641 – 0.881

Table 5.12d – Sex-Specific Incidence Rates – Radial Neck Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.841	0.663 – 1.019
Male	0.679	0.518 – 0.840
Total	0.761	0.641 – 0.881

Table 5.12e – Age-Adjusted Overall Incidence Rate – Radial Neck Fractures

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.740	0.705 – 0.775

Table 5.12f – Age-Specifc Incidence Rates – Radial Neck Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
18-29	0.814	0.561 – 1.067
30-39	0.802	0.543 – 1.061
40-49	0.629	0.400 – 0.858
50-59	0.567	0.289 – 0.845
60-69	0.442	0.115 – 0.769
70-79	0.700	0.214 – 1.186
80+	0.181	0 – 0.536
Total	0.682	0.568 – 0.796

Table 5.12g – Sex-Specific Incidence Rates – Radial Neck Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Female	0.753	0.584 – 0.922
Male	0.609	0.456 – 0.762
Total	0.682	0.568 – 0.796

Table 5.12h – Age-Adjusted Overall Incidence Rate – Radial Neck Fractures (Mason I)

Group	Incidence Rate (per 10000 persons per year)	95% Confidence Interval
Total	0.659	0.626 – 0.692

The rate of radial neck fractures and Mason I radial neck fractures is similar in all age groups with the exception of a lower rate in individuals 80 and older. There is however, overlapping of the confidence intervals. The rate is greater in females than in males, although there is a slight overlap of the confidence intervals.

6. DISCUSSION

6.1 Introduction

The study was successful at identifying counts and rates of elbow injuries in the city of Calgary during a three-year period from April 1, 2002 to March 31, 2005. The study was also successful at identifying the potential sources, and the associated magnitude, of the misclassification bias that may be present in measuring these injuries. In addition, the study was successful at determining the degree to which elbow injuries are miscoded using the ICD 10 coding system within the Calgary Health region.

6.2 Rates of Elbow Injuries

6.2.1 Injury Patterns and Distribution

The pattern of elbow injuries provides interesting information regarding the distribution of the injuries amongst different age and gender groups. This information is valuable in that it offers a foundation upon which further epidemiologic research may be built. An appreciation of the number of injuries that occur, and in whom those injuries occur, allows for a better understanding of the disease process. It also provides the population denominator for the calculation of outcomes and complications of the disease process. Combined, this information may better direct the treatment of such injuries, as further population-based research will allow for the identification of those injuries that do poorly.

6.2.2 Overall Injuries

Although the counts of injuries, which range from a high of 295 in the youngest age group to 81 in the oldest age group, suggest that the frequency of injury is greater in younger individuals, the rate of injuries of approximately 6 per 10000 persons per year in all groups except age 80 and older, indicates that the incidence is fairly evenly distributed amongst all age groups. This is largely explained by the population at risk for injury and the population distribution in the city of Calgary during the period under study (Appendix 11). As would be expected, the number of individuals at risk is lower in the older age groups, particularly in individuals over the age of 60, which range from 52830 (age 60 to 69) to 18400 (age 80 and older). The population at risk in the group age 80 and older is one eighth as large as the population at risk in the age group 40 to 49 in the city of Calgary during the period under study (18400 versus 153805). Taking into account the population distribution and the incidence rates, individuals older than 80 are at greater risk for sustaining a traumatic elbow injury.

The counts of injuries are greater in younger males than in younger females, but reverses in the older age groups (Figure 5.1). This again reflects the distribution of Calgary's population, with a greater number of younger males and a greater number of older females. The incidence rates are slightly greater in females than in males (6.324

per 10000 persons per year versus 5.934 per 10000 persons per year), suggesting that females may be at a slightly greater risk of injury than males. However, there is considerable overlap of the confidence intervals, suggesting that the rates may in fact be quite similar. Standardization of the overall incidence rate to the population of Canada in 2001, results in a slight increase in the overall rate to 6.314 per 10000 persons per year from 6.131 per 10000 persons per year. This is explained by the higher numbers of older individuals in the population of Canada compared to the population of the city of Calgary (Appendix 11).

Clinically, elbow injuries will be seen more frequently in younger individuals specific to the city of Calgary, as the number of younger individuals at risk is much greater than in older individuals. However, the incidence rates would suggest that older age and possibly female sex might be risk factors for such injuries.

6.2.3 Dislocations

The counts of dislocations, which range from a high of 22 in the youngest age group to 3 in the oldest age group, and the associated incidence rates, which gradually decrease from 0.448 per 10000 persons per year in the group age 18 to 29 to 0.086 per 10000 persons per year in the group age 70 to 79, suggest a decreasing occurrence of such injuries with increasing age. With the exception of the group age 80 and older, where the incidence rate climbs to 0.543 per 10000 persons per year, these findings are similar to those of Josefsson et al. in their study in Malmo, Sweden, completed in

1986.[44] They found the greatest incidence of dislocations without fracture in skeletally mature, younger individuals. Intuitively, this would be expected, as an associated fracture would be more likely in those with “weaker” bone. This would apply to children with open growth plates, and older individuals with osteoporosis. The high rate of dislocations in the group age 80 and older (0.543 per 10000 persons per year) may be related to the relatively small size of that group. Three dislocations occurred in this age group during the period under study. With only 18400 individuals, the incidence rate changes considerably if the number of dislocations decreases by 1 (0.362 versus 0.543) or 2 (0.181 versus 0.543). Thus, the small numbers within this age group, as well as the relatively short period of study, may explain the spike in incidence seen in individuals’ age 80 and older.

6.2.4 Fractures

Fractures occur at a similar rate in all age groups, at a rate of about 5 per 10000 persons per year, with exception of the group age 80 and older, where the rate rises to 15.043 per 10000 persons per year. The counts of fractures, which range from 241 to 66 are thus proportional to the percentage of the population in each age group, with the exception of the group age 80 and older. There is a gradual trend toward increasing incidence with increasing age, which is in keeping with the trends seen in most population-based studies on upper extremity fracture incidence, but it is not as dramatic as the rise in rates seen in most studies.[46-51, 53, 55] None of these studies separate fractures of the distal humerus and proximal radius and ulna from the overall total. The trend of increasing fracture incidence with age is observed with fractures of the distal radius, proximal humerus, proximal femur, and vertebrae, which all occur with increasing frequency in older populations.[46-51]

The two population-based studies on distal humerus fractures by Robinson et al. and Rose et al., present somewhat differing trends.[43, 54] The study by Robinson et al., performed in Scotland, found a bimodal distribution of the incidence of distal humerus fractures with a greater incidence in younger and older individuals (12 to 19 and 80+). Additionally, the rates were greater in younger males then younger females and older females than older males.[43] The study by Rose et al., performed in Minnesota, found much less variation in the incidence of fractures of the distal humerus, but did find slightly greater rates in older and younger populations. Rose et al. concluded that there is a minimal increase in distal humerus fracture incidence with increasing age and that the higher incidence among older females are primarily due to proximal humeral fractures.[54] Again, in the present study, the small population in the group age 80 and older (18400) may have had an effect on the higher incidence rate seen in that group.

6.2.5 Fracture-Dislocations

The counts of fracture-dislocations show a larger number of such injuries in younger males and middle-aged females (Figure 5.1). The incidence rates, however, show an increasing incidence of these injuries with increasing age, from a low of 0.390 per 10000 persons per year in the group age 30 to 39 to a high of 1.087 per 10000 persons per year in the group age 80 and older. However, there is overlap of the confidence intervals in almost all age groups. Joseffson et al. did not present the incidence rates by age of fracture-dislocations separate from the incidence rates of all dislocations, and therefore it is difficult to determine if there was an increasing incidence of fracture-dislocations with increasing age in that study.[44] Intuitively, as with dislocations, one would expect more associated fractures with a dislocation in older age groups because of the quality of the bone. Thus, it would be more likely that an older individual would sustain a fracture-dislocation than a dislocation alone.

6.2.6 Dislocations (Desault Classification System)

The counts of injuries and associated incidence rates of dislocations and fracture-dislocations of the ulnohumeral joint classified with the Desault classification system reflect the combined counts and associated incidence rates of the dislocations and fracture-dislocations described above. The bimodal distribution of the incidence rates, with a rate of approximately 9 per 10000 persons per year in the groups age 18 to 29 and age 80 and older, and approximately 6 per 10000 persons per year in all other age groups, reflects the higher rate of dislocations without fracture in younger individuals and the higher rate of fracture-dislocations in older individuals. The distribution of the type of dislocation is similar to the study by Joseffson et al. with the exception of a much greater number of unspecified dislocations in the Swedish study (27 versus 7). Posterior dislocations were by far the most common type, followed by lateral, in both studies.

With the exception of unspecified dislocations, posterior dislocations occurred at a rate of 11.2 to 1 in the study by Joseffson et al and 13.5 to 1 in the present study.[44]

6.2.7 Distal Humerus Fractures

Separating fractures of the distal humerus from the other injuries demonstrates incidence rates more in keeping with the work of Robinson et al. than Rose et al.[43, 54] The incidence rates increase with increasing age in all groups of distal humerus fractures separated by AO group or Jupiter and Mehne group. For the AO classification system, the most dramatic rise in incidence rates occurs in group A, with an increase in the rate from 0.122 per 10000 persons per year in the youngest age group to 2.899 per 10000 persons per year in the oldest age group. Group C follows this, with an increase from 0.163 per 10000 persons per year in the youngest age group to 1.449 per 10000 persons per year in the oldest age group. Group B has the least dramatic rise, with an increase from 0.102 per 10000 persons per year in the youngest age group to 0.906 per 10000 persons per year in the oldest age group.

The greater rise in group A is related to the high number of A2.3 or extraarticular transcondylar distal humerus fractures that occur in older age groups, with a total of 11 in the group age 80 and older and 19 in all individuals older than 60. This fracture subtype, most commonly seen in older females, tends to occur specifically in patients with weaker bone and at lower energy levels than would be required to cause a fracture in younger, healthier bone. The occurrence of this injury subtype in older females also contributes to the higher rate of fractures seen in females than in males. For the Jupiter and Mehne classification system, the most dramatic rise is seen in the extraarticular group, with an increase from 0.122 per 10000 persons per year in the youngest age group to 3.080 per 10000 persons per year in the oldest age group. A similar increase is seen in both the unicondylar group (0.061 per 10000 persons per year in the youngest age group to 0.906 per 10000 persons per year in the oldest age group) and bicondylar/articular surface group (0.204 per 10000 persons per year in the youngest age group to 1.449 per 10000 persons per year in the oldest age group). This is again related to the high number of low unspecified, low flexion, and low extension fractures in older age groups (10 in the group age 80 and older and 19 in individuals older than 60).

6.2.8 Proximal Radius and Ulna Fractures

As with fractures of the distal humerus, there are limited population-based studies on the incidence of fractures of the proximal radius and ulna. Most of the studies do not separate proximal fractures from shaft fractures and distal fractures.[46, 51-53, 55] The study by Baron et al., performed in United States, presented the population-based incidence of fractures of the proximal radius and ulna in patients between the ages of 65 and 89. The authors present the rates based on gender and race (white or black) and do not present overall rates. Because the authors do not provide the population at risk, it is difficult to calculate the combined rate. However, the presented rates of 1.5 to 8.6 per 10000 persons per year compare favorably to the rates of 5.426 to 8.696 per 10000 persons per year in the present study.[50]

Examining the counts and incidence rates of the proximal radius and ulna fractures separated by AO group provides some insight into the frequency of occurrence of these fractures. Group B fractures are by far the most common type, occurring at a rate more than 4 times that of group A fractures and more than 13 times that of group C. Within group A, the incidence rates show a similar rate of occurrence of these fractures in all age groups and in both sexes, with rates that range from 0.715 per 10000 persons per year to 0.963 per 10000 persons per year. The most common type in group A, type A2.2 or fractures of the radial neck, occurs in a bimodal distribution. The rates in the younger and older age groups are closer to 0.8 per 10000 persons per year compared to rates of 0.5 per 10000 persons per year in the middle age groups. However, there is a significant drop-off in rates in the oldest age group (0.181 per 10000 persons per year). This may again be attributable to the small size of this group, where an increase in 1 A2.2 injury would have had a dramatic affect on the incidence rate for this group. In addtion, there is overlap of the confidence intervals, particularly in the older age groups.

Within group B, the incidence rates are similar in all age groups at approximately 4 per 10000 persons per year, with the exception of individuals age 80 and older where the rate almost doubles (7.246 per 10000 persons per year). The two most common types in group B, types B1.1 or unifocal intraarticular fractures of the proximal ulna, and type B2.1 or simple undisplaced and displaced fractures of the radial head, occur in opposite distribution patterns. The incidence rate of B1.1 fractures increases with increasing age, with a 6 times greater rate in the group age 80 and older compared with the younger age groups (6.341 per 10000 persons per year versus 1.018 per 10000 persons per year). The incidence rate of B2.1 fractures decreases with increasing age, with a 2.5 times greater rate in the younger age group than the older age group (2.484 per 10000 persons per year versus 0.906 per 10000 persons per year). The incidence rate patterns for fractures of the proximal radius and ulna, separated by AO group and subgroup, has not previously been described in the literature.

6.2.9 Olecranon Fractures

The counts and associated incidence rates of olecranon fractures demonstrate higher rates in older age groups, with rates ranging from 0.712 per 10000 persons per year in the youngest age group to 6.522 per 10000 persons per year in the oldest age group. Type IIa and IIb, or simple and comminuted fractures of the olecranon without a dislocation of ulnohumeral joint, are the most common types occurring at an average rate of 0.469 per 10000 persons per year and 0.385 per 10000 persons per year respectively. The distribution of these two types is similar, and both occur at an increasing rate with increasing age. The overall incidence rate is in keeping with the overall incidence rate of olecranon fractures presented in a population-based study on the outcomes of olecranon fractures performed in Sweden in 2002. Karlsson et al. found a rate of 1.08 olecranon fractures per 10000 persons per year in all age groups, compared to 1.117 per 10000 persons per year found in the present study.[45]

6.2.10 Coronoid Fractures

Previous work on the incidence of coronoid fractures is lacking, with no population-based studies identified. The counts and associated incidence rates of coronoid fractures show some variation in rates over age groups, with higher rates in the groups age 60 to 69 (1.010 per 10000 persons per year) and 80 and older (1.087 per 10000 persons per year), and lower rates in the group age 70 to 79 (0.438 per 10000 persons per year). The most common type, type I, occurs with a similar rate in all age groups, ranging from 0.438 per 10000 persons per year to 0.715 per 10000 persons per year, suggesting that the other types of coronoid fractures contribute more to the variation seen in the overall rates. Type I coronoid fractures, or tip fractures, represent a shear injury, as there are no capsular attachments at the tip of the coronoid. This would suggest that these injuries may represent either a subluxation or dislocation of the elbow joint, with the distal humerus causing the shear injury of the tip when the episode of instability occurs.[2] Thus the incidence rate of dislocations may be greater based on the inclusion of the majority of coronoid fractures within the category of fracture-dislocations.

6.2.11 Monteggia Fracture-Dislocations

As with coronoid fractures, there are no population-based studies on the incidence of Monteggia fracture-dislocations. The distribution of type of Monteggia fracture-dislocation is variable within the non-population-based studies; with some studies suggesting that type I occurs most frequently, while others suggest that type II is most common.[85-91] None of these studies discuss the age distribution of these injuries. The counts and associated incidence rates in the present study show an increasing rate with increasing age, with a fairly significant rise after age 49 (0.130 per 10000 persons per year in the group age 40 to 49 versus 0.532 per 10000 persons per year in the group age 50 to 59). Type II (posterior) injuries are slightly more common with 18 injuries, followed by type I (anterior) with 13 injuries and type III (lateral) with 11 injuries that occur with a similar frequency.

6.2.12 Radial Head and Neck Fractures

Herbertsson et al., in population-based study performed in Sweden in 2004, found an incidence rate of 2.854 per 10000 persons per year.[42] This compares to a combined rate of 3.493 (2.811 + 0.682) per 10000 persons per year in the present study. The breakdown of those injuries according to the Broberg and Morrey modification of the Mason classification system varied somewhat from the distribution seen in the present study. The Broberg and Morrey modification differs from the Hotchkiss modification in that it also includes type IV, which is an associated dislocation of the radius with the radial head fracture.[110] The ratio of type I to type II to type III injuries in the Swedish study was approximately 13 to 6 to 1, whereas the ratio in the present study was approximately 8 to 1.5 to 1.[42] The greater number of more severe injuries in the present study may be explained in part to an incomplete capture of fractures of the radial head and neck. This will be discussed further in the limitations section.

6.3 Misclassification

The percentage of misclassified cases and missed cases provides an estimate of the potential overestimation and underestimation of the incidence rates based on a review of ICD 10 codes from the Calgary Health Region health records database. In other words, if incidence rates for elbow injuries were estimated based solely on ICD 10 codes, there exists the potential for error related to misclassification of those injuries. In the present study the magnitude of the misclassified cases was measured at 17.2%, while the magnitude of the missed cases was 2.5%. Thus, for elbow injuries and the Calgary Health Region health records database, estimates of injuries based on ICD 10 codes would have more likely resulted in an overestimation of the number of injuries, as the number of misclassified cases greatly outweighed the number of missed cases.

Of the previously performed population-based studies, all three fracture-specific studies reviewed the radiographs of the included cases as part of the study methodology. However, none of the studies comment on the exclusion of misclassified cases. Additionally, all three studies utilize a trauma registry as a means of capturing the cases to be reviewed. None of the studies provide an assessment of the validity of these registries, but rather base the study on the assumption that the database is comprehensive.[42-44]

The population-based studies presenting incidence rates of unclassified fractures were variable in their assessment of the completeness of the capture of cases, the validity of the coding system, and the degree of misclassification of cases. These issues have previously been discussed in section 3.1.2. Only the study by Garraway et al. raised the issue of misclassification of cases. Although the authors sampled 10% of other cases classified as injury or accident as a means of identifying missed fractures, they did not comment of the number of cases identified, and thus did not provide an estimate of the underestimation of injuries that may have existed. None of the studies, including those studies that reviewed radiographs or charts as part of the study methodology, provided a measure of the number of cases misclassified.

6.4 Miscoding

There was a moderate level of agreement between the authors (the reference standard) and the health records department for the ICD 10 code or codes assigned to each case. Previous literature on the accuracy of the ICD 9 coding system identified sources of error at multiple points along the pathway from patient admission to final coding within the health records department. O'Malley et al. suggested that the main error sources along the "patient trajectory" include the amount and quality of information at admission, communication among patients and providers, the clinician's knowledge and experience with the illness, and the clinician's attention to detail, while the main error sources along the "paper trail" include variance in the electronic and written records, coder training and experience, facility quality-control efforts, and unintentional and intentional coder errors, such as misspecification, unbundling, and upcoding.[111] Although similar work has not been done on the ICD 10 coding system, the degree of discordance within the present study would suggest that similar sources of error may exist in the ICD 10 system.

The sources of error were not specifically identified in the present study (section 6.5.3), however certain deficiencies in the coding of elbow injuries were identified. The selection of codes does not correlate well with the comprehensive classification systems for fractures of the distal humerus. Intercondylar and transcondylar fractures do not have individual codes, and were often coded as “supracondylar” by the health records department. This lead to a high degree of miscoding for fractures of that type, as the authors coded these fractures as “other part of lower end”. Although it could be argued that intercondylar and transcondylar fractures are a subtype of the supracondylar fracture, the treatment and outcome of these injuries mandates a clearer definition for coding purposes.

Fractures of the proximal radius and ulna have more clearly defined categories in the ICD 10 coding system. However, there was still a high degree of discordance. This was largely due to codes being incorrectly or incompletely applied to the cases. For fractures of the radial head and neck, the treating physician did not clearly distinguish between these two fracture types in the discharge diagnosis, and used the two fracture types interchangeably. This also applied to fractures of the proximal ulna, with coronoid fractures occasionally being referred to as fractures of the olecranon. This contributed to the miscoding of these types of fractures. Additionally, codes were incompletely applied due to either the treating physician not including each component of the injury or the health records department missing a component of the diagnosis.

Dislocations are well defined in the ICD 10 system, with categories based on the direction of the dislocation. Miscoding resulted from dislocations being categorized as “unspecified” when the direction was clear from either the radiographs or information contained in the chart. In the majority of cases where cases were miscoded as “unspecified”, the direction of the dislocation was not clearly stated in the discharge diagnosis. Thus these cases were placed in the “unspecified” category rather than a more appropriate direction specific category. This lead to discordance between the code applied by the authors (the reference standard) and the code applied by the health records department.

6.5 Limitations

All research endeavors, no matter how well planned and implemented, has specific limitations relating to the collection of data, the methods of analysis, and the interpretation of outcomes. This study has its own set of limitations, which impact the interpretation of the study findings and their potential applications to future research. An assessment of these limitations allows the reader to evaluate the quality of the findings and to potentially develop strategies to ameliorate these limitations in future research.

6.5.1 Denominator Data

The denominator data used for the calculation of injury incidence rates was taken from the 2001 Canadian census, which provides estimates of the overall, age-specific (by decade), and sex-specific population of the city of Calgary in 2001. During the period under study, from 2002 to 2005, there was a change in the population of the city of Calgary, with an increase in the overall population and an increase in certain age ranges (most likely younger age ranges). These changes will be reflected in the estimates from the 2006 Canadian census. For the purposes of this study, the use of the 2001 census data would result in an overestimation of the incidence rates, due to the increase in the population of the city of Calgary during the period under study (2002 to 2005) This would have resulted in an increase in the value of the denominator used in the incidence rate calculations, and thus a decrease in the calculated incidence rate. However, the presentation of the data with the associated 95% confidence intervals provides the reader with a range of possible values for the estimates of the incidence rates and takes into account the uncertainty associated with the use of the 2001 census data as the denominator in the incidence rate calculations.

6.5.2 Data Sources

The use of the Calgary Health Region health records database allowed for the collection of all cases treated with the region's adult acute care hospitals, adult rehabilitation hospitals, and sub-acute treatment facilities. Because of the severity of elbow injuries, and the need for an orthopaedic opinion, the majority of such cases would be seen at one of these sites. There remain, however, a number of reasons why a case may not have been captured by the CHR health records database, and these are discussed in the four following sections. The study did not attempt to estimate the magnitude of cases not captured by the database, and thus it is unclear how these cases would have impacted upon the estimates of the incidence of elbow injuries presented in the study.

6.5.2.1 Primary Care Physician

Following an injury, a patient may choose to seek initial treatment from their primary care physician. The treating physician’s level of comfort with fractures and dislocations of the elbow may determine whether or not that patient is referred for further assessment, and where that further assessment occurs. Injuries such as an uncomplicated elbow dislocation or an undisplaced or minimally displaced fracture may not require a further orthopaedic opinion. These cases would therefore be treated outside of the region’s hospital-based system and would not be captured by the CHR health records database.

6.5.2.2 Orthopaedic Surgeon

The majority of acutely injured patients requiring an orthopaedic opinion are referred to the on-call orthopaedic surgeon at one of the acute care sites within the region. It is at the discretion of the treating surgeon as to where and when the referred patient is assessed and treated. Should that surgeon choose to see and treat that patient in his or her private office, and not at a site within the region, that patient may not enter the hospital-based system for treatment. Thus, this case would also not be captured by the CHR health records database.

6.5.2.3 Workers' Compensation Board

The Workers' Compensation Board covers individuals injured while on the job, and any treatment required for that individual is overseen and paid for by the WCB. The Workers' Compensation Board maintains records for such patients, and access to these records is limited by the privacy regulations of the board. Although most elbow injuries are severe enough to require treatment at one of the acute care sites, a certain percentage of cases would have been assessed and treated at another location. As such, unless a Workers' Compensation Board patient was seen within the region's hospital-based system, such as an emergency department of one of the adult hospitals, this case would not have been captured by the CHR health records database.

6.5.2.4 Cast Clinic Visits

Visits by patients to a cast clinic held by the orthopaedic surgeons at the three adult hospital sites (Foothills Medical Centre, Peter Lougheed Centre, Rockyview General Hospital) are not captured by the Calgary Health Region health records database, as these visits are not coded using the ICD 10 coding system. Thus, any injury that is seen by an orthopaedic surgeon exclusively in the case clinic setting, without also being seen in an additional hospital setting captured by the database would be missed. An example of this would be a fracture referred in by another physician that was not seen in the emergency department and does not require admission for further treatment.

6.5.3 Bias

The credibility of a study's results depends on the plausibility of alternate explanations for the study's findings. Sources of systematic error, or bias, may be introduced at multiple points during the planning and conduct of a study that may affect the validity of the outcomes. The two major types of bias that may exist in the present study include selection bias and misclassification bias.

6.5.3.1 Selection Bias

The potential sources of selection bias in this study include the database from which the cases were initially identified and the additional ICD 10 codes selected to estimate the number of missed cases. The limitations of the Calgary Health Region health records database have been outlined above, however the use of this database alone may have impacted the estimate of the incidence of certain types of elbow injuries included in this study. Injuries treated by a primary care physician, a private practice orthopaedic surgeon, or under the auspices of the Worker's Compensation Board, may not have been included for review. This would have resulted in an underestimation of the actual incidence of some injuries. Because records outside of the CHR health records database cannot be sampled due to privacy and logistical reasons, it is impossible to measure the potential magnitude of this selection bias.

The choice of additional ICD 10 codes was based on the expert opinion of the study authors. The selected codes all applied to the elbow or to the anatomic regions above and below the elbow joint. In addition, the disease processes selected were all acute and traumatic in nature. Thus, the additional codes were the plausible alternatives to the fracture and dislocation codes that could be used for traumatic conditions of the elbow joint. The number of missed cases identified using the additional codes, and the estimate of the underestimation of the incidence rates using this method, is affected by the choice of codes. The use of additional or alternative codes may have resulted in an increase or decrease in the estimate of this underestimation.

6.5.3.2 Misclassification Bias

Classification of the radiographs and chart notes by the authors is the foundation upon which the estimates of the incidence rates are based. The study methodology attempts to identify sources of misclassification that may exist when identifying injuries from a database such as the CHR health records database. However, misclassification may also occur during the authors' classification of the identified injuries. Although both authors can be considered experts in the field under study, the past clinical experience of the authors impacts upon the classification of the injuries based on the radiographs and chart notes. The relatively poor reliability of the classification systems would suggest that a percentage of the classified cases would be open for discussion, and that another set of observers may choose to classify the cases differently.[38, 39] Ultimately, this would lead to a degree of misclassification of the identified cases by the study authors, and would affect the estimated incidence rates. Since a reference standard for the authors was not used, this misclassification cannot be accurately measured.

6.5.4 Miscoded Cases

The percent agreement between the ICD 10 code assigned by the authors and the original ICD 10 code assigned by the health records department was measured to assess the accuracy of this coding system for traumatic elbow injuries. Although the study was successful at measuring the accuracy of this system, it did not determine at what point the miscoding might have occurred. Miscoding may be the result of an incorrect discharge diagnosis with the correct associated code, a correct discharge diagnosis with an incorrect associated code, or both an incorrect discharge diagnosis and an incorrect associated code. Although the measured percent agreement provides an estimate of the degree of miscoding, the study methodology limits the identification of the true source of the miscoding.

6.5.5 External Validity

The generalizability of the results of a study determines the extent to which those results are externally valid. The estimates of the overall incidence rates have been standardized to the 2001 Canadian census for the purpose of increasing the generalizability of the results. However, the methodology of the present study does not examine whether the characteristics of the population of the city of Calgary place that population at a greater or lesser risk for sustaining a traumatic elbow injury. Although there are limited existing population-based studies on the incidence of traumatic elbow injuries, the findings of the present study are in keeping with previously published results (sections 6.2.2 to 6.2.12). This would suggest that the characteristics of the present study population are similar to those of the previously studied populations, at least with regard to traumatic elbow injuries. This would also suggest that these findings could be generalized to other similar populations.

6.6 Applications and Recommendations

6.6.1 Applications

The information presented in this study highlights the relative magnitude of the clinical burden of various dislocations, fractures, and fracture-dislocations of the elbow. This in turn raises many questions about the clinical outcomes of these injuries, and brings greater attentions to those injuries that are more common, such as fractures of the radial head and neck, and fractures of the olecranon. The incidence rates presented provide a population-bases denominator that may be used for future research on outcomes and complications, allowing for a better estimation of the percentages of positive and negative outcomes and of major and minor complications.

In addition to the clinical and research applications, the study highlights the weaknesses of the existing system for classifying, recording, and identifying injuries in a health records database. Although the study is specific to elbow injuries, the degree of misclassification present may be extrapolated to other injury types within the health records database. This should alert researchers, administrators, and policy makers to the potential hazards of decision making based on incidence and prevalence rates generated from an ICD based health records systems. This also leads to certain recommendations outlined in the following section.

6.6.2 Recommendations

Issues raised during the completion of this study have lead to the development of a number of recommendations for researchers, clinicians, administrators, and policy makers. These recommendations relate to the development of a comprehensive classification system for elbow injuries, refinements to the ICD 10 coding system, and the creation of a fracture registry.

6.6.2.1 Comprehensive Elbow Injury Classification

The classification of elbow injuries requires a system that is comprehensive, easy to use, reproducible, and valid. The existing AO and Jupiter and Mehne classification systems are both comprehensive, but both are cumbersome and difficult to remember. In addition, the AO system had been shown to have, at best, moderate reliability in studies performed on its use for upper extremity fractures. The fracture-specific systems are simpler and thus easier to use. Although studies on their reliability are limited, the fewer number of types or categories of injuries would suggest that there reliability may be greater. Future comprehensive systems must strike a balance between the relative simplicity and clinical applicability of the fracture-specific systems, and the completeness of the comprehensive systems.

6.6.2.2 ICD Refinements

The ICD 10 system has built upon previous iterations of the ICD system with the inclusion of a greater number of categories for fractures of the distal humerus and proximal radius and ulna. Most specifically for fractures of the distal humerus, categories for transcondylar, epicondylar, and articular surface fractures should be added to allow for the classification and recording of these injuries correctly within a health records database system. Such refinements, made with the clinical relevance of such injuries in mind, increase the utility, accuracy, and reproducibility of such a system.

6.6.2.3 Fracture Registry

Previous studies on the population-based incidence of elbow injuries highlighted in this research have commented on the use of a fracture registry as a means of collecting data for research purposes. The use of such a registry for total joint arthroplasty is in use in many jurisdictions, including the recent introduction of such a registry in Canada. Such a registry can be an invaluable tool for the evaluation of the incidence and outcomes of multiple clinical problems. The creation and use of such a registry for dislocations and fractures may allow for increased accuracy in the assessment of the burden of disease related to such injuries. It may also allow for the ongoing evaluation of such injuries, including an assessment of positive and negative outcomes and complications. The ongoing development of the electronic medical record in Alberta may allow for the transfer of information from such records into a fracture database specifically designed to record orthopaedic and/or musculoskeletal injuries.

6.6 Conclusions

The present study is the first comprehensive North American population-based study to present the incidence of elbow injuries utilizing expertise-based classification. The counts of injuries classified according to general, comprehensive, and fracture-specific classification systems are presented along with the associated incidence rates and their respective 95% confidence intervals. The overall incidence rates, age-specific incidence rates, and sex-specific incidence rates for the city of Calgary are included and are based on the population from the 2001 Canadian census. The overall rates are standardized to the 2001 Canadian census to increase the generalizability and the external validity of the study results. The study also provides an estimate of the overestimation and underestimation of the incidence of elbow injuries for cases captured from the Calgary Health Region health records database. Finally, the study provides an estimate of the degree of miscoding present in the Calgary Health Region health records database for elbow injuries utilizing the International Classification of Diseases coding system version 10. It is hoped that future investigations will utilize this information to better evaluate the outcomes and complications of the treatment of elbow injuries, and to assist in the understanding of the sources of error and bias for epidemiologic studies of injuries utilizing a health records database.

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Appendix 1 – ICD 10 Codes for Fractures and Dislocations of the Elbow

Fracture of humerus

S42390 – Unspecified, closed
S42391 – Unspecified, open
S42400 – Supracondylar, closed
S42401 – Supracondylar, open
S42410 – Lateral condyle, closed
S41411 – Lateral condyle, open
S42420 – Medial condyle, closed
S42421 – Medial condyle, open
S42430 – Unspecified condyle, closed
S42431 – Unspecified condyle, open
S42480 – Other part of lower end, closed
S42481 – Other part of lower end, open
S42490 – Unspecified part of lower end, closed
S42491 – Unspecified part pf lower end, open

Fracture of radius and ulna

S52000 – Olecranon process of ulna, closed
S52001 – Olecranon process of ulna, open
S52010 – Coronoid process of ulna, closed
S52011 – Coronoid process of ulna, open
S52020 – Monteggia's, closed
S52021 – Monteggia's, open
S52080 – Other/multiple of upper end of ulna, closed
S52081 – Other/multiple of upper end of ulna, open
S52090 – Unspecified upper end of ulna, closed
S52091 – Unspecified upper end of ulna, open
S52100 – Head of radius, closed
S52101 – Head of radius, open
S52110 – Neck of radius, closed
S52111 – Neck of radius, open
S52120 – Radius with ulna, upper end, closed
S52121 – Radius with ulna, upper end, open
S52700 – Multiple fractures of forearm, closed
S52701 – Multiple fractures of forearm, open
S52180 – Other/multiple of upper end of radius, closed
S52181 – Other/multiple of upper end of radius, open
S52190 – Unspecified upper end of radius, closed
S52191 – Unspecified upper end of radius, open

Appendix 1 – ICD 10 Codes for Fractures and Dislocations of the Elbow (Continued)

Dislocation of elbow

S530 – Radial head
S53100 – Anterior, closed
S53101 – Anterior, open
S53110 – Posterior, closed
S53111 – Posterior, open
S53120 – Medial, closed
S53121 – Medial, open
S53130 – Lateral, closed
S53131 – Lateral, open
S53180 – Other, closed
S53181 – Other, open
S53190 – Unspecified, closed
S53191 – Unspecified, open

Appendix 2 – Desault Classification System for Elbow Dislocations

Anterior	proximal radius/ulna are anterior relative to the distal humerus
Posterior	proximal radius/ulna are posterior relative to the distal humerus
Lateral	proximal radius/ulna are lateral relative to the distal humerus
Medial	proximal radius/ulna are medial relative to the distal humerus
Divergent	proximal radius is lateral and proximal ulna is medial relative to the distal humerus (the proximal radioulnar joint becomes disrupted)

Appendix 3 – AO Classification System for Distal Humerus Fractures

A1 Extra-articular fracture, apophyseal avulsion
.1 lateral epicondyle
.2 medial epicondyle, non incarcerated
.3 medial epicondyle, incarcerated

A2 Extra-articular fracture, metaphyseal simple
.1 oblique downwards and inwards
.2 oblique downwards and outwards
.3 transverse

A3 Extra-articular fracture, metaphyseal multifragmentary
.1 with an intact wedge
.2 with a fragmented wedge
.3 complex

B1 Partial articular fracture, lateral sagittal
.1 capitellum
.2 transtrochlear simple
.3 transtrochlear multifragmentary

B2 Partial articular fracture, medial sagittal
.1 transtrochlear simple, through the medial side
.2 transtrochlear simple, through the groove
.3 transtrochlear multifragmentary

B3 Partial articular fracture, frontal
.1 capitellum
.2 trochlea
.3 capitellum and trochlea

C1 Complete articular fracture, articular simple, metaphyseal simple
.1 with slight displacement
.2 with marked displacement
.3 T-shaped epiphyseal

C2 Complete articular fracture, articular simple, metaphyseal multifragmentary
.1 with an intact wedge
.2 with a fragmented wedge
.3 complex

C3 Complete articular fracture, multifragmentary
.1 metaphyseal simple
.2 metaphyseal wedge
.3 metaphyseal complex

Appendix 4 – Jupiter and Mehne Classification System for Distal Humerus Fractures

Extracapsular

Lateral epicondyle
Medial epicondyle

Extraarticular

High unspecified
High extension
High flexion
Low unspecified
Low extension
Low flexion
Abduction
Adduction

Unicondylar intraarticular

Low lateral (Milch I)
High lateral (Milch II)
Low medial (Milch I)
High medial (Milch II)

Bicondylar intraarticular

Lateral lambda
Medial lambda
High T-shaped
Low T-shaped
H-shaped
Y-shaped

Articular surface

Capitellum
Trochlea

Appendix 5 – AO Classification System for Proximal Radius and Ulna Fractures

A1 Extra-articular fracture, radius intact
.1 avulsion of the triceps insertion from the olecranon
.2 metaphyseal simple
.3 metaphyseal multifragmentary

A2 Extra-articular fracture, of the radius, ulna intact
.1 avulsion of the bicipital tuberosity of the radius
.2 neck simple
.3 neck multifragmentary

A3 Extra-articular fracture of both bones
.1 simple of both bones
.2 multifragmentary of one bone and simple of the other
.3 multifragmentary of both bones

B1 Articular fracture, of the ulna, radius intact
.1 unifocal
.2 bifocal simple
.3 bifocal multifragmentary

B2 Articular fracture, of the radius, ulna intact
.1 simple
.2 multifragmentary without depression
.3 multifragmentary with depression

B3 Articular fracture, of the one bone, with extra-articular fracture of the other
.1 ulna, articular simple
.2 radius, articular simple
.3 articular multifragmentary

C1 Articular fracture, of both bones, simple
.1 olecranon and head of radius
.2 coronoid process and head of radius

C2 Articular fracture, of both bones, the one simple and the other multifragmentary
.1 olecranon multifragmentary, radial head simple
.2 olecranon simple, radial head multifragmentary
.3 coronoid process simple, radial head multifragmentary

C3 Articular fracture, of both bones, multifragmentary
.1 three fragments of each bone
.2 ulna, more than three fragments
.3 radius, more than three fragments

Appendix 6 – Mayo Classification System for Olecranon Fractures

Type Ia

Undisplaced
Simple

Type Ib

Undisplaced
Comminuted

Type IIa

Displaced
Simple
Stable

Type IIb

Displaced
Comminuted
Stable

Type IIIa

Displaced
Simple
Unstable

Type IIIb

Displaced
Comminuted
Unstable

Appendix 7 – Regan and Morrey Classification for Coronoid Fractures

Type I

Tip fracture

Type II

Greater than a tip fracture and less than 1/2 of the coronoid

Type III

Greater than 1/2 of the coronoid

Appendix 8 – Bado Classification of Monteggia Fracture Dislocations

Type I

Proximal ulna fracture with associated anterior radial head dislocation

Type II

Proximal ulna fracture with associated posterior radial head dislocation

Type III

Proximal ulna fracture with associated lateral radial head dislocation

Type IV

Proximal third radius and proximal third ulna fracture with associated anterior radial head dislocation

Appendix 9 – Hotchkiss Modification of the Mason Classification System for Radial Head and Neck Fractures

Type I

Less than 2 mm of displacement
Amenable to non-operative treatment

Type II

Greater than 2 mm of displacement
Amenable to open reduction and internal fixation

Type III

Multifragmentary
Not amenable to internal fixation and requiring radial head replacement

Appendix 10 – Additional ICD 10 Codes

Fracture of the humerus and shoulder girdle

S42300 – Shaft of the humerus, closed
S42301 – Shaft of the humerus, open
S42700 – Multiple fractures of clavicle scapula and humerus, closed
S42701 – Multiple fractures of clavicle scapula and humerus, open
S42800 – Other part of shoulder and upper arm, closed
S42801 – Other part of shoulder and upper arm, open

Fracture of the radius and ulna

S52200 – Shaft of ulna, closed
S52201 – Shaft of ulna, open
S52300 – Shaft of radius, closed
S52301 – Shaft of radius, open
S52400 – Shaft of radius and ulna, closed
S52401 – Shaft of radius and ulna, open
S52700 – Multiple fractures of forearm, closed
S52701 – Multiple fractures of forearm, open
S52800 – Other parts of forearm, closed
S52801 – Other parts of forearm, open
S52900 – Unspecified forearm, closed
S52901 – Unspecified forearm, open

Crushing Injuries

S473 – Crushing injury of upper arm
S477 – Crushing injury of multiple sites of shoulder and upper arm
S478 – Crushing injury of other specified part of shoulder and upper arm
S570 – Crushing injury of elbow
S578 – Crushing injury of other parts of forearm
S579 – crushing injury of forearm part not specified

Traumatic Amputation

S481 – Traumatic amputation level between shoulder and elbow
S489 – Traumatic amputation shoulder and upper arm level not specified
S580 – Traumatic amputation at elbow joint
S581 – Traumatic amputation level between elbow and wrist
S589 – Traumatic amputation forearm level not specified

Contusions

S500 – Contusion of elbow
S501 – Contusion of other/unspecified parts of forearm

Superficial Injuries

S507 – Multiple superficial injuries of forearm
S508 – Other superficial injuries of forearm
S509 – Superficial injury of forearm not specified

Open Wounds

S5100 – Open wound of elbow, uncomplicated
S5101 – Open wound of elbow, complicated
S5170 – Open wound of elbow, multiple uncomplicated
S5171 – Open wound of elbow, multiple complicated
S5180 – Open wound of other part of forearm, uncomplicated
S5181 – Open wound of other part of forearm, complicated
S5190 – Open wound of forearm, part unspecified, uncomplicated
S5191 – Open wound of forearm, part unspecified, complicated

Multiple Injuries

S497 – Multiple injuries of shoulder and upper arm
S498 – Other specified injuries of shoulder and upper arm
S499 – Unspecified injuries of shoulder and upper arm
S597 – Multiple injuries of forearm
S598 – Other specified injuries of forearm
S599 – Unspecified injury of forearm

Sprains and Strains

S532 – Traumatic rupture radial collateral ligament
S533 – Traumatic rupture ulnar collateral ligament
S5340 – Sprain and strain of radial collateral ligament
S5341 – Sprain and strain of ulnar collateral ligament
S5342 – Sprain and strain of radiohumeral joint
S5343 – Sprain and strain of ulnohumeral joint
S5348 – Other sprain and strain of elbow
S5349 – Unspecified sprain and strain of elbow

Appendix 11 – Population at Risk (2001 Canadian Census)

City of Calgary

	Female	**Male**	**Total**
18 to 29	80810	82935	163745
30 to 39	76280	77550	153830
40 to 49	76190	77615	153805
50 to 59	46675	47330	94005
60 to 69	27365	25465	52830
70 to 79	21545	16535	38080
80 +	12165	6235	18400
Total	341030	333665	674695

Canada

	Female	**Male**	**Total**
18 to 29	2334265	2332470	4666735
30 to 39	2343350	2276250	4619600
40 to 49	2489415	2422880	4912295
50 to 59	1857430	1822570	3680000
60 to 69	1242010	1165400	2407410
70 to 79	1022280	800600	1822880
80 +	613820	318225	932045
Total	11902570	11138395	230400965