Outcomes of Hip Fractures at Teaching Hospitals Versus Non-Teaching Hospitals

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ABSTRACT

Hip fractures in adults are associated with a large burden of suffering in the United States and are a major focus of various advocacy groups, professional organizations and government agencies. Strategies for prevention of hip fractures include primary prevention of osteoporosis, secondary prevention of fractures in patients with asymptomatic osteoporosis, tertiary prevention of complications in patients with hip fractures, and quarternary prevention of long-term disability from hip fracture. As a tertiary prevention option, surgery to repair a hip fracture has many benefits but is still associated with negative outcomes. This research establishes the evidence base and proposes a secondary analysis for determining whether patients treated for hip fracture at teaching hospitals experience fewer negative outcomes than do patients treated at non-teaching hospitals. A systematic review of the literature does not permit the drawing of firm conclusions about teaching hospital status, but a secondary analysis of data from the Nationwide Inpatient Sample (NIS) database could advance our understanding of the context of hip fracture outcomes. A study sample, based on patients with ICD-9 diagnosis codes for hip fracture, can be drawn from admissions represented in the NIS database, and outcomes including rates of mortality, rates of various postoperative complications, lengths of stay, cost, and discharge dispositions can be correlated with forms of treatment and teaching hospital status.

TABLE OF CONTENTS

Introduction and Background

Hip fractures in adults are associated with a large burden of suffering in the United States and are a major focus of various advocacy groups, professional organizations and government agencies. Each of the two main mechanisms for the fracture of any bone is associated with different risk factors, strategies for prevention, and treatment options. Therefore, any attempt to describe treatment and prevention of hip fracture in adults should account for the differences in pathogenesis in order to tailor research or interventions toward one or the other.

First are the fractures occurring as a result of high energy trauma, such as those happening during a motor vehicle collision. Individuals at greatest risk for high energy trauma tend to be younger, more active, and male. The second important cause of fractures in adults is associated with bone fragility, such that even a low-energy mechanism of trauma, like a fall from the same level, causes a fracture. Bone fragility is attributable to diseases that increase the rate of bone resorption in comparison to bone creation, such that bone is made weaker over time. Although many diseases are capable of weakening bone, such as chronic renal disease and Paget's disease, an overwhelming majority of fragility fractures of the hip are linked to osteoporosis.[21]

Burden of Suffering – the population perspective

A report by the Surgeon General in 2004 estimated that 10 million people in the United States, aged 50 and older have osteoporosis of the hip. Three times that number of people in the same population have osteopenia of the hip, putting them at increased risk for developing osteoporosis. Individuals at greatest risk for developing osteoporosis are postmenopausal white women, with a lifetime prevalence of 35 percent. However, the risk of osteoporosis and the burden of disease affects both men and women of all racial backgrounds and is expected to increase as the population ages. In fact, the report estimates that 1 out of every 2 patients over the age of 50 will get, or be at risk for, osteoporosis of the hip.[21]

The cost of providing care to patients with osteoporotic fractures is concomitant with the estimate of lifetime prevalence: today, we spend approximately $17 billion on the problem each year in the United States, and the annual cost is expected to approach $50 billion dollars by the year 2040.[22, 23] Average total charges in 2003 (in U.S. dollars) for a hip fracture hospitalization were $28,200 for women and $32,200 for men. These charges, however, do not reflect the cost associated with care provided at skilled nursing facilities or other post-hospital continuing care centers.[24]

Burden of suffering – the patient perspective

Of the 1.5 million osteoporotic fractures occurring in the United States each year, almost 300,000 are hip fractures. Of the three major sites for fragility fracture (hip, spine and forearm), those that occur in the hip are associated with the greatest morbidity and mortality.[21] Thirty-day mortality has been estimated at 10 percent. Twenty to 30 percent of patients die within one year after having surgery for a fractured hip.[25]

A study of mortality after orthopedic surgery found an overall in-hospital mortality rate of 0.9 percent with half of the deaths occurring after surgery for hip fracture. Compared to other patients having orthopedic surgery, patients with hip fractures had a much higher rate of dying in the hospital (OR=5.80, 95% CI=4.70-7.00). This odds ratio was from a univariate analysis, so that confounding by age and presence of co-morbidities may have overestimated the actual risk of mortality due solely to hip fracture.[26] However, there is no debate that hip fracture itself places patients at increased risk for morbidity and mortality.

During hospitalization for hip fracture, patients are at increased risk for complications such as delirium, pneumonia, urinary tract infections and pressure sores, as well as complications resulting from surgery such as wound infections and complications of anesthesia.[27, 28] An often overlooked problem after having a broken hip is the fear of falling and having another fracture, fear that can reach the point that even patients who have the physical capacity to do so do not resume their usual pre-fracture activities,.[27, 28]

After discharge, hip fracture patients often require temporary or permanent care in post-hospital care facilities. Continuing institutional care (CIC) centers, including skilled nursing facilities, are playing an increasingly large part in the treatment of these patients. In just one decade (1993 to 2003) the percentage of patients transferred to CIC following hospital admission for hip fracture increased substantially, from 72.4 to 84.6 percent of all women and from 67.1 to 79.3 percent of all men.[24]

Prevention and Treatment of Hip Fractures

Several strategies prevent hip fractures. Primary prevention strategies involve prevention of osteoporosis through vitamin D and calcium supplementation as well as weight-bearing exercise. Secondary prevention involves identifying and treating patients in the asymptomatic stage. People at risk, especially postmenopausal women aged 65 years and over, are screened for osteoporosis with dual-energy x-ray absorptiometry (DXA). Patients with osteoporosis and osteopenia of the hip identified by screening are often treated with bisphonates, vitamin D and calcium in order to increase bone mass.[1] Tertiary prevention in patients with hip fractures involves decreasing the rate and impact of associated complications, and strategies at this stage are mainly surgical. Depending on the type of fracture, surgery typically encompasses either internal fixation or hemiarthroplasty.[2] The benefit of internal fixation and hemiarthroplasty over non-operative treatments is that patients begin weight-bearing almost immediately after surgery, thus strengthening the damaged bone, encouraging healing, and preventing some of the complications of bed rest, such as urinary tract infections, decubitus ulcers, delirium, and pneumonia. Following treatment, quarternary prevention includes strategies to rehabilitate, restore function, prevent new falls, and protect the hip from future damage.[29]

Despite the benefits of surgery, many complications can result from hip fracture repair. Negative outcomes can often be attributed to the risks associated with hospitalization, bed rest, surgery, anesthesia, advanced age, and pre-existing medical conditions. Even in patients who are mobilized on postoperative day one, bed rest is not completely avoidable, as patients often must wait until co-morbidities are assessed and treated before they can undergo surgery. Surgery itself can lead to complications including bleeding, wound infection, deep vein thrombosis, pulmonary embolism, failure of implanted devices, and even death.

Given the fact that health care costs for treating osteoporotic fractures are projected to soar in the future, and that acute complications of hip fractures lead to an increased cost of care, it is important to find ways to reduce such complications. Analysis of negative outcomes can suggest interventions to reduce complications and attempt to reduce costs. Thus far, many studies of negative outcomes have looked at how provider and hospital characteristics influence outcomes. Characteristics that may affect outcomes for various diseases and surgical procedures include hospital volume of hip fractures, provider volume of surgical procedures performed, hospital bed size, and the hospital's teaching status.[3-19]

The Role of Teaching Hospitals

Teaching hospitals occupy a unique and important niche in the American health care system. As the name implies, these hospitals are responsible for the training and professional development of physicians, nurses, pharmacists and other health care professionals. Consequently, teaching hospitals are often on the cutting edge in terms of research and use of newer and experimental technologies. In addition, these hospitals often provide specialized services not available at other facilities, such as burn care and bone marrow transplantation, and act as a "safety net" for patients who may not otherwise be able to obtain care.[4, 30]

Several different classification systems delineate the difference between a teaching hospital and a non-teaching hospital, a distinction that is especially important for policymakers who are responsible for determining reimbursement rates. Reimbursement rates for teaching hospitals are often different than those for non-teaching hospitals, especially reimbursement rates for Medicare and Medicaid patients, who comprise a large percentage of those served by teaching hospitals. For purposes of this paper, a teaching hospital is one that fulfils the AHA criteria of having an American Medical Association-approved residency program or it is a member of the Council of Teaching Hospitals (COTH).[31]

Teaching hospitals are associated with higher costs of care, a factor that may be undesirable to managed care organizations. Of the major safety net hospitals in the U.S. (those hospitals that provide higher rates of charity care and underwrite greater amounts of "bad debt"), 82 percent are teaching hospitals. Furthermore, academic medical centers (AMCs) – those teaching hospitals with a medical school, hospital, outpatient centers, and faculty practice plan, which only make up 2 percent of the total hospital population, provide 23 percent of the $28.1 billion of uncompensated care. These reasons all contribute to the higher cost of care at teaching hospitals and the even higher cost of care at the subset of teaching hospitals that are also AMCs.[30] The care of underserved populations is increasingly falling on AMCs.[32]

Like most hospitals, teaching hospitals rely heavily on the income generated by provision of routine services. Historically, the higher charges paid by private payers and the U.S. government for provision of these services helped subsidize the academic and charitable missions of teaching hospitals. Teaching hospitals could claim that higher charges are a result of the better quality of care provided, a claim indirectly supported by public opinion surveys that frequently rank teaching hospitals higher than non-teaching hospitals.[4]

It is not clear that these claims of superior care are actually supported by the data. One author has proposed that teaching hospitals are less likely to provide proper care during the treatment of common afflictions because of the increased involvement of inexperienced trainees and the decreased involvement of senior attending physicians.[4] Hip fractures are not uncommon, and procedures to repair these fractures are performed at various types of hospitals throughout the U.S. Given the fact that charges for hip fracture hospitalizations have been rising and are projected to continue rising, it is important to determine whether teaching hospitals can justify their higher costs.

It is the purpose of this paper to test the hypothesis that patients treated for hip fracture at teaching hospitals have fewer negative outcomes than do patients treated at non-teaching hospitals. To do this, I will review the current literature on care provided by teaching hospitals versus non-teaching hospitals in cases of hip fracture. I will then propose a study design, using the Nationwide Inpatient Sample (NIS) database, to test the teaching hospital hypothesis (see pp 18-20 below for a detailed description of the data and analysis, and Table 7 for descriptions and definitions of the variables I can identify in the data).

Systematic Review

I performed a systematic review of the literature to determine whether previous studies appear to support or refute the hypothesis that patients admitted to teaching hospitals for hip fractures experience better outcomes, such as lower rates of in-hospital mortality, decreased length of stay (LOS), lower overall costs as measured by edited charges for hospitalizations, and fewer postoperative complications such as infection or decupitus ulcers.

Study Selection

I began by querying the list of all published studies using the Nationwide Inpatient Sample (NIS) database, which is provided on the Health Care Utilization Project (HCUP) website of the Agency for Healthcare Research and Quality (AHRQ).[33] After copying all of the citations from the list of publications into Microsoft Word, I employed the software's "Find" function to search individually through the titles of the 458 citations for the terms *teaching*, *academic*, *fracture*, and *hip*. I also skimmed through these citations looking for publications that appeared to be related to AMCs, including the terms *hospital characteristics*, *hospital factors*, and *medical school-affiliated hospitals*. This technique produced a total of 32 studies for further review.

Next, I searched PubMed. To find publications related to the NIS database that may not have been included on the HCUP website, I queried the PubMed database using the search term *Nationwide Inpatient Sample*, limiting the results to human studies and English articles. This search yielded 270 studies for further review.

Finally, I searched PubMed for articles associated with outcomes of health care obtained in teaching hospitals. Limiting my results to human studies, English publications, clinical trials, meta-analyses, randomized control trials, and review articles, I combined search terms related to quality with search terms related to hospital type using the Boolean operator *AND*. I combined the related search terms within each subject group using the Boolean operator *OR*. The appearance of the final query was (*outcomes* OR *mortality* OR *morbidity* OR *complications* OR *quality*) AND (*hospital type* OR *hospital characteristics* OR *teaching status*). This algorithm returned 141 studies for further review.

I evaluated the abstracts of these 443 studies produced by all three search strategies to determine if they met the criteria of describing the outcomes of health care in a particular group of patients, and using the hospital's teaching status as a major variable of interest. If I read an abstract and could not tell if these themes were explored, I skimmed the full-length article to determine if the study should be included or excluded for review.

Many of the 443 total studies described differences in outcomes for different types of hospitals. The majority of the studies involved a description of how varying levels in the volume of procedures performed either by surgeons or by hospitals influenced outcomes in patients having that procedure. Other hospital characteristics studied extensively included the hospital region (Northeast, Midwest, South or West) and type of ownership (public or private). Only 17 of the 443 articles described differences in outcomes for teaching versus non-teaching hospitals.

Fifteen of the 17 studies were secondary analyses of observational data, and I assessed these for content and quality. The other two studies were systematic reviews; I compare their results with my results in the Discussion section of this paper (see pp. 22-24 below). None of the studies assessed differences in outcomes in patients with hip fractures. Therefore, any assessment of differences in outcomes between teaching hospitals and non-teaching hospitals int this literature can be discussed only for other procedures, but this discussion may suggest variables for analysis of hip fracture outcomes in the NIS database. In the pages to follow, I discuss the results of this review of the literature of outcomes in teaching hospitals and non-teaching hospitals for a variety of diagnoses other than hip fractures.

Assessing the quality of literature

I reviewed the 15 secondary analyses of observational data and abstracted information about each study using a uniform method. The abstraction results, presented in Table 1 (pp. 26-31 below), include the type of study design, study source population, study population, measurements used, significant results, and the study's strengths and weaknesses. Many of the studies contained similar strengths and weaknesses, and these are synthesized in Table 2 (p 31 below). After I completed data abstraction, I reviewed each study using AHRQ's recommendations for assessing the quality of observational studies.[34] I assigned ratings within each of the AHRQ evidence quality categories using a 0 to 3 scale (0=poor, 1=fair, 2=good, and 3=excellent), and I concluded by totaling the category scores for a final evidence quality score (see Table 3, p. 33 below).

Study question. I reviewed each study for clarity, focus, and appropriateness of its study question,[34] and gave all but four of the studies ratings of "excellent" in this category. I gave an "excellent" rating to studies that appropriatly narrowed the study question and identified a specific population, intervention, comparison and outcome.[3, 5-8, 10, 13, 19, 35-37] Studies that did not receive this rating had questions that were too broad or that could not be answered using the methods described within the study.[9, 38-40]

Study population. According to AHRQ, study populations in observational studies should be adequately described with sample size justification.[34] The populations from which researchers drew samples were well-described in twelve of the fifteen studies and earned ratings of "excellent." What these studies had in common was that each used a large administrative database (Kids' Inpatient Database or NIS) from which to draw samples. Documentation about Kids' Inpatient Database (KID) and NIS is easily found online, and most papers using such a database simply paraphrase the sponsor's documentation for each database when describing the study population.[3, 5-10, 13, 38-40] Romano et al only received a "good" rating in this category for not providing an estimate for the number of admissions upon which the source population was based.[38] Thornlow and Stukenborg also only received a "good" rating for not justifying the sample size, though like most studies they provided a complete description of the NIS .[19] Knapp received the lowest score in the group for doing only a fair job at describing the population of patients that make up the "Hospital Compare" data set.[35]

Comparability of subjects. Comparability of subjects in observational studies should be based on explicit inclusion and exclusion criteria; similarity of groups at baseline; and similarity of the study population to the source population.[34] One of the benefits of using the NIS is that it allows for the study of health care in the United States across various hospitals, regions, payers, providers, and diseases. Therefore, the study population drawn from the NIS is comparable to the entire United States population. The NIS also allows for explicit inclusion and exclusion criteria to be applied in most cases. Many studies earned "excellent" ratings in this category because they benefited from the attributes of generalizability and comparability of the NIS.[3, 10, 13, 19, 39, 40] I assumed that if a study did not specify exclusion criteria, the study did not use any.

Two studies received only "good" ratings for failing to provide clear justification for the chosen exclusion criteria.[36, 38] Differences in coding for variables within the NIS or KID databases limited comparability of subjects leading to potential confounding in three studies and ratings of only "fair" in this category.[5, 6, 9] One study was unable to include patients having procedures performed at outpatient surgery centers, thus limiting comparability to the target population.[7] Another study was unable to group patients according to type of gastric bypass surgery performed (open versus laparoscopic), which may be a confounding factor in the analysis of the effect of teaching hospital status on patient outcomes.[8] These two studies were also given ratings of "fair."

The two papers with poor comparability between groups and between the source study populations were by Rutledge and Knapp. Rutledge did not compare the group of patients admitted to Medical School-Associated Hospitals (MSAHs) with the group admitted to non-MSAHs.[37] Knapp provided absolutely no description of baseline characteristics between groups; nor did this study specify inclusion or exclusion criteria.[35]

Exposure or intervention. For a study to receive a rating of "excellent," it had to define the exposure or intervention in question clearly; measure the exposure in a standard, valid and reliable way; and be measured equally across study groups.[34] All studies except for one were rated as "excellent" in this category because the NIS and KID databases reliably and clearly define teaching versus non-teaching hospitals across admissions.[3, 5-10, 13, 19, 36, 38-40] Knapp distinguished between teaching and non-teaching hospitals in a different, but still reliable and valid manner.[36] The only study to receive a "poor" rating in this category did not describe how MSAH and non-MSAH were defined, and how these were measured using the NIS database.[37]

Outcome measurement. Outcomes, the point of the studies, require particularly careful definition. AHRQ says that excellent observational studies should clearly define outcomes; blind assessors to exposure status; and use a validated, reliable standard for assessing outcome.[34] Because these were secondary analyses, none of the studies could address blinding . All of the studies relied on de-identified administrative data containing elements related to both exposure and outcomes, both of which had already been measured and coded prior to being analyzed by researchers. It is doubtful that researchers changed the already-coded data to yield results more or less favorable results in regards to outcomes at teaching hospitals.

As for clearly defining primary and secondary outcomes *a priori* and using a standard method in assessing outcomes, most studies excelled. No studies earned "fair" or "poor" ratings in this part of the analysis. However, one clear distinction led to studies being labeled either "good" or "excellent." All of the studies in this review tried to measure quality of care at teaching versus non-teaching hospitals based on either outcome measures or process measures of quality. Though it is hotly debated in the literature, it seems that process measures of quality are regarded as the more valid of the two types of quality measures. [4, 11, 41] For this reason, I only gave top ratings to studies that used validated process measures of quality. Of the studies, five met this criterion.[10, 13, 19, 35, 36] One study used a process measure of quality that has not been validated so it received only a "good" rating.[40]

The nine studies that relied on outcome measures, as opposed to process measures, as surrogate markers for quality varied in the number and types of measures employed. The most common measures were in-hospital mortality, length of stay, and charges for a given admission.[3, 5-10, 37-39]

Statistical analysis and reporting of data. Observational studies are subject to bias and so a good observational study requires the use of appropriate statistical tests as well as assessment of confounding and application of multivariate logistic regression analysis such that the results report an appropriate measure of effect and statistical precision.[34] Only three out of the fifteen studies employed these criteria and were rated "excellent."[3, 10, 13] The paper by Knapp was the only one not to address confounding. In fact, Knapp received the "poor" rating for not describing how any of the results presented in the paper were derived.[35] Another study, by Romano et al., received the same rating for not describing the numerator and denominators used in frequency calculations.[37]

Two studies received "fair" ratings for performing appropriate analyses and adjusting for confounding, but not reporting levels of significance.[9, 38] Of the eight studies that received "good" ratings, six received this rating for not providing appropriate measure of risk of having an outcome based on the exposure.[7, 8, 19, 37, 39, 40] The other two studies also met all of the criteria specified by AHRQ, but in one case researchers were unable to account for potential selection bias due to limitations of the NIS dataset.[5] In the other case, researchers provided two different analyses arriving at different results but only one method of analysis was specified *a priori*.[6]

Conclusions. Of all the papers reviewed, none of the authors made erroneous conclusions that were not supported by the data or failed to account for potential biases and limitations. Nevertheless, all of the studies were based on observational data extracted from administrative databases leading to limitations in choosing the most appropriate measures of quality of care and leading to potentially-biased results. Unfortunately, it is nearly impossible to account for every potential confounder in an observational study because some confounding factors have yet to be elucidated. It is for this reason that I could not rate any of the studies as "excellent." By its very nature, an observational study is subject to biases that are less likely to be present in well-designed randomized control trials. However, I did grant each of the studies a "good" rating for doing the best job possible given the limitations imposed by the data and discussing these limitations in detail.

Results of the systematic review

The main difficulty I encountered when rating and comparing results of each study was that the studies used a variety of proxy measures for quality of care provided at teaching versus non-teaching hospitals. Furthermore, the inclusion and exclusion criteria were very different across studies. Therefore, we can only rely on the trends suggested by the evidence and cannot, for example, compare results for, for example, actual charges, lengths of stay, or in-hospital mortality rates.

Charges. Three studies compared charges for specific procedures between teaching hospitals and non-teachings hospitals. After controlling for case severity and inflation, only two of the three studies found a significant difference between charges based on teaching status. The study by Cosper and colleagues found no significant difference ($p>0.05$) between the charges at teaching hospitals and non-teaching hospitals, though for two out of the three procedures they studied there seemed to be a trend towards greater charges at the teaching hospitals.[9] The two studies with significant results ($p<0.0001$), however, reported opposite findings - one study finding higher charges for cholecystectomies and the other finding lower charges for gastric bypass at teaching hospitals (see Figure 1).[7, 8]

Length of stay (LOS). All but one of the four studies that compared the LOS at teaching versus non-teaching hospitals compared actual LOS (after accounting for transfers to other hospitals).[7-9] One study used prolonged LOS (PLOS), defined as LOS greater than the 75th percentile for the particular procedures across all hospitals, but did not find a significant difference in PLOS according to teaching status.[10] Two of the studies reported a statistically significant increase in LOS for cholecystectomies and gastric bypasses performed at teaching hospitals ($p<0.0001$). Another study that compared actual LOS for different procedures found different results for each procedure and did not provide an estimate of significance.[9] Figure 2 is a bar graph of these three studies, with the statistically significant shown to the left.

In-hospital mortality. Based on the information that I gathered in this review, it is difficult to say for certain whether patients treated at teaching hospitals experience better or worse outcomes than do those treated at non-teaching hospitals. Six of the 15 studies I reviewed presented mortality risk according to the hospital's teaching status. These six studies estimated the risk for nine groups of patients undergoing treatment and the results were varied (see Table 4). Except where noted, each of the odds ratios is adjusted for case severity and only the items in bold are statistically significant.

Patients treated for head and neck cancer (HNC) and hypoplastic left heart syndrome (HLHS) were more likely to die during admissions at non-teaching hospitals.[3, 6] However, in cases of trauma and stroke for which thrombolytics were not used, patients were more likely to die at a teaching hospital.[5, 38] Relationships between in-hospital mortality and teaching status for hepatic, pancreatic and esophageal resection was slightly confusing. The greater risk of in-hospital mortality at teaching hospitals following hepatic resection lost statistical significance after controlling for the volume of such procedures performed at the hospital and severity of the case. Pancreatic resections were associated with a statistically significant higher risk of inpatient mortality after controlling for severity but not after controlling for procedural volume. Only the severity adjusted odds ratio was statistically significant for esophageal resections.[10]

Complications and morbidity. Few of the authors found significantly different complication rates and post-operative morbidity between teaching and non-teaching hospitals. Using AHRQ's Patient Safety Indicators, Duggirala et al attempted to compare the rates of certain postoperative events based on teaching status but found conflicting results. Their multivariate analysis revealed that patients at "major teaching hospitals," a term which was poorly defined, were more likely to experience venous thromboses, pulmonary embolism and pneumonia than those at non-teaching hospitals. Patients treated at "other teaching hospitals" (also poorly defined) were more likely to experience venous thromboses, pulmonary embolism, urinary tract infections, and pulmonary compromise.[13] Other attempts to compare quality of care across differing hospitals found that patients at teaching hospitals were at a higher risk of receiving potentially ineffective care, but lower risk of receiving potentially unnecessary care.[38]

Generalizability of results and future studies.

The generalizability of these study results to the target population, patients admitted to hospitals in the United States, can be summarized as fair to good. Factors that favor generalizability of results are that the majority of studies drew samples from large, representative source populations and that most studies specified reasonable inclusion and exclusion criteria. Limitations to generalizability are mainly based on the potential for bias that exists as a result of observational study designs as well as the wide variability in results, as discussed above.

Variability may be attributable to the fact that each study in the systematic review examined a different health condition or procedure. For example, the lower risk of in-hospital mortality following Stage I palliation for HLHS could be a function of services that are more widely available at teaching hospitals, including pediatric intensive care and greater accessibility to specialists.[6] Whereas non-thrombolytic treatment for acute ischemic stroke may not require the availability of a broad variety of specialists or as intensive care, reducing the risk of inpatient mortality at non-teaching hospitals.[5]

Overall, a few conclusions can be drawn from this systematic review. Future studies are needed to further explore the relationship between quality of care provided at teaching and non-teaching hospitals. As the gold standard for testing hypotheses, randomized control trials may be an option for assessing quality differences, although ethical issues regarding randomizing patients might arise, especially for emergent or urgent admissions. Even if randomization were performed only in elective cases, blinding patients and providers would be nearly impossible. For these reasons, and for reasons of practicality, I have designed a study using the NIS database to examine differences in outcomes of hip fracture for patients admitted to teaching versus non-teaching hospitals.

METHODS

Design

The purpose of this study was to determine if short-term outcomes following hip fracture repair are associated with a hospital's teaching status. I hypothesize that teaching hospitals have better short-term outcomes than do non-teaching hospitals. In order to answer this question, I will perform a secondary analysis of data within the Nationwide Inpatient Sample (NIS) database.

Ethics

This study was declared exempt from review by the Institutional Review Boards of the School of Public Health at the University of North Carolina (Chapel Hill, NC) and Duke University Health System (Durham, NC).

Database

The NIS database is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by AHRQ. It contains data about inpatient hospitalizations as represented by hospital discharge abstracts and is the largest source of publicly available information regarding such hospitalizations in the United States. The purpose of this database is to allow researchers and policymakers to examine trends in both discharge-level outcomes and hospital-level outcomes. Examples of discharge outcomes include length of stay, cost, effectiveness, and access to hospital care. Hospital outcomes include mortality rates, complication rates, and patterns of care. Using the NIS, policymakers and researchers can examine outcomes across various geographic regions, payers, hospital types, and providers.

The study sample will be drawn from the population of hospital inpatient discharges represented in the NIS databases for the years of 1990 through 2003.[20] Each annual database contains every hospital discharge from the approximately 1000 hospitals sampled. Hospitals in what the AHRQ refers to as the sample's "target universe" are all hospitals within the United States that are categorized by the American Hospital Association (AHA) as community hospitals. This includes all non-federal, short-term general and specialty hospitals, exclusive of all institutional hospital units such as those in prisons and mental institutions, long-term facilities, rehabilitation hospitals, psychiatric hospitals, and chemical dependence treatment centers.[42] To ensure that the NIS is representative of the target population, AHRQ bases the sample on a twenty percent stratified sampling model representing a sampling frame of 90% of all hospital discharges in the United States, using the following hospital characteristics as strata: geographic region (Northeast, North Central, West, or South), hospital ownership (public, private, not-for-profit, or private investor-owned), location (urban versus rural), teaching status (teaching versus non-teaching), and bed size (small, medium, or large).[43] Sampling probabilities are proportional to the number of institutions represented within each stratum.

The NIS database contains publicly available, de-identified information that can be derived from a typical hospital discharge abstract. Such data include primary and secondary diagnoses; primary and secondary procedures; admission and discharge status; total charges; length of stay; hospital characteristics; and patient demographic information. Despite the limitations imposed by data collection based on discharge abstracts, the NIS contains the largest, most nationally representative data regarding hospitalizations in the United States. The results of each annual NIS data collection are validated against other national databases including the National Hospital Discharge Survey (NHDS), the Medicare Provider Analysis and Review (MedPAR), and the AHA Annual Survey database.[44] Missing data were excluded from this analysis. See the database's website, at http://www.hcup-us.ahrq.gov/nisoverview.jsp, for further information about the nature of the sample, and technical documentation.

Sample Selection

From the NIS, I have selected those records with an ICD-9 primary diagnosis code related to fracture of the hip for inclusion in this study's sample. I excluded discharge records from analysis if patients had primary or secondary diagnoses suggestive of pathologic fracture due to primary bone malignancy or metastatic cancer. I also eliminated the records of patients under the age of 55 years old to limit the number of cases in which fracture was a result of high energy trauma. Figure 3 shows a map of the sample selection with inclusion and exclusion criteria. Tables 5 and 6 give the actual ICD-9 codes and NIS variable names used in including and excluding subjects.

Main Outcomes Measures

Table 7 shows the actual variable names and codes used to extract outcomes from the NIS database. Outcomes of interest for this study include rates of mortality, rates of various postoperative complications, lengths of stay, cost, and discharge dispositions. The postoperative complications that were identified a priori are postoperative infection, pulmonary embolism, deep vein thrombosis, pneumonia, need for blood transfusion, decubitus ulcers, sciatic nerve injury, and implant failure. Discharge dispositions will be grouped according to routine discharge versus other types of discharge as a measure of postoperative disability. Non-routine discharges included transfers to short-term hospitals, skilled nursing facilities, intermediate care facilities and other non-specified types of facilitites. Discharges with home health care and patients leaving against medical advice will also included in the non-routine discharges group. Outcomes will be stratified according to patient age (less than or greater than 70 years old).

Main Effect

Using univariate analyses I will compare both discharge- and hospital-level outcomes between hip fracture patients at teaching versus non-teaching hospitals. Significant risk factors for negative outcomes on univariate analysis will be included in a multivariate logistic regression analysis.

Covariates

I have identified several potential patient and hospital-specific covariates within the NIS database. These potential confounders were identified a priori and included patient sex, patient age, patient race, median household income for the patient's zip code, admission source, and hospital size. Because teaching hospitals may treat more complicated patients, in order control for confounding, I created a clinical comorbidity score to represent each patient's other comorbidities using the well-known Charlson and colleagues risk index, as modified by Deyo and colleagues – now often called the Charlson/Deyo Index -- for use with administrative databases dependent on ICD-9 codes.[45] The paper by Deyo and colleagues describes two different methods for creating a co-morbidity score to be used, depending on the availability of prior diagnoses. The de-identified data in the NIS obviate the possibility of identifying prior hospitalizations and linking them to a patient's index hospitalization. In the absence of the index hospitalization information, we used the method for creating an index that accounts for the lack of availability of a patient's prior medical history. Using Deyo's methods, I grouped patients into categories based on comorbidity scores of 0, 1, 2, and 3 or more.

Results

I have yet to complete the data analysis. As the results become available, I will present them as described and displayed in the shells for Tables 8-10. Table 8 will provide the baseline characteristics of patients admitted for hip fracture to teaching and non-teaching hospitals. Table

9 will present findings by type of hospital; the data in Table 9 will begin providing the test of the central hypothesis of better outcomes in teaching hospitals. Table 10 will represent the differences as risk-adjusted odds ratios for different outcomes by hospital type, once again testing the central hypothesis.

DISCUSSION

Hip fractures are a major public health problem in the United States; studying their outcomes is of great importance. One variable in patient outcomes for many kinds of hospital admissions is the teaching status of the hospital. At present, we lack a straightforward analysis of differences in hip fracture outcomes by hospital type, leaving us to extrapolate the results of other studies to the problem of hip fractures. These other studies are based on observational data and are subject to inherent biases, and their results conflict with one another.

Two other published systematic reviews confirmed my own finding of inconsistent results in comparisons of quality across teaching and non-teaching hospitals. These reviews[4, 41] also found that any analysis of this issue is limited by the quality of the data analyzed and variations in defining "teaching hospital." Despite the benefits to analysts of large administrative databases, such as increased generalizability and availability of data, these databases are far from perfect as research tools, since they were created as claims databates, and any conclusions drawn from their use should be treated with some skepticism. Nevertheless, each reviews identified a small trend toward provision of better care at teaching hospitals, [4, 41] and one of the reviews made a point of noting that for common conditions, especially in elderly patients, major teaching hospitals probably provide a higher quality of care.[4]

We need further analyses, and more tests of evidence, of the quality of care for hip fractures treated at teaching and nonteaching hospitals. If, after controlling for other variables known to influence outcomes, teaching hospitals appear to be associated with better quality, this finding would be important in itself. The finding would also generate a new research agenda, to try to determine what about teaching hospitals is responsible for the improved outcomes, and how those features might be incorporated into the care provided by nonteaching hospitals.

My systematic review of the literature led to the hypothesis that patients with hip fractures will experience better outcomes, such as decreased charges, shorter LOS, and lower rates of in-hospital mortality, if they are treated at teaching hospitals. I have designed a retrospective cohort study to test that hypothesis. The NIS data enables me to compare outcomes in teaching and non-teaching hospitals, controlling for other differences in hospitals, such as volume of procedures and private versus public hospital ownership, as well as potential differences in patient populations. Limitations of the database, similar to the limitations of the studies evaluated in my systematic review, are also described. The only data obtainable from hospital discharge records, the basis of the NIS database, are subject to administrative coding errors. Nonetheless, the database is the largest all-payer hospital discharge database in the country and is representative of the hospitalized United States population.

This proposed test of hypotheses in an established secondary database, grounded in a systematic review of the literature, creates an opportunity to determine whether teaching hospitals appear to provide higher quality of care to patients admitted for hip fractures, and whether better quality of care appears to be associated with better patient outcomes, as measured by lower rates of in-hospital mortality, lower charges, shorter length of stay, and fewer postsurgical complications. I hope to present the results of my analysis in a future paper and submit the paper for publication. If the findings suggest that, ceteris paribus, teaching hospitals have better hip fracture outcomes, we will want to find out why, and find ways to improve hip fracture outcomes in all hospitals.

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I

APPENDIX : TABLES AND FIGURES

Table 1: Observational Studies Reviewed

Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Allareddy and Konety, 2006	2° data analysis of observational data (Retrospective cohort)	NIS 2000-2003	IC = All admissions with a 1° diagnosis corresponding to the ICD-9 codes for head and neck cancer (HNC) EC = none specified n = 24,803	▪ provide demographic characteristics of patients hospitalized for HNC during the years 2000-2003 ▪ identify predictors of in-hospital mortality	▪ Hospital characteristics ▪ Patient characteristics ▪ UvA and MvLRA describing the influence of patient and hospital characteristics on in-hospital mortality	▪ Patients treated for HNC at TH less likely to die than those at NTH	†Positive: ▪ Used a previously validated method to adjust for confounding effect of comorbidities Negative: ▪ Did not use process measures
Bateman, Schumacher, Boden-Albala, et al., 2006	2° data analysis of observational data (Retrospective cohort)	NIS 1999-2002	IC = all admissions with 1° diagnosis of acute ischemic stroke admitted through the E.R. EC = admissions in KS, IL, OH, UT, WA, and WV due to lack of certain codes n = 248,964	▪ Identify factors associated with in-hospital mortality after administration of thrombolysis in acute ischemic stroke patients	▪ Characteristics of patients and hospitals) ▪ Disposition ▪ Complications ▪ MvLRA of predictors of in-hospital mortality	▪ Neither patients treated with or without thrombolysis for acute ischemic stroke were more likely to die at TH vs NTH	†Positive: ▪ Found mortality rates similar to those in RCTs ▪ Adjusted for comorbidties Negative: ▪ Differences between patients may be a source of bias

† See table of positive/negative aspects for all NIS studies in Table 2

Table 1. Observational Studies, continued

Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Berry, Cowley, Hoff and Srivastava, 2006	2° data analysis of observational data (Retrospective cohort)	KIDS 1997 and 2000	IC = patients with ICD-9 diagnostic codes for hypoplastic left heart syndrome (HLHS) and procedural codes for stage I palliation EC = those with procedural codes for modified Stage I palliation, Stage II palliation, and Stage III palliation n = 1634	▪ evaluate the mortality of children with HLHS undergoing stage I surgical palliation when performed in teaching and nonTHs	▪ basic characteristics of patients undergoing stage I palliation for HLHS ▪ hospital volumes of stage I palliation performed ▪ UvA and MvLRA of predictors of in-hospital mortality after stage I palliation	▪ Patients treated at non-THs significantly more likely to die during hospitalization	Positive: ▪ Large multi-state, multi-center database, study of rare diagnosis and procedure ▪ Accounted for some bias Negative: ▪ Changing selection criteria different results ▪ Decreased generalizability due to lack of inclusion of high procedural volume states) ▪ Observational data may yield selection bias
Carbonell, Lincourt, Kercher, et al., 2005	2° data analysis of observational data (Retrospective cohort)	NIS 2000	IC = all patients with ICD-9 procedure codes for cholecystectomy EC = none specified n = 93,578	▪ To examine patient and hospital characteristics to determine whether they specifically influence the outcome of cholecystectomy	▪ Patient demographics ▪ Hospital characteristics ▪ MvLRA of predictors of morbidity and mortality	▪ Hospital teaching status was not associated with risk of mortality or morbidity ▪ THs associated with longer LOS, greater charges, d lower rates of laparoscopic cholecystectomy	†Positive: ▪ Results are similar to other studies Negative: ▪ Only includes inpatients

Table 1. Observational Studies, Continued

Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Carbonell, Lincourt, Matthews, et al., 2005	2° data analysis of observational data (Retrospective cohort)	NIS 2000	IC = all patients with diagnosis of morbid obesity having gastric bypass EC = none specified n = 5876	▪ Analyze the influence of hospital and patient demographics on outcomes	▪ LOS ▪ Charges ▪ Morbidity ▪ Mortality	▪ Non-THs had longer LOS, increased charges, and increased comorbidity index ▪ No differences in morbidity or mortality	†Positive: ▪ Used a validated system for adjusting for co-morbidity Negative: ▪ Could not distinguish between open and laparoscopic gastric bypass
Cosper, Hamann, Stiles and Nakayama, 2006	2° data analysis of observational data (Retrospective cohort)	KIDS 2000	IC = patients with ICD-9 procedure code for appendectomy, pyloromyotomy or diagnosis of intussusception EC = none specified n = 87,565	▪ provide a broad picture of 3 common pediatric surgical conditions in the United States	▪ LOS ▪ Charges ▪ Hospital characteristics	▪ Inconsistent results: urban TH had greater LOS only for appendectomies and higher chargers for appendectomies and pyloromyotomies	Positive: ▪ Accounted for transfers to other hospitals in LOS ▪ Large database Negative: ▪ No levels of significance reported and differences between LOS and charges fairly small ▪ State-by-state reporting differences

Table 1. Observational Studies Continued

Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Dimick, Cowan, Colletti and Upchurch, 2004	2° data analysis of observational data (Retrospective cohort)	NIS 1996-1997	IC = patients having esophageal, hepatic or pancreatic resections EC = none specified n = 6657	▪ To determine if teaching status is associated with outcomes for 3 complex surgical procedures	▪ Inpatient mortality ▪ Prolonged LOS (>75th percentile for LOS across facilities)	▪ No greater risk for mortality or prolonged LOS for any procedure after adjusting for patient characteristics and hospital volume	†Positive: Adjusted for potential confounders
Duggirala, Chen and Gergen, 2004	2° data analysis of observational data (Retrospective cohort)	NIS 1990-1996	IC = all patients undergoing surgery EC = patients admitted from SNFs, patients with certain comorbidities, transfers from other hospitals n = unknown # of admissions	▪ To compare postoperative adverse event rates between THs and non-THs	▪ Postoperative adverse events: ▪ VTE/PE ▪ Pulmonary compromise ▪ Pneumonia ▪ UTI	▪ MvLRA found higher risk of VTE/PE, pneumonia at major THs, higher risk of VTE/PE, pulmonary compromise and UTI at other THs	†Positive: ▪ Used validated method for adjusting for severity and case mix
Knapp, 2006	2° data analysis of administrative data	"Hospital Compare" data via Health Quality Alliance	IC = ? EC = ? n = ? admissions	▪ To compare selected process measures of care at major THs, integrated THs, other THs and NTHs	▪ AHRQ process measures of care for treatment of CHF, MI, pneumonia and antibiotic prophylaxis for surgery	▪ THs perform better in MI and CHF care ▪ Other measures are similar across types of hospitals	Positive: ▪ Compared process measures Negative: ▪ Poorly reported methods ▪ Unknown adjustment ▪ Observational, non-randomized

Table 1. Observational Studies, continued							
Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Mullins, Diggs, Hedges, et al., 2006	2° data analysis of observational data (Retrospective cohort)	NIS 1995-2000	IC = patients with codes for injury EC = codes for foreign bodies entering through an orifice, late effects, certain complications n = 1,769,782	▪ develop universal measures of outcome and processes of care	▪ rates of injury by region ▪ death rates ▪ LOS ▪ Potentially ineffective care ▪ Potentially unnecessary care	▪ Urban non-THs were more likely to provide potentially unnecessary care but had lower risk of inpatient mortality and ineffective care	†Positive: ▪ Accounted for potential confounders Negative: ▪ Unknown levels of significance
Romano, Geppert, Davies, et al., 2003	2° data analysis of observational data (Retrospective cohort)	NIS 2000	IC = all admissions for the year 2000 EC = none specified n = 36, 318,000	▪ The association of safety indicators with hospital characteristics	▪ Patient Safety Indicators (PSIs) developed by AHRQ	▪ Urban THs had greater rates of death in low-mortality DRGs, decubitus ulcers, leaving foreign bodies in surgery, iatrogenic pneumothorax, infections due to medical care, postoperative bleeding, postoperative metabolic derangements, postoperative VTE	†Positive: ▪ Validity of codes chosen for PSIs reviewed by many experts Negative: ▪ Unknown numerator and denomenators ▪ Odds ratios and significance levels not reported
Rutledge, 1997	2° data analysis of observational data (Retrospective cohort)	NIS 1988-1992	IC = patients undergoing cholecystectomy EC = ? n = 351,201	▪ Do Medical School Associated Hospitals (MSAHs) have higher charges and LOS than non-MSAHs?	▪ Mean charges ▪ LOS	▪ Inconsistent results for charges and LOS ▪ MSAHs led use of laparascopic technology	†Negative: ▪ Unknown definition for MSAHs

Table 1. Observational Studies, continued

Authors, Year	Study Design	Source Pop.	Study Pop.	Study Question	Measurements	Significant Results	Findings
Thornlow and Stukenborg, 2006	2° data analysis of observational data (Retrospective cohort)	NIS 2000	IC = 10% sample of all discharges for the year 2000 EC = ? n = ? admissions	▪ To examine the relationship between preventable adverse events and hospital ownership type and teaching status	▪ AHRQ PSIs	▪ No statistically significant differences between hospital ownership teaching status and patient outcomes	†Positive: ▪ Attempted to risk-adjust comparisons Negative: ▪ Difficult to assess quality across many indicators ▪ No comparison of risk across hospitals
Tilford, Aitken, Anand, et al., 2006	2° data analysis of observational data (Retrospective cohort)	NIS 1988-1999	IC = children hospitalized with traumatic brain injury EC = n = ? admissions	▪ To estimate the benefits from more aggressive treatment in terms of life years saved in children with traumatic brain injuries	▪ In-hospital mortality ▪ Use of intracranial pressure monitoring (ICPM)	▪ No significant difference in mortality between urban TH and NTH ▪ Urban THs were not more likely to use ICPM	†Positive: ▪ Used logistic regression to control for injury severity
Todd, Arthur, Newgard, et al., 2004	2° data analysis of observational data (Retrospective cohort)	NIS 1998-2000	IC = patients with ICD-9 codes for splenic injury EC = patients > 80 n = 14,901 admissions	▪ To assess which factors influence the decisions of surgeons in managing splenic trauma	▪ Processes of care for splenic injury	▪ Surgeons at THs less likely to perform splenectomy and laparatomies	†Positive: ▪ Adjusted for injury severity using a validated severity score

Table 2 : Positive and Negative Aspects of the NIS Database

Positive:	Negative:
▪ Drawing from a large source population may lead to greater generalizability to the target population	▪ Disease severity is difficult to adjust for
▪ Definitions of teaching hospitals and non-teaching hospitals are specific	▪ Observational data may liead to increased bias
	▪ Administrative data limits the variables available
	▪ Outcomes are dubious markers of quality of care
	▪ Only short-term outcomes can be measured
	▪ Multiple visits by one patient for the same problem can not be accounted for

Table 3 : Quality Ratings for Reviewed Studies

Study	Question	Popula-tion	Compara-bility	Exposure or Intervention	Outcome Measurement	Statistical Analysis Data Reporting	Discussion	Total Score
Allareddy and Konety, 2006	3	3	3	3	2	3	2	19
Bateman, Schumacher, Boden-Albala, et al., 2006	3	3	1	3	2	2	2	16
Berry, Cowley, Hoff and Srivastava, 2006	3	3	1	3	2	2	2	16
Carbonell, Lincourt, Kercher, et al., 2005	3	3	1	3	2	2	2	16
Carbonell, Lincourt, Matthews, et al., 2005	3	3	1	3	2	2	2	16
Cosper, Hamann, Stiles and Nakayama, 2006	1	3	1	3	2	1	2	13
Dimick, Cowan, Colletti and Upchurch, 2004	3	3	3	3	3	3	2	20
Duggirala, Chen and Gergen, 2004	3	3	3	3	3	3	2	20
Knapp, 2006	3	1	0	3	3	0	2	12
Mullins, Diggs, Hedges, et al., 2006	1	3	2	3	2	1	2	14
Romano, Geppert, Davies, et al., 2003	3	2	2	3	3	0	2	15
Rutledge, 1997	3	3	0	0	2	2	2	12
Thornlow and Stukenborg, 2006	3	2	3	3	3	2	2	18
Tilford, Aitken, Anand, et al., 2006	1	3	3	3	2	2	2	16

Todd, Arthur, Newgard, et al., 2004	2	3	3	3	2	2	2	17

Table 4 : Odds ratios for in-hospital mortality during various types of admissions		
	Risk at TH	**Risk at NTH**
	OR (95% CI)	**OR (95% CI)**
Head and neck cancer[3]	**0.72 (0.58-0.89)**	1.00
Thrombolysis after acute ischemic stroke[5]	1.13 (0.87-1.47)	1.00
Non-Thrombolytic treatment after acute ischemic stroke[5]	**1.09 (1.05-1.13)**	1.00
Stage I Palliation HLHS[6]	1.00	**2.6 (1.3-5.3)**
Cholecystectomy[7]	1.00 (0.95-1.34)	1.00
Pancreatic resections (unadjusted)[9]	**2.3 (1.7-3.2)**	1.0
Pancreatic resections (severity adjusted) [9]	**1.7 (1.2-2.4)**	1.0
Pancreatic resections (volume adjusted) [9]	1.1 (0.8-1.7)	1.0
Hepatic resections (unadjusted) [9]	**1.5 (1.1-2.3)**	1.0
Hepatic resections (severity adjusted) [9]	1.4 (0.9-2.2)	1.0
Hepatic resections (volume adjusted) [9]	0.9 (0.5-1.6)	1.0
Esophageal resections (unadjusted) [9]	1.4 (0.9-2.1)	1.0
Esophageal resections (severity adjusted) [9]	**1.8 (1.1-3.2)**	1.0
Esophageal resections (volume adjusted) [9]	1.4 (0.7-2.6)	1.0
Trauma[38]		**0.85 (0.81-0.89)**

Table 5 : Inclusion criteria
[DX1 - DX15] =
Fracture of neck of femur = 820
Fracture of unspecified part of the neck of femur, closed = 820.8
Fracture of unspecified part of the neck of femur, open = 820.9
Pertrochanteric fracture of the femur, closed = 820.2
Fracture of intertrochanteric section of the femur, closed = 820.21
Fracture of the subtrochanteric section of the femur, closed = 820.22
Fracture of unspecified trochanteric section of the femur, closed = 820.20
Pertrochanteric fracture of the femur, open = 820.3
Fracture of intertrochanteric section of the femur, open = 820.31
Fracture of the subtrochanteric section of the femur, open = 820.32
Fracture of unspecified trochanteric section of the femur, open = 820.30
Transcervical fracture, closed = 820.0
Fracture of the base of the neck of the femur, closed = 820.03
Fracture of the epiphysis of the neck of the femur, closed = 820.01
Fracture of the midcervical section of the femur, closed = 820.02
Fracture of an unspecified intracapsular section of the femoral neck, closed = 820.00
Other transcervical fracture of the femur, closed = 820.09
Transcervical fracture, open = 820.1
Fracture of the base of the neck of the femur, open = 820.13
Fracture of the epiphysis of the neck of the femur, open = 820.11
Fracture of an unspecified intracapsular section of the femoral neck, open = 820.10
Other transcervical fracture of the femur, open = 820.19

Table 6 : Exclusion criteria
[DX1 - DX15] =
Malignant neoplasm of bone or articular cartilage = 170
Malignant neoplasm of lower extremity = 170.7
Malignant neoplasm, site unspecified = 170.9
Secondary malignant neoplasm = 198
Secondary malignant neoplasm of bone or bone marrow = 198.5
Secondary malignant neoplasm of lower limb = 196.5
Neoplasm, uncertain behavior = 238.9
Neosplasm, unspecified site within bones of the lower limb = 239.9
Pathologic fracture (cause unknown) = 733.10
Pathologic fracture of the femur, not otherwise classified = 733.15

Table 7 : Outcome variable codes

Main outcome variables	NIS and ICD-9 codes
Mortality	[DIED] = 1 (died during hospitalization)
Postoperative complications:	[DX1-DX15] = (See below for ICD-9 codes)
Postoperative infection	Post-operative wound infection = 998.59 Postoperative wound infection, unspecified = 686.9
Pulmonary embolism	Pulmonary embolism and infarction = 415.19 Postoperative pulmonary embolism = 415.11
Deep vein thrombosis	Thrombophlebitis during or resulting from a procedure NEC = 997.2 Thrombophlebitis of the deep veins of the lower extremities = 451.1 Thrombophlebitis of the femoral vein = 451.11 Thrombophlebitis of the deep vessels of the lower extremity, NEC = 451.19 Thrombophlebitis of the lower extremity, not specified = 451.2
Pneumonia	Viral pneumonia = 480 Pneumococcal pneumonia = 481 Other bacterial pneumonia = 482 Pneumonia due to other specific organism = 483 Pneumonia in other infectious disease = 484 Bronchopneumonia, organism not specified = 485 Pneumonia, organism unspecified = 486
Need for blood transfusion	Transfusion of blood and blood components = 99.0 Perioperative autologous transfusion of whole blood or blood components = 99.00 Exchange transfusion = 99.01 Transfusion of previously collected autologous blood = 99.02 Other transfusion of whole blood = 99.03 Transfusion of packed cells = 99.04 Transfusion of platelets = 99.05 Transfusion of coagulation factors = 99.06 Transfusion of other serum = 99.07 Transfusion of blood expander = 99.08 Transfusion of other substance, including blood surrogate = 99.09
Decubitus ulcers	Decubitus ulcers = 707.0
Sciatic nerve injury	Sciatic nerve injury = 956.0 Lesion of sciatic nerve = 355.0

Table 7 : Outcome variable codes (continued)	
Main outcome variables	NIS and ICD-9 codes
Implant failure	Mechanical complication of internal orthopedic device, implant, and graft = 996.4 Mechanical complication of other specified prosthetic device, implant and graft = 996.5 Inflammation reaction due to internal prosthetic device, implant, and graft = 996.6] Other complication of internal device, implant, and graft = 996.7
Length of stay	[LOS]
Cost	[TOTCH] = edited total charges
Discharge dispositions	1990-1997: [DISP] 1998-2003: [DISPUNIFORM]
Routine	[DISP] = (1) routine [DISPUNIFORM] = (1) routine
Non-routine	[DISP] = (2) short-term hospital, (3) SNF, (4) intermediate care, (5) another type of facility, (6) home health care, (7) AMA, (20) died [DISPUNIFORM] = (2) transfer to short term hospital, (5) other transfers including SNF, intermediate care, and another type of facility, (6) home health care, (7) AMA, (20) died in hospital, (99) discharged alive, destination unknown

Table 8 : Baseline characteristics of patients admitted for hip fractures

Baseline characteristics		Teaching Hospitals		Non-teaching hospitals	
		Age < 70	Age > 70	Age < 70	Age > 70
		Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%
Sex	Male				
	Female				
	Missing				
Race	White				
	Nonwhite				
	Missing				
Mean Deyo Score					
Discharge disposition	Routine				
	Non-routine				
	Missing				
Mean income (by zip code)	$1-25,000				
	$25,001 – 35,000				
	> $35,000				
	Missing				
Admission source	ED				
	Other				
	Missing				
Hospital size	Small				
	Medium				
	Large				

Table 9 : Outcomes of hip fractures by hospital teaching status

Main Outcomes	Teaching Hospitals		Non-teaching hospitals	
	Age < 70	Age > 70	Age < 70	Age > 70
	Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%	Freq (%)/Mean or Median (50%) – S.D/25-75%
In-hospital mortality				
postoperative complications:				
postoperative infection				
pulmonary embolism				
deep vein thrombosis				
pneumonia				
need for blood transfusion				
decubitus ulcers				
sciatic nerve injury				
implant failure				
Length of Stay				
Cost				
discharge dispositions				
routine				
non-routine				

Table 10 : Risk of negative outcomes of hip fracture by teaching status

Main Outcomes	Outcome Rate - TH	Outcome Rate - NTH	Adjusted Odds Ratio
In-hospital Mortality			
Postoperative complications:			
postoperative infection			
pulmonary embolism			
deep vein thrombosis			
pneumonia			
need for blood transfusion			
decubitus ulcers			
sciatic nerve injury			
implant failure			
length of stay			
Cost			
discharge dispositions routine non-routine			

Figure 1 :Total charges by teaching status and procedure performed

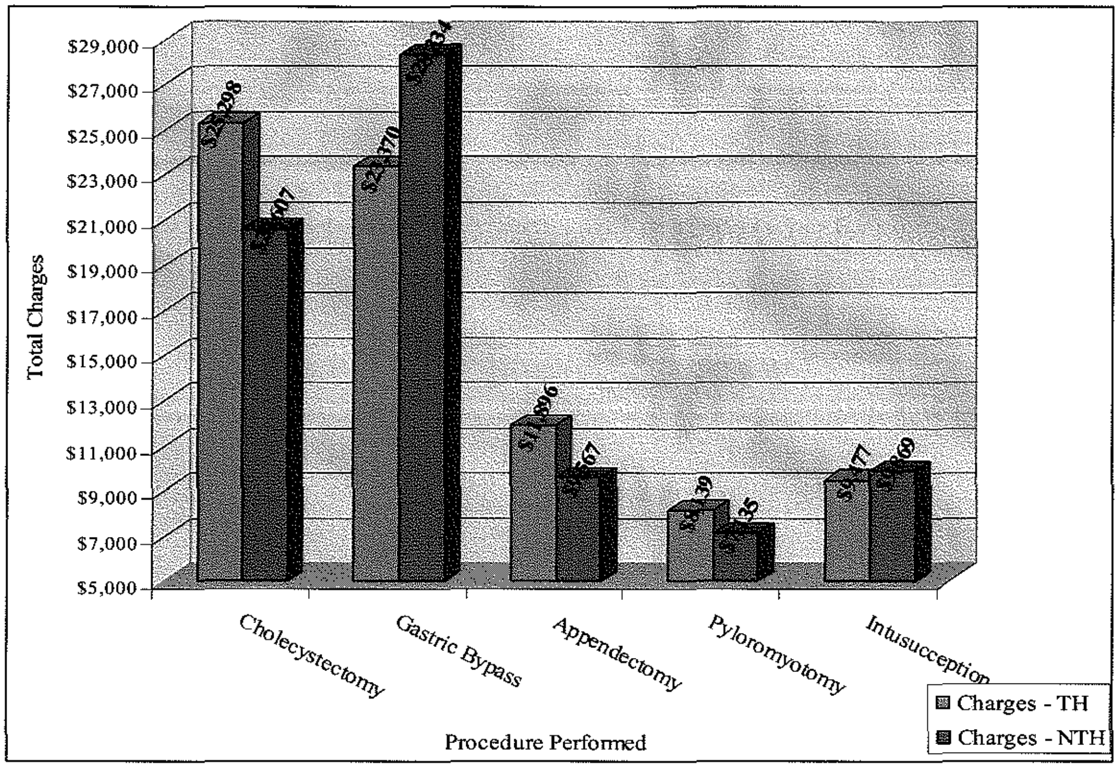


Figure 2 : Length of stay (LOS) by teaching status and procedure performed

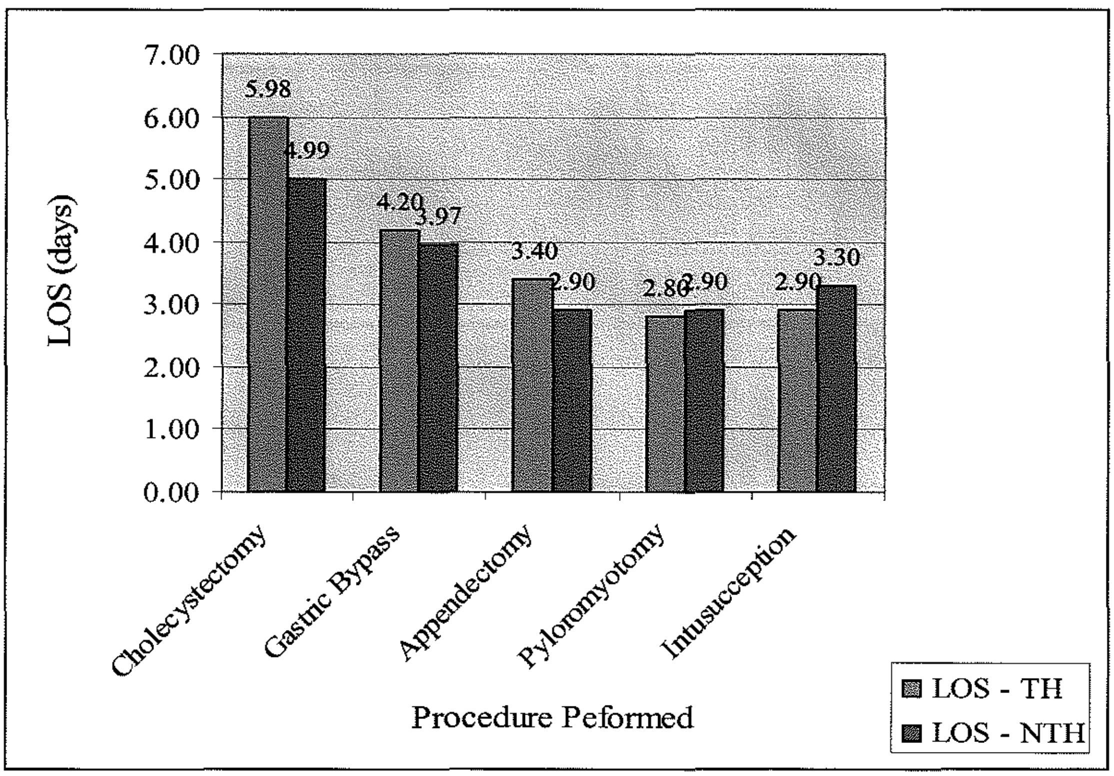
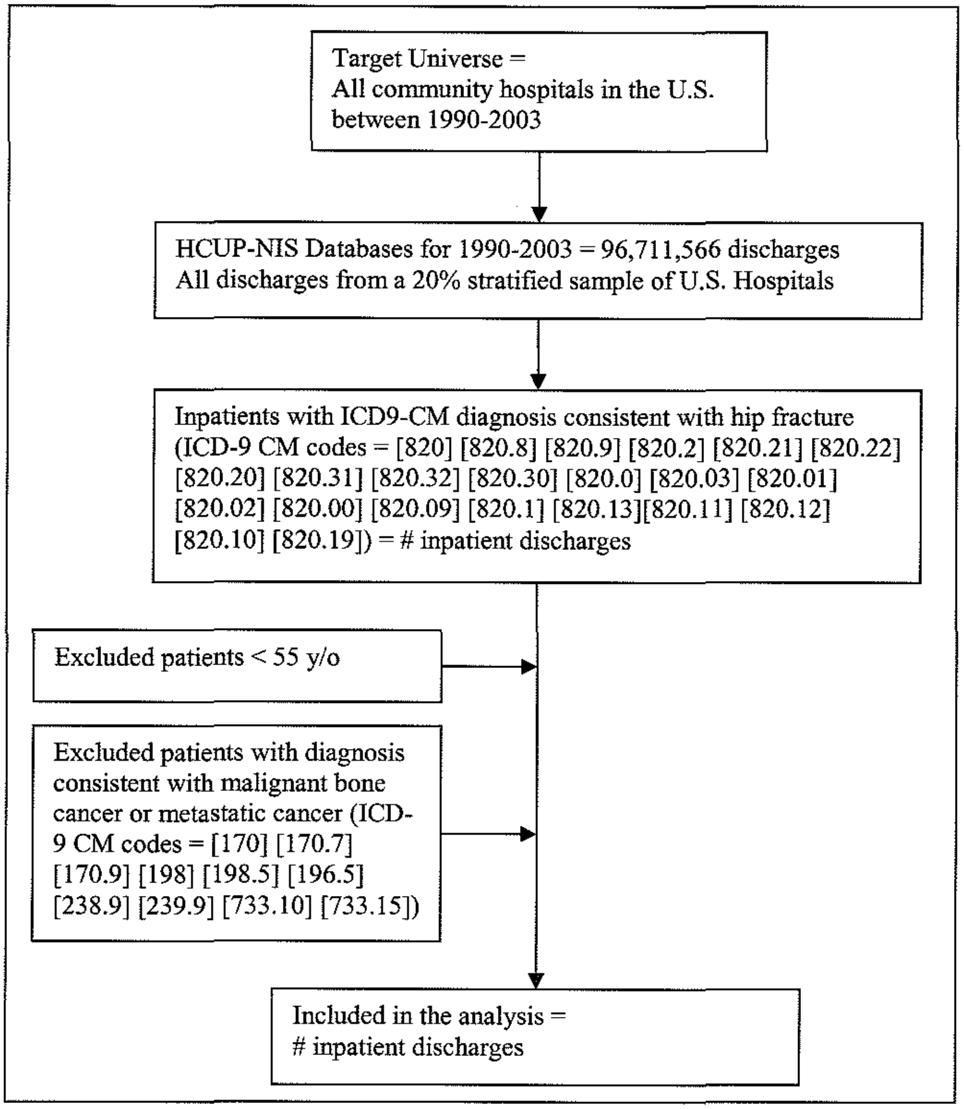


Figure 3 : Mapping of inclusion and exclusion criteria



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