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An economic assessment of defensive medicine

Chang, Timothy Tin Yau, Ph.D.

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U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

AN ECONOMIC ASSESSMENT OF DEFENSIVE MEDICINE

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By
Timothy T.Y. Chang

Dissertation Committee:

Walter Miklius, Chairman
Richard Guillory
Loren Yamamoto
Burnham Campbell
John Bauer
James Moncur

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ABSTRACT

Defensive medicine is defined as an alteration of medical practice by physicians to reduce the possibility of malpractice litigation. The purpose of this study is to investigate the extent to which doctors in emergency room situations practice defensive medicine. The frequencies at which three types of medical diagnostic procedures are requested for emergency room patients are compared across three types of hospitals that each represents a different malpractice environment. The difference in the frequencies at which tests are being performed at one particular hospital versus the control hospital (without malpractice) represents the quantification of the practice of defensive medicine when other causes of variation are controlled for.

Three clinical procedures are studied: skull x-rays for head trauma patients, cervical spine x-rays for neck injury patients, and computed tomography for suspected stroke patients. Primary data was gathered from the individual patient records from the selected hospitals. Various attributes were specifically selected in order to get sufficiently similar and yet a representative sample from each source.

Statistical test based on normal probability distribution showed that physicians practicing in hospitals with threats of malpractice ordered significantly greater numbers of tests compared to the control hospital verifying the practice of defensive medicine. The samples of selected patients across the three types of hospitals were tested to be homogeneous with respect to age and sex. However, homogeneity of severity of cases can only be attained in head-trauma and neck injury cases across the sample hospitals.

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CHAPTER ONE

INTRODUCTION

Defensive medicine, according to the report of the Secretary's Commission on Medical Malpractice, is "the alteration of medical practice by physicians to reduce the possibility of malpractice litigations and to provide a legal defense in the event of these litigations" [DHEW 1973]. By providing medical care beyond what is necessary to treat the condition, it is expected that the threat of malpractice is reduced. Defensive medicine creates a safety margin against making an error or being accused of not taking proper care against errors. Tancredi & Barondess [1978], defines defensive medicine even more specifically as "the use of diagnostic and end-treatment measures explicitly for the purposes of averting malpractice suits" and "the intentional behavior of physician's to protect themselves from accusations of negligence." Physicians will use additional diagnostic procedures to provide documentation that a wide range of tests and treatments are used in the patient's care. This study focuses specifically on the use of diagnostic procedures for defensive medicine.

There is an unanimous agreement that unnecessary use of medical procedures exists [Fowkes 1984; Bell & Loop 1971;

Bull 1968; Phillips 1978; Boulis 1978; Masters 1980; Eyes 1978; Harwood 1971; Roberts 1972; Cummin 1980; Freed 1980]. According to Fowkes [1984], overutilization is characterized as procedures performed for no clear medical reasons or those not necessarily for the improvement of patients' conditions. However, there remains disagreements concerning the significance of the contribution of the various determinants of excessive utilization. After World War II, two factors were allegedly the major causes of the sharp increase in the use of medical procedures (i.e. for defensive medicine): the steady increase in the number of claims of medical malpractice [Duke 1973; DHEW 1973; Jean 1986; Tancredi 1978], and the large litigation settlements which caused the inevitable increase in medical malpractice insurance premiums. For instance, Florida, being one of the states that has the largest number of malpractice litigations, had a five-fold increase in premium between 1983 and 1987 [Table 1]. Other studies, however, contend that factors such as patient characteristics, direct economic gains to physicians, increased coverage provided by health insurance plans, and technological advances in medicine are the more significant determinants of excessive utilization. Attempts are made in this study to control for these possible sources of variation in the frequencies of tests across the three hospitals to be able to isolate the extent of the effect of the malpractice environment.

Table 1

Medical Malpractice Insurance Premium

	1983	1984	1985	1986	1987*	1987**
Family Practice	4,310	5,368	7,206	11,866	15,123	18,415
Internal Medicine	7,825	9,768	14,179	20,090	25,511	30,442
Emergency Medicine	9,777	15,100	22,925	36,471	47,925	58,304
General Surgery	21,971	27,538	38,483	59,893	78,918	95,875
Anesthesiology	23,939	27,538	38,483	55,915	73,623	88,838
Orthopedic Surgery	27,073	33,380	47,863	79,785	105,167	130,817
Neurological Surgery	37,569	49,787	74,967	115,548	152,525	192,420

Note:

[1] These rates are weighted averages of the rates charged in Dade and Broward Counties, Florida, calculated by Professor Bernard Webb, Georgia State University.

[2] Source of Data:
Blair, Roger and Dewar, Marvin., "How to end the crisis in Medical Malpractice Insurance." Challenge March-April 1988. pp36-41

* Rates are effective as of January 1, 1987
** Premium changes effective July 1, 1987

Quantifying the extent of defensive medicine is not very easily accomplished because physicians may take any combination of a number of precautionary steps to guard against malpractice lawsuits. Using scenario comparison, this paper attempts to assess the extent to which defensive medicine is practiced. Primary data on emergency room patients are collected from three types of hospitals in Hawaii: Health Maintenance Organisation (H.M.O), fee-for-service, and military hospital. Measurement of defensive medicine is achieved by comparing the frequencies at which procedures are performed across the different types of hospitals that each represents a different malpractice environment. The difference in the frequencies at which tests are being performed at a particular hospital versus the control hospital (without malpractice threat) represents the quantification of the practice of defensive medicine.

Background literature on malpractice and defensive medicine are reviewed in Chapter Two. Specifically, two controversial studies, one by the editorial board of Duke Law Journal in 1971 and another by Nathan Hershey in 1972 will be discussed.

In Chapter three, the Random Utility Model (R.U.M.) is used to model physicians' behavior in ordering diagnostic procedures. Then the method, scenario comparison combined with R.U.M., for verifying the extent of defensive medicine is described. Three hypothesis to be tested by this study are also presented in this chapter.

Chapter Four describes how the sample hospitals and patients were selected. Three hospitals are selected on the basis of criteria described in Chapter Three and geographical location. Patients or cases were chosen on the basis of injuries incurred: head trauma, neck injury and suspected stroke. The study focuses on three separate clinical procedures: skull x-rays for head trauma patients, cervical spine x-rays for neck injury patients, and computed tomography for suspected stroke patients. The basic data was collected from medical records.

Chapter Five discusses conclusions that may be drawn from this study. The test based on normal probability distribution is used to determine if the empirical findings are consistent with the hypotheses. A test for homogeneity of the data was carried out by using the Kolmogoroff-Smirnoff test.

CHAPTER TWO

LITERATURE REVIEW

2.1 BACKGROUND ON DEFENSIVE MEDICINE

Malpractice. Whereas definitions once read "injurious or negligent behavior", today most definitions include a particular reference to the medical profession, i.e. "especially a physician." Medical malpractice received great attention in academic and professional literature since the early 1970's when malpractice insurance premiums first began to skyrocket as a result of increase in number of medical malpractice claims and large litigation settlements [Duke 1973; DHEW 1973; Jean 1986; Tancredi 1978].

Increase in the number of malpractice litigations and insurance premiums had tremendous impact on physicians' behavior especially when the American Medical Association recently established a central data bank where information regarding the misconduct of physicians are filed and can be retrieved for the purposes of peer evaluations. In order to avoid the possibility of malpractice litigations and high premiums, many physicians have stopped practicing high risk medicine. For instance, a great majority of family physicians no longer provide obstetric services. In some extreme cases, physicians have abandoned practicing medicine entirely. In majority of the cases, however, doctors continued practicing medicine, but they are taking additional precautions in treating their patients [Cooter 1986]. These precautions include the performance of excessive diagnostic procedures or tests that may serve no gains in patients' prognostic condition.

2.2 SUMMARY OF THE LITERATURE ON DEFENSIVE MEDICINE

One researcher estimated that the increase in medical expenditures due to increased defensive medicine was about 3.5 times the increase in malpractice premiums in 1984 [Editorials 1987; Reyonlds 1987]. The Health Insurance Association of America and the Department of Health indicated that defensive medicine, induced by the fear of litigation, is costing $3 to $7 billion a year [Tancredi 1978]. Although other opinion surveys also supported the claims of widespread practice of defensive medicine [Paxton 1974; Lipson 1976; McClenahan 1970; Phillips 1978; Hall 1976; Karas 1980; Tancredi 1978], two formal studies, the first by the Duke Law Journal and the second by Nathan Hershey, claimed that defensive medicine played only a minor role in the upsurge of the use of medical procedures. Statistical and definitional difficulties, however, do not allow these studies to draw definitive conclusions on the extent of the practice of defensive medicine.

While the significance of the practice of defensive medicine is still controversial, there is no disagreement that excessive utilization of medical procedures exists. For example, in examining the efficacy of skull radiographs due to head trauma, Bell and Loop [1971] have shown that 2/3 of the x-rays were unnecessary. Similar findings were expressed by many subsequent studies [Phillips 1978; Boulis 1978; Masters 1980; Eyes 1978; Harwood 1971; Roberts 1972; Cummins 1980; Freed 1980]. The most current study was conducted by the University of Wales Colleges of Medicine in 1984 [Fowkes 1984]. With the implementation of an effective guideline, the rate of the x-rays utilization could have been reduced by 51% with no serious repercussions of undetected head injuries [Fowkes 1984]. Despite the findings of these studies, the number of skull radiographs had not declined. It is believed that the increases are caused by non-medical reasons, one of which is defensive medicine

2.3 THE DUKE LAW JOURNAL STUDY

The purpose of the Duke Law Journal study was to determine if overuse of medical procedures is motivated by the threat of malpractice litigation. The study used surveys of physicians concerning hypothetical situations for medical specialties in Dermatology, Obstetrics-Gynecology, Orthopedics, Otolaryngology, Pediatrics, Plastic Surgery, Psychiatry, and Urology. These specialties were carefully selected on the basis that malpractice threat would be an influencing factor. A hypothetical situation for selected procedures was developed to include just enough data for realism and just enough generality to illicit a sufficiently wide range of responses. The physician was then asked [a] how often he would follow the described procedure, [b] what is his opinion about its medical usefulness, and [c] if he would have followed the procedure, why would he chose to do so. In the [c] question, seven possible reasons especially designed to reveal his motivation to avoid malpractice were provided for the physician to chose from, allowing him several selections. The surveys were sent to two specifically chosen states: California, to represent the group faced with both high malpractice insurance premiums and high rate of malpractice claims, and North Carolina, as the control group, which is low in both these areas. Of the 1,545 questionnaires sent, 54% were answered and returned.

The results showed that defensive medicine exists, and it is influenced by the threat of malpractice suits, but not as extensively as alleged -- only 20% of the physicians admitted that they practiced defensive medicine. In general, physicians in North Carolina utilize more procedures than those in California. Thus, the Journal concluded that factors other than the threat of litigation, such as economic incentives on the physician, the demands of the patients, and the growing cost and sophistication of medical technologies have greater impact on the overutilization of medical resources. Abrams [1979] also shares this view, citing the economic incentives brought about from increasing health insurance coverage. This conclusion also gained support from Dr. Patricia Danzon's testimony in the 1984 hearings before the Committee on United States Senate. Dr. Danzon testified that there were no reliable estimates for "defensive medicine" and that there are certainly many unnecessary tests and procedures being done, "but much of this results from the incentives being created by the "fee-for-service" reimbursement system ..." [Senate Hearing 1984].

Some shortcomings of this study should be noted. First, a study using a survey method of data gathering is prone to bias from the self-selection of the respondents. It is not a probability sample since respondents themselves chose to send in their reply. Second, the physicians were informed that the survey was to be used to determine the extent of defensive medicine due to malpractice threat and that the report may be used to propose changes in the law. This knowledge may have an influence on the physician's responses to the survey. Third, the survey gathered opinion data only; no attempt was made to verify their choices against impartial experts, nor was there any attempt to determine what their responses would be under average patient-contact conditions. Fourth, the survey dealt only with testing the effect of malpractice threat on extra procedures, not on a medically justified procedure. Most of these shortcomings are strongly linked to the method of survey data gathering.

2.4 THE NATHAN HERSHEY STUDY

The objective of Hershey's 1973 study, similar to the Duke study, was to investigate the impact of liability considerations on physicians' use of medical procedures. This study had substantially more shortcomings due to the unscientific methods used. The study used interviews of seventeen physicians in the Pittsburgh area, chosen on the basis of the author's belief that, through personal association with them, they would answer questions candidly.

The physicians were asked to discuss [a] the influence of malpractice considerations, [b] the nature and extent of defensive medicine, [c] the effect on quality and cost of medical care, and [d] the effect on physician-patient relationships. The study redefined defensive medicine as "poor practice induced by the threat or fear of litigation." Medical procedures that are induced by the threat of malpractice but result in improved diagnosis were not considered as defensive medicine.

Based on the interviews, the researchers concluded, in agreement with the Duke study, that defensive medicine was not practiced excessively as alleged, and suggested that factors such as personal characteristics of the physicians and their patients have greater weight in determining the extent of overutilization. The study further concluded that these physicians feel that those who claim defensive medicine is a large, widespread problem represent only a small but vocal portion of the medical community.

The Hershey study, as with the Duke study, is fraught with statistical and definitional problems. First, the physicians were chosen in personal association with the researcher from the same area, obviously lacking randomness and not representative of physicians nationwide. Second, the definition of defensive medicine used in the study may not have been consistent with that used by the physicians. Third, the answers were allowed to be conversational, lacking a sufficiently rigid structure to draw clear conclusions. Fourth, since the interviews were done over the telephone, often recorded, and the respondents were known by the researcher, it's highly likely that their responses would not be as "candid" as the researcher had hoped. It is human nature for physicians to be reluctant to admit that they provide anything other than good medical treatment; not many would be expected to admit to using defensive medicine. It should be noted that the researcher himself recognized these shortcomings and suggested that a study with more rigorous planning and construction be done to make meaningful conclusions.

2.5 CHAPTER SUMMARY

In summary, owing to the statistical and definitional difficulties, these studies could not draw definitive conclusions regarding the extent of the practice of defensive medicine or the extent of the overutilization of diagnostic procedures as a result of medical malpractice litigations. The problems of these studies can be summarized as: [1] the definition of defensive medicine is vague; [2] use of non-probability sample through primary survey are prone to bias from the self-selection of samples and the low response rate.

Although theory and opinion have established a rationale for practicing defensive medicine, no definitive empirical conclusions can be drawn on the extent of the practice of defensive medicine. Some studies suggested that other factors such as economic incentives, and patients' profiles played a more important role in causing overutilization, but even these studies could not make definitive conclusions because of statistical and definitional problems.

CHAPTER THREE

THE RESEARCH METHODS AND HYPOTHESES

3.1 INTRODUCTION

Defensive medicine is defined as the alteration of medical practice by physicians to reduce possibility of malpractice litigations. Studies cited in the previous chapter have attempted to verify, through questionaires and surveys, the practice of defensive medicine by medical doctors. Although these studies have indicated that some physicians practice defensive medicine, there has not been any study that directly measures the extent of it. The sharp increase in health care costs during the last decade have been taken to be one indication of the effect of the tightening of the malpractice environment or in the increase of the practice of defensive medicine. But there have been debates on the significance of the contribution of defensive medicine versus other possible factors (patient profiles, insurance coverage, technical advancement etc) to the increase in total health care bill. This study will attempt to provide a measure of the extent of the practice of defensive medicine by comparing the frequency by which three medical diagnostic procedures are requested by physicians in three different malpractice scenarios.

In this chapter, the Random utility Model (R.U.M.)is first presented. Following is a description about how physicians modify medical practice in order to cope with the threat of malpractice. Then the method, scenario comparison combined with the R.U.M., for verifying the practice of defensive medicine is described. The hypotheses to be tested by this study are presented last.

3.2 RANDOM UTILITY MODEL, A GENERAL FORM

The Random Utility Model (R.U.M.) is a model of discrete choices (yes or no, whether to test or not to test) with utility maximization as the criteria for making a choice. Suppose an ith individual has to choose among a set of m alternatives. Each alternative generates a level of utility which is affected by X_j independent variables and e factor. The utility for the mth choice is:

$$U_{im} = \Sigma\, b_{ij}X_{ijm} + e_{im}$$

where U_{im} is the value of utility of the ith individual when he chooses the mth alternative;

X_{ijm} is the value of the jth attribute which is hypothesized to influence the choice for a given mth alternative;

b_{ijm} is the coefficient reflecting the weight of the independent variables on influencing the level of utility;

e_{im} is a "catch-all" variable (error term) which influences the choice but cannot be readily measured or recognized.

The individual will choose the alternative which generates the highest utility. The probability of choosing the mth alternative can be expressed as:

$$P_{im} = \text{Prob}\ [(U_{im} > U_{in})]$$

where n is an alternative different from the mth.

With the assumption that e_{im} are independent, the probability that the ith individual chooses the mth alternative can be derived as: [See McFadden 1974 for a full derivation].

$$P_{im} = \exp\ (U_{im})\ /\ \Sigma\ \exp\ (U_{im})$$

3.3 MODELLING PHYSICIAN BEHAVIOR

Given any patient-physician contact there is a possibility that the patient will suffer some adverse outcome that might or might not be due, at least in part, to the physician. For any adverse outcome, the patient may or may not sue for malpractice.

For the physician to be able to properly and sufficiently treat a patient, he may need to order medical diagnostic procedures. These tests not only provide the benefit of proper diagnosis of a patient's condition but also serve to lessen the probability of any adverse outcome and, hence, lessen the probability of medical malpractice litigation. In the event that there is an adverse outcome and the physician gets sued, the diagnostic procedures will provide the evidence that a wide range of tests and treatments was used in the patients care. Diagnostic procedures can therefore serve the physician two purposes (benefits): for diagnosis and for reducing potential loss from malpractice litigation. Under these conditions, more tests will be ordered than is necessary for diagnostic purposes.

In some situations, however, such as in H.M.O., physicians may be discouraged to order precautionary tests because the increase in overall cost of treatment reduces the physician's income or share of the profit. In these cases, the net benefit to the physician for ordering these procedures is lower and they may order fewer precautionary tests.

As a hedge against the risk of financial loss from malpractice litigations, physicians may also purchase liability insurance. Existing forms of malpractice coverage has limits; the insurer will pay any claims against the physician up to the specified limit and the physician is responsible for the remainder claim.

Physician behavior as described above is modelled in this study as follows:

[1] Assume all physicians are rational such that they make decisions aimed at maximizing their utility.

[2] Assume the utility of a typical ith physician is a function of wealth.

$$U_i = U(W_i)$$

where $U'(W_i) > 0$, and $U''(W_i) < 0$

$$W = W_o + Y - I - B - R$$

W_o physician's current wealth;

Y physician's current income. Since most of the emergency physicians are paid on a salary basis. Y is considered exogenous;

I	Malpractice insurance premium which is a function of r, probability of malpractice claim; $I'_r>0$; $I''_r<0$
B	Cost of tth procedure ordered.;B=f(t) where t=0 or 1, and B is greater than zero;
R	R is the compensation, which is in excess of malpractice insurance coverage, granted by the court as a result of litigation.

[3] Assume the compensation to the physicians in the sample hospitals are comparable in the long run.

[4] Assume every complaint will lead to litigation and all litigation will result in award of compensation to the patients. The probability of successful malpractice claims is denoted as r.

[5] Assume that if a certain test is performed, inadequate diagnosis will not be used as grounds for malpractice litigation.

[6] Assume malpractice threat and cost of tests are the only sources of differences among hospitals studied here. Other factors, such as quality of care, are similar among the sample hospitals.

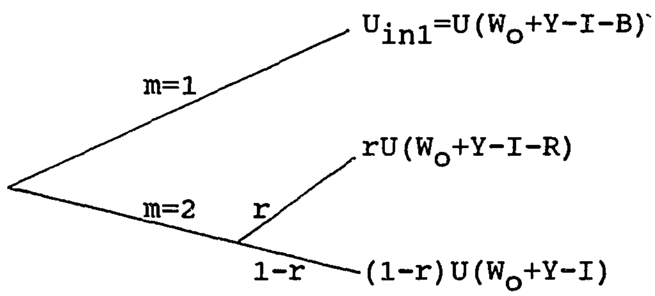
3.4 RANDOM UTILITY MODEL AND SCENARIO COMPARISON

For this study, the practice of defensive medicine is measured by comparing the frequency at which three types of diagnostic procedures are requested in three environments. The first scenario is considered as control or ideal scenario where medical doctors can practice without malpractice threat and costs of test do not affect their income. In the first scenario, tests are therefore requested mainly for diagnostic purposes. The second scenario is one where physicians may be sued for malpractice but tests can be ordered without reducing their potential income. The third scenario is one where physicians may be sued and costs of test are partially paid indirectly by the physicians. In the second and third scenarios, ordering tests will serve two purposes: for diagnosis and for reducing the potential loss from malpractice suits. The difference in the frequencies at which tests are being performed between the second and third scenarios versus the control scenario is a quantification of the extent of the practice of defensive medicine.

Suppose a physician must decide whether a certain diagnostic test should be performed within the third scenario where both B and R are non-zero. Two alternatives (m=1 or 2) of such decision are "to order test; m=1" and "not to order test; m=2". If a test is ordered, the ith physician is protected from a malpractice suit, his utility is given as $U_{in1}=U(W_o+Y-I-B)$. However, if the test is not ordered, m=2, then there is a chance r that there will be a successful claim against this ith physician versus a chance of (1-r) that there will be no such claims. The expected utility for not ordering the test can be expressed as

$$EU_{in2}= [rU(W_o+Y-I-R) + (1-r)U(W_o+Y-I)]$$

The alternative utility situations for a physician deciding on whether to order a test or not may be represented as follows.



By applying R.U.M., the probability that the ith physician will order the test can be expressed as:

$$P_{in1} = \exp(U_{in1}) \;/\; [\exp(U_{in1})+\exp(EU_{in2})$$

Similarly, the probability that the ith physician will not order the test can be expressed as:

$$P_{in2} = \exp(EU_{in2}) \ / \ [\exp(U_{in1})+\exp(EU_{in2})$$

It follows that the relative odds of testing versus not testing (P_{in1}/P_{in2}) can be written as:

$$P_{in1}/P_{in2}=[\exp(U_{in1})/\exp(EU_{in2})]$$

Interpretation of the odds-ratio depends on whether the value is less than, equal to, or greater than 1.

[1] The ith physician is more likely to order a certain test, if
$P_{in1}/P_{in2} > 1$, and
$\exp[U_{in1}] > \exp[EU_{in2}]$, and
$U_{in1} > EU_{in2}$

[2] The ith physician is less likely to order a certain test, if
$P_{in1}/P_{in2} < 1$, and
$\exp[U_{in1}] < \exp[EU_{in2}]$, and
$U_{in1} < EU_{in2}$

[3] The ith physician is indifferent in test ordering, if

$P_{in1}/P_{in2} = 1$, and

$\exp[U_{in1}] < \exp[EU_{in2}]$, and

$U_{in1} = EU_{in2}$

By extending the same structural form of "relative odds ratio", the likelihood that a physician will order test within another scenario (n+1) can also be assessed relative to a reference scenario (n) as follows:

[1] If the ith physician is more likely to order a test in nth scenario than in (n+1)th scenario, then the ratio in nth environment will be greater than that in (n+1)th environment.

$$[P_{in1}/P_{in2}] > [P_{i(n+1)1}/P_{i(n+1)2}]$$

This expression can also be written as:

$\exp[U_{in1}-EU_{in2}] > \exp[U_{i(n+1)1}-[EU_{i(n+1)2}]$

or $[U_{in1} - U_{i(n+1)1}] > [EU_{in2} - EU_{i(n+1)2}]$

[2] If the ith physician is less likely to order a test in nth environment than in (n+1)th environment, then the ratio in nth environment will be smaller than that in (n+1)th environment.

$$[P_{in1}/P_{in2}] < [P_{i(n+1)1}/P_{i(n+1)2}]$$

This expression can also be written as:

$$\exp[U_{in1} - EU_{in2}] < \exp[U_{i(n+1)1} - EU_{i(n+1)2}]$$

or $[U_{in1} - U_{i(n+1)1}] < [EU_{in2} - EU_{i(n+1)2}]$

[3] If the ith physician is likely to order same number of tests in nth environment than in (n+1)th environment, then the ratio in nth environment will be equal to that in (n+1)th environment.

$$[P_{in1}/P_{in2}] = [P_{i(n+1)1}/P_{i(n+1)2}]$$

This expression can also be written as:

$$\exp[U_{in1} - EU_{in2}] = \exp[U_{i(n+1)1} - EU_{i(n+1)2}]$$

or $[U_{in1} - U_{i(n+1)1}] = [EU_{in2} - EU_{i(n+1)2}]$

3.5 GENERATION OF TESTABLE HYPOTHESES

Different tendencies for ordering a test are expected for the three different scenarios. These are discussed below.

[a] Scenario with no malpractice threat and no testing cost to physician, n=1

If the physician decides to order a test, his level of utility can be expressed as:

$$U_{i11}=U(W_o+Y), \quad \text{with } B=0 \text{ and } I=0$$

If the test is not ordered, the physician still get the same level of utility.

$$\begin{aligned} EU_{i12} &= [rU(W_o+Y) + (1-r)U(W_o+Y)], \; r=0 \\ &= U(W_o+Y) \end{aligned}$$

It follows that the "odds-ratio" can be expressed as:

$$\begin{aligned} [P_{i11}/P_{i12}] &= \exp[U_{i11} - EU_{i12} \\ &= \exp[U(W_o+Y) - rU(W_o+Y) \\ &\quad - (1-r)U(W_o+Y)] \\ &= 0 \end{aligned}$$

The physician does not have incentive to order additional tests beyond what is considered medically necessarily for diagnosis.

[b] Scenario with malpractice threat and no testing cost to physician, n=2

If the physician decides to order a test, his level of utility can be expressed as:

$$U_{i21}=U(W_o+Y-I), \quad \text{with } B=0 \text{ when } t=1$$

If the test is not ordered, there is a chance r that there will be successful claims against this ith physician or there is a chance (1-r) that there will be no such claims. The expected utility for not ordering the test can be expressed as:

$$EU_{i22}=[rU(W_o+Y-I-R) + (1-r)U(W_o+Y-I)]$$
$$\text{with } B=0 \text{ when } t=0$$

The "odds-ratio" can be expressed as:

$$\begin{aligned}[P_{i21}/P_{i22}] &= \exp[U_{i21} - EU_{i22}] \\ &= \exp[U(W_o+Y-I)-rU(W_o+Y-I-R) \\ &\quad - (1-r)U(W_o+Y-I)] \\ &= \exp[r\{U(Wo+Y-I)-U(Wo+Y-I-R\}]\end{aligned}$$

Given that there is no cost to the physician for ordering the diagnostic procedures, he will order more tests when the probability (r) of successful claims and amount of claims (R) are higher.

[c] Scenario with malpractice threat and non-zero testing cost to the physician, n=3

If the physician decides to order a test, his level of utility can be expressed as:

$U_{i31}=U(W_o+Y-I-B)$, with $B>0$ when $t=1$

If the test is not ordered, there is a chance r that there will be successful claims against this ith physician or there is a chance (1-r) that there will be no such claims. The expected utility for not ordering the test can be expressed as:

$EU_{i32}=[rU(W_o+Y-I-R) + (1-r)U(W_o+Y-I)]$
with $B=0$ when $t=0$

Then the "odds-ratio" can be expressed as:

$$\begin{aligned}[P_{i31}/P_{i32}] &= \exp[U_{i31} - EU_{i32}] \\ &= \exp[U(W_o+Y-I-B) - rU(W_o+Y-I-R) \\ &\quad - (1-r)U(W_o+Y-I)] \\ &= \exp[r\{U(W_o+Y-I)-U(W_o+Y-R)\}]/ \\ &\quad \exp[U(W_o+Y-I)-U(W_o-I-B)\}]\end{aligned}$$

The physician in this scenario will order more tests if the potential loss in utility due to a patient's successful malpractice claim (R) exceeds the loss in utility due to ordering a test.

Comparing accross the three scenarios:

[1] n=1 versus n=2

$[P_{i11}/P_{i12}] < [P_{i21}/P_{i22}]$ for $R>0$. The freqency at which tests will be ordered in the second scenario will be higher than in the control scenario given that successful malpractice claim is greater than zero. This difference is a measure of the extent of the practice of defensive medicine.

[2] n=1 versus n=3

$[P_{i11}/P_{i12}] < [P_{i31}/P_{i32}]$ for $R>0$ and $B>0$. The frequency with which tests will be ordered in the third scenario will be higher than that in the first scenario (control) as long as R and B are not zero. The differences in frequencies is a measure of defensive medicine modified by cost consideration.

[3] n=2 versus n=3

$[P_{i21}/P_{i22}] > [P_{i31}/P_{i32}]$ for $B>0$. The frequency with which tests will be ordered in the second scenario will be higher than that in the third scenario if the cost of testing to the physician is not zero.

CHAPTER FOUR

DATA COLLECTION

4.1 INTRODUCTION

This chapter first discusses the selection of hospitals, followed by the selection of symptoms and procedures, and then the collection of the individual level patient data.

4.2 SELECTION OF HOSPITALS

Two different environmental conditions are controlled for: the first is physicians' testing costs and the second is threat of malpractice suit. Hospitals can have various combinations of these conditions: a hospital with both malpractice and testing costs, one with neither, one with only malpractice, and one with only testing costs. All three but the last combination, a hospital with only testing costs, are represented in this study. A military hospital represents the control scenario; a fee-for-service hospital represents a scenario with threat of malpractice and no testing costs; and an H.M.O. type hospital represents a scenario with threat of malpractice and testing costs. Each hospital is described in detail below.

a. Military Hospital

The threat of malpractice litigation and economic incentives are considered to be absent in military hospitals. Although Congress enacted the Federal Tort Claims Act to waive the government from sovereign immunity in medical malpractice, the individual physician is not held personally liable [Hearing 1986]. Thus, physicians are not necessarily concerned about the threat of litigation. In contrast to civilian physicians, the military physician is compensated strictly based on rank scale which is independent of the amount of work they do. Therefore, utilization of clinical procedures due to the threat of litigation or economic incentives is not likely to occur in military hospitals.

b. "Fee-For-Service" Hospital

A "fee-for-service" hospital operates under a system where the costs of the procedures are charged to the patients. In reality the patients share the costs with their health insurance company, and often with their employer. The hospital charges the patient for the service and his/her insurance company pays for all or a portion of the fee. In this "third-party" insurance system, which involves the hospital, the patient, and a health insurance company, it is believed that additional procedures can more easily be ordered since neither the physician nor the patient is charged for the tests. Under ceteris paribus, the additional test will be ordered as long as the price of the test exceeds its marginal cost to the physician. As discussed in Chapter Three, since the law of negligence holds each physician liable for his negligent behavior, the incentive for ordering a test is high.

c. Hospital With Prepaid Health Care System (H.M.O.). Under this program, patients prepay for their health care by making monthly payments (usually in the form of payroll deductions) to a hospital acting as their own medical insurance company (referred to as Health Maintenance Organization or H.M.O.). When providing medical treatment, these institutions use the collected premiums to pay the physicians. These premiums represent the institution's revenues, thus giving the institution a strong incentive to minimize costs in an effort to maximize profits. The administrators of the institutions are less likely to condone excessive testing and have an incentive to keep tighter control on their physicians' use of facilities [Cutting 1971, Boardman 1971]. Usually half of the surplus is distributed as incentive compensation to the physicians who contribute the most to the profitability of their practice [Fleming 1971]. Unlike a "fee-for-service" institution, it is in the interest of the physician to avoid ordering unnecessary tests. However, the physicians in these organizations are still subject to malpractice liabilities. As established in Chapter Two, the risk of malpractice declines when more tests are ordered. These opposing influences should promote more control of procedures not present in "fee-for-service" institutions.

Ensuring that hospitals are comparable is vital for reaching a conclusive result. Without comparability, it is difficult to show that an outcome is influenced by the factor under consideration. To minimize this problem, the hospitals were selected for their comparability. First, all the hospitals were selected from the same geographical region. This close proximity serves to minimize differences in staff practices, hospital technology, and physical or social environment. Second, to control for variations in cost constraints among hospitals, cases are restricted to only emergency room cases. Since most emergency room physicians are paid salary, differences due to factors such as fees and volume are considered to be small.

4.3 SELECTION OF SYMPTOMS AND PROCEDURES

The best case scenario would be that all physicians under the different environments face exactly the same cases and patients, with the same test decisions. Since the best case is not obtainable, several steps have been taken to achieve a reasonable degree of comparability among samples. First, minimizing differences in symptoms and procedures is achieved by limiting the types of cases to specific symptoms and limiting procedures to specific tests. Second, those symptoms with a high degree of probable excessive utilization such as radiography have been chosen. Many research studies documented that radiography, also called "x-ray", exhibits a high rate of excessive utilization [Abrams 1979; DHEW 1973; McClean 1981; Phillips 1978; St. John 1956; Boulis 1978; Masters 1980; Bell 1971; Eyes 1978; Harwood 1971; Fowkes 1984]. For this study, the three chosen procedures and their related symptoms are skull x-rays for suspected head trauma, cervical spine x-rays for suspected neck injuries due in automobile accident victims, and computed tomography (CT) for suspected stroke. Each is described in detail below with a short justification of how they meet the criteria discussed.

4.3.1 Skull X-Ray and Head Trauma

As it is defined in Dorland's medical dictionary, head trauma is "a wound or injury to the head which can be caused by a direct or indirect forceful impact." It is sometimes difficult to assess the extent of a head injury based on the nature in which it was received because "the immediate brain damage that results from head trauma is dependent upon the force applied to the head, the area of its application, and whether the head is flexed or freely movable [Lewis 1987; Lusted 1968, 1977]". Skull fracture is a significant concern in that it may allow brain contents and cerebrospinal fluid to leak out permitting contamination of the intracranial space, intracranial collections of blood, and swelling of brain tissue [Tintinalli 1985; Bouzarth 1988]. An untreated head injury may cause brain impairment, cranial nerve damage, and intracranial infection which can result in death [Baker 1983; Jennet 1980; Schwartz 1984]. An immediate treatment is critical to true head injuries within first six hours of injuries [Mock 1947]. Plain x-ray films of the skull can reveal the presence of skull fracture, chronic raised intracranial pressure, abnormal intracranial calcification, and shift in the pineal gland [Lewis 1987]. Most radiologists agree that there is an excessive utilization of skull x-rays to rule out fractures [Philips 1978]. The experts also found that most of the utilization of skull x-rays were performed in emergency departments in which physicians request the procedure on practically all patients with any history or signs of skull trauma, seizures, or headaches [Phillips 1978; Evans 1977].

4.3.2 Cervical Spine X-Rays and Neck Injuries

The neck is a compact area that contains major components of life support systems: the respiratory system, the central nervous system, and the cardiovascular system [Demuth 1985]. Injuries to the cervical spine may be classified as fractures, dislocations, or combination of both. In the emergency department, fractures of the vertebral body are probably the most commonly observed type of bony injury [Lewis 1987]. The neck is frequently injured in automobile collision [Barr 1983]. As a result of the impact from automobile collision, the sudden acceleration causes hyperextension of the head and the neck beyond normal physiologic limits, which is called cervical strain. Patients with acute cervical sprain may have some limitation of neck motion and muscle tenderness. A more serious neck injury may result in fracture and/or dislocation of neck bones. Other clinical diagnostic indications of spinal cord injury includes: [1] a history consistent with spinal cord injury; [2] impaired level of consciousness; [3] any neurologic deficits; [4] localized deformity or swelling; [5] head or facial injury; and [6] unexplained hypotension [Schwartz 1978]. An untreated fracture of the cervical spine may result in neurological problems [Simmons 1978]. Fractures and dislocations of this type can be detected by a cross-table lateral cervical spine x-ray [Bouzarth 1978]. Although documentation has established that a major force is required to cause a fracture [Simons 1978] and that only 5% to 10% of all unconscious patients who were injured in automobile accidents have spine injuries [Bouzarth 1978], use of the cervical spine x-ray is common in emergencies involving automobile accidents.

4.3.3 CT Scan and Cerebrovascular Accidents (Stroke)

Stroke is a vascular disease which results in damage of the brain tissue. It can be caused by a rupture of a blood vessel in the brain or by an occlusion of a blood vessel where oxygen supply to the brain is restricted. Without sufficient oxygen, the brain tissues undergo ischemic necrosis (infarction) and is destroyed within seconds [Fisher 1972]. The occurrence of stroke is sudden and may cause permanent damage. The classic signs of stroke includes focal neurological deficits such as hemiplegia, numbness, sensory deficit, dysphasia, blindness, diplopia, dizziness, headache, and dysarthria [Fisher 1972].

Computed tomography (CT) scanning combines radiographic and computer technology to produce cross-sectional images of the head and body. CT scanning can produce high quality images of soft tissue structures such as cerebral edema, brain tumors, stroke, subdural and epidural hematomas. [Institute 1977, Gordon 1975, Hounsfield 1973, Ambrose 1973, Lanksch 1977, Evens 1977, Isherwood 1977]. In the past, certain categories of patients with clinical stroke were treated with anticoagulation which would introduce morbidity in patients with a hemorrhagic stroke. The risk of this particular treatment is eliminated by CT scanning which can accurately detect intracerebral hemorrhage even when the spinal fluid examination shows no blood [Evens 1977]. This non-invasive technique is superior to traditional diagnostic tools such as conventional x-rays and procedures such as cerebral angiography [Isherwood 1977; Berland 1987].

As expected with any highly technical and sophisticated procedure, the cost of CT scanning is high. The price of a scanner ranges from $300,000 to $700,000 [Institute 1977]. The operating costs for CT unit were estimated at $371,000 per year [Institute 1977]. Justification of CT usage often rely on the physicians' discretion. Fear of malpractice litigation encourages defensive medical practice, usually expressed as excessive use of diagnostic tests such as CT scanning [McClenahan 1970]. Furthermore, the growing share of personal health care expenditures covered by third-party reimbursement has reduced the incentives to control use.

4.4 DATA COLLECTION

All the data were collected from the medical records in the hospitals. To maintain as much comparability among samples as possible, the data is collected from the same time frame (May 31, 1988 through April 30, 1989). All the records in the emergency departments are filed in chronological order. Every second record was reviewed and the first 100 cases which met the criteria of each symptom were selected.

Particular limitations for each symptom were used to minimize variations among cases. In the head trauma symptom, all cases with indications of forceful impacts to the head such as abrasions, lacerations, contusions, and concussions are selected. These cases may involve falling accidents or blows to the head caused by an intention to harm, as in a fight, or an accident, as in a falling object. For neck injuries, cases are limited to automobile accidents to minimize variations in severity. In the stroke symptom, cases are limited to the age group 40 to 90 years, which is most susceptible to stroke, with complaints of headache and at least two of the neurological deficits listed above.

4.5 SPECIFICATION OF VARIABLES

The variables included in the search can be grouped into two basic categories: characteristics, and physical condition of patients.

The variables for characteristics include the patient's basic characteristics of age, and sex. Other variables such as patients occupation and health insurance coverage are measured, but are not used in the applied model because of the lack of completeness.

The patient's physical condition is measured by a severity index. This index is based on "The Abbreviated Injury Scale" [American 1985] and the physician's assessment of injury during the physical examination. Different scores are assigned to indicate a level of severity for each specific condition. The three highest scores are squared and then summed to provide the "injury severity score". This score serves as the index with which a patient's total injuries may be graded. For example, in the head trauma case, a patient with loss of consciousness will score an index of nine while another patient with only superficial scalp lacerations will score an index of one. The scores were not provided in the patient's files since the index is not usually a part of standard emergency practice, but is part of many research applications. Therefore, it was necessary to calculate the scores individually, following the specifications noted in "The Abbreviated Injury Scale" [American 1985].

CHAPTER FIVE

HYPOTHESIS TESTING AND RESULTS

5.1 INTRODUCTION

Samples of patients were taken from three types of hospitals each representing one of the three scenarios or environments of malpractice. The frequencies at which selected procedures were requested in each of the hospitals are tabulated. The frequencies for each procedure are then compared across the three hospitals to test the various hypotheses about the practice of defensive medicine. The Z test is used to test the significance of the difference in the frequencies among the hospitals.

Before proceeding to the next section, a note must be made about how the other potential causes or sources of increases in the number of diagnostic procedures ordered are controlled for in the study which then allowed for the effects of defensive medicine to be isolated. Since the data collected is cross-section (medical cases within a period of one year), factors like technological advances and medical insurance coverage can be assumed not to have changed radically over the short period of time. The sample hospitals, as discussed in the last chapter, were chosen such that differences in staff practices, hospital technology, etc. are minimum. In terms of patient characteristics, the Kolmogoroff-Smirnoff test is applied to verify homolgeneity of the samples from the three different hospitals. Results from the homogeneity tests are presented below.

5.2 TABULATION OF FREQUENCY OF PROCEDURES

Frequency for each medical procedure is calculated as the number of tests performed divided by the number of cases. For any particular hospital three frequencies or proportions are calculated: [1] x-ray requested among the head trauma patients; [2] Cervical spine x-rays among the neck injury patients; and [3] C.T. scans among the suspected stroke patients. The results are shown in table 2.

The military hospital has substantially lower frequencies of requests for in skull and c-spine x-rays (22% for skull x-rays, 49% for c-spine x-rays) than its civilian counterparts (34%-39% for skull x-rays and 72-73% for c-spine x-rays). These figures are consistent with the first and second hypotheses. Since military physicians are not exposed to malpractice suits, they should order less tests.

Table 2

Frequency of ordering clinical procedures by hospitals

	SKULL X-RAYS %	N	C-SPINE X-RAYS %	N	C.T. SCAN %	N
FEE-FOR-SERVICE	39%	135	73%	100	76%	149
H.M.O.	34%	100	72%	100	40%	100
MILITARY	22%	128	49%	111	18%	106

Note:

[1] Abbreviations

C-spine x-ray:	Cervical spine x-ray
C.T. Scan:	Computed Tomography Scan
H.M.O.:	Health Maintenance Organization
N:	Sample size

[2] Source of data: Based on primary data collection from medical records in each hospital.

The two civilian hospitals are similar to each other in their frequencies in these two procedures. This finding is not consistent with the third hypothesis. The difference in testing costs in the civilian world would lead us to expect higher frequencies in fee-for-service hospital than in H.M.O. hospital.

5.2.1 Testing the Significance of Differences in Frequency of Procedures

Two basic statistical methods were considered for testing the difference between two sample proportions (frequencies): one based on the normal probability distribution and the other based on the Chi-square distribution. In this study, the method based on normal probability distribution is chosen for the following reasons:

[1] At the same level of significance, the probability of rejecting a false null hypothesis is greater for the normal distribution than it is for Chi-square test [Kazmier 1979];

[2] The normal probability distribution is superior for large sample testing of the difference between proportions; that is, when each sample size, n, is

equal to or greater than 100 [Kazmier 1979]. The sample sizes in this study all equal or exceed 100;

[3] Test based on the normal distribution allows for one-tail and two-tail tests while Chi-square test is equivalent to a two-tail test only [Kazmier 1979]. In this study, one-tail test is required for testing the hypothesis outlined in Chapter three.

To illustrate the testing of the significance of the difference between proportions, suppose fewer tests are expected to be requested in a military hospital (n=1) than in a fee-for-service hospital (m=2). The hypothesis testing is set up as follows:

Ho: $f_{nj} \geqslant f_{mj}$

Ha: $f_{nj} < f_{mj}$

where

f_{nj}	Frequency of jth procedure ordered in nth hospital;
f_{mj}	Frequency of jth procedure ordered in mth hospital;
n,m=1	Military hospital;
2	Fee-for-service hospital;
3	H.M.O. hospital; where n is not equal to m;

$j=1$	Skull x-rays;
2	C-spine x-rays;
3	Computed Tomography (CAT Scan)

The significance of the observed difference between two sample proportions is tested using the Z test statistic as follows:

$$z = \frac{P_{nj} - P_{(n+1)j}}{Q}$$

where

P_{nj} Number of procedures (X_n) ordered divided by the sample size (N_n) in nth hospital; i.e. $P_{nj}=X_n/N_n$;

Q Standard error of the difference between proportions for a given procedure

Null hypothesis (Ho) can be rejected if the calculated Z value is smaller than the critical value based on 5% level of significance by using one-tailed test.

5.2.2 Test Results

[1] When comparing the military and fee-for-service hospital, Table 3 shows that the null hypothesis (that military has higher frequency of procedures than fee-for-service hospital) is rejected for all three procedures. The result is consistent with our first hypothesis outlined in chapter three.

Table 3

Contingency table for hypothesis testing
Comparison of utilization of clinical procedures
Military and fee-for-service hospitals

Contingency Table

	Skull x-rays			C-Spine x-rays			C.T. Scan		
	T	NT	TTL	T	NT	TTL	T	NT	TTL
Military	28	100	128	54	57	111	19	87	106
F.F.S.	53	82	135	73	27	100	113	36	149
Total	81	182	263	127	84	211	132	123	255

Hypothesis

	Skull x-rays	C-Spine x-rays	C.T. Scan
Ho:	$f_{11} \geqslant f_{21}$	$f_{12} \geqslant f_{22}$	$f_{13} \geqslant f_{23}$
Ha:	$f_{11} < f_{21}$	$f_{12} < f_{22}$	$f_{13} < f_{23}$

Test Results

	Skull x-rays	C-Spine x-rays	C.T. Scan
Alpha value	0.05	0.05	0.05
Critical value (1 tail)	-1.65	-1.65	-1.65
z test statistics	-2.99	-3.56	-9.14
Results:	Reject Ho	Reject Ho	Reject Ho

Note:
Abbreviations:
- T: Number of cases that the procedures are performed;
- NT: Number of cases that no procedures are performed;
- TTL: Total number of cases

Owing to malpractice threat, fee-for-service hospital has higher frequency of procedures.

[2] When comparing military and H.M.O. hospital, Table 4 shows that the null hypothesis (that military has higher frequency of procedures than H.M.O. hospital) is rejected for all three procedures. The result is consistent with our second hypothesis outlined in chapter three. Owing to malpractice threat, H.M.O. hospital has higher frequency of procedures.

[3] When comparing fee-for-service hospital and H.M.O. hospital, Table 5 shows that the null hypothesis (that fee-for-service has the same frequency of requesting for a procedure than H.M.O.) is rejected for all three procedures except for CAT scan. The results for skull and c-spine x-rays are are inconsistent with third hypothesis outlined in chapter three. Difference in frequency of tests due to costs of procedure is not observed for skull and cervical spine x-rays. The reason for this inconsistency will be discussed later in this chapter.

Having tested for the statistical significance of differences in proportions across hospitals, homogeneity of the data is tested next to verify the validity of the differences in frequencies described above.

Table 4

Contingency table for hypothesis testing
Comparison of utilization of clinical procedures
Military and H.M.O. hospitals

Contingency Table

	Skull x-rays			C-Spine x-rays			C.T. Scan		
	T	NT	TTL	T	NT	TTL	T	NT	TTL
Military	28	100	128	54	57	111	19	87	106
H.M.O.	35	65	100	72	58	100	40	60	100
Total	63	165	228	126	85	211	59	149	206

Hypothesis

	Skull x-rays	C-Spine x-rays	C.T. Scan
Ho:	$f_{11} \geqslant f_{31}$	$f_{12} \geqslant f_{32}$	$f_{13} \geqslant f_{33}$
Ha:	$f_{11} < f_{31}$	$f_{12} < f_{32}$	$f_{13} < f_{33}$

Test Results

	Skull x-rays	C-Spine x-rays	C.T. Scan
Alpha value	0.05	0.05	0.05
Critical value (1 tail)	-1.65	-1.65	-1.65
z test statistics	-2.01	-3.40	-3.49
Results	Reject Ho	Reject Ho	Reject Ho

Note:
Abbreviations:
- T: Number of cases that the procedures are performed;
- NT: Number of cases that no procedures are performed;
- TTL: Total number of cases

Table 5

Contingency table for hypothesis testing
Comparison of utilization of clinical procedures
Fee-for-service and H.M.O. hospitals

Contingency Table

	Skull x-rays			C-Spine x-rays			C.T. Scan		
	T	NT	TTL	T	NT	TTL	T	NT	TTL
H.M.O.	35	65	100	72	58	100	40	60	100
F.F.S.	53	82	135	73	27	100	113	36	149
Total	88	147	235	145	55	200	153	96	249

Hypothesis

	Skull x-rays	C-Spine x-rays	C.T. Scan
Ho:	$f_{21} = f_{31}$	$f_{32} = f_{32}$	$f_{23} = f_{33}$
Ha:	$f_{21} \neq f_{31}$	$f_{32} \neq f_{32}$	$f_{23} \neq f_{33}$

Test Results

	Skull x-rays	C-Spine x-rays	C.T. Scan
Alpha value	0.05	0.05	0.05
Critical value (2 tail)	1.96	1.96	1.96
z test statistics	-0.78	-0.16	-5.72
Results	Can't reject Ho	Can't reject Ho	Reject Ho

Note:
Abbreviations:
- T: Number of cases that the procedures are performed;
- NT: Number of cases that no procedures are performed;
- TTL: Total number of cases

5.3 KOLMOGOROFF-SMIRNOFF TEST (K-S TEST)

5.3.1 Method

The validity of the results presented in the previous section depends on the homogeneity and comparability of the samples taken from the different hospitals. If the samples are found to be heterogeneous in terms of patient characteristics, for example, then definite conclusion cannot be made about the effects of malpractice threat on the frequency at which tests are ordered by physicians in the different hospitals. It could be argued that physicians treat different types of patients differently.

No two samples are exactly alike. To test the homogeneity of samples in this study, one needs to ask the question: Would the physician's decision to order test change if he was to provide service to patients in another type of hospital? If his decision remains the same, one may conclude that the differences in patient characteristics does not significantly affect his decision, or the conclusion may be made that patient profiles are homogeneous. Whichever is the case, we only need to determine if the decision will remain the same given any two different samples of patients.

The Kolmogoroff-Smirnoff Test tests for homogeneity between two samples according to certain profile variables such as sex and age. Although there are other statistical tests for homogeneity, the K-S test is chosen for its ability to detect differences in samples through a comparison of the shape of the cumulative frequency distributions of physicians' decision. One may conclude that two samples are derived from the same population if they have similar cumulative frequency distributions. Specifically, the K-S test will determine whether the physicians' decisions would be the same if they were to provide service to patients coming from another hospital. The test covers differences in the shape of the cumulative distribution, the behavior of mean and median, the dispersion, the skewness, and the probability distribution functions. [Sachs 1984, Winkler 1975] Sachs refers to this test as the "sharpest homogeneity test" for determining whether two independent samples were drawn from the same population. Compared with other tests such as the Chi-square test, it is more sensitive for detecting the heterogeneity of two samples [Sachs 1984].

The K-S test procedure consists of [1] formulation of two opposing hypothesis; [2] calculation of test statistics; [3] derivation of a decision rule; and [4] application of decision rule to the calculated sample statistics. The hypothesis for testing homogeneity can be formulated as:

Ho: The two observed samples are homogeneous (i.e. the physicians' decisions would be the same if they were to provide service to patients coming from another hospital);

Ha: The two observed samples are not homogeneous.

The test statistic for the greatest observed ordinate difference between the two empirical cumulative distribution functions are given as:

$$D = \max |(F1/n1 - F2/n2)|$$

where Fi — cumulative frequencies of the ith distributions

ni — sample size of the ith sample.

As a decision rule, the critical value is given by:

$$D_{(a)} = K_{(a)} \sqrt{(n1+n2)/(n1.n2)}$$

Where $K_{(a)}$: constant depending on level of significance a;

ni : Sample size of the ith samples; $(n_i + n_{i+1}) > 35$;

If the K-S statistic is less than the critical value, the null hypothesis (Ho) cannot be rejected at the given level of significance. Otherwise, the alternative hypothesis (Ha) will be accepted.

5.3.2 Testing with the K-S procedure

[1] Selection and estimation of sample parameter as standard for comparison.

H.M.O. hospital is chosen as the standard for comparison. The coefficients are estimated using a probit model in which the decision to order a test is the dependent variable and patients' characteristics are the independent variables. The regression equation is given as:

$$\hat{Y}_{ijk} = \hat{a}_{ijk} + \hat{b}_{ijk}(AGE) + \hat{c}_{ijk}(SEX) + \hat{d}_{ijk}(SEV)$$

Where i: ith procedure. e.g. Skull, CSP-xrays, or CT scan;
j: jth sample hospital which is H.M.O. in this case
k: kth observations

The estimated equations for each clinical procedure are shown below as well as in Table 6.

$$\hat{Y}_{11k} = -2.1164 + 0.0065(AGE) + 0.1426(SEX) + 1.3413(SEV)$$

$$\hat{Y}_{21k} = -0.5709 + 0.0193(AGE) + 0.2025(SEX) + 0.6226(SEV)$$

$$\hat{Y}_{31k} = -0.3658 - 0.0061(AGE) - 0.3158(SEX) + 0.5902(SEV)$$

[2] Comparison of samples

Patient data from other hospital, say, fee-for-service hospital, is inputted into each the equations above. The cumulative frequency distributions of the

Figure 1

Homogeneity Test For Patient Profiles

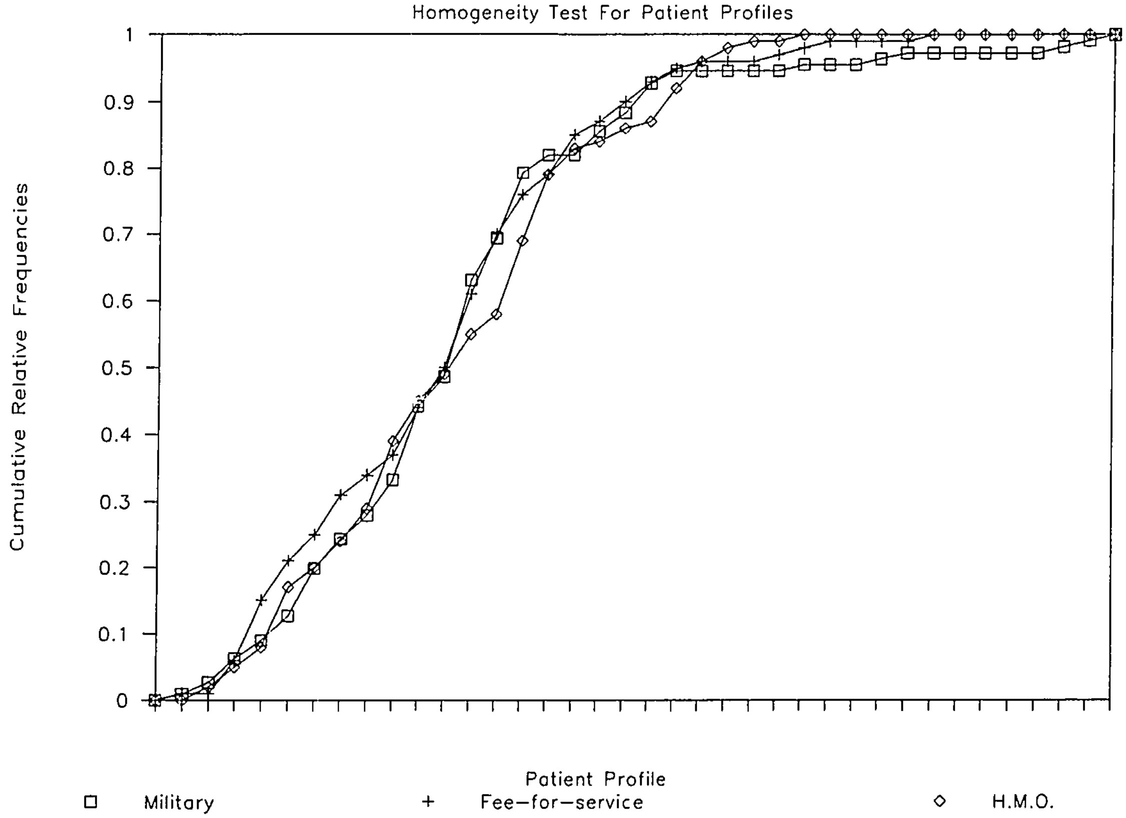


Table 6

Estimation of Sample Coefficients - Probit Model
H.M.O. is chosen as standard for comparison

$$\hat{Y}_{ijk} = \hat{a}_{ijk} + \hat{b}_{ijk}(AGE) + \hat{c}_{ijk}(SEX) + \hat{d}_{ijk}(SEV)$$

Where
- i: ith procedure. e.g. Skull, CSP-xrays, or CT scan;
- j: jth sample hospital which is H.M.O. in this case
- k: kth observations
- Y: Decision to order test. Y=1 when the test is ordered. Y=0 when the test is not ordered.

	$\hat{a}$	$\hat{b}$	$\hat{c}$	$\hat{d}$
Skull x-rays	-2.1164	0.0065	0.1426	1.3413
Cervical spine x-rays	-0.5709	0.0193	0.2025	0.6226
C.T. Scan	-0.3658	-0.0061	-0.3158	0.5902

estimated Y_{ijk} is tabulated for both the H.M.O. and fee-for-service hospital and compared. The K-S test statistic is measured as the maximum vertical distance between two distributions of the estimated Y_{ijk}. As an example, Figure 1 compares the cumulative frequency distributions of the three hospitals for skull x-rays. Table 7 shows the K-S test statistics for each clinical procedure of any two sample hospitals. The test statistic values range from 0.1226 to 0.1469 for skull x-rays, 0.0839 to 0.1200 for cervical spine x-rays, and 0.1832 to 0.3992 for CT scans.

[3] Testing for sample homogeneity

At the 5% level of significance (alpha level), the associated critical value is calculated in Table 7. The critical values range from 0.1678 to 0.1820 for skull x-rays, 0.1875 to 0.1923 for cervical spine x-rays, and 0.1728 to 0.1896 for CT scans.

Based on these computations, we cannot reject the null hypothesis (Ho) that the samples are homogeneous at 5% level of significance for all procedures except for C.T. scan when comparing fee-for-service with either the H.M.O. or military hospital.

Table 7

Test of sample homogeneity: Kolmogoroff-Smirnoff Test

Given:

$$D = \max|(F1/n1 - F2/n2)|$$

with critical values

$$D(a) = K(a) \sqrt{(n1+n2)/(n1.n2)}$$

where		
	Fi	cumulative frequencies of the ith distributions
	ni	sample size of the ith sample.
	K(a)	constant depending on level of significance a;
	ni	Sample size of the ith samples; $(n_i+n_{i+1}) > 35$;

	Skull x-rays		C-spine x-rays		C.T. Scan	
	D	C.V.	D	C.V	D	C.V.
F.F.S. - MILITARY	0.1469	0.1678	0.0839	0.1875	0.3992	0.1728
F.F.S. - H.M.O.	0.1354	0.1800	0.1200	0.1923	0.2373	0.1758
H.M.O. - MILITARY	0.1226	0.1820	0.1137	0.1875	0.1832	0.1896

Note:

[1] Abbreviations

C-Spine x-rays:	Cervical Spine X-Ray
F.F.S.	Fee-for-service Hospital
H.M.O.	Health Maintenance Organization
C.V.	Critical value at 5% level of significance

5.4. DISCUSSION

5.4.1. The effect of malpractice

The findings that there are significant differences in the frequency of ordering test procedures is consistent with our hypothesis that physicians order more tests when faced with malpractice threat. However, this conclusion could not be drawn for the C.T. scan procedure.

With the C.T. scan, the K-S test indicated that the samples were not homogeneous when comparing military against fee-for-service and when comparing H.M.O. against fee-for-service hospitals at a 5% level of significance. Although the H.M.O. and military samples were shown to be homogeneous, the D value was only slightly under the critical value. In an attempt to study the cause of the heterogeneity of the samples, it was found that severity of stroke cases are significantly different among hospitals. Table 8 reveals that the cases in the fee-for-service hospital are consistently more serious than the cases in either the military hospital or H.M.O. hospital. However, there is no difference in the severity of the cases between the military and H.M.O. hospitals. These findings are consistent with the results of the K-S test.

Table 8

Hypothesis Testing: Disease severity among sample hospitals
For C.T. Scan procedure

Ho: Severity of Stroke is not significant different between hospitals.
Ha: Severity of Stroke is significant different between hospitals.

	H.M.O.-F.F.S	H.M.O.-MILITARY	F.F.S.- MILITARY
Severity Index	1.52 - 2.37	1.52 - 0.87	2.37 - 0.87
Variance	7.47 - 8.46	7.47 - 4.59	8.46 - 4.59
t-Value	2.34	1.89	4.74
Degree of freedom	221	188	253
Alpha value	0.05	0.05	0.05
Critical value	1.96	1.96	1.96
Result	Reject Ho	Accept Ho	Reject Ho

Since greater numbers of severe cases provide justification for more frequent tests, it seems then, that the effect of malpractice litigation is magnified by the difference in serverity when comparing the fee-for-service hospital with the military hospital.

5.4.2. The effect of the cost of tests

According to the random utility model, ceteris paribus, physicians should tend to order more tests under environments where costs to physicians are less. In reality, the differences in the costs between the two sample cilivian hospitals are not observed.

Although the H.M.O. hospital has incentives as a "first-party" insurer to minimize clinical procedures, these incentives may have only a minor impact on the decisions made by emergency room physicians. A review of the policy for the emergency department reveals that stipulations to restrict a physicians' ability to order tests cannot be established. Furthermore, the emergency physician will not benefit directly from the savings of not ordering a test. Rather, the gains will go to the department which performs the test. Through interviews with H.M.O. physicians, it is found that the incentive is an insignificant determinant in their decision to order clinical procedures. One physician also added that the hospital had not distributed its profits, if there were any, for several years.

If the assumption concerning the costs of testing was revised such that the H.M.O. hospital and fee-for-service hospital had no significant differences, there should be no difference in the frequency of tests among the civilian hospitals. These predictions are consistent with the empirical findings. There are no differences in utilization of skull x-rays and cervical spine x-rays between H.M.O. and fee-for-service hospitals.

5.5. CONCLUSIONS

Despite the empirical and theoretical difficulties in simulating a physicians' decision to order clinical procedures, the following conclusions can be made.

[1] Defensive Medicine exists.

Defensive medicine is practiced, or, malpractice threat is a significant determinant in the decision to perform a test. Frequency of tests in all the procedures chosen is consistently higher in the civilian hospitals than the military hospital [Table 2]. The effects of other possible determinants, such as severity and patient profiles have been tested, and it was found that these factors do not have a significant influence in the utilization of the procedures except in the case of CT scan.

[2] H.M.O. and Fee-For-Service Hospitals are similar. For skull x-rays and cervical spine x-rays, both hospitals have similar test frequencies [Table 2 and Table 5]. The previous analysis indicated that these hospitals have very similar patient profiles, severity of cases, and threat of malpractice litigation. The existing difference in the testing costs to physicians between these two hospitals does not seem to have a significant effect on the frequency at which tests are ordered. When the difference in the costs of tests is removed, differences observed in the frequency of tests performed disappear. This observation is consistent with the findings in previous sections.

[3] The Fee-For-Service Hospital has significantly more severe stroke cases than the Military Hospital. The hypotheses of this study are based on the assumption that severity of cases is the same in all samples. Data tabulations indicate that the fee-for-service hospital consistently has cases with more severity than the military hospital [Table 8].

In addition to the difference in malpractice threat, differences in case severity intensifies the differences in the test frequencies between these two hospitals. Generally speaking, people who are older, more overweight, exercise less, and have poorer diets are more prone to suffer heart attacks and strokes. One may assume that a fee-for-service population consists of more older people than a military population, which means they are more prone to heart attack and stroke. However, because age is a major factor, samples from all hospitals were limited to the same age group, effectively eliminating age as the cause of the severity difference. One may further speculate that although the age groups are the same, because military personnel have gone through physical training, including exercise and diet, a military population of any age group will tend to be in better physical condition than a civilian population of the same age group. Further investigations of the difference in severity are beyond the scope of this paper. Although the marginal effect of defensive medicine cannot be observed by comparing the fee-for-service and military hospital, the results are believed to be consistent with previous summary when the effects of severity are taken into consideration.

Overall, the possibility of a malpractice suit appears to be an effective inducement for physicians to order more tests, thereby engaging in defensive medicine.

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