ISD Technology: A Strategy for Reduction of Low-Dose Radiation Exposure in Human Beings

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ABSTRACT

The primary purpose of this project is to refocus the current national health care debate. It is the first attempt to provide scientists, health care providers, health care policy makers, politicians, health care payers and public health advocates with a method to improve health care and cut costs through decision-making strategies based primarily on medical standards and secondarily on fiscal considerations. The method for decision-making described in this paper proves more cost-effective and medically sound than current practices.

Illness Specific Diagnostic (ISD) tables are introduced as a method to reduce inappropriate use of ionizing radiation in medicine. The use of ISD tables destroys the myth of a single medical standard of care and focuses on the diagnostician as the individual most capable of diagnosing disease(s) in human beings. Additionally, ionizing radiation has been used routinely under the guise that the resulting benefits outweigh the risks involved in a procedure. This dubious tradition is questioned in this document. Attention is drawn to the inappropriate amount of radiation patients receive when ionizing diagnostic tests are performed with marginal or no diagnostic benefit. The results of a pilot study are presented that explicate the reduction of needless radiation to patients and associated reduction of costs that becomes possible in the presence of appropriate scientific medical standards. Ultimately, quality medicine is indeed the most cost-effective medicine possible.

The current practice by which the United States Congress issues laws aimed at dictating quality medicine is both desperate and dangerous. Politicians and legislators would be wise to focus their efforts on methodologies that establish standards of care in a scientific manner that does not interfere with medical practice. ISD technology is precisely such a scientific method. It establishes the standard of medical care at the facility from which the ISD tables are generated.

ISD tables bring much needed order to diagnostic testing and create a level playing field with which to evaluate medical centers' specificity, sensitivity, and ability to diagnose and treat diseases in humans.

Introduction

This manuscript introduces an interdisciplinary method for disease diagnosis (1). This method addresses difficult issues that face health care in the United States today. Health care cost containment, development of medical standards, and reducing ionizing radiation risk are discussed in this report.

It is known know that physicians, for a variety of reasons, order diagnostic tests inappropriately (2). It has been estimated that as much as 95% of all human-made ionizing radiation exposure is caused by medical use (3,4,5). Overall, between 120 million and 180 million diagnostic radiographic tests are performed annually. Traditionally, the risk associated with radiographic diagnostic testing was outweighed by the resulting benefit. However, more recently, the validity of this tradition has come under scrutiny (6).

Diagnostic tests that utilize ionization radiation have an associated risk (7). The NRC adopted the linear non-threshold dose-effect relationship. Although there are some who argue the scientific merit of the NRC's adoption of the LNT model, there are those who support the NRC's position (8,9,10). Archer's epidemiological work in this area continues to illuminate the risks associated with ionizing radiation.

The risk of unnecessary or inappropriate ionizing radiation is more than an academic debate (11). On September 9, 1994, the FDA issued "Important Information for Physicians and Other Health Care Professionals" (12). That communiqué warned practitioners about burns to patients from fluoroscopically-guided invasive procedures. The report noted cases of severe erythema caused by cardiological and interventional radiological procedures involving long fluoroscopic beam time (60 minutes or more) and high dose rates (20 R/ minutes), with estimated doses of approximately 2000 R/min. Injuries ranged from early transient erythema to secondary ulceration. Among other risks cited by the FDA advisory were concerns about late effects, the recessive nature of radiation injury, and "Delayed Symptoms" in which (other than erythema) the effects of radiation may not appear until weeks following the exposure. Moreover, the practitioner who administers radiation and reportedly, the one with the expertise to diagnose radiation toxicity may not come in direct contact with the patient after the procedure has been performed (13,14).

Finally, the risk is not limited to ionizing radiation. On April 25, 1995, the FDA issued "Warning" notices instructing video companies and the public to cease using ultrasound equipment for non-medical purposes or risk confiscation of the equipment. When non-medical video companies create "keepsake" inutero fetal ultrasound images, they are engaging in the inappropriate use of a medical device, an illegal activity. Generally,

public health experts agree that casual exposure to ultrasound should be avoided. As a result, the FDA concluded that exposing humans to ultrasound with no medical benefit cannot be justified (15).

Diagnostic testing contributes significantly to healthcare spending in the United States which exceeded $1 trillion dollars in 1997 (16). In an effort to hold down costs, the United States Congress passed the Balance Budget Act of 1997, which among other activities, cut medicare funding to healthcare providers across the board. Once herald by the US government as a mechanism to reduce health care cost, managed care health maintenance organizations (HMO) are reported in a state of financial crisis (17). The shift toward managed care, HMOs, and capitation is embraced as the answer to the ever-increasing cost of health care. A consequence of this shift in reimbursement strategies includes a rapid increase in outpatient services (18). Outpatient services shift costs and, in certain cases, increase the rate at which testing is performed (19). Moreover, despite all incremental efforts form reform to reduce cost, not much really has changed fundamentally (20, 21). Additionally, medical errors are on the rise (22).

Although much effort has gone into health care cost reduction and cost containment, very little effort has gone into the development of new medical standards that fit the current economic reality.

Health care resources consumption reduction is a secondary consequence when providers improve their accuracy in selecting diagnostic tests. A methodology to reduce ionizing radiation exposure to human beings by decreasing diagnostic testing is presented. Illness Specific Diagnostic (ISD) tables assist providers at a specific medical center in selecting the most accurate diagnostic test for their patients. Each center creates its own ISD table base on the historical performance of the medical staff.

Materials And Methods

Problem Definition

Fundamentally, this paper challenges the current standard of care applied in medical disease diagnosis. It seeks the modification of physicians' behavior as it relates to the selection of a diagnostic test for confirmation of a disease in a human host in an effort to decrease the health risk that patients are exposed to with no medical benefit.

Also addressed in this study is the introduction of *Diagnosimetrics*[1] (The application of quantitative analysis to the art of disease diagnosis) as the appropriate method for the development of medical center's ISD tables. Diagnosimetrics are the complementary opposites of "outcome studies". They are tangentially connected in that they study medical-diagnostic-testing.

The question of a medical center's diagnostic capacity and its effect on the center's ISD table values is explored. The thorny questions of what constitutes a competent medical diagnostic work-up and the related issue of needlessly exposing patients to ionizing radiation exposure are addressed. This study tests the following hypotheses:

1. Ho: The mean number of positive and negative diagnostic tests used by a physician to diagnose a specific disease at a specific medical facility pre-ISD application
   = the mean number of positive and negative diagnostic tests used by a physician to diagnose a specific disease at a specific medical facility post-ISD application.
   H1: The mean number of positive and negative diagnostic tests used by a physician to diagnose a specific disease at a specific medical facility pre-ISD application
   ≠ the mean number of positive and negative diagnostic tests used by a physician to diagnose a specific disease at a specific medical facility post-ISD application.
2. Ho: The mean amount of radiation absorbed dose (rad) exposure received by a patient for the diagnosis of a specific disease at a specific medical facility pre-ISD application
   = the mean amount of Roentgen exposure received by a patient for the diagnosis of a specific disease at a specific medical facility post-ISD application.
   H1: The mean amount of Roentgen exposure received by a patient for the diagnosis of a specific disease at a specific medical facility pre-ISD application
   ≠ the mean average amount of Roentgen exposure received by a patient for the diagnoses of a specific disease, at a specific medical facility, post-ISD application.

Pilot Study Design: Practical Applications

Locations for this pilot study were medical centers within the United States. Initially, 10 medical centers were invited to take part in the pilot study. A medical center could consist of all types of hospitals , outpatient

[1] **Diagnosimetrics** is a term Hernandez developed in graduate works as a student at the University of Tennessee at Knoxville. Diagnosimetric = di-ag-nos, - NL. Gr. Diagnosis, fr. diagignoskenin to, Fr. dia through, as under + gignoskein - to know.
= si =(se) adv. [It., Sp., & Pg., fr. L. sic So, That] musical, artistic
= Metric = Met ric - L. Metricus, fr. Gr. Metrikes - relating to measuring.

diagnostic centers, and HMO-owned hospitals or clinics. Physician-based Health Maintenance Organizations (HMOs) and other medical facilities were also suitable subjects for this pilot study. The only requirement for participation was that the medical center be able to trace a patient's diagnostic work-up to a Diagnostic Related Group (DRG) intervention (23). Of the 10 respondents, 2 are presented in this limited trial.
The procedures were as follows:

Prior to the disease selection, an individual was identified as the pilot study coordinator (PSC)at each medical center. The PSC developed the data-base abstraction team (DBAT). DBAT is a collection of interdisciplinary experts from across an array of departments within the medical center. Each diagnostic modality from all ancillary areas should have representation on the DABT team. An expert may be a physician, technologist, nurse or physician's assistant (PA).

Once a medical center was identified, the selection of the diseases to undergo ISD analysis was open to discussion. The only restriction was that the diseases could not be related to psychiatric disorders. The utilization review department identified the number of disease occurrences per unit of time, so the hospital disease occurrence rate defined the number of medical records to pull per unit of time. The answer to the questions, "How many medical records do I need to pull? How far back in time do I go?" was related to the occurrence rate of the disease and diagnostic capacity.

Once the disease selection was complete, the pilot study took on four distinct phases:

Phase-I Medical records abstraction. The medical records department's library staff located the medical records identified by the utilization review department. The records were DRG-sorted and stacked. The medical records were abstracted according to the variables identified on the ISD data collection sheet.

Phase-II ISD Table generation. Once abstracted, the data was entered into the ISD data base generator. The result was the production of ISD tables and their correspondent diagnosimetric values. The ISD generator contains the algorithm programs that produce the relative diagnosimetrical value of each diagnostic test. The explication of which is beyond the scope of this work. The tables were validated and returned to the medical centers.

Phase-III Education and communication. The DBAT was reconvened and expanded to include members of management and executive management. The purpose of this meeting was the creation of timetables and subcommittees.

Phase-IV Establishment of the medical center's specific disease diagnostic profile (DDP). A team of medical staff (possibly peer review members) perused the diagnosimetric results, and selected and agreed on the spread of diagnostic test(s). This step is key because it defines and establishes the new medical standard for the diagnosis of the disease in question. The DDP's date of implementation was established.

The DDPs were shared with the medical staff. The staff was instructed to order the diagnostic test(s) as outlined by DDP findings. Any physician member was free to order any test. However, for the purpose of this study, physicians were instructed to order the test(s) identified by the DDP and then proceed with their course of diagnostic testing. The DDP's date of implementation was given.

The DBAT was convened, and the medical records for the same DRGs classification were abstracted for the same variables abstracted in Phase I. Only those medical records post-DDP implementation date were selected for this review.

Illness Specific Diagnostic Technology Design

As previously discussed, ISD technology is parametric. ISD diagnosimetric results are experiential, discrete, nominal data sets. ISD technology evaluates a known universe of data and produces values that are absolute and free from the uncertainty of inferential statistical analysis. ISD diagnosimetric results are real number values whose roots are derived from the historical concatenation of diagnostic testing results performed at a specific medical center with prospective application where they are created.

Operationally, the dependent variable of this study is the diagnostic test that is dependent on a specific disease and diagnostic capacity at a medical center.

The patient's medical record is abstracted in accordance with the variables identified in the ISD data collection sheet. The ISD data collection sheet is divided into the following three sections: hospital characteristics, patient demographics, and diagnostic procedure characteristics.

Each medical record, which consists of a unique individually numbered file, is given a specific identification number. The "key", which correlates the patient's medical record number and ISD's unique case identifier is held by, and belongs to, the center. In this way, patient confidentiality is maintained. This study reflects a medical staff's pattern of test utilization, and, as such, is not concerned with individual medical records. Each procedure is identified by a unique Physicians' Current Procedural Terminology (CPT) code (24).

The medical center's name, type, region, and number of hospital beds are the center characteristic variables that are analyzed. The case number, date of birth, religion, insurance type, sex, occupation (before retirement), tobacco use, admission date, and discharge date are the patient demographics variables that are analyzed. The DRG number, DRG name, modality, diagnostic test name, diagnostic test CPT, diagnostic test

result, physician ordering the test, physician generating the test result, evaluative test date, and evaluative test result are the diagnostic procedure characteristic variables that are analyzed. Diagnostic and evaluative test result variable has three possibilities: positive, negative and equivocal. A diagnostic test is the first use of a test. An evaluative test is the second application of the same diagnostic test. It evaluates the efficacy of an intervention, or disease progression.

The ISD data collection sheets are gathered, and their contents are entered into a computer-spread sheet function for analysis (ISD Generator). The data are contained in one large master file. A diagnosimetric value is an approximation of the odds ratio that assumes the specificity of a diagnostic test will exceed 0.50. This assumption holds true for most diagnostic tests.

The odds ratio is modified to account for a specificity of 0.50. An additional modification is made to account for the inherent values of negative findings in the diagnosis of a disease. Additionally, a further adjustment is applied to account for the fact that not every DRG medical record will include all diagnostic tests in the master file. A weight is also required to account for evaluative tests. Finally, the diagnosimetric results are ranked by absolute values, and a negative sign (-) is an indication of the spread from the most positive diagnostic test.

Findings

The ISD table and its diagnosimetric values from Hospital 1A and Outpatient Center 1 are presented in Tables 3 and 5 respectively. Among diseases studied at Hospital 1A, pneumonia is presented below. The disease pneumonia uncomplicated was abstracted and generated 112 medical records (cases). The 112 medical records contained 1003 diagnostic tests.

Hospital 1A
DRG NAME: PNEUMONIA

Procedure	Modified Odds Ratio (+/-)	Diagnosimetric Result
Arterial Blood Gas	98/0	0.947
CBC	115/3	0.740
SMA 18	96/6	0.521
Chest x-ray	119/15	0.512
SAM 6	58/3	0.343
Sputum culture	58/29	0.117
EKG (ECG)	43/22	0.084
Urine Culture	6/24	0.083
Cold AGG	3/17	0.038
Urinalysis	47/55	-0.062
TB Skin Test	1/19	-0.114
Acid-Fast Bacilli	1/32	-0.220
Blood Culture	2/58	-0.382
Cytology	0/43	-0.692
Syphilis	0/63	-0.919

Table 3. ISD table for Pneumonia.

Of the 1003 diagnostic procedures performed, 647 had positive values, and 356 had false negative values. All 112 cases were confirmed at discharge with the disease pneumonia. Therefore, this hospital's sensitivity for the disease pneumonia is 65%, and the specificity was 100%. Because ISD tables are disease-specific, there are no false positive or true negative results. This value is unique to this hospital and reflects the medical center's diagnostic capacity.

The test at this hospital that is most likely to appropriately identify pneumonia is the arterial blood gas (See Table 3). It is 100% sensitive in identifying the disease pneumonia in patients at this facility. The test most likely not to identify the presence of the disease pneumonia is the test for syphilis.

A reduction of 905 total diagnostic tests was recorded. This reduction represents an approximate reduction in the number of diagnostic tests used to diagnose the disease pneumonia at this facility. Moreover, this reduction of 90% increases the facility specificity for this disease to 100%. This is the maximum savings possible if only one diagnostic test is performed. Pre-ISD application, the average number of diagnostic tests per admission was approximately 9 tests. Post-ISD application, if the only diagnostic test used to diagnose the disease pneumonia is the arterial blood gas, the average number of diagnostic tests per procedure drops to 1 — approximately an 89% maximum reduction in diagnostic test consumption per admission. The ISD tables identify the test with the greatest propensity to identify the disease in question. However, the DDP is an interdisciplinary convention. The choice of the number of tests to include in the facility's DDP is facility-specific.

Therefore, the specific reduction in diagnostic test resource consumption is more accurately described in greater detail later in this work.

Outpatient Center-1 underwent diagnosimetric assessment for the disease peptic ulcer uncomplicated. The abstraction generated 133 medical records for diagnosimetric evaluation. The results are presented in Table 5. The 133 records generated 1251 diagnostic tests. Of the 1251 tests performed on the 133 patients, 297 had positive results, and 954 had false negative results. The specificity for the disease peptic ulcer uncomplicated at Outpatient Center-1 measured approximately 74%. At this facility, the test most likely to confirm the disease peptic ulcer uncomplicated is the upper GI series. The test most unlikely to confirm the disease peptic ulcer uncomplicated is the test Computer Axial Tomography Scan (CT) of the abdomen.

Here we find a maximum reduction in diagnostic test consumption of approximately 90%. Pre-ISD application, the number of diagnostic tests per admission was approximately 10. Post-ISD application, the average number of diagnostic tests drops to 1, if only 1 diagnostic test is invoked to diagnose the disease peptic ulcer uncomplicated. This represents an approximate 90% maximum reduction in diagnostic resource consumption per illness.

Outpatient Center-1
DRG NAME: Peptic Ulcer Uncomplicated

Procedure	Modified Odds Ratio (+/-)	Diagnosimetric Results	Radiation Exposure in mR/hr[a]	
			mR Procedure Total[c]	mR/Patient[b]
Upper GI	132/2	0.972	933,846.0	6,969.00
Right Shoulder	0/1	-0.020	2,381.00	2,381.00
Oral Cholecystogram	43/67	-0.160	633,600.00	5,760.00
Pelvic Ultrasound	28/67	-0.272		
IVP	45/93	-0.300	422,970.00	3,065.00
Chest PA/LAT	32/178	-0.310	42,000.00	200.000
EKG (ECG)	4/89	-0.810		
Abdominal MRI	1/132	-0.850		
Abdominal Ultrasound	4/91	-0.885		
Barium Enema	3/115	-0.996	1,333,400.00	11,300.00
CT Abdomen	1/123	-0.997	27,825,600.00	224,400.00

[a] Average measured skin exposure per film or unit of fluoro time in milliroentgen (mR).
[b] Average measured skin exposure per diagnostic test at this facility in mR.
[c] Average calculated exposure per diagnostic cohort.

Table 5. ISD table for Peptic Ulcer Uncomplicated

Of interest in this diagnosimetric table are the columns, “mR Procedure Total” and “mR/Patient Total.” These columns represent the radiation exposure a patient was likely to receive and the total amount of radiation exposure this cohort of patients was likely to receive — a maximum reduction in radiation exposure of about 96%. The maximum radiation reduction per patient is approximately 97%.

ISD tables are nominal scale frequency counts, dichotomous, exhaustive categories that are nonparametric data sets. The question of whether the observed decrease in values post-ISD technology application is significant is addressed with the use of Fisher’s Exact Test for Significant Changes (Philips 1978). Given Fisher’s equation

$$P = \frac{(a + b)!(c + d)!(a + b)!(b + d)!}{n!a!b!c!d!}$$

substituting the values in Table 6 and solving the above equation, a P value of 0.566 is obtained. The null hypothesis is rejected with a confidence of 99%. This is a significant reduction. There are no other possible permutations to explore. ISD technology restricts the possible results to the one tail.

Mean Test Scores Pre- and Post-ISD Application		
	Positive Results[a]	Negative Results[b]
Pre ISD Mean	5.78	3.17
Post ISD Mean	1.00	0.00

[a] The total number of positive results divided by the total number of cases.
[b] The total number of negative results divided by the total number of cases.

Table 6 Pre- and Post-Mean Diagnostic Test Results--Hospital 1A

The same is the case with the mean radiation exposure at Outpatient Center-1. Of the 1251 diagnostic tests, 853 used ionizing radiation. Of the 853 ionizing radiation diagnostic tests used to diagnose the disease uncomplicated peptic ulcer disease, 232 had positive findings, and 621 had negative findings. The mean average radiation exposure for the 232 positive diagnostic tests is 9.94 R, and the average radiation exposure for the 621 negative diagnostic tests is 26.6 R. Post-ISD average positive test radiation exposure decreases to approximately 6.969 R; post-ISD application radiation exposure decreases to approximately 0.00 R. The question of whether the observed decrease in the average amount of positive and negative diagnostic tests radiation exposure is significant is again addressed with the use of Fisher's Exact Test for Significant Changes. Arranging the data into a table (Table 7) and solving Fisher's equation results in a P value of 0.458. The null hypothesis is rejected with a 99% confidence. This is a significant reduction. There are no other possible permutations to explore. ISD technology restricts the possible results to the one tail.

Mean Radiation Exposure Pre- and Post-ISD Application		
	Positive Results[a]	Negative Results[b]
Pre-ISD Mean Radiation Exposure	9.94	26.6
Post-ISD Mean Radiation Exposure	6.97	0.00

[a] Mean radiation exposure in Roentgen.
[b] Mean radiation exposure in Roentgen.

Table 7. Pre- and Post-Mean Exposure Results Medical Center-1

The findings of this report support the null hypothesis that the mean radiation exposure a patient is likely to receive pre-ISD application is not equal to the mean radiation exposure a patient is likely to receive post-ISD application. Similarly, the mean number of diagnostic tests used by a physician pre-ISD application is not equal to the mean number of diagnostic tests used by a physician post-ISD application, and both findings are not related to chance.

The findings are significant. ISD technology is effective in reducing inappropriate diagnostic testing and has the capability to significantly reduce the amount of ionizing radiation a patient receives at a specific medical center. The pilot study demonstrates that it is possible to change physician behavior in ordering diagnostic tests. The use of ionizing radiation in diagnostic medicine under the tradition that the radiation risk is outweighed by the benefit of results is no longer valid, and the current use of radiation in medicine violates As Low As Reasonably Achievable (ALARA) principles.

Moreover, the study refutes the myth of a single medical standard of care and supports the assertion that the diagnostician is the person most capable of performing the clinical diagnosis of disease(s) in human beings.

Finally, the study supports the researcher's position as it relates to refocusing the national health care debate in such a way that scientists, health care providers, health care policy makers, health care payers, politicians, and public health advocates begin to base medical decisions first on medical standards, before focusing on secondary financial considerations. Indeed, the failure to do so has proved short-sighted and counterproductive.

Discussion and Implication for Usage

As stated earlier, high quality medicine is cost-effective medicine. When policy makers and politicians center health care policy primarily on economic considerations, the quality of health care suffers. This dangerous practice must be discouraged. It misplaces the emphasis of analysis.

Once the DDP is agreed upon, it sets the diagnostic medical standard at the medical center in which ISD tables are constructed and applied. Symptom-based diagnostic testing should not be allowed.

For instance, the diagnostic work-up cost at Hospital 1A for the 1003 procedures was $40,131.90 and represents $120,360.41 in charges, as illustrated in Table 8. The maximum cost savings post-ISD implementation was about 98%. The maximum reductions in charges was about 97%. Works in progress continue to identify real reduction in the cost of health care in the order of 60-90%

Hospital 1A DRG Name: Pneumonia				
Procedure	Unit Cost	Global Charges	Total Cost	Total Charges
Arterial Blood Gas	6.66	69.80	652.68	6,840.40
CBC	47.50	112.50	5,605.00	13,275.00
SMA 18	87.98	169.80	8,973.96	17,319.60
Chest x-ray	23.50	75.00	3,149.00	10,050.00
SAM 6	32.50	64.30	1,982.50	3,922.30
Sputum Culture	50.00	153.70	4,350.00	13,371.90
EKG (ECG)	8.95	119.24	581.75	7,750.60
Urine Culture	58.00	167.00	348.00	1,002.00
COLD AGG	35.59	89.60	106.77	268.80
Urinalysis	42.50	128.60	4,675.00	14,146.00
TB Skin Test	6.50	18.90	130.00	378.00
Acid fast Bacilli	37.98	90.67	1,253.34	2,992.11
Blood Culture	34.50	134.20	2,070.00	8,052.00
Cytology	107.83	323.50	4,636.69	13,910.50
Syphilis	25.67	112.40	1,617.21	7,081.20
Totals	$605.66	$1,829.21	$40,131.90	$120,360.41

Table 8. Hospital 1A Cost and Charges

The DDP adopted at Hospital 1A is presented in Table 9. Two procedures used together were identified as a comprehensive approach to diagnosing the disease pneumonia. The arterial blood gas and the chest x-ray (PA/LAT) establish the new standard for diagnoses of the disease pneumonia uncomplicated at Hospital 1A.

Procedure	Hospital 1A DDP Global Charges	Unit Cost
Arterial Blood Gas	69.80	6.66
Chest x-ray	75.00	23.50
Total	$144.80	$30.16

Table 9. Hospital 1A DDP Table for Pneumonia

The new standard of diagnostic medicine significantly increased the quality of care as defined by the improved accuracy with which Hospital 1A was able to diagnose pneumonia. The cost to diagnose the disease fell approximately $30.16, a reduction of 95% in direct costs. It was a meaningful reduction in direct cost because the primary focus was on establishing an appropriate standard of care. This cannot be overemphasized. The reduction in charges was equally impressive. Instead of charging $1,829.21 for the 112 cases of pneumonia, the global charge calculates to approximately $148.00 or about a 92% reduction. This is an extremely significant reduction. The reduction in global charges represents the relative diagnostic risk that medical centers take on when entering into a capitated arrangement.

ISD tables draw physicians to the most efficient diagnostic work-up. As medical centers build and use diagnosimetrics technology to gain diagnostic accuracy, the rise in sensitivity results in an optimal diagnostic standard of care at that facility.

It was stated earlier that outcome is to business what diagnosimetrics is to medicine. By their statistical design, outcomes always carry a degree of uncertainty. Outcome studies, yield insight on patterns of diagnostic resource consumption in isolation from diagnostic capacity. Berenson and Holahan's work to categorize the Health Care Finance Administration Common Procedure Coding System (HCPCS) into a new system of 21 types-of-service categories were supported by: completeness of the new category definitions, and immunity to changes in technology and variations among facilities. Their analysis of more than 7000 procedure codes into a new system of service categories, is a classic case of outcomes analysis — by its very design riddled with measures of uncertainty, qualification of measured values and a desire for broad application (25).

Similar results to those presented in this study occurred at other facilities. This was the case at Outpatient Center-1, as outlined in Table 10.

The DDP at Outpatient Center-1 was established in selection of the upper GI series. In this manner, a new diagnostic standard was set. This new diagnostic standard resulted in significant cost reduction to this

facility. Specifically, a reduction in real total cost was measured at approximately 82%. The 133 peptic ulcer uncomplicated disease cases represented a total reduction of cost from $55,159.00 to approximately $9,990.00. Furthermore, the reduction in charges was equally impressive. Global charges were reduced from $4,659.00 to approximately $375.00, or a 92% reduction in charges.

Outpatient Center-1
DRG NAME: Peptic Ulcer

Procedure	Unit Cost	Global charge	Total Cost	Total Charges
Upper GI	75.00	375.00	9,900.00	50,250.00
Right Shoulder	25.00	125.00	25.00	125.00
Oral Cholecystogram	58.00	225.00	6,380.00	24,750.00
Pelvic Ultrasound	27.00	400.00	2,565.00	38,000.00
IVP	36.00	425.00	4,968.00	58,650.00
Chest PA/LAT	21.00	125.00	4,410.00	26,250.00
EKG (ECG)	6.00	109.00	558.00	10,137.00
Abdominal MRI	56.00	1,100.00	7,448.00	146,300.00
CT Abdomen	48.00	825.00	5,952.00	102,300.00
Barium Enema	51.00	450.00	6,018.00	53,100.00
Abdominal Ultrasound	73.00	500.00	6,935.00	47,500.00
Total	$467.00	$4,659.00	$55,159.00	$557,362.00

Table 10. Outpatient Center-1

Moreover, a significant reduction in the amount of radiation exposure received by patients is reported. The mean radiation exposure per patient admission was reduced from 254,075.00 mR to approximately 6,969.00 mR, or an approximate 98% reduction post ISD application. By any measure, that is a significant reduction of needless and inappropriate ionizing radiation exposure.

Fture Applications

The cost to equip a hospital to treat all diseases will become increasingly prohibitive. A significant portion of a medical center's annual expenditures goes toward acquiring and maintaining patient care equipment. Health care organizations in the United States spend approximately 7.3 billion dollars annually to purchase or replace this equipment. Another $700 million is spent annually to maintain it (26).

Additionally, the process administrators use to determine which patient care equipment to procure in a capitated environment is currently in transition (27).

Medical centers are keenly aware of the pitfalls associated with facility planning (28). No one hospital will be able to afford to treat every disease. Strategically, medical facilities will need to network within health systems. Moreover, health care delivery systems will need technologies that can provide the scientific understanding of how to redistribute resources.

At Outpatient Center-1, we found the frequent use of the 116 negative CT scans of the abdomen intriguing. Why 134 MRI scans of the abdomen, of which only one was positive? In part, the answer was found in the center's diagnostic capacity. Outpatient Center-1 had recently (less than 1¼ years ago) purchased a state-of-the art CT scanner. At about the same time, the center entered into an arrangement with a mobile MRI service.

Health care delivery systems would be wise to formulate long term strategies using the level of detail provided by diagnosimetrical technologies. The decision of which medical center in a health alliance system to designate as a "center of excellence" in cardiology, diseases of the alimentary tract, diseases of the urinary system and others is extremely complicated. The lack of an objective scientific tool for the assessment of the standard of care has made these decisions highly problematic.

Diagnosimetrics allows for the evaluation of diagnostic capacity across medical facilities as it relates to DDP. ISD tables provide the level field of analysis currently missing in today's outcome-driven atmosphere. ISD tables make possible the comparison and evaluation of medical centers' diagnosimetrical values. This comparison could be useful as integrated health systems begin the task of facility planning.

Currently, federal, state, and local government regulations have refrained from defining the appropriateness of a diagnostic test because they lacked diagnostic tools which define appropriateness at a specific medical center. Consequently, patients are needlessly exposed to risk associated with ionizing radiation. The notion that such radiation risks are outweighed by the resulting benefit(s) is clearly outdated. Politicians and public health policy makers would be well served by diagnosimetrical technology because it defines the appropriateness of a medical test at a specific medical facility, and consequently, delineates the appropriate medical standard. Federal, state, and local governments would provide a greater degree of public safety by requiring medical centers to define appropriateness in terms of a center's DDP.

Diagnosimetrics brings much needed order to the process of disease diagnosis, and in doing so, shifts the focus of the current health care debate from an ill-advised and chaotic decision-making process based primarily on financial considerations, to a systematized decision-making process based first on medical standards and then on important, although secondary financial factors.

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