Ethical Choice in the Medical Applications of Information Theory

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Abstract

Background Alongside advances in medical information technology (IT), there is mounting physician and patient dissatisfaction with present-day clinical practice. The effect of introducing increasingly complex medical IT on the ethical dimension of the clinical physician's primary task (identified as direct patient care) can be scrutinized through analysis of the EMR software platform.

Questions/purposes We therefore (1) identify IT changes burdensome to the clinician in performing patient care and which therefore lower quality of care; and (2) suggest methods for clinicians to maintain high quality patient care as IT demands increase.

Methods Elemental relationships from information theory and physical chemistry are applied to the profit-generating creation and flow of medical information between patients, physicians, administrators, suppliers, and insurers. Ethical implications for patient care and the doctor-patient relationship are drawn in the light of these relationships.

Where are we now? Little has been accomplished, or even discussed, regarding limiting healthcare IT growth. Quality of patient care is expected to suffer unless physicians carefully scrutinize, refine and occasionally reject portions of the increasing healthcare IT burden being placed upon them.

Where do we need to go? Better medicine, simply understood as more effective prevention and treatment of musculoskeletal disease, is our professional goal. We need to establish mechanisms whereby we can limit, control or even reverse IT changes that hinder this goal. Clinicians must confront the negative impact many healthcare IT changes have on patient care.

How do we get there? Suggestions for maintaining high standards of practice in the face of the new IT burden include: (1) Increasing IT time-awareness. Clinicians should examine actual time spent in clinical versus computer-based activity and implement changes if that ratio is too high. (2) Increasing IT goal awareness. (3) Examine the software creating a medical record to see how much of what it records is there for financial, as opposed to medical reasons. Is the software helping my patient or someone else's bottom line? Is it for talking to colleagues about sick people or to insurance companies?

Introduction

The word "Doctor" means teacher. For those of us he trained, Doctor Frank Stinchfield was among the greatest of all teachers of medicine. He taught, above all, simply, using rules. Great clarity in complicated situations, as well as a working definition of the shared values and duties which identified us as doctors ourselves, came with Dr. Stinchfield's simple 'first rule for doctors'. "Your job is to take the best care of these people that you can."

Massive change is now underway in American medicine [9]. It is largely from without, driven by governmental and business interests that have found political as well as financial capital to be made off the work of those who treat patients. These drivers of change in medicine do not live by

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medicine's rules, nor do the changes they bring incentivize physicians to do so.

Physicians are dependent, collectively and individually, on medicine's own special, 3000-year-old set of rules [5, 8, 12]. They are the rules of Hippocrates, Maimonides, the Bible, Lao Tze, Avicenna, essentially the rules of all the physicians through the ages who have put the welfare of their patients above their own. I believe the most dangerous aspect of today's massive incursion of corporate and governmental power into the doctor-patient relationship may be its tendency to make us ignore the rules of medicine that have traditionally governed the doctor-patient relationship. That sacred space of medicine has been invaded by a trespasser with neither a nurse's heart nor a physician's blood. The vasculature and nervous system of this invader is the electronic medical record (EMR).

Inefficiency in the Health Care Delivery System

Consider the case of a patient who smashed his thumb with a hammer at work. After visiting the emergency department at a nearby hospital, he was referred to me for followup. I introduced myself, asked him what happened, took his history, examined him, looked at his radiographs, gave him a light, protective splint, and taught him about elevation. It took approximately 5 minutes. Then I faced the New York Workmen's Compensation Board forms. There are 190 spots to fill out on the forms required for me to treat this patient and (hopefully) be paid. These new forms have been designed so that only a treating physician can fill them out accurately. Completing such forms may require more time than treating the patient, particularly if one is prone to thinking carefully about, or answering truthfully, the questions on that form.

This scenario begs a simple question: How long should the doctor take on this form? Why is our "paperwork"—the forms, the coding, the EMR, the CPOE, the computerized prescriptions, the 15 different passwords, the usernames, and the PINs that change every 2 months—so hard and time-consuming? There is but one overarching reason why insurance companies, the government, and our administrators have made the "paperwork" so hard: money. Insurance does not pay us if these forms are not filled out perfectly. The harder they are, the more "mistakes" are made and the longer the insurer retains the invested (and profitable) capital it would lose in paying our bill. A good doctor cannot complete all the required forms alone; he or she could not see enough patients in a day to pay their overhead.

So doctors hire software vendors and coders to fill out the forms, with less physician input, so the doctors can actually do their jobs—treating patients—while somebody

else, paid by the doctor, deals with the forms. The software is an interface between the form and the doctor. It might grab data already present in digital form elsewhere, like day of the accident, name, social security number, and put it in for them. It would then take some smaller amount of clinical data, provided by the physician, and using one strategy or another apply it to the large number of clinical questions on the form [7].

Medical record and billing software clearly puts the doctor onto a slippery slope, at the bottom of which the medical record is used only to make money (or decrease liability); the information required or generated by this software is no longer a tool of patient care because it is often not accurate. Physicians are easily herded onto this slippery slope by "software improvements" bought to deal with unnecessarily difficult "paperwork," falling fees, and code-based reimbursement.

Consideration of this specific patient's case clearly demonstrates that coding is not a particularly good thing for patient care—simply because it takes up so much of a doctors' time and mental energies. Coding started as a trivial inconvenience, and it can be quite easy in a subspecialized practice. However, coding has become a source of enormous inefficiency in the US healthcare delivery system. For a generalist coding is hard: the codes are inadequate, special cases abound, "paying combinations" vary by each insurer and change all the time—it is one way they make money. Coding is very important financially, though it is a bit of a game. Clinicians should not be spending time thinking about coding during working hours. Nor should they be spending \$50,000 a year on a hired coder.

Is any of our coding/EMR effort or money actually going to help sick people get well? Does great coding or an EMR make for better care? Consider the most effective medical users of the very best EMR system digging out the most accurate, best-paying codes. Where would one expect to find the head, or heart, of a doctor so thoroughly competent at this business? This doctor necessarily spends less time with patients and less time learning new medicine. Here is another great cost of the information technology (IT) revolution, one borne only by the sick: the lost attention of their doctors.

How about the cost to the country as a whole of this pay-the-doctor-by-code system? Coding costs at least 12% of the money insurance companies pay me. This includes the cost of a coder, the charges of the billing company, and the computers that hook us up to them.

The Medical Data Supply Chain

Our country does not purchase care very efficiently [15]. Of what insurance companies pay me, I estimate 60% goes

to overhead and approximately one-third of that overhead is beneficial to my patients: the administrative assistants who help them in the office, the office environment itself. Two-thirds of my overhead goes to the billers, the coders, the computers, and insurance, accruing no benefit to my patients. Put another way, a simplified billing scheme and tort reform (liability reasons also account for much of the electronically generated medical record) could save the country 50% of its doctor bills without lowering that undeniably important incentive to good care, a doctor's income [10].

Nevertheless, a more careful consideration of coding might be the only way to resolve what I believe is a serious problem for the country and for doctors [2]. We must consider this fact: codes can only be “checked” against doctors' data—our notes, reports, and most importantly, other codes—which doctors themselves submit. There is no other referee. There are only the ICDM-CPT correspondence charts and high school graduates in front of computer screens checking our bills against them. Doctors enter both procedure and diagnostic codes. No one else can. At some point every one of the financial, administrative, and regulatory workers (who make their money from, but not by doing, medicine) have to take a doctor's word about what is wrong with and what has been done to the patient. In our system, the doctor is the only sensor, the only part of the data transmission chain—running from the most humble patient to the CEO of Aetna—that is capable of producing digitized data. These digitized medical data can be thought of as the food that the whole rest of the system runs on.

An ecobiologic metaphor describes our current system well. The high-order consumers of this digitized medical data are insurers, regulators, and hospital administrations: they would be the large carnivores. A step down would be coders and software vendors, billing staffs, or the billing companies—the herbivores. However, the doctors are the grass—the sole producers of the actual medical data by means of which all the others make their incomes. Every person who makes a living in health care depends on physician-generated data for his or her income.

The Physician as Transducer

Moving information from the human mind to digital code involves data compression and transduction. A transducer is a device which, most broadly, converts one type of energy or signal into another. A loudspeaker converts an electrical signal into sound signals. A microphone converts sounds into electrical currents. Transducers in informatics convert information-carrying signals from one

type to another—a translation program (or a human translator) for instance, functions as a data transducer when it converts an English sentence to French. Data transduction is called “lossy” when it causes a loss of information in the process of transduction. This is a specific way of saying “inaccurate”. Data compression simply means decreasing the overall amount of data in a signal in a way that hopefully maintains the transmitted data's usefulness.

Current Procedural Terminology (CPT) or International Classification of Diseases (ICD) coding is, functionally, a type of data compression [1]. The huge amount of data that is gathered by a human doctor's mind in interviewing and examining a patient is reduced, or compressed, to two or three 5 digit (15 byte) codes for injection into our financial informatic system. This type of lossy transduction also happens when using drop-down menus on EMR programs—instead of the whole English language (plus the little drawings we put in charts) with which to communicate these data (the information in the doctor's mind after seeing the patient), they are reduced to a relatively small number of choices, represented by a far smaller number of bytes.

Sensors function as transducers also—the oxygen saturation monitor on a patient's finger, for example, converts the intensity of red light bounced off a fingernail into an electronic signal or data stream representing moment to moment oxygen saturation. In the most basic understanding of healthcare information systems, the physician is a sensor—a transduction device that interacts with the physical world object called “the patient” or “this case” (which we can define as “patient + labs and diagnostic imaging”) and produces mental data. The physician's clinical impression is the original “analog” signal; it is the highest quality information in the system.

Doctors and nurses are not just transducers as sensors, however. They are also transducers of another, more financially important kind; they are data transducers much like the JPEG or MPEG compression programs used for digital pictures. These common programs use algorithms to reduce the amount of data to be stored, hopefully in a way that does not decrease picture quality too much. The author who writes a 60 page children's version of *Moby Dick* is, similarly, functioning as a lossy transducer of Melville. Physicians as sensors (the first type of transducer), having gathered their clinical impressions, then also function as (lossy) data transducers when they compress those impressions into notes or codes and send them on into the healthcare information system. This second type of transduction—data transduction—simply means starting with our more or less subjective impressions, called judgments, and producing objective reports and codes.

The Dilemma: to be Good Doctor or a Good Data Transducer

It is clear that the analog medical “signal” that exists most perfectly in the mind of the examining physician, degrades when he compresses it into codes and drop-down menu choices ie, information is lost in transduction. Here is the heart of an ethical dilemma we have been facing, perhaps unwittingly, for several decades. It involves being pulled in two directions: toward being a good doctor or toward being a good transducer [4]. To be a good transducer a doctor is told to simplify (ie, lump) medical information for entry into the digitized informatic architecture: to look at the carpenter’s thumb and simply see a 927.3, fill out the forms in tight agreement with this code, and move on to the next client. However, to be a good doctor, he or she must refine his understanding of the problem into ever more categories, splitting broad categories (e.g. swollen thumb) into many more and narrower ones (paronychia, felon, frostbite, snakebite, crush injury, rheumatoid disease, etc.) to better understand and treat a patient. They need to think about the medical problem, the pain, the psychosocial issues.

So in addition to taking large amounts of our time and attention away from patient care, there is an intrinsic opposition between doing good medicine and effective interaction with our profit-driven electronic healthcare data systems. A good doctor also must be realistic about the ultimate reasons for so much more IT being mandated by hospitals, insurers, and the government. These reasons have largely to do with people in IT, corporate, regulatory, and government positions—people other than clinicians—making money. Tens of billions are being spent; surely there are much less expensive ways to guard against the usual reason cited by IT proponents for the enormous build-up, which center around increased patient safeguards against illegible prescriptions, rare drug interactions and allergies [6]. Google offers limitless, secure, free data storage; we can upload and cross index every patient’s chart for free right now.

Where Do We Need To Go?

Medical data come only from doctors; they are dense, subjective in their origins, and undergo compression, corruption, and planned loss as they enter the government/hospital/insurance machinery that they feed—the behemoth called “our national medical information system.” A (minimally) mathematical look at this will demonstrate the only way to tame the behemoth.

The Dumb End User (DEU) Interface, Free Energy, and Information Theory

There is an amazing interface between thermodynamics and information theory (Fig. 1A–B). Entropy, S , negative information, was described by Claude Shannon [13, 14], the father of information theory, by summing the probability of the occurrence of a given discreet variable times its natural logarithm. This is really the same quantity we all used in high school chemistry (described by J. Willard Gibbs [11] in the second equation) to measure the disorder produced by a chemical reaction and (among others) determine if that reaction would or would not be spontaneous. This connection between canonical disorder (Gibb’s S) and information loss (Shannon’s S) is an important one for physicians. It is the mathematical statement of a truth realized by anyone with a messy desk: disorder produces loss of information.

How should doctors interface with complex medical IT structures? We must start by realizing the underlying realities of information transmission. They mimic thermodynamics. The Gibbs Free Energy equation, $G = H - TS$, described a quantity (called the Gibbs free energy) associated with every chemical reaction by this law: “A reaction is spontaneous if its free energy (G) is negative”. Focusing on the S in the informatic as opposed to thermodynamic context, we can also think of it as signal loss, static, loss of accuracy, mistakes, or untruth in an informatic system. But they really are the same. (G , H and S herein will stand for the “change” in free energy, enthalpy and entropy over the reaction. T is temperature in kelvins), H is the energy term—called enthalpy—the heat of reaction. Giving off lots of heat, noise, or light means a chemical reaction has a large, negative H . There is no accepted analog of enthalpy in information theory but given the fact that the system we are considering is ultimately financially, as opposed to energy-driven, it will work well to be considered to represent the economic value of a bit stream to its source relative to its destination, in words, how much money is riding on the data. So when the codes arrive at the insurance office the more money the sender of that code stands to receive from the recipient

$$\text{A } S = -\sum p(x) \ln p(x)$$

$$\text{B } G = \Delta H - T\Delta S$$

G = Gibbs free energy; H = enthalpy (heat) of a reaction; T = temperature; S = entropy.

Fig. 1A–B (A) Shannon entropy equation of information theory p = the probability of the transmitted value $\times$ being equal to known, true, value. (B) Gibbs free energy equation of thermodynamic theory. G = Gibbs free energy; H = enthalpy (heat) of a reaction; T = temperature; S = entropy.

(the insurance company) because of the transmission of the information in that code, the larger negative value of H there is. $G = H - TS$ thus implies that as H becomes a large negative number G will become negative, ie, the reaction will be spontaneous. This enthalpy side of the free energy equation predicts what is known from common sense and experience, that doctors and hospitals will tend to transmit more expensive codes.

The entropy part of the equation, S , is perhaps more important. G becomes negative as S gets larger, ie, as the amount of disorder, misinformation, inaccuracy or lossiness associated with transmitting that data goes up. Thus lossy transduction always tends to be spontaneous [3]. The informatic implication here is that medical data transduction accompanied by a high degree of information loss (“lossy” transduction) is the “natural tendency” of our information systems.

Remember that physicians function as transducers: as sensors first—turning real-world data from histories, physicals, and labs into the clinical impressions in their minds—and then as data transducers, producing reports and codes. The natural tendency is to lose the sensitivity to those signals in nature (signals such as the subtle features of a physical exam and history) to which a good doctor is trained to respond. That is, continuing to pay enough attention to notice the less obvious historical or physical exam finding that yields the difficult diagnosis. A slight affect change during questioning, a subtle tenderness, a gait change or a mild apraxia noticed by a good diagnostician—these will tend to be missed. It is a constant, uphill struggle to avoid this.

But remember that in addition to being transducers as sensors, physicians are also data transducers: transducers of clinical information as they send it on to patients and (alas) insurance companies. The information loss in coding diagnoses and procedures is natural, yet the Gibbs free energy relationship also offers a solution. It is possible in the chemistry laboratory to perform reactions whose free energy change is positive; it is done by coupling the “uphill” reaction to a bigger “downhill” one. The spontaneous reaction of iron and salty water to make rust has a negative Gibbs free energy. But if you put in enough H (heat) you can drive the reaction back to iron again. You had to burn something to make that heat though—so the bigger, spontaneous “downhill” burning reaction drives the iron-to-rust reaction backwards or “uphill” back to iron. Similarly, driving spontaneous reactions backward toward a more ordered state (lower S) can be accomplished by coupling to a reaction that increases entropy. This is seen in evaporating a plate of saline; we get disordered, hydrated sodium and chloride ions to turn into highly ordered salt crystals by coupling to the evaporation of water which involves many more molecules going from the

relatively more ordered liquid state to a completely disordered gas.

The “free energy” we have to put into our medical “information reactions” (the transmissions of physician-created health data within our profit-driven health information systems) to make them run uphill toward good medicine can be in the form of H —enthalpy (which is money or incentives). This means if we had enough money, we would be able to continue the practice of good, accurate medicine by paying for the privilege ourselves. This will rarely be practical. The free energy we put into our medical information reactions can, however, also be in the form of negative S , the opposite of randomness, which is order, information, or accurate transduction.

The laws of thermodynamics then tell us two things: (1) financially driven informatic systems tend to lower quality; and (2) the sustained mental effort of physicians is necessary to maintain their practice of high-quality medicine.

Discussion

Where Are We Now?

Where we are now is at a precipice. And we are now hopefully aware of a natural tendency, much like the law of gravity, for our field of medicine to fall down from this edge to a state of efficiently-delivered, well-documented, mediocre- to- poor patient care. The wings we have in the growing world of medical IT are untried and small. It has been a real struggle for many of us even to achieve level flight. Yet from this precipice, if not to fall we must climb. Doctors must engage their minds in this struggle to gain altitude—to take better care of those entrusted to them. They must recognize that the way, in fact, of nature, is for the quality of their work to deteriorate. Doing a good job for our patients, as medical IT takes more and more physicians’ time, energy, and focus away from sick human beings, is going to take specifically directed mental effort. It is the effort of constantly reminding oneself “the computer is not my job—this patient is.”

Where Do We Need Go?

The most basic relationships of information theory and thermodynamics yield a rule of medical informatics, nearly as simple as one of Dr Stinchfield’s: a good doctor must work diligently to avoid the natural tendency of all financially driven informatic systems. Medical end-users must therefore critically evaluate every new hoop they have to jump through.

The specifics of doing this are difficult to enumerate because they will vary so much with each physician's circumstances and abilities. They will always involve wresting control from business and administrative interests however. Avoiding the IT-driven slide into well-documented clinical mediocrity for some will demand collective action—organizing with other physicians and insisting on a more intuitive, or faster software interface, or a better help desk, or biometric security as opposed to endlessly more and more complicated password changes are examples. For others it will mean individual choices and actions: learning another software platform or how to code your own templates or databases might be a worthwhile investment of time and effort. Being perfectly honest with oneself about time might be the most universal example of what the individual can do. Using computers to help oneself see more and more patients, for less and less money each is at the heart of the trend toward degradation of clinical medicine. Refusing to participate in low-paying plans might be the most effective push-back against this that an individual can make.

Making noise is not the hallmark of American doctors. Their training makes them easy to load hard jobs onto, embarrassed to say “Hey, that’s too much extra work.” Doctors like being busy. But we need to achieve a state of awareness in which doctors ask with every new demand, “Is this new thing they’re making me do making me a better doctor or not?” If the answer is “no,” they must work to stop it or at the very least complain.

How Do We Get There?

How do we get to a nationwide electronic medical record system that is actually beneficial to patient care? First by a clear understanding of our roles: it is the doctor who knows what is best for his or her patient. When the changes foisted on us are bad we must refuse to participate. There are a million of us; someone is going to feel it if we push back on bad rules, bad systems, and bad IT changes. Second, physicians must not stop evaluating what is actually beneficial for their patients and what is not. They must receive education in IT in medical school and for the rest of their lives. For each doctor to be thoroughly IT savvy is the goal. Third,

we must not go gentle. We must change the status quo—laws and regulations, corporate and political power-structures—when the direction it is taking our field is away from the goal that only we are trained to recognize. The courage of our initial convictions as physicians can be our only driver in this. No agency, no regulator, no software provider will do it. Only doctors can protect good medicine.

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