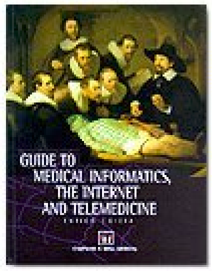
Introduction to Medical Informatics



This introduction is taken from the "Guide to Medical Informatics, the Internet and Telemedicine" by Enrico Coiera (Chapman and Hall, 1997).

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If physiology literally means 'the logic of life', and pathology is 'the logic of disease', then medical informatics is the logic of healthcare. It is the rational study of the way we think about patients, and the way that treatments are defined, selected and evolved. It is the study of how medical knowledge is created, shaped, shared and applied. Ultimately, it is the study of how we organise ourselves to create and run healthcare organisations. With such a pivotal role, it is likely that in the next century, the study of informatics will become as fundamental to the practice of medicine as anatomy has been to the last.

Medical informatics is thus as much about computers as cardiology is about stethoscopes. Rather than drugs, X-ray machines or surgical instruments, the tools of informatics are more likely to be clinical guidelines, formal medical languages, information systems, or communication systems like the Internet. These tools, however, are only a means to an end, which is the delivery of the best possible healthcare.

Although the name 'medical informatics' only came into use around 1973 (Protti, 1995), it is a study that is as old as medicine itself. It was born the day that a doctor first wrote down some impressions about a patient's illness, and used these to learn how to treat their next patient.

Informatics has grown considerably as a medical discipline in recent years fuelled, in part no doubt, by the advances in computer technology. What has fundamentally changed is our ability to describe and manipulate medical knowledge at a highly abstract level, as has our ability to build up rich communication systems to support the process of healthcare.

The rise of medical informatics

Perhaps the greatest change in medical thinking over the last two centuries has been the ascendancy of the scientific method. Since its acceptance, it has become the lens through which we see the world, and governs everything from the way we view disease, through to the way we battle it.

It is now hard to imagine just how controversial the introduction of theory and experimental method into medicine once was. Then, it was strongly opposed by the views of the empiricists, who believed that observation, rather than theoretical conjecture, was the only basis for the rational practice of medicine.

With this perspective, it is almost uncanny to hear again the old empiricists' argument that 'medicine is an art', and not a place for unnecessary speculation or formalisation. This time, the defenders are not fighting against those who wish to put our understanding of disease and treatment on a theoretical ground. Rather, it is against those who wish to develop formal theoretical methods to regulate the communal practice of medicine. Words like clinical audit, outcome measures, healthcare rationing and even evidence-based medicine now define the new intellectual battleground.

While the advance of the scientific method is pushing medical knowledge down to a fine grained molecular and genetic level, events at the other end of the scale are forcing the change. Firstly, the enterprise of medicine has become so large that it now consumes more national resources than any country is willing to bear. Despite sometimes heroic efforts to control this growth in consumption, the healthcare budget continues to expand. There is thus a social and economic imperative, coming from outside healthcare, that is intent on controlling its processes.

However, the structure of medical practice is also coming under pressure from within. The scientific method, long the backbone of medicine, is now under threat. The reason for this is not that experimental science is unable to answer the ever pressing questions about the nature of disease and its treatment. Rather, it is almost too good at its job. As medical research ploughs ahead in laboratories and clinics across the world, like some great theory machine, medical practitioners are being swamped by its results. So much research is now published each week that it can literally take decades for the results of clinical trials to translate into changes in clinical practice.

So, healthcare workers find themselves practising with ever restricting resources, and unable, even if they had the time, to keep abreast of the knowledge of best practice hidden in the literature. As a consequence, the scientific basis of clinical practice trails far behind that of clinical research.

Two hundred years ago, enlightened physicians understood that empiricism needed to be replaced by a more formal and testable way of characterising disease and its treatment. The tool they used then was the scientific method. Today we are in analogous situation. Now the demand is that we replace the organisational processes and structures that force the arbitrary selection amongst treatments with ones that can be formalised, tested, and applied rationally.

Modern medicine has moved away from seeing disease in isolation, to understanding that illness occurs at a complex system level. Infection is not simply the result of the invasion of a pathogenic organism, but the complex interaction of an individual's immune system, nutritional status, environmental and genetic endowments. By seeing things at a system level, we come ever closer to understanding what it really means to be diseased, and how that state, however defined, can be reversed.

We now need to make the same conceptual leap and begin to see the great systems of knowledge that enmesh the delivery of healthcare. These systems produce our knowledge, tools, languages and methods. Thus, a new treatment is never created and tested in intellectual isolation. It gains significance as part of a greater system of knowledge, since it occurs in the context of previous treatments and insights, as well as the context of a society's resources and needs. Further, the work does not finish when we scientifically prove a treatment works. We must try to communicate this new knowledge, and help others to understand, apply, and adapt it.

These then, are the challenges for medicine. Can we put together rational structures for the way clinical evidence is pooled, communicated, and applied to routine care? Can we develop organisational processes and structures that minimise the resources we use, and maximise the benefits delivered? And finally, what tools and methods need to be developed to help achieve these aims in a manner that is practicable, testable, and in keeping with the fundamental goal of healthcare - the relief from disease? The role of medical informatics is to help develop a rational basis to answer these questions, as well as to help create the tools to achieve these goals.

The scope of informatics is thus enormous. It finds application in the design of decision support systems for practitioners (e.g. Miller, 1994), in the development of computer tools for research (e.g. Hunter, 1993), and in the study of the very essence of medicine - its corpus of knowledge (e.g. Keravnou, 1992). Yet the modern discipline of medical informatics is still relatively young. Many different groups within healthcare are addressing the issues raised here, and not always in a co-ordinated fashion. Indeed, these groups are not always even aware that their efforts are connected, nor that their concerns are ones of informatics.

The first goal of this book is to present a unifying set of basic informatics principles, which influence everything from the delivery of care to an individual patient, through to the design of whole healthcare systems. Its next goal is to present the breadth of issues which concern informatics, show how they are related, and to encourage research into understanding the common principles that connect them.

Each area that is covered has been written with three criteria in mind - its **possibility**, its **practicability**, and its **desirability**. Possibility reflects the science of informatics - what in theory can be achieved? Practicability addresses the potential for successfully engineering a system or introducing a new process - what can actually be done given the constraints of the real world? Desirability looks at the fundamental motivation for using a given process or technology.

These criteria are suggested in part because we need to evolve a framework to judge the claims made for new technologies, and those who seek to profit from them. Just as there is a long-standing symbiosis between the pharmaceutical industry and medicine, there is a newer and consequently less examined relationship between medicine and the computing and telecommunication industries. Clinicians should try to judge the claims of these newcomers in the same cautious way that they would examine claims about a new drug (Wyatt, 1987). Perhaps more so, given that clinicians are far more knowledgeable about pharmacology than they are about informatics and telecommunications.

Overview of the book

The book is organised into a number of parts, all of which revolve around the two distinct strands of information and communication. The unique character of each strand is explored individually. There is also an emphasis on understanding the rich way in which they can interact and complement each other.

Part 1 - Basic Concepts in Informatics

Like medicine, informatics has both theoretical and applied aspects to its study. This first part of the book is focused on developing an intuitive understanding of the basic theoretical concepts needed to approach informatics practice in a principled way. Three fundamental ideas underpin the study of informatics - the notions of what constitutes a model, what one means by information, and what defines a system. Each of these three ideas is explored to develop an understanding of how one can develop complex information and communication systems.

A recurring theme in this part will be the need to understand the limitations imposed upon us whenever we create or use a model of the world. Understanding these limitations defines the ultimate limits of possibility for informatics, irrespective of whichever technology one may wish to apply in its service.

Part 2 - Information Systems in Healthcare

The chapters in this part explore the special character of information systems in healthcare. The electronic medical record (EMR) is discussed in many different guises throughout the book, and its role and scope are introduced here. Information systems like the EMR manage a wide variety of activities. Ultimately, the way that these activities are modelled, measured and then managed is determined by information system design.

Sometimes, leaving things unsaid or informal is more productive. Consequently, the important concept of system formality is also introduced here, since it is not always appropriate to build information systems. Indeed it can often be counterproductive. Understanding the role of formality helps informed decisions to be made before information systems are introduced.

The concept of formality also helps us to understand the different roles that communication and information systems play in healthcare. The final chapter in this part spends some time describing how one sets out to build such systems, and some of the design problems that bedevil that process.

Having laid down these foundational ideas in the first two parts of the book, the next two parts turn to focus on two information problems that are specific to healthcare - protocol-based care, and clinical coding.

Part 3 - Protocol-based Systems

Clinical guidelines or protocols have been in limited use for many years. The current emphasis on evidence-based medical practice has made it more likely that healthcare workers will use, and perhaps be involved in the design and maintenance of protocols.

In this part, the various forms and uses of protocols are introduced. Their characteristic advantages and limitations of are also discussed. These are then used to formulate a set of protocol design principles. Finally, the various roles that computer-based protocol systems can play in clinical practice are outlined. These cover both traditional 'passive' support where protocols are kept as a reference, and active systems in which the computer uses the protocol to assist in the delivery of care. For example, protocols incorporated into the EMR can generate clinical alerts or make treatment recommendations.

Part 4 - Language, Coding and Classification in Healthcare

If the data contained in electronic patient record systems is to be analysed, then it needs to be accessible in some regular way. This is usually thwarted by the variations in medical terminology used by different individuals, institutions and nations. To remedy the problem, large dictionaries of standardised medical terms have been created.

The chapters in this section introduce the basic ideas of concepts, terms, codes and classifications, and demonstrate their various uses. The inherent advantages and limitations of using terms and codes are discussed. The last chapter in particular looks at some more advanced issues in coding, describing the theoretical limitations to coding, and outlines practical approaches to managing these issues, as well as presenting open research questions.

Part 5 - Communication Systems in Healthcare

While interpersonal communication skills are fundamental to patient care, the process of communication has, for a long time, not been well supported technologically. Now, with the widespread availability of communication systems supporting mobility, voice mail, electronic mail and video-conferencing, new possibilities arise. The chapters in this section introduce the basic types of communication services and explain the different benefits of each.

Given that much of the technology is new for many, one chapter is devoted to describing the basics of the various different communication systems now available. The final chapter in this part examines the field of telemedicine, in the context of these new technologies. The potential of telemedical systems within different areas of healthcare is described, but the importance of carefully choosing the right set of technologies for a given problem is emphasised.

Part 6 - The Internet

Information systems are starting to become indistinguishable from communication ones, and this convergence is perhaps nowhere more apparent than with the Internet. This part explores in detail the phenomenal rise of the Internet and the World Wide Web, and examines why its technologies have proven to be so revolutionary. The complex way that the Web alters the balance of information publishing and access is explained, along with the consequences of these changes. The full impact of the Internet on healthcare has yet to be felt. Some of the many different ways that it will change healthcare are presented here, from the way communication occurs, through to the change it will have upon the doctor-patient relationship.

Part 7 - Intelligent Clinical Decision Support

The concluding chapters of the book look to some of the most complex computer systems created so far - those based upon the technologies of artificial intelligence (AI). The early promise of computer programs that could assist clinicians in the process of diagnosis have come to fruition, and they are now in routine use in many clinical situations. AI techniques also permit the creation of systems able to assist with therapy planning, information seeking, and the generation of alerts.

The final chapter in this part looks in detail at the way technologies like expert systems and neural networks can help interpret clinical signals. They find application in creating intelligent patient monitors, and potentially, autonomous therapeutic devices like self-adjusting patient ventilators.