Chapter 1
The Health Information Revolution

Healthcare quality improvement is an economic and moral necessity. The transformation, which is needed to improve productivity and effectiveness, will rely on computer interoperability to deliver information when and where required, support soundly-based decision-making, eliminate unnecessary repetition, reduce delays and avoid errors.

Interoperability is one of the core themes of the US Federal Health Information Technology Strategic Plan, which states: "to effectively exchange health information, health IT systems and products must use consistent, specific data and technical standards."[1]

Health interoperability has been given a massive impetus in the 2009 Health Information Technology for Economic and Clinical Health (HITECH)[2] initiative, which encapsulates in its name the economic and clinical necessities for healthcare IT. The nominal focus is to deliver the promise of an interoperable electronic healthcare record (EHR) for all Americans by 2014, but the real goal is to improve value for money (Blumenthal 2009).

Before receiving HITECH payments, each doctor (or other eligible professional) has to demonstrate that he or she is a meaningful user of a certified interoperable EHR system. The early focus is on:

- e-Prescribing, including decision support
- Information exchange including laboratory and radiology reports, demographic and administrative data, and visit summaries
- Quality data sets

Tom Daschle, President Obama's original nominee as Secretary of Health, describes the problem being addressed:

> Our health care system is incredibly primitive when it comes to using the information systems that are common in American workplaces. Only 15 to 20 percent of doctors have

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[1] The ONC-Coordinated Federal Health Information Technology Strategic Plan: 2008–2012: Using the Power of Information Technology to Transform Health and Care. Department of Health and Human Sciences, 3 June, 2008.

[2] Part of the American Recovery and Reinvestment Act, 2009 (ARRA).

Fig. 1.1 Functionality of a comprehensive EHR system

Only 1.5% of US hospitals have comprehensive electronic health records (EHR) systems of the type called for in the HITECH Act; a further 7.5% have basic systems (Jha et al. 2009). What is a comprehensive EHR? An expert consensus view of the functionality required suggested 24 core functions (see Fig. 1.1) in four main groups:

- Clinical documentation
- Test and imaging results

- Decision support
- Computerized provider-order entry

In ambulatory care (doctors' offices), the proportion of doctors using comprehensive and basic EHR systems are 4% and 9%, respectively (DesRoches et al. 2008).

The problem is not one of technology. In the United Kingdom, all GPs (yes, 100%) use EHRs in their consulting rooms and a large proportion work paper-free – they rely entirely on electronic records while consulting. However, GP surgeries, in which all records are electronic, are not able to share data with hospitals, primarily because the hospitals do not use computers for maintaining patient records. In 2009, most hospital doctors do not use computers for maintaining case notes in the consulting room or at the bedside.

There are several reasons why GPs use computers but hospital doctors do not (Benson 2002). Incentives have played a big part. Over a 40-year period, the leaders of the GP profession worked with the government to provide incentives and to remove barriers to computerizing practices. By 1996, 96% of British GPs were already using computers.

The story of the computer-printed prescription form used in England FP10 (comp) provides a good example of the way that governments can remove barriers to computerization. The computer form is twice the width of a standard prescription, with a large blank area on the right-hand side. The original reason for the blank space was that narrow tractor-feed printers were not available when the form was developed (for use in one practice only) in the mid-1970s. The blank right-hand side was later used to provide each patient with a record of his or her medication; this is so useful that no one has seriously considered doing away with it. In 1981, the Department of Health approved the national use of the form, in spite of well-founded reservations that the wider form would be more expensive and computers would make it easier to prescribe more, hence increasing costs. This simple regulatory change was critical in enabling the development and spread of GP computing, where computer-assisted repeat prescribing saves time and improves legibility and safety. In most other countries computer-printed prescriptions remained illegal for many more years, slowing their uptake of computing.

On the other hand, hospital computing has been treated as an administration overhead (a cost to be contained), and doctors have not been offered incentives or other encouragement to become involved. At a time when almost 100% of prescriptions written by GPs are computerized, the proportion of computerized hospital prescriptions is tiny (probably less than 2% but likely to increase rapidly).

One issue has been resistance by hospital doctors and managers. This is not new. Based on his experience in implementing comprehensive EHR systems during the early 1970s, Melville Hodge wrote:

> Success has repeatedly been demonstrated to be the consequence of each doctor, one at a time, coming to see how his performance is enhanced by investing his always scarce time in learning how to use the system efficiently. Similarly hospital managers must participate in and buy into a carefully designed benefits realization program before they can be reasonably expected to act. (Hodge 1990)

There are other difficulties also. What works well in GP surgeries does not scale to work in acute hospitals. Attempts to replicate the success of GP computing in hospitals have failed repeatedly. You cannot shoehorn a system that works well for one specialty into another.

GPs work as individuals working mainly in a single consulting room, but hospital clinicians work as teams and are highly mobile; their work is more diverse and specialized than that of general practice. Hospitals need excellent communication within the work-group, between doctors, nurses, and other professions. For example, about 70% of the tasks performed by junior hospital doctors are done together with another member of staff, usually another doctor (Westbrook et al. 2008).

The information systems used by each specialty need to work together, which requires the deployment of stringent interoperability standards for each use case. Many of the standards required have not been agreed; many of those that have been agreed have not yet been deployed.

The NHS Informatics Review, 2008,[3] sets out a vision to support patient-centered care in a way that empowers patients to be more involved in their care and staff to improve NHS performance (Fig. 1.2).

To help achieve buy-in from hospital doctors the review identified five key features, which are referred to in the report as the "Clinical 5":

- Patient Administration System (PAS) with integration with other systems and sophisticated reporting
- Order Communications and Diagnostics Reporting (including all pathology and radiology tests and tests ordered in primary care)
- Letters with coding (discharge summaries, clinic, and Accident and Emergency letters)
- Scheduling (for beds, tests, theaters, etc.)
- e-Prescribing including "To Take Out" (TTO) medicines

The review also identified that a major program of standards development would be needed to enable these goals to be achieved.

1.1   Health Care is Communication

Health care is a communications industry. Most healthcare processes involve exchanging information; billions of documents are generated. Consider four different types of communication, based on the physical distance that the information has to travel:

- Within the work-group, to record and manage the care of individual patients
- Between specialized diagnostic and treatment departments, to request services and to report results

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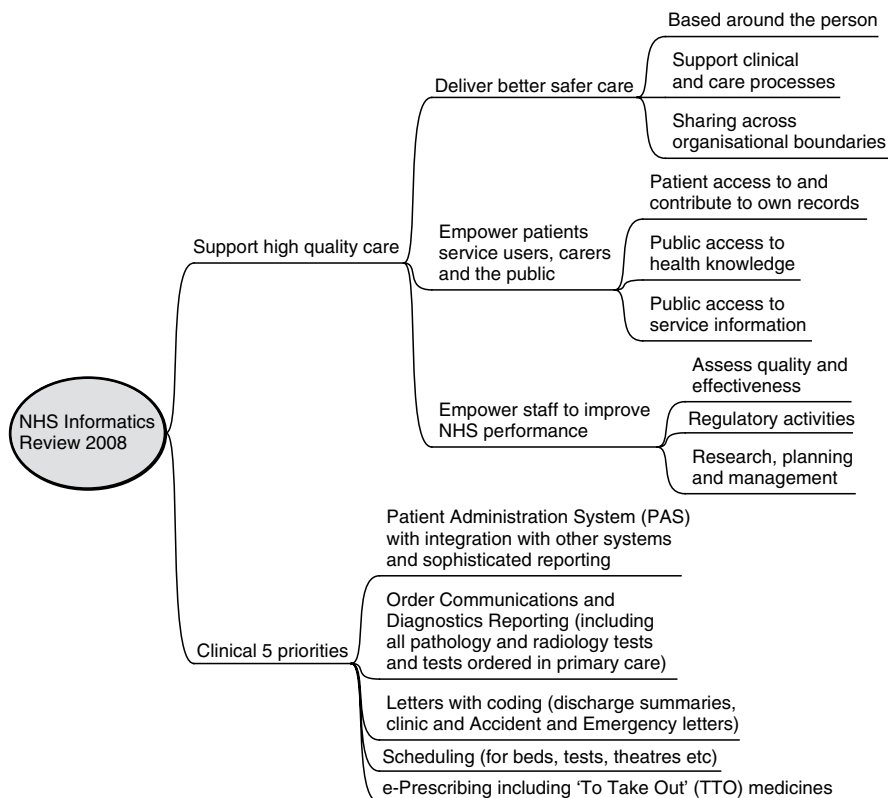[3] Health Informatics Review. DH July 2008, Ref 10104

Fig. 1.2 NHS Informatics Review

- Across organization boundaries between hospital doctors GPs and community staff, to ensure continuity of care
- From the care provider to payers and regulatory agencies, for revenue and accountability

These four categories of communication are listed in decreasing order of information volume yet in increasing order of use of information technology. It is like a banana republic that invests in airports and motorways, but does nothing to improve transport for the millions in the cities.

Historically, healthcare information systems have been organized hierarchically, with the government or payer at the top, then provider organizations such as hospitals, followed by departments, clinicians, and ultimately the patient (GP computing in the UK is a notable exception to this model). This hierarchy reflects the flow of money, authority, and power, but has little in common with the natural flow of healthcare information needed to care for individual patients; patient care has more in common with a social network, with each individual patient at the centre of their own net.

1.2   Patient-Centric Health Care

The patient is the sole reason for healthcare activity, and so we should focus on meeting the patient's needs. Each patient wants to live longer, feel well, and be able to do what he or she wants. Health care is changing from a paternalistic model to one of partnership between patients and healthcare professionals.

In 2001, the Institute of Medicine's *Crossing the Quality Chasm* set out a manifesto for transforming healthcare systems to become safe, effective, patient-centered, timely, efficient, and equitable. It called for urgent action to automate all clinical, financial, and administrative information, and to share that information electronically among clinicians, patients, and appropriate others within a secure environment (Institute of Medicine 2001).

In the traditional healthcare model, care was based around discrete visits and episodes of care; professional autonomy led to variability as each care professional decided on investigations and treatment based on their own training and experience. Safety was an individual responsibility; the patient record was primarily a record of what had happened and was kept secret. The system as a whole defended professional demarcation, focused on cutting costs, reacted to patient needs as and when they arose. This model is disappearing fast, but we still rely on information systems that were originally conceived and designed for that environment.

The new patient-centric model is quite different: care is based on continuous healing relationships, customized according to individual patient needs and values, with the patient as the ultimate source of control. Knowledge is shared, information flows freely, and decision-making is evidence-based. Transparency and collaboration are virtues, patient needs are anticipated, and effort is devoted toward reducing waste (that is, any activity that delivers no benefit to the patient) (Fig. 1.3).

This change toward partnership and patient-centered care involves changes in information systems architecture, more along the lines of social networking than the traditional enterprise-centric systems that have been implemented over the last 30 years or so. A prerequisite of personal health records (PHR) systems is data liquidity using open standards. Unfortunately, most existing EHR systems have incompatible means of acquiring, processing, storing, and communicating data (Mandl et al. 2001).

Most patients, doctors and other healthcare professionals find it surprising that when so much of what we do is performed over the Internet, we are still not able to share information seamlessly to provide joined-up patient-centric care. Coiera has pointed out that health systems are socio-technical systems, involving the interaction of people and technology and that we cannot design organizational and technical systems independently of each other, nor expect to reinvent healthcare systems successfully without a thorough understanding of the technology needed to make all the parts interoperate smoothly (Coiera 2004).
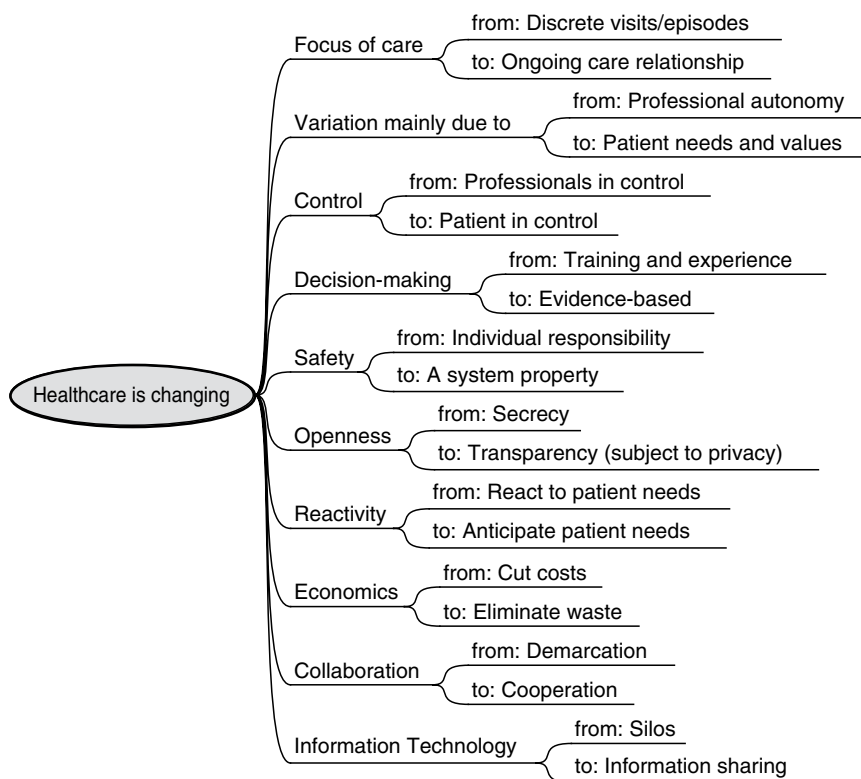
Fig. 1.3 Differences between traditional and patient-centric health care

1.3 Stages of Information Handling

Let us go back to basics. Information handling has evolved over several thousand years through four distinct stages as originally set out by Marshall McLuhan in *Gutenberg's Galaxy (*McLuhan 1962).

In the first stage, information and knowledge was held only in the human brain and transferred from one person to another by speech. Oral tribal culture provides an example. Access depends on the presence of the person with the knowledge, which is lost forever when a person dies. A good deal of one-to-one health care still relies on the human memory and speech.

The second stage began with the invention of handwriting. Handwritten records are formatted at the time of writing, cannot be replicated without transcription, and often illegible. Modern health care, involving teams of doctors and nurses, each doing a specialized task, would be impossible without written records.

The third stage was triggered by the invention of printing by Johannes Gutenberg around 1455, which provided the means to replicate and broadcast information widely. This led to the Renaissance, the Age of Enlightenment, the Industrial Revolution and the Information Society. The impact of this top-down broadcasting and dissemination of knowledge on medical education has been massive, but there has been little impact on how people perform routine health care and maintain care records.

The fourth and last stage, the electronic age, has its origins in the development of electronic computers and information science during World War II and has been gathering pace exponentially ever since, driven by the Laws of Moore and Metcalfe, leading to the explosive development of the Internet, the Web, mobile phones, and social networking.

Moore's Law is the prediction made in 1965 that the power of computer devices would continue to double every 2 years; this has held good for almost 60 years and shows few signs of stopping yet.

Metcalfe's Law is based on the twin observations that the cost of adding each user to a network is linear but the value each user obtains from that network depends on the number of users they can link to. Thus, as networks grow, the value to each user continues to increase and the total value of the network increases exponentially.

It is surprising that health care, the largest and quintessential information-based industry, has failed to harness these forces and become joined-up for so long. The oral tradition and handwritten manuscripts remain prevalent throughout most of the sector (Fig. 1.4).

Health professionals are overwhelmed by information. Herbert Simon noted:

> Information consumes the attention of its recipients; a wealth of information creates a poverty of attention and a need to allocate that attention amongst the overabundance of information sources that might consume it. (Simon 1971)

The value of information lies in its use, which falls into two main categories: clinician support at the point of care, and service management.

Clinician support includes all of the tasks needed to support clinical decision-making, to order tests and treatment, to correspond with patients, hospital specialists, GPs, community and social care services, and to review clinical performance. The nature of clinical care is ultimately determined by the natural history of disease processes, which are highly complex but do not change. Clinical care is task-oriented. At any moment a clinician is performing one of a number of well-defined tasks, which differ considerably from specialty to specialty, with some overlap. Clinical care comprises thousands of discrete tasks, each of which has its own information and communication needs and requires systems, terms, and classifications tailored to the needs of the task.

Service Management is focused on meeting the contractual obligations of commissioners and regulators, which, unlike clinical processes, are subject to frequent and regular change. Managers do not need to understand every detail of clinical care. They focus on providing a safe, courteous, and efficient service, by enabling the smooth administration of each patient's stay or visit, monitoring the quality of care provided in terms of safety, patient experience, and effectiveness,
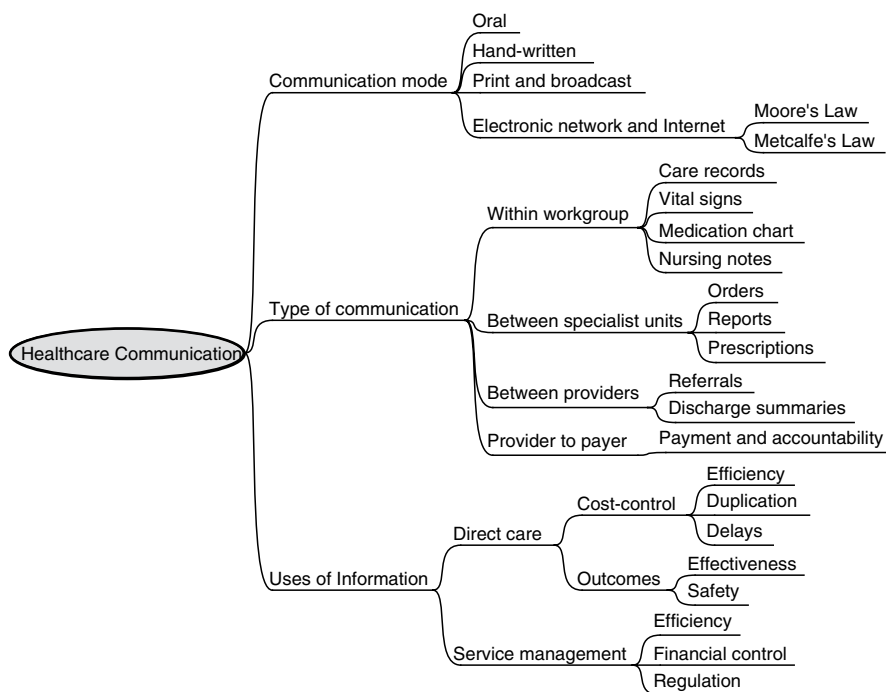
Fig. 1.4 Aspects of healthcare information and communication

costs and opportunities to improve efficiency. Management information is invariably classified into a relatively small number of discrete groups.

Clinical decisions, such as ordering tests, therapy, referrals, and care, determine the cost and outcome of care. Only a small proportion of cost variance in health care can be attributed to service efficiency (doing things right). Most cost and outcome variance is the result of differences in clinical management, individual doctors' patterns of treatment and investigation (doing the right things). It is always important to do tests efficiently, but if the test is inappropriate (e.g., it is repeated without good reason), it is a waste of resources irrespective of how efficiently it is performed.

Donald Berwick has written:

> The ultimate measure by which to judge the quality of a medical effort is whether it helps patients (and their families) as they see it. Anything done in health care that does not help a patient or family is, by definition, waste, whether or not the professions and their associations traditionally hallow it. (Berwick 1997)

Paper-based patient records are widely recognized as not fit for purpose. For example:

> The medical record is an abomination … it is a disgrace to the profession that created it. More often than not the chart is thick, tattered, disorganised and illegible; progress notes, consultants notes, radiology reports and nurses notes are all co-mingled in accession

sequence. The charts confuse rather than enlighten; they provide a forbidding challenge to anyone who tries to understand what is happening to the patient. (Bleich and Lawrence 1993)

A paper record can be used only in one place by one person at a time and is often not where it is needed. Once to hand, it is hard to find what you want in a disorganized, illegible, inconsistent, incomplete, badly sorted bundle of paper. The user has to do all of the work to glean any useful information.

The electronic patient record is key to improved clinical decision-making and accountability. Information quality is a paramount concern. Computer-based patient records are legible and the information can be displayed in many different ways to suit the task at hand. Several people can work on it at different places at the same time, saving the delays and effort required to locate, retrieve, and transport paper. Prompts can improve quality and safety, prevent key data being omitted, and save time by not needing to record the same data time and again.

1.4   Health Care Is Complex

Health care is inherently fractal. The more closely you look, the more complexity you find. The information in hospital medical records is enormously varied; it includes: referral and discharge letters from different doctors; investigation findings from laboratories and diagnostic imaging departments, medication charts, nursing notes, ECG traces, plus the history, examination, progress notes, and plans kept by each doctor.

It is easy to overlook just how flexible paper-based patient records are, in spite of their deficiencies.

Healthcare communication and information flow patterns involve many people over a wide geographical area and diverse subject matter. For example, over 30,000 GPs in England refer over 15 million patients a year to 60,000 hospital and community doctors and receive more than 40 million clinic and discharge letters in return. Each primary care doctor can refer patients to any specialist and each specialist can receive referrals from any GP (Fig. 1.5).

Each doctor also communicates with a multitude of specialized investigation and treatment services, community care agencies, administrative and funding bodies. This complex many-to-many communication pattern is prevalent throughout the health and social care services.

The workflow is varied, depending on what is the matter with the patient and at what stage they are in the process; it changes from one patient to another and from one care setting to another. The half-life of information (how long a piece of information has any value) differs enormously in different contexts, such as in outpatient clinics, on the wards, in intensive care, and during an operation in an operating theatre.

Each class of clinician has its own needs. The Department of Health recognizes more than 60 clinical specialties for doctors plus a similar number of other nursing,
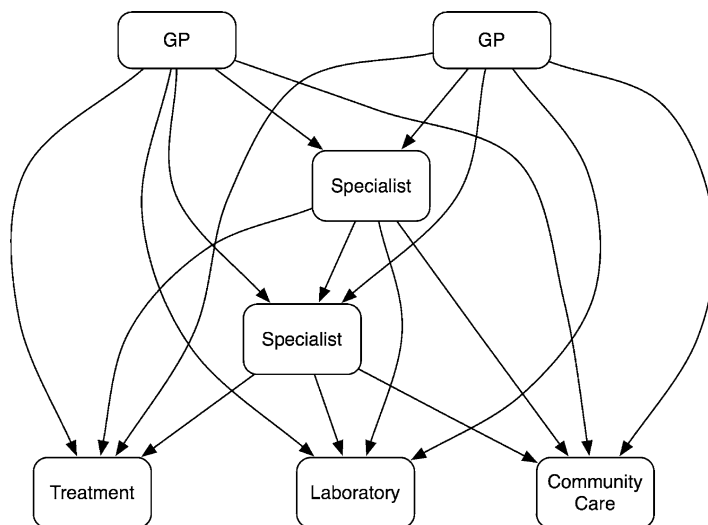
Fig. 1.5 Information flows

therapy and investigation specializations. Each specialty has its own governance, education, and quality assurance requirements, speaks its own dialect and has its own ways of working. Clinical heterogeneity helps explain why many successful electronic patient record systems are limited to single specialties, such as general practice, maternity care, or renal dialysis, where the needs are relatively homogeneous and well-understood.

The situation is exacerbated because most healthcare professionals are mobile and can be found on any ward where they have patients, in clinics, at any one of several hospitals, on domiciliary visits in the community, in laboratories, or in their own office.

The concept of the one-size-fits-all patient record has not been very successful except where great efforts have been made to tailor the system to individual needs and management has been able to mandate its use, such as in the Veterans Administration hospitals, where clinicians were offered no choice as to whether or not to adopt it.

1.5   Looking Back

Sometimes it pays to stand back and take the long view. We now have almost 40 years experience in implementing EHRs and know what works and what does not. There is no excuse for not learning the well-documented lessons of history

1.5.1   Problem-Oriented Medical Records

The Problem-Oriented Medical Record (POMR), first described by Larry Weed in 1968 (Weed 1968), was one of the first and most influential attempts to improve the structure of the patient record.

Weed's POMR divides the record into two parts. The first, called the database covers the patient's social, family, and past medical history. The second main section is the progress notes. Progress notes are organized under problems.

A problem is anything that causes concern, not only a diagnosis. The problem list is a list of all the patient's problems indicating those that are active and those that have been resolved.

Each progress note has a problem heading and four subheadings, using the acronym SOAP:

S – Subjective, meaning the information provided about history and symptoms by the patient or relative.
O – Objective, meaning information obtained by direct examination of the patient or from clinical investigations (laboratory, radiology, etc.).
A – Assessment, meaning the clinicians assessment about what is the matter with the patient (diagnosis), prognosis, etc.
P – Plan, meaning the future plan of action, including investigations and treatment (drug prescriptions, physiotherapy, surgery, and so on). Drugs prescribed are also listed in a separate medication list. This section is a problem-specific care plan.

From 1967 to 1982 Larry Weed was funded by the US government to implement a remarkable problem-oriented electronic patient record system known as PROMIS, based on the use of touch-screen terminals. This pioneering project was implemented for many years on medical and gynecological wards at the University of Vermont, but it was withdrawn after federal funding ceased (Schultz 1988). Weed went on to develop problem-knowledge couplers (PKC), which match detailed patient information with an extensive medical database to provide guidance tailored to individuals (Weed 1991).

The POMR concept was taken up in primary care in the United Kingdom where most GP systems are problem-oriented, linking medication and tests with problems (Fig. 1.6).[4]

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[4] The first widely used problem-oriented GP system in the was Abies System 5, introduced in 1987, distributed by AAH Meditel, and one of the ancestors of iSOFT's Lorenzo system.
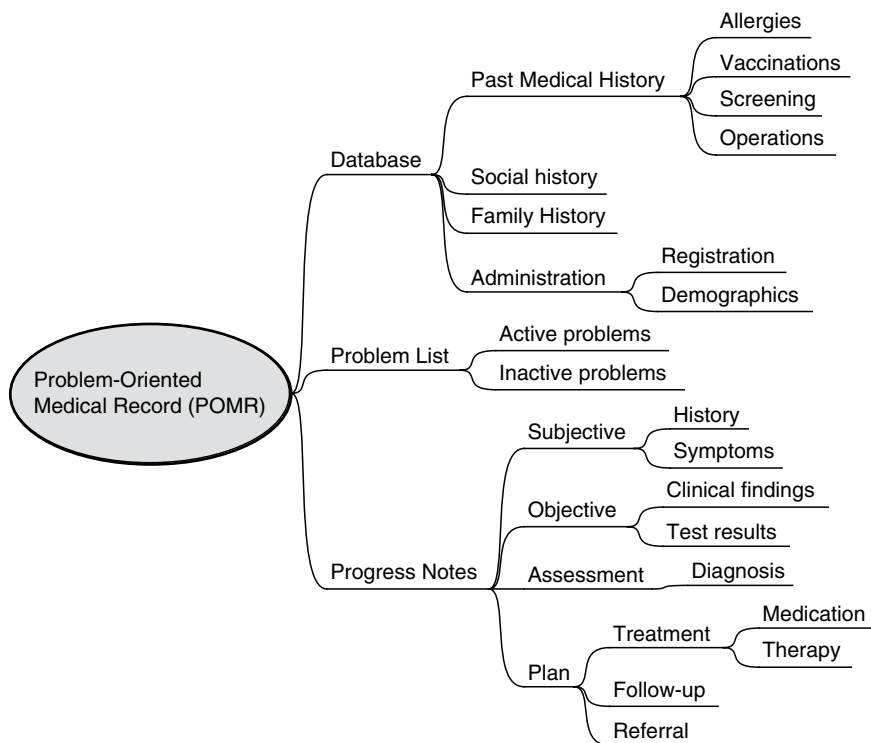
Fig. 1.6 Problem-Oriented Medical Records (POMR)

1.5.2   El Camino Hospital Project

The first hospital to implement a comprehensive EHR was the El Camino hospital in California, which went live in 1971. This was subjected to a detailed 6-year evaluation that compared its costs and other outcomes with those of control hospitals. Such detailed long-term evaluations are rare, but other studies have shown similar findings. Introducing electronic health records into a large hospital i difficult and time-consuming, but the scale of efficiency improvements can be large.

The following quotes come from an account of the experience by Melville Hodge, who led the project for the supplier (Hodge 1990).

The project met:

massive resistance from important segments of the medical staff, spreading quickly to ... national newspaper headlines. This resistance, initially justified in part by early system shortcomings, seemed intractable.

Hodge warns:

> Never forget that introduction of [EHR] into a hospital impacts a <u>human</u> organization to perhaps an unparalleled degree. If the need to manage the change process is ignored, resistance and even rebellion may be reasonably predicted.

The resistance was overcome:

> by effective leadership of the more visionary El Camino physicians.

The outcome was that 10 years later, the hospital chief executive could claim:

> [T]he hospital inpatient cost per case is 40% less than the county average for 13 similar community hospitals.

1.5.3   The NHS National Programme for IT

The English National Health Service National Programme for IT (NPfIT) demonstrates the need for appropriate standards to be fully deployed (Brennan 2005). The central recommendation of the Wanless Report, which led to the creation of the program was for:

> a doubling of spending on ICT to fund ambitious targets of the kind set out in the NHS Information Strategy. To avoid duplication of effort and resources and to ensure that the benefits of ICT integration across health and social services are achieved, the Review recommends that stringent standards are set from the centre to ensure that systems across the UK are fully compatible with each other. (Wanless 2002)

More detail was provided in a Strategy document 3 months later, which stated:

> The core of our strategy is to take greater control over the specification, procurement, resource management, performance management and delivery of the information and IT agenda. We will improve the leadership and direction given to IT, and combine it with national and local implementation that are based on ruthless standardisation. (DH 2002)

The vision of integration across health and social services and cross-UK compatibility had been quietly dropped. The focus was to provide a centrally procured set of one-size-fits-all systems. However, the NHS is not a monolithic organization, but may be better thought of as comprising thousands of units linked by a single payer. It is more like an industry sector than a single service. Linking such an eco-system requires integration standards to be deployed everywhere.

The Strategy listed ten key elements of the national program, the final one being to:

> create national standards for data quality and data interchange between systems at local, regional and national levels. (*op cit* paragraph 2.3.2)

At the outset, the National program underestimated the requirement to develop and deploy the standards needed to enable interoperability at all levels and focused attention on providing only those needed to support links to national services.

The Strategy even implied that the relevant standards were already available.

Work is already underway on a strategy for electronic Clinical Communications and a
report is due at the end of March 2002 (sic). This will guide the implementation of the
electronic pathology results to GPs and GP to GP record transfer (both due in December
2002); radiology reporting and electronic discharge summary implementation due to
commence in March 2003; and the standards for the electronic transfer of prescriptions will
be available later this year. (*op cit* paragraph 4.2.2)

The first phase of the project, between April 2002 and March 2003, was to be
used to:

define the data and data interchange standards we will require in the future. (*op cit*
paragraph 1.2.3)

These targets were missed. One of the reasons was that at that time the
responsibility for standards development was spread across several independent
organizations with responsibility for strategic direction, defining standards, ratifying
standards and certification testing. No one was in control of the whole picture.
These national functions were eventually brought together under NHS Connecting
for Health, but this took until April 2005 and by then many key decisions on scope,
technology, and budgets had been set.

A major effort was directed toward the development of data interface specifications
for national services using HL7 Version 3, but the specification and deployment of
local and regional services was left to the Local Service Providers who adopted
different releases of Hl7 Version 2.

In Canada, the Health Infoway project has learnt some of these lessons and in
2006 established a centrally funded Infoway Standards Collaborative, to:

support and sustain health information standards and foster collaboration to accelerate the
implementation of pan-Canadian standards-based solutions.[5]

In the United States, the HITECH Act has established a statutory Health Information
Standards Committee as well as a budget of $2 billion to support the Office of the
National Coordinator for Health Information Technology (ONCHIT) to build the
requisite infrastructure; develop health information exchange capabilities at the
regional and state levels; and provide grants to assist with implementation, educa-
tion adoption, and interoperability.

1.5.4 Lessons from Denmark

The development and deployment of healthcare interoperability standards are hard,
but important lessons can be learnt from experience in Denmark, which has been
uniquely successful in linking primary care doctors with laboratories, hospitals,
and pharmacies.

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[5] http://www.infoway-inforoute.ca/lang-en/standards-collaborative

In 1994 the Danish Government established MedCom as a national public project collaborating with public authorities, healthcare organizations, and private firms. Initially, a small group of experts developed a set standards for referrals, discharge letters, laboratory and radiology requests and reports, prescriptions, and reimbursement claims, which were based on European standards developed by CEN TC251. Between 1994 and 1996 these specifications were piloted in 11 independent locally managed projects, revised and retested in a further 15 projects. The experience gained was brought together in voluminous documentation:

> in such detail and so accurately and precisely that the overwhelming opinion is that MedCom's standards can indeed be used from Gedser to Skagen (from one end of Denmark to the other). (MedCom 1996)

Unfortunately, the early optimism (hubris) was not justified. The information sent was not always displayed or was misinterpreted due to ambiguity in data definitions of data elements, local coding schemes, and lack clarity about which elements were mandatory or optional. These issues were tackled in a 3-year consolidation project leading to revised standards and compulsory certification. By the end of 2002, 53 software versions had been certified and the error rate reduced by more than 70% (Johansen et al. 2003).

By 2008, all Danish GPs receive discharge summaries and lab results electronically; most prescriptions and referrals are also sent electronically. One of the key lessons is that success has taken time to achieve (Fig. 1.7) (MedCom 2008).
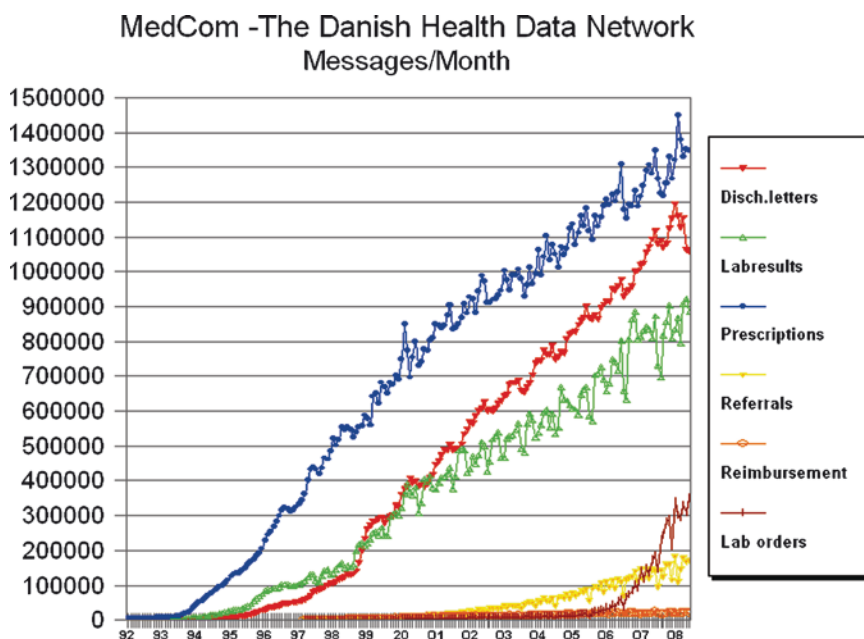
Three factors contributed to the Danish success.

Fig. 1.7 Rise in interoperability in Denmark over the 16-year period 1992–2008. Source: Medcom

Steady political support was provided over many years, even when things went badly. Central support kept the stakeholders together and enabled modest direct financial incentives for participants. As in the United Kingdom, the use of computers by GPs is voluntary, but appropriate incentives produced high participation.

Second, the project was established as a formal collaboration between government, industry, and healthcare providers. Funding is provided one-third each by the state, the County Association, and other sources including doctor's organizations and industry (Protti and Johansen 2003).

Third, the project was proactive and innovative in training suppliers to understand the specifications in precisely the same way. For several years, usually in winter when the weather is bad in Denmark, a few programmers from each software supplier were invited to a special workshop on the Mediterranean coast. These workshops achieve high levels of attendance, collaboration, and bonding.

1.6 Evidence-Based Medicine

Evidence-based medicine (EBM) is one of the most important developments in the clinical use of information over the last 20 years, representing a sea change in the way that clinicians are taught to think. EBM addresses the challenge of finding a way to ensure that clinicians base their day-to-day decision-making on current best evidence. All too often clinicians are unaware of the available evidence or fail to apply it. Even those who are aware of the evidence risk making the wrong recommendations if they do not involve patients in the decision-making process (Guyatt et al. 2004).

EBM is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence-based medicine requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research and our patient's unique values and circumstances (Straus et al. 2005).

The practice of EBM has five steps:

1. Convert our need for information (about prevention, diagnosis, prognosis, therapy, causation, etc.) into an answerable question
2. Track down the best evidence to answer the question
3. Critically appraise the evidence for validity and applicability
4. Integrate the critical appraisal with our clinical expertise and our patient's unique biology, values, and circumstances
5. Evaluate our performance

The first step is to identify the answerable questions.[6] There are two main types of questions – background and foreground.

Background questions occur when we have limited knowledge of the subject. These usually begin with a question root (who, what, where, when, how, why), followed by a verb and a disorder, e.g., "what causes Lyme disease?"[6]

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[6] Lyme disease is an infectious disease transmitted by ticks.

Foreground questions ask for specific knowledge about managing patients with a disorder and are usually specific to a patient's problem, intervention (treatment, test, exposure, perception, etc.), comparison interventions (if relevant) and clinical outcomes of interest.

These questions can be grouped into ten central issues in clinical work:

- Clinical findings – history and physical examination
- Aetiology – causes of disease including iatrogenic forms
- Clinical manifestations – how often and when a disease causes clinical manifestations
- Differential diagnosis – possible causes (likely, serious, and responsive to treatment)
- Diagnostic tests – selection and interpretation of tests to confirm or exclude a diagnosis
- Prognosis – likely clinical course and possible complications
- Therapy – appropriate treatments
- Prevention – risk factors and screening
- Patient experience and meaning – empathy with the patient's situation
- Self-improvement

This classification of types of clinical question could be used to classify access to answers in electronic knowledge tools, using appropriate icons or color codes.

Detailed advice of a general in guidance needs to be tested for issues that make the instructions locally impractical, such as

- Burden – is the frequency too low to warrant action?
- Beliefs – do the risks outweigh the benefits?
- Bargain – are there better uses of our resources?
- Barriers – are there insurmountable barriers (geographic, organizational, traditional, etc.) to adoption?

These are referred to as the "killer Bs."

In her survey of implementing evidence-based findings, Greenhalgh notes that "standard issue" guidelines and protocols and didactic education are usually ineffective, while high-quality, computerized decision support and interactive hands-on education are much more effective (Fig. 1.8) (Greenhalgh 2001).

1.7 EHR System Functional Model

In this field, as in many others, one of the difficulties is definition of terms. What do we mean by the terms such as e-prescribing or clinical decision support? We need an agreed set of definitions so that users, regulators, purchasers, and suppliers can be sure that they are all talking about the same thing.
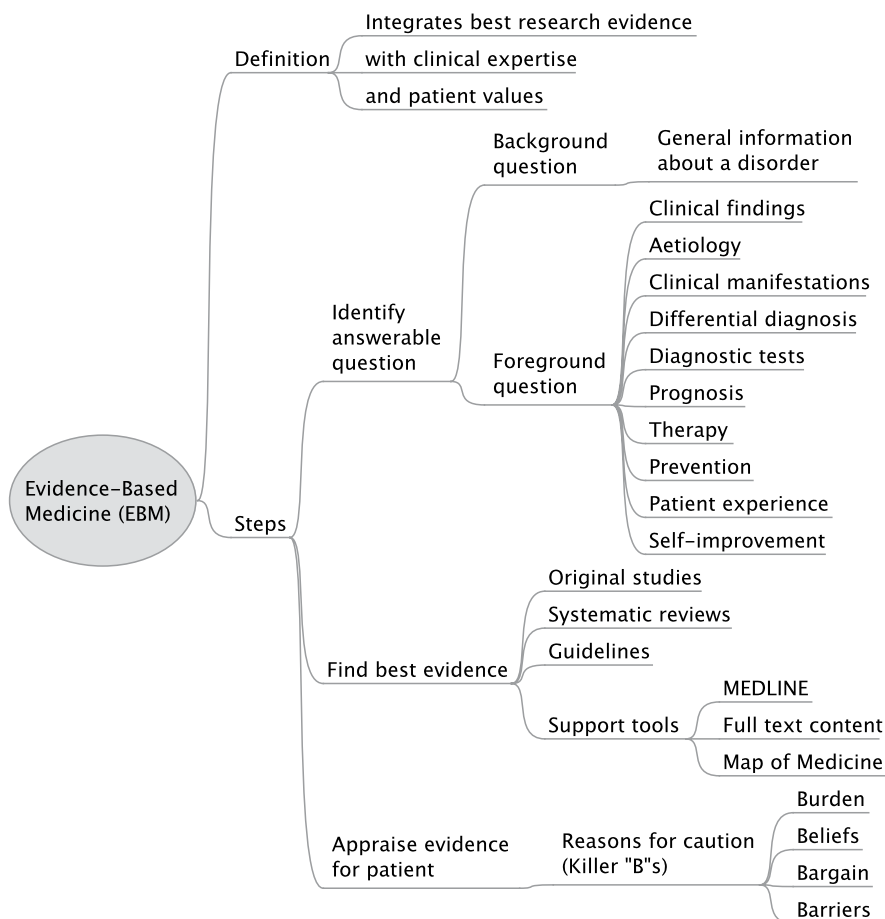
Fig. 1.8 Evidence-based medicine

The need for shared understanding of meaning is the core problem of health interoperability and is the central theme running through the whole of this book.

A comprehensive hierarchical breakdown of the capabilities of EHR systems has been developed by HL7 as the EHR System Functional Model (EHR-S FM). At the top level, there are three groups of functions[7]:

- Direct care: functions used for providing direct health care, or self-care, to one or more persons
- Supportive: functions that use EHR data to support the management of healthcare services and organizations
- Information Infrastructure: backbone elements of security, privacy, registry, interoperability, and terminology

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[7] HL7 EHR System Functional Model: A Major Development Towards Consensus on Electronic Health Record System Functionality. A White Paper, 2004
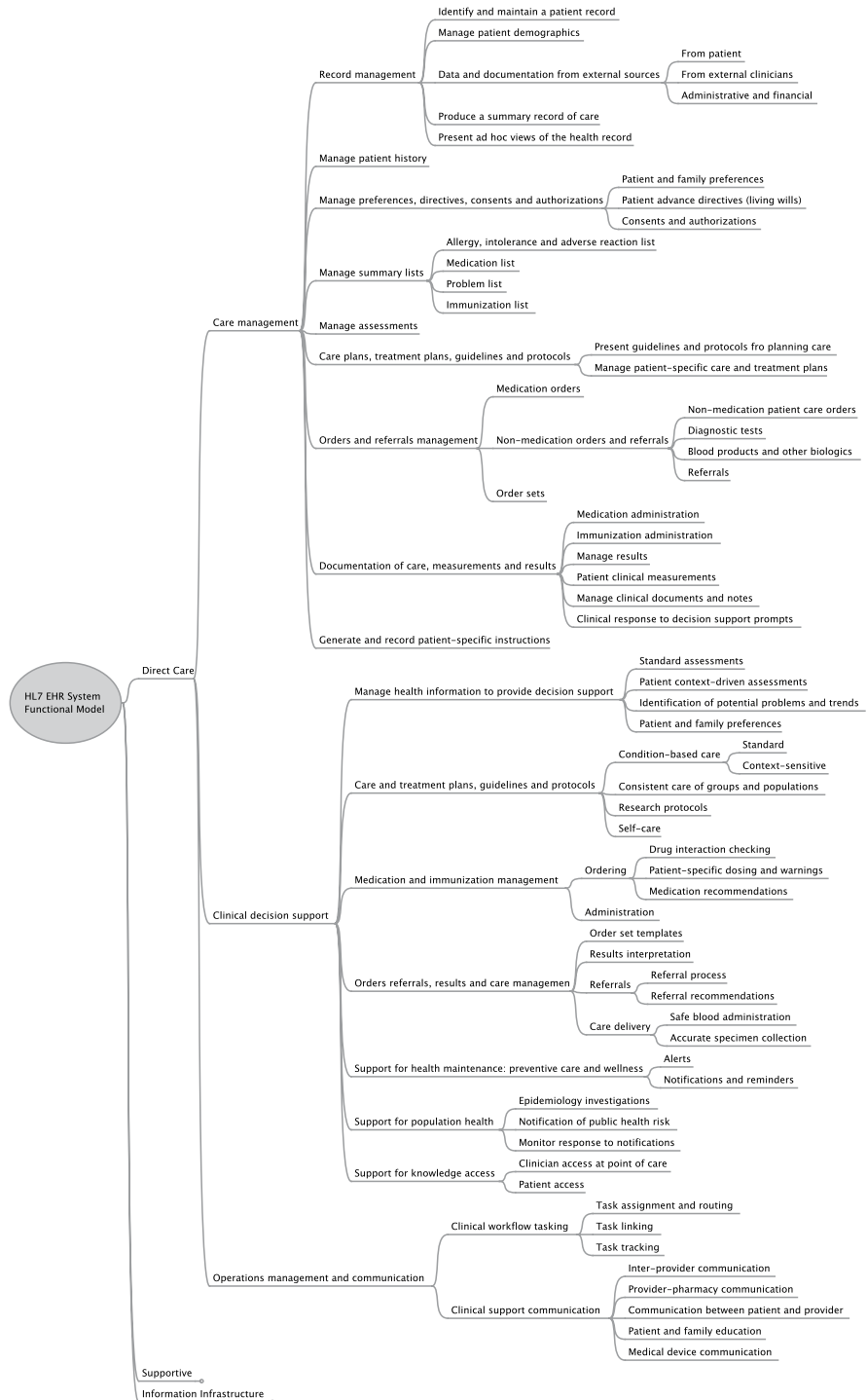
Fig. 1.9 Direct care functions

The whole HL7 EHR System Functional Model taxonomy is shown as an Annexe to this chapter; it provides an overview of the scope of health informatics in general and EHRs in particular. It provides a reference list of over 160 functions that may be present in an Electronic Health Record System (EHR-S).

The function list is described from a user perspective with the intent to enable consistent expression of system functionality. This EHR-S Functional Model, through the creation of Functional Profiles, enables a standardized description and common understanding of functions sought or available in a given setting (e.g., intensive care, cardiology, office practice in one country or primary care in another country).

The EHR-S FM is not a list of specifications for messaging, implementation, or conformance. Nor is it a specification for an actual EHR-S. However, the EHR-S FM is a valuable resource for industry, healthcare providers, governments, and other organizations to uses as a common language (tool) for discussing the functionality of electronic health records (Figs. 1.9–1.11).
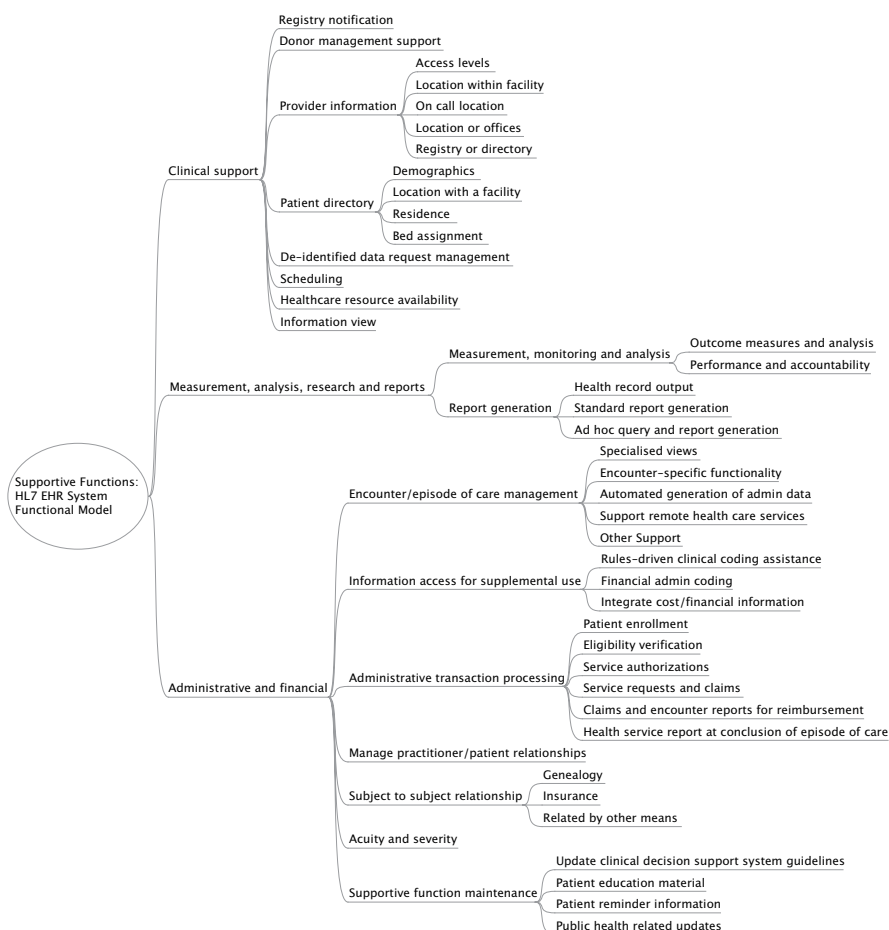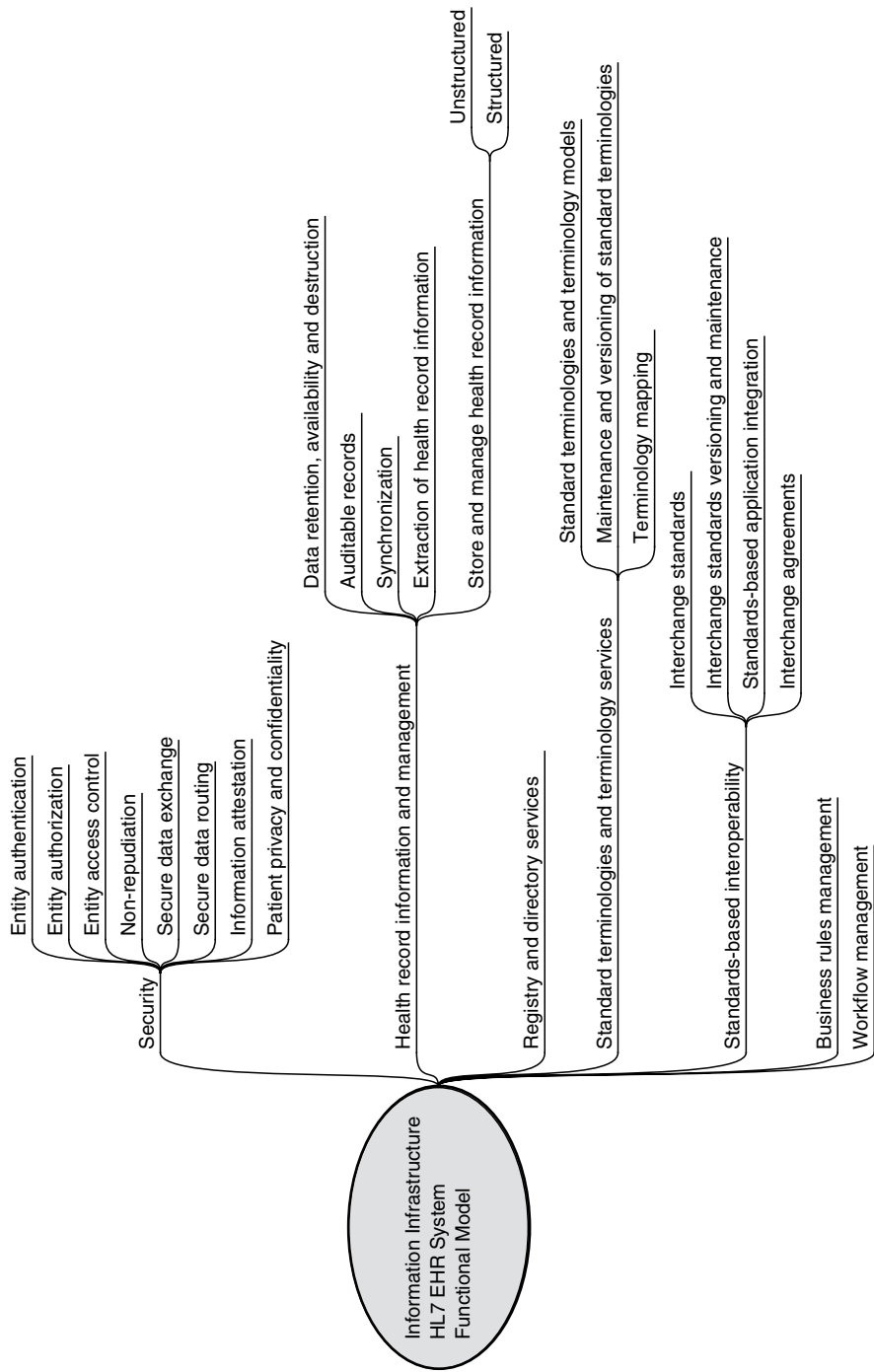

Fig. 1.10 Supportive functions

Security
- Entity authentication
- Entity authorization
- Entity access control
- Non-repudiation
- Secure data exchange
- Secure data routing
- Information attestation
- Patient privacy and confidentiality

Health record information and management
- Data retention, availability and destruction
- Auditable records
- Synchronization
- Extraction of health record information
- Store and manage health record information
  - Unstructured
  - Structured

Registry and directory services

Standard terminologies and terminology services
- Standard terminologies and terminology models
- Maintenance and versioning of standard terminologies
- Terminology mapping

Standards-based interoperability
- Interchange standards
- Interchange standards versioning and maintenance
- Standards-based application integration
- Interchange agreements

Business rules management

Workflow management

Information Infrastructure HL7 EHR System Functional Model

Fig. 1.11 Information infrastructure functions