EHR IMPACT
European Commission, DG INFSO & Media
e-Mail: ehr-impact@empirica.com

Qualitative report on

The socio-economic impact of the electronic health records and health information network in Israel

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About EHR IMPACT

The EHR IMPACT study was commissioned by DG INFSO and Media, unit ICT for Health, and will result in ten independent evaluations of good practice cases of interoperable electronic health record (EHR) and ePrescribing systems in Europe and beyond. The goal of the study is to support ongoing initiatives and implementation work by the European Commission, Member States governments, private investors, and other actors. The study aims to improve awareness of the benefits and provide new empirical evidence on the socio-economic impact and lessons learnt from successfully implemented systems.

Full project title

Study on the economic impact of interoperable electronic health records and ePrescription in Europe

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This report is deliverable D2.3j of the EHR IMPACT study. It addresses the socio-economic impact of the electronic health records and health information network in Israel from a qualitative perspective.

Authors

Tom Jones[2], Alexander Dobrev[1], Dainis Zegners[1], Veli N. Stroetmann[1]

[1]empirica Communication & Technology Research, Germany; [2]TanJent Consultancy, UK

Contact

For further information about the *EHR IMPACT* study, please contact:

empirica	TANJENT CONSULTANCY
empirica Communication and Technology Research Oxfordstr. 2, 53111 Bonn, Germany Fax: (49-228) 98530-12 www.empirica.com ehr-impact@empirica.com	***TanJent*** Hereford UK Tel: +44 7802 336 229 www.tanjent.co.uk tomjones@tanjent.co.uk

The EHRs and Health Information Network (HIN) in Israel

Socio-economic impact and lessons learnt for future investments in interoperable electronic health record and ePrescribing systems

Qualitative report

Tom Jones[2], Alexander Dobrev[1], Dainis Zegners[1], Veli N. Stroetmann[1]

[1]empirica Communication & Technology Research, Germany
[2]TanJent Consultancy, UK

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Disclaimer

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The study team

This study is conducted by: empirica

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Abbreviations

A&E	Accident & Emergency services
CMO	Chief Medical Officer
CTO	Chief Technology Officer
ECG	Electrocardiogram
EHRI	EHR IMPACT study
EHR	Electronic Health Record
EMR	Electronic Medical Record
GP	General Practitioner
HIE	Health Information Exchange
HII	Health Interoperability and Intelligence
HIN	Health Information Network
HIPAA	Health Insurance Portability and Accountability Act
HL7	Health Level Seven
HMO	Health Maintenance Organisation
HPO	Healthcare Provider Organisation
MDS	Minimal Data Set
MRSA	Methicillin-Resistant Staphylococcus Aureus
PACS	Picture Archiving and Communication System
SOA	Service-Oriented Architecture
UMS	Unified Medial Schema
UPMC	University of Pittsburgh Medical Center
VPO	Virtual Patient Object
VPR	Virtual Patient Record
WHO	World Health Organisation

EXECUTIVE SUMMARY

The electronic health records (EHRs) and Health Information Network (HIN) in Israel are analysed as one of eleven implemented and ongoing good practice cases in the context of the EHR IMPACT (EHRI) study. EHRI investigates the socio-economic impact of eHealth utilisation, with specific focus on interoperable EHR and ePrescribing systems in Europe and beyond. This is one of two qualitative case study reports.

Israel's healthcare reforms in the mid-nineties introduced competition into the market for healthcare. The new healthcare model motivated health maintenance organisations (HMOs) to change their strategies and seek new ways of providing and managing healthcare. The HIN has been identified as one of the tools supporting this.

The HIN has been developed and implemented in the Israeli context and beyond. The function of the network is to share all medical information existing in a wide array of disparate informational systems and make it accessible at every point of care through the use of an interoperability solution specifically created for health information exchange (HIE).

The network was first rolled-out in 2001 across the facilities of Israel's largest HMO. In 2003, the government-owned Sheba Medical Centre in Tel Aviv, the largest medical centre in Israel, adopted the system for its internal use and joined the HIN in 2004. Rambam Medical Centre in Haifa, which provides medical services to the majority of Israel's northern population and also serves as a military hospital, joined the network a few months later. The HIN now spreads across the whole of Israel, affecting healthcare provision of more than 5 million people, nearly 70% of Israel's population. It covers a wide range of healthcare, including primary and dental care, hospital care and tertiary services. Its users number in the tens of thousands including physicians, nurses, pharmacists, paramedics, laboratory and imaging technicians and administrators.

The main HIN goal is to provide healthcare professionals with the clinical and health information they need to treat and care for their patients. This includes information about each patient's hospitalisation history, diagnosis test requests and results, visits, prescriptions and dispenings, laboratories, imaging, pathology, procedures, surgery, medical treatments, Accident & Emergency encounters, outpatients, nursing care, sensitivities and allergies, main complaints, problem list, GP encounters, and vital signs.

The HIN makes locally available information accessible for qualified caregivers within the network. It plays an important role at the intersection between primary and hospital care by enabling prompt, simple and rapid communication across healthcare service boundaries to support direct and continuous patient care.

When a healthcare professional asks the network for data about a specific patient, it checks the treatment relationship for the user's permission for access to a patient's file. The HIN then creates a Virtual Patient Record (VPR) out of information from all relevant data storage sites in hospitals, community clinics and pharmacies. The presented screen resembles an ordinary EHR. After the VPR is closed, it disappears, leaving only a record of the access.

The HIN has a multi-tier service-oriented architecture (SOA) interoperability platform provided by dbMotion that enables flexibility, scalability and adaptability to the changing demands of different organisations and diverse ICT environments. The HIN's design adheres to strict security and privacy directives such as those outlined in America's Health Insurance Portability and Accountability Act (HIPAA), and international standards such as SI ISO 17799, the Information Security Management System Certification.

A lot of healthcare professionals have adopted the HIN willingly. Many say that that they cannot imagine working without a HIN, especially young doctors who have no experience of working without it.

The main benefits from using the HIN are quick and easy access to the patient's medical history at the point of care, leading to better communication, better decisions, safer care and efficient use of time. Patients receive safer care, with a reduced exposure to risk, and healthcare teams are supported in improving clinical decisions and efficiency by sharing information between healthcare professionals across the whole healthcare chain.

There is no delay in either starting or extending treatment, or deciding that there is no need for action. The HIN can provide information about patients' medical histories and sensitivities, and so inform professionals about treatment options, especially those to avoid. Doctors can avoid over-prescribing. Patients avoid the risks, discomfort and sometimes journeys to hospitals or prolonged hospitalisations. Sometimes caregivers share with the patient his/her HIN information as shown on the screen during consultation, creating a better dialogue between healthcare professionals and patients.

Nurses in primary care integrate with the work of hospital nurses, avoiding the need for them to reassess transferred patients. Transfer from hospital to primary and community care is much smoother and better organised.

A valuable benefit is from the ability to check patients' medications dispensed by pharmacies, as a failure to conform to the medication regime can be identified. GPs can also monitor patients' compliance with referrals to hospital services via the HIN.

The HIN offers hospital teams a lot of benefits in time savings and efficiency. Typically, about 20% of a person's time used to be dedicated to record retrieval. Overall improvements in discharge procedures have achieved savings of 10-15 min per patient where the use of existing hospital notes has replaced full re-typing of notes. Using the HIN for admissions can save up to a day a week on clerking. The time saved increases the time available for patients.

Information from the HIN has also improved epidemiology services and infection control, handover procedures between shifts in hospitals, and bed management, which is especially critical because many wards in Israel operate near or at 100% occupancy.

Now, people in healthcare provider organisations (HPOs) trust the HIN data, leading to a paradigm shift in the focus of HPOs to using good clinical and patient information to seek continuous and sustainable improvements in the value of the healthcare provided.

Third party payers have reliable information available on the performance and workloads of their HPOs and can use this to develop policies, strategies, plans and projects for service development and improvement.

Ultimately, even greater future benefits are expected for the HIN from upgrades enabling the progression towards semantic interoperability in which advanced aggregation and clinical logic can be applied. The foundation for this semantic interoperability functionality is dbMotion's Unified Medial Schema (UMS) based on HL7 V3 and the Reference Information Model and its vocabulary domain, which leverages information architectures that do not share common terminologies, vocabularies, or code structures.

The case study could not have access to economic cost information, so it is not possible to indicate the economic monetary value, or net benefit, of the Israel HIN, nor the time needed to realise a net benefit. It is not likely to be much shorter than other EHRI case studies. Decision makers need to estimate these themselves.

The HIN model offers decision makers an eHealth option that builds on their existing ICT investments by providing healthcare professionals with access to virtual EHRs. Proven benefits are realisable and risks are manageable. HIN equivalents are in use, or under implementation,

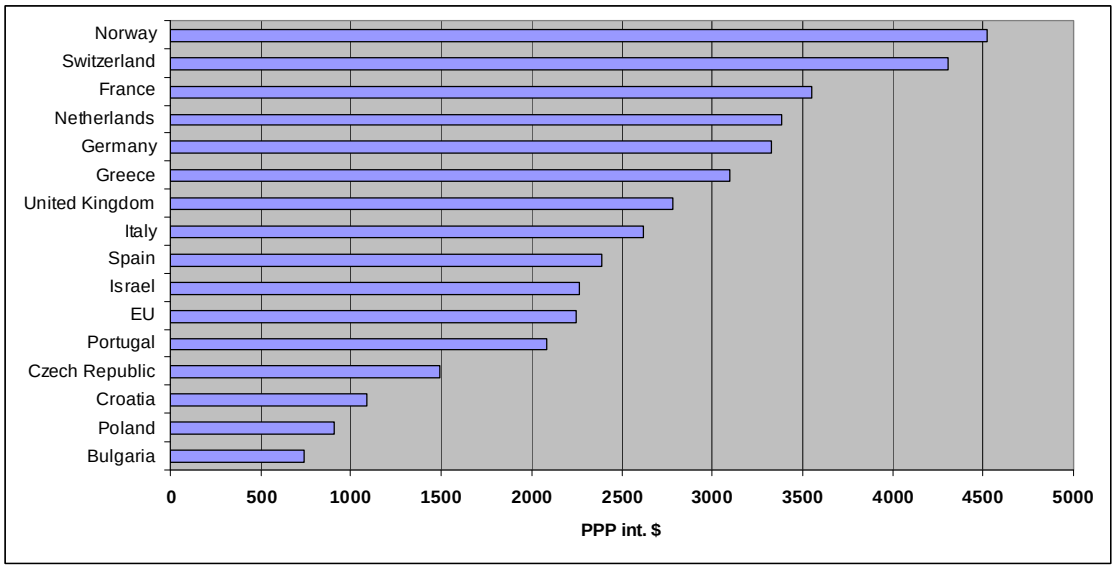
in several different healthcare systems in several countries, including the USA, Belgium and France, which confirms the transferability of the HIN model.

1 Background

1.1 Health system setting

Israel has a population of 7.2 million[1] and enjoys an average income equivalent to Western-European levels. GDP spent on healthcare and total expenditure per capita on healthcare is also comparable to Western Europe, although the per capita spending was slightly below the mode as shown in Chart 1.

Chart 1: Total per capita spending on health, PPP$ in 2006



Source: WHO[2]

Average life expectancy is relatively high: 82 years for females and 79 years for males.[3]

The Ministry of Health is responsible for health policy in Israel. Its key functions are management of the governmental healthcare budget, drafting of healthcare laws for consideration by parliament and regulating the health care sector. It also owns and operates almost half of the nation's hospitals.

In January 1995, in an effort to set healthcare on a more economically sound path, a national health insurance law went into effect, creating a compulsory healthcare system based on four not-for-profit service providers, the health maintenance organisations (HMO) Clalit, Leumit, Maccabi and Meuhedet. The largest is Clalit, which covers some 60% of the population. Every member pays in proportion to his or her income, and each is entitled to the same quality and range of medical services.[4] Every citizen is entitled to a standardised minimal basket of medical services specified by the Ministry of Health. A formal review and update of this basket takes place every year. These healthcare reforms are ongoing.

The four competing HMOs provide medical services and healthcare. They are independent, but operate within a legal and regulatory framework defined by the government. Citizens can

[1] The Central Bureau of Statistics of Israel
[2] Based on WHO Statistical Information System (WHOSIS), http://www.who.int/whosis/en/
[3] WHO Statistical Information System (WHOSIS), http://www.who.int/whosis/en/
[4] "The Story of Clalit Health Services", http://www.clalit.co.il/HE-IL/english

freely choose between them, and they must accept all applicants. The Ministry of Health collects premiums from citizens based on their income. These health insurance contributions are proportional to income ranging from 3.8% to 4.8%. The government distributes these funds to the HMOs, according to their membership numbers, weighted appropriately by factors such as the age of members. In addition, citizens pay a contribution to treatment costs, currently up to a maximum of 150 USD per month.

Citizens can arrange supplementary insurance additional to the guaranteed minimal basket to cover services such as visits to private physicians, treatment in private hospitals and complementary medicine. HMOs and private insurance companies offer supplementary insurance, and about 60% of the population take it up.[5]

Israel has a highly accessible primary care system. Costs of primary care visits are usually fully covered. Most primary healthcare professionals work for HMOs, either as salaried employees or as independent physicians. They also act as gatekeepers to other health services, providing authorisation to access services such as hospital-based specialists and most community-based specialists.

There are 48 general hospitals in Israel, with approximately 14,200 beds. The government owns almost a half, about 30% belong to Clalit, 16% are in public ownership, and 8% privately owned.

1.2 Place of EHR, ePrescribing and interoperability in the framework

The Israeli healthcare system underwent massive reforms during the 1990s. Much of these followed the recommendations of the Netanyahu Commission, which highlighted the problems of the Israeli healthcare system at the end of the 1980s. One of the recommendations of the commission was to invest heavily in information systems. As a result, a national plan, enhanced by inter-sectoral and non-governmental cooperation, supports the development of ICT infrastructure in the healthcare sector.[6] The investment model is that the government sets and supports the overarching eHealth policies and strategies, with healthcare provider organisations (HPO) responsible for direct investment. The reforms of the healthcare system increased competition in the healthcare market and actors have to look for ways to become more competitive by improving the quality and efficiency of healthcare. This guides the direct investment in eHealth.

[5] Rosen, B. in Thomson, S. and Mossialos, E. (ed.) Health care systems in transition: Israel. Copenhagen, European Observatory on Health Care Systems,5(1) (2003).
[6] WHO, Global Observatory for eHealth, Report on Israel, http://www.who.int/goe/data/country_report/isr.pdf

2 The EHRs and Health Information Network (HIN)

The Health Information Network (HIN) has been developed and implemented in the Israeli context and beyond. The function of the network is to share all medical information existing in a wide array of disparate informational systems and make it accessible at every point of care through the use of an interoperability solution specifically created for health information exchange (HIE).

2.1 Context and development of the initiative

Israel's healthcare reforms in the mid-nineties introduced competition into the market for healthcare. Citizens can change their health insurer easily, in contrast to the previous situation. The new healthcare model motivated health maintenance organisations to change their strategies and seek new ways of providing and managing healthcare.

HPOs used many local electronic systems for administrative and medical information. Each one operated in isolation with its own data repository. Healthcare professionals were dependent on patients to recall critical medical information and bring relevant documents with them.[7] The HIN was designed to change this. Additionally, it promised to reduce overall IT costs by exploiting some economies of scale and avoid unnecessary medical procedures and tests.

An early project failed in 1999. It involved an exchange of faxes and digital files and was impractical and ineffective. Data security issues were also irresolvable.[8] A group was set up to identify and define the prerequisites for a solution of the data-sharing problem. The core idea was to define the minimal data set (MDS) needed by healthcare professionals when they deal directly with their patients. The prerequisites were[9]:

- Leave data to remain where it is and not interfere with existing systems
- Integrated data to be delivered to every point of care
- The data to be available on time and on demand
- The data to be complete and accurate
- The system to be able to drill-down to further relevant data on demand and on time
- The system to adhere to strict security and privacy frameworks.

Similar problems were also challenging single HPOs, such as the Soroka Hospital. Soroka Hospital is Clalit's largest tertiary hospital. It provides 20% of Clalit's hospital activity, serves 16% of Israel's population spread across 60% of the territory in the south of the country. About 620 doctors and 1,600 nurses work there, and about 850 million medical tests are conducted each year[10]. Various disparate information systems operated throughout the hospital and doctors wanted a way to access them easily. Primary care clinics around Soroka Hospital also used their own data repositories, and data exchange between the clinics and the hospital was required. Soroka Hospital started a local, independent information initiative to deal with these challenges. This initiative was the foundation for the HIN.

[7] Interviews with HMO management
[8] Interviews with HMO management
[9] Interviews with HMO management
[10] Interviews with HPO management

This HIN now spreads across the whole of Israel, affecting healthcare provision of more than 5 million people, nearly 70% of Israel's population.[11] It covers a wide range of healthcare, including primary and dental care, hospital care and tertiary services.

The network was first rolled-out across a health maintenance organisation's facilities including:

- 1,350 primary healthcare clinics and regional health centres
- 8 general hospitals with 4,400 beds providing a full range of inpatient care
- A rehabilitation centre with 240 beds for short and long-term care
- 2 geriatric hospitals
- 2 psychiatric hospitals
- A children's tertiary medical centre with 224 beds
- 370 pharmacies
- Alternative medicine clinics
- 70 dental care clinics
- 80 laboratories and
- 35 radiology facilities.

Each year, there are over 56 million patient contacts, including 27 million visits to general practitioners, eight million referrals to specialists, 0.7 hospital admissions, five million outpatient visits and 15 million call centre enquiries[12].

The HMO's more than 33,000 employees include 8,000 physicians, 11,000 nurses, 1,400 pharmacists, 4,600 paramedics, laboratory and imaging technicians, and 8,000 administrators[13].

In 2003, the government-owned Sheba Medical Centre in Tel Aviv adopted the system for its internal use and joined HIN in 2004. Sheba Medical Centre is the largest medical centre in Israel, with 1,700 beds, 120 departments and clinics, serving more than 1.2 million outpatients and 110,000 inpatients each year. Within two months, they were fully connected and healthcare professionals at Sheba Hospital could access data of patients treated in other facilities as if they were working within a single organisation.

Rambam Hospital joined the network a few months later. Rambam Medical Centre is in Haifa and is also owned and run by the government. It has 900 beds and provides medical services to the majority of Israel's northern population. It also serves as a military hospital.

2.2 The health services affected

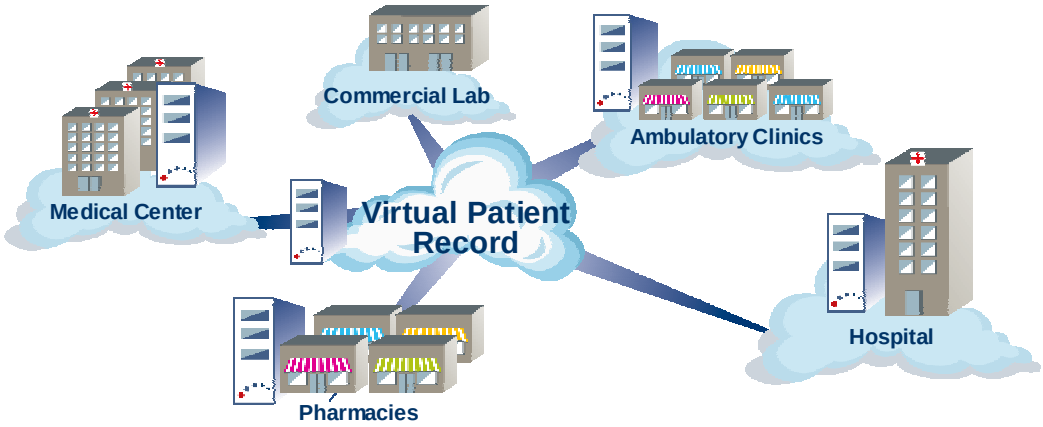
General practitioners (GP) as family doctors are at the core of the primary healthcare system. They can refer patients to specialists for treatment and can consult specialists directly for advice on services such as obstetrics, gynaecology, dermatology and ophthalmology. Patients have to register with a GP.

The HIN allows referrals to become more than a one way transfer of responsibility to another HPO. Most patients receive treatment from all types of health services, from primary care, through secondary and tertiary hospital and specialist care, rehabilitation, dental care, medication treatment, to home care by community care services. Many patients have regular contacts with a number of these services, all of which are affected by the HIN. As illustrated in figure 1 below, the HIN provides a virtual patient record as the information link between

[11] HIN Statistics, provided by dbMotion
[12] HMO Statistics, provided by Clalit Health Services – corporate presentation
[13] HMO Statistics, provided by Clalit Health Services - corporate presentation

all types of services. This changes the information base at each facility and thus affects the services it provides.

Figure 1: The virtual patient record



Source: dbMotion

2.3 Components and functionalities

2.3.1 Clinical information

The main HIN goal is to provide healthcare professionals with the clinical and health information they need to treat and care for their patients. This includes information about each patient's:

- Hospitalisation history
- Diagnosis test requests and results
- Visits
- Prescriptions and dispenings
- Laboratories
- Imaging
- Pathology
- Procedures
- Surgery
- Medical treatments
- Accident & Emergency (A&E)
- Outpatients
- Nursing care
- Sensitivities and allergies
- Main complaints
- Problem List
- GP encounters
- Vital signs

If healthcare professionals need it, time series of data is available, such as the sequence of diagnostic test results, to help identify trends.

2.3.2 Clinical documentation

Healthcare professionals can only use the HIN to access information, but not enter it except for a function to create admission and discharge notes. It enables doctors to create new notes or letters based on existing materials in the system. This is done by automatically extracting

relevant content from documents in the system and using it as the basis for new ones. This also helps to improve legibility by avoiding bad hand-writing.

2.3.3 Messaging between healthcare professionals

Since 2003, the HIN has a messaging system added to its functionality. It lays an important role at the intersection between primary and hospital care by enabling prompt, simple and rapid communication across healthcare service boundaries to support direct patient care.

2.4 The system in practice

The HIN makes locally available information accessible for everybody within the network. When a healthcare professional asks the network for data about a specific patient, it creates a Virtual Patient Record (VPR). It presents on a screen all specified data stored at various locations in the appropriate system in a way that resembles ordinary EHRs. This happens in real time, with an average response time of currently less than 5 seconds. After the caregiver has looked at the VPR and closed it, it disappears, leaving only a record of the access.

Initially, the HIN checks the treatment relationship for the user's permissions for a patient file entry. Then it sends a request to all relevant data storage sites in hospitals, community clinics and pharmacies.

The clinical documentation component enables clinicians to create summary and discharge letters. A network of local clinical data repositories, based on a single uniform data model, was created. Using a federated and de-centralised web-based architecture, this system can query asynchronously the entire set of local repositories, integrate the responses and present healthcare professionals with a unified, integrated patient record for viewing only. The HIN ensures that the patient medical information viewed is the most recent and includes laboratory results from other repository or legacy systems and with other comparable historical data.

Primary care

Internal usage of electronic medical records (EMR) has been widespread amongst primary care clinics and GPs in Israel for many years, partly as a prerequisite for reimbursement from health insurance organisations. Every GP is obliged to comply with the process. The introduction of HIN in primary care provides doctors with access to data from other clinics and hospitals.

This is especially valuable for new patients and organising follow-up care for patients discharged from hospital. GPs now have more data on their patients' hospital episodes than when they had before through conventional discharge letters. GPs are informed promptly if one of their patients is about to be discharged from hospital so that follow-up care can be arranged immediately. The messaging system is also useful in dealing with patients who are hospitalised, though it seems that nurses use it more than doctors, who prefer to discuss matters by phone.

When pharmacies dispense medication on prescription, the event is available within the HIN. GPs can then establish that patients have the medication they need.

Hospital care

Doctors in the Accident & Emergency (A&E) units use the HIN to access historical patient data, such as previous diagnostic test results, to support their decisions about subsequent

stages of healthcare needed by their patients, such as the need for admission to inpatient services. This was not possible before the creation of the HIN because it took too long to retrieve conventional paper-based patient records from the archives. Doctors' decisions had to rely extensively on their experience and knowledge, sometimes with missing facts. Nurses use the network to locate available, free hospital beds for patients who need admission.

On wards, the HIN is a substitute for routine paper-based records, enabling data to be available faster. With the HIN, the record is available before patients arrive. The HIN is used to write admission notes and discharge letters, and bed management is improved.

Hospital managers have direct access to all current inpatients in their hospital or district. They use the system for planning and monitoring purposes. They do not have access to clinical information.

Nurses can access all relevant microbiology data, procedures and laboratory data. This is valuable for their role in infection control.

2.5 Technology

2.5.1 Overview

The HIN has a multi-tier service-oriented architecture (SOA) interoperability platform provided by dbMotion that enables flexibility, scalability and adaptability to the changing demands of different organisations and diverse ICT environments. Each layer has multiple functionality that facilitates interoperability and health information exchange (HIE). It provides the framework for effective and efficient communication between the layers, as well as offering web-services to external consumers. There are several security mechanisms throughout the information aggregation, integration and presentation, each stage complying with security standards, including HIPAA[14]. In addition, sophisticated business processes define access to the information.

dbMotion's Unified Medical Schema (UMS) is the data model used by all the layers, enabling aggregation and integration of clinical data into a comprehensive, patient-centric, unified medical record delivered through a Virtual Patient Object (VPO).

The HIN has two main components: HIE and clinical documentation.

Health Information Exchange (HIE)

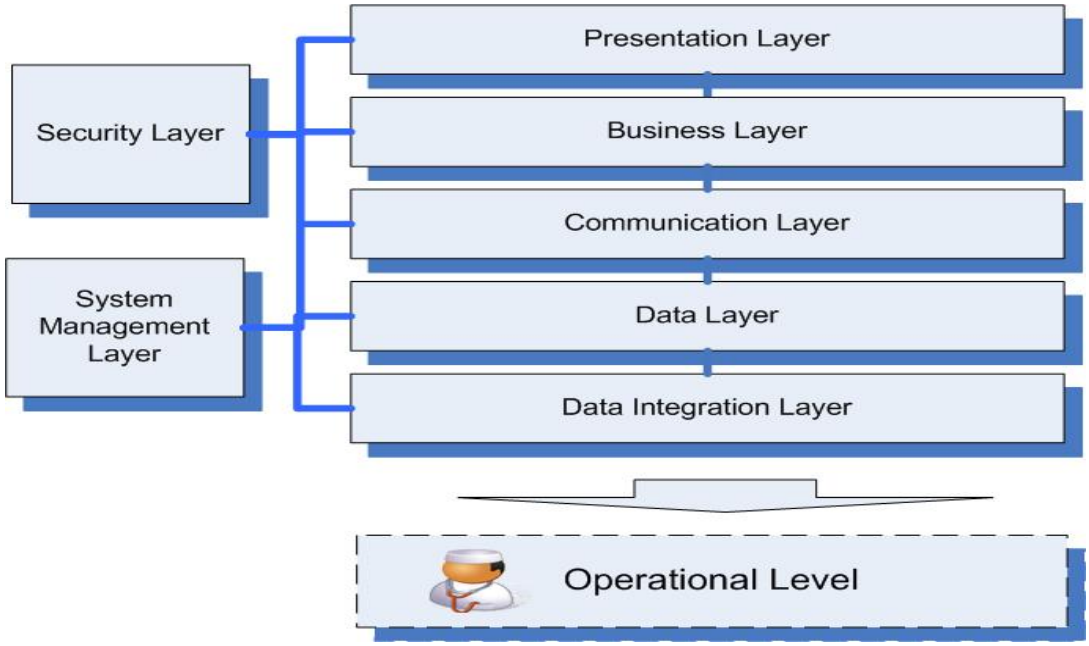
The network comprises a number of locally installed nodes. Each one is to connect to, and communicates with, the local clinical and operational systems that consist of multiple layers. Each layer incorporates a number of subsystems and functions to carry out multiple functions. The layers and their functions, depicted in the node architecture in figure 2 below, are:

- Data Integration Layer: acquires data from local clinical and operational systems and transformation into the UMS
- Data Layer: manages and stores collected data and provides a single interface, based on the UMS, for all data requests
- Communication Layer: collects data from other nodes in response to data requests
- Business Layer: integrates, applies business rules and provides data to users requesting medical information

[14] Health Insurance Portability and Accountability Act (HIPAA), US Government, http://www.hipaa.org/

- Presentation Layer: web-based viewer used at points of care to display integrated medical information
- Security Layer: defines and enforces security safeguards throughout separate layers
- System Management Layer: applications and tools for managing sub-systems.

Figure 2: Node architecture



Source: dbMotion

Clinical documentation component

The HIN's database is comprised of a series of the clinical data repositories (CDRs) and includes information on all patient events in hospitals. Amongst its many roles, these CDRs function as a dispatch reference database, identifying all documents belonging to a certain patient, regardless of the information system they are stored in. An interface to the CDR is developed for all new clinical ICT. This ensures that all relevant data is stored and made accessible through the HIN.

2.5.2 Security and confidentiality

The HIN's design adheres to strict security and privacy directives such as those outlined in America's Health Insurance Portability and Accountability Act (HIPAA)[15], and international standards. In 2006, the HIN was accredited by SI ISO 17799, the Information Security Management System Certification.

The HIN's modular technology determines the way it deals with security and confidentiality issues. All users have their own network security profile. Access restrictions to data are set depending on users' roles and positions. As documents are not structured, restrictions are not set to parts of the documents. Access is classified as either/or. Healthcare professionals only have access to data about patients they are currently treating. For hospital users, it includes

[15] Health Insurance Portability and Accountability Act (HIPAA), US Government, http://www.hipaa.org/

a period of 30 days after a patient's discharge from hospital, allowing for post-discharge updates and clarifications.

A Legal and Medical Ethics Committee specifies different user roles and associated data access rights. It defines who is a caregiver, and so the medical and healthcare disciplines that comprise caregiving, the conditions for a caregiver-patient relationship, the duration of the relationship and the medical data that caregivers can view.[16]

The organisations using the HIN can decide which data to share or withhold within the network. For example, psychiatric hospitals can and do withhold information from general hospitals, whilst caregivers within the psychiatric hospitals have full access to all medical data.

Patients can decide which information about them is confidential and not to be shared. Discussions are underway to provide patients an option to opt-out of the HIN completely.

2.5.3 Software development, installation and challenges

During development, four different set-up committees defined the prerequisites for the HIN and monitored their implementation. The set-up committees were[17]:

- Steering Committee
- Legal & Medical Ethics Committee
- Users Committee
- Chief Medical Officer (CMO) in charge.

Designing the HIN to meet users' needs required weekly meetings with a User Committee comprising five to six doctors and three to four nurses. These meetings took place during the first six months of the development phase. In the second six-month phase, they were monthly.[18]

The Legal and Ethics Committee had a continuous role of constant monitoring. During the first six-month phase, it met once or twice a week, and then met monthly.

The main challenge for the software development team was to design a solution that satisfied the Committees' specified prerequisites, including[19]:

- No single point of failure
- No need to replace existing information systems
- Adhere to security and privacy standards
- Performance
- Defined minimal data set
- Ability to drill-down into detailed data
- Ease of implementation with minimal training and support staff
- Scalability, flexibility, robustness
- Data remaining in original location and format
- Data only available for specific patient-centric queries
- Data only available at time of medical care
- Data available on view-only basis.

[16] Interviews with HMO management
[17] Interviews with HMO management
[18] Interviews with HMO management
[19] Interviews with HMO management

At the same time, the development team had to reflect the characteristics of large organisations and heterogeneous ICT. There are many different clinical systems, and not all were designed to share data with each other, so data sharing interfaces had to be developed.

The development process did not stop when the HIN became operational. It continues as an ongoing process. Installing new systems requires connection with the HIN, often needing new features.

2.6 Level of interoperability

The HIN's technology platform provides a high level of interoperability that enables each patient's unified medical history to be accessed from various information systems. Data is virtually presented in a unified, integrated manner from different information systems, formats and sites, with the original data remaining in their source informational systems. Each user/organisation can decide on the extent to which they wish to share data. Organisations do not have to agree on the same standards.

Effective interoperability is at the HIN's core. It enables a wide range of information systems to share information, use and understand new incoming data and, most importantly, to preserve the original data, even when it is stored in different formats and information systems. Applying these principles relied on solutions that offered interoperability using a sophisticated data model, a scalable platform built on open standards and a sound application development framework. The solution is based on service-oriented architecture (SOA), enabling systems to use data from each other applying functionality that is agnostic to the architecture employed in the originating information systems.[20]

Ziv Ofek, founder and CTO of dbMotion, set out the service-oriented architecture (SOA) used successfully in Israel.[21] The value is in accessing and exploiting information in many disparate systems by building applications with distinct software services distributed over a network, reused and combined to create new applications. A SOA-based platform facilitates interoperability among existing clinical or administrative systems, workflows and processes. This agnostic functionality is vital because the numerous applications in a healthcare organisation are from different vendors and have their own structure, development tools and underlying logic.

The SOA framework underlies individual systems and technologies, removing the challenge of data sharing from the transaction level. It expands usability of data by facilitating greater functionality than simply moving data from one location to another. SOA enables applications and services to connect complex, heterogeneous and non-standard ICT environments logically, creating an agile platform that can adjust to evolving needs. A SOA domain provides specific benefits such as platform independence; security standard implementation for authentication, authorisation and federation; reusability; agility; business process encapsulation; autonomy and well-defined service boundaries.

These effects are particularly important for healthcare, where a multitude of clinical systems has grown and executives have struggled with the dilemma of leveraging the enterprise's investment in ICT whilst supporting an increased need for seamless data sharing. A SOA framework allows the healthcare enterprise to implement a full complement of widely varied systems to optimise performance, quality and outcomes. All systems are empowered to share

[20] Data Sharing. Semantic interoperability approach allows multiple HIT systems to understand and make use of incoming data (2009). Daniel Drawbaugh. ADVANCE for Health Information Executives. Available at: http://health-care-it.advanceweb.com/Article/Data-Sharing.aspx

[21] Transforming Information into Intelligence. Service-oriented architecture enables health care enterprises to provide sharable, usable data to their consumers (2008). Ziv Ofek. ADVANCE for Health Information Executives. Available at: http://health-care-it.advanceweb.com/Article/Transforming-Information-into-Intelligence.aspx

data through semantic interoperability. This level of functionality allows multiple clinical and administrative consumers across the enterprise to have meaningful access to a wealth of data that was previously unavailable to them.

The interoperability provided by the HIN's SOA ensures that:

- Providers have unified, longitudinal medical records at points of care that provide comprehensive histories of diagnoses and therapeutic interventions to enhance healthcare efficacy, minimise errors and improve patient safety. Time wasted in tracking down missing information, or ordering of duplicate tests and studies due to unavailable results is minimised.
- Quality officers can aggregate and analyse data across the enterprise more easily. They can monitor compliance with quality initiatives, identify areas for improvement, generate reports for regulatory agencies and design pay-for-performance initiatives.
- Clinical researchers can automate labour-intensive, time-consuming date collection, organisation and understanding data. This allows organisations to shift the focus of their resources and therefore move far more quickly, efficiently and effectively to the core research itself.

Supporting all these activities required the HIN to be a modular, federated and de-centralised network. Adding new blocks to the model is relatively easy. Interoperability extends across all available information systems in all locations.

Of the three EHRI interoperability classifications of potential interoperability, limited connectivity and extended actual connectivity[22], the Israel HIN reaches the highest, extended and actual. The network connects existing systems across disparate geographical locations. This integration of systems goes beyond simple connection and conformance to standards to real inter-operation.

The interoperability, interoperation, and thus facilitated collaboration cover teams of doctors, nurses, other health professionals, and management and administrative actors. Informal carers and patients have no direct access, which is in line with the design and philosophy of the system – to support health professionals in their daily work. The classification according to type of connectivity is summarised in Table 1 below.

Table 1: Scope of interoperability of the Israel HIN[23]

Type of connectivity	Characteristics	Israel HIN
Single site	People within teams and between teams in one organisation	Yes
Multi-site	People within teams and between teams in one organisation	Yes
Regional	People, teams and organisations in one region	Yes
National	People, teams, organisations and regions in one country	Yes
International	People, teams, organisations, regions and countries	No

[22] EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn, http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf
[23] ibid.

3 Case analysis

3.1 Process change

3.1.1 Workflow

Primary care

Upon the introduction of a HIN in Israel, most GPs were already using EMRs, so workflows for their regular patients did not change much. Minor changes occurred for patients recently or currently needing hospital services. GPs can use the HIN to access three different lists of patients associated with their practice: patients currently admitted to A&E, patients currently hospitalised and patients currently in outpatient clinics. Many GPs access this information at the beginning of their working day. [24]

Discharge of patients into community care

The HIN provides information about scheduled discharges so that primary care and community services can set up to sustain continuity of care. Previously, patients left hospital without their GPs' knowledge. When patients visited their GPs for follow-up care, GPs often had to deduce all relevant information from discharge-letters, if the patient even had these with them, or by trying to call relevant hospital doctors. Now, GPs have all the data gathered within the hospital available through the HIN.

Another facility provided by the HIN is the pre-discharge letter, primarily used by nurses. Hospital nurses prepare these and send to community nurses to inform them about the status of patients and the planned discharge date so they can continue care more easily.[25] Services for discharged patients include oxygen at home, antibiotics, dressings, injections, physiotherapy and occupational therapy. Setting these services in place before discharge provides a faster start to continuous care and treatment by supporting teamwork by integrated nursing teams in hospital and community care.[26]

Hospital care

A&E

Doctors can see and review patients, then use the HIN to look for data about medical histories and to assess the need for tests and admission. For decisions to admit, nurses use the network to locate available beds. Before the HIN was introduced, post-stabilisation decisions in A&E depended on the patient's condition, and, at most, on local records of the patient.[27]

Wards

Doctors usually refer to the records of newly admitted patients' before seeing them. Before the HIN, this was mainly feasible for patients who had planned admissions and had their medical records already retrieved from the archives. For some emergency patients, retrieval may take some time, especially where the long-term archives are located outside the

[24] Interviews with HMO management and doctors
[25] Interviews with primary care clinic management and doctor
[26] Interviews with primary care clinic doctors
[27] Interviews with hospital nurses

hospital, sometimes in a different town.[28] In these cases, the HIN results in different workflows, sometimes avoiding the need to retrieve records.

Doctors also use the network to write admission notes that can include previous data or copy-and-paste sections from old notes. Discharge letters can be prepared using the same facility. In the paper-based system, reports were written from scratch each time.

Bed management has changed with the HIN. Real-time bed state information is available, showing occupancy and availability that facilities effective admission, discharge and bed management.[29] Without the HIN, nurses would spend substantial amounts of time physically examining bed occupancy.

Infection control

Epidemiology nurses use the HIN each day to review all microbiology data and relevant procedures and match procedures to laboratory results.[30] From this information, they can plan and implement appropriate infection control measures promptly. The paper-based predecessor system relied on manual counting of incidents, with reports being delayed due to time consuming procedures.

3.1.2 Clinical practices

Generally, the HIN's impact on clinical practices is not so much in that they change, but that they are able to provide better quality care by using the increased availability of medical data.[31] Lost data is no longer an issue, so doctors save time on new and duplicate examinations and other procedures. The clinical decisions professionals make are better informed, thus improving the quality of care.

Now doctors always have access to current and past medications, laboratory results, operation history etc. With HIN, GPs now access clinical information about their patients from hospital episodes. The most utilised information is test results. GPs can know quickly and easily the history of the test results of each patient, and use this information in clinical decisions. Where patients have recently been in hospital and completed a series of tests, the accompanying information is especially valuable to GPs who can act on that knowledge and avoid repeating tests. This means they can direct treatments better. Primary care doctors can track patients' progress better due to access to data on events in hospitals and homecare. This is especially important for chronic and long-term patients, where regular monitoring and planning is essential[32].

In serious cases, GPs monitor patients' progress through hospital treatments and prepare for their role after patients are discharged. This has proven valuable for patients who need extensive hospital treatment, such as cancer services, and continue to rely on their GPs throughout the whole course of their treatment. In some circumstances, GPs have monitored progress whilst they are away from their health centres, offices and surgeries.

GPs use information about prescriptions and dispensing for patients to test the practices of some patients to visit several GPs to seek prescription drugs for illicit purposes. The HIN shows each GP visit, and previous prescriptions are available to view which can expose excessive requests. On a more positive side, GPs use the same information to monitor part of patients' non-compliance with their drug regime, especially where patients have failed to take prescriptions to pharmacies for dispensing. In these cases, GPs can take corrective clinical decisions.

[28] Interviews with hospital doctors
[29] Interviews with hospital nurses
[30] Interviews with hospital nurses
[31] Interviews with hospital doctors
[32] Interviews with hospital and primary care doctors

Real-time data provided by the HIN enhances patient security, especially in some specific emergency cases. For example, doctors treating semi-conscious patients with head injuries can use the network to access information about patients' sensitivities to different types of CT scans.[33] Doctors often use the HIN to look up laboratory results that arrive only post-discharge. Without the network, they would have to call several times until the results are available on wards and provided by hospital nurses.[34]

Anecdotal experiences from Israel and a comparable EHR environment in the USA offer parallels illustrating the effect of a HIN on clinical practice. Healthcare professionals at the University of Pittsburgh Medical Center (UPMC) have access to interoperable clinical information based on the technology used by the HIN in Israel. The following is a short selection of real-life examples:

- A patient with abdominal pain attended the A&E department was referred for a standard workup. A nurse consulted the patient's medical history and discovered that the patient had a history of an aortic aneurysm. The prescribed course was changed, and the patient sent immediately for a CT scan that revealed an acute dissection with the likelihood of rupture. The team mobilised the operating team at a tertiary centre, and before transfer, the nurse established that the patient was taking a blood thinner. The team initiated appropriate therapy during transfer, preventing further delay of surgery and most certainly saving the patient's life.
- A patient found delirious by neighbours arrived at the A&E unconscious. The hospital's EHR contained no relevant data. On consulting the comprehensive patient record, the healthcare professionals discovered a history of chronic liver failure with secondary issues including Hepatitis C. The A&E physician rapidly diagnosed hepatic coma and prescribed medication to lower the patient's life-threatening ammonia level. Simultaneously, the team took the proper steps to safeguard themselves against the patient's blood-borne pathogen status, Hepatitis C.
- A patient arrived at UPMC St. Margaret complaining of back pain and requested narcotic pain medication, saying that he had not seen his GP in months. The GP's office was not available to verify the claim but the patient's medical history showed that he had recently seen his GP who prescribed 60 Percocets. The patient's abuse of narcotics was established and appropriate treatment prescribed.
- A young man arrived at the A&E with abdominal pain. The physician prescribed a CT scan of his abdomen, requiring IV contrast. He had received treatment in other hospitals that documented an allergy to IV contrast. It was also in his outpatient chart in an ambulatory EHR. This allergy record was in three disparate sources and the patient could conceivably have received this dye if he was unable to relay this information directly, but doctors had access to the information they needed to prescribe the appropriate care and avoid serious, if not fatal, consequences.

In addition to the changes at the point of care, business intelligence software uses anonymous data from the HIN to compile comparative performance indictors so that GPs can know and review their performance. Examples are[35]:

- Hospitalisation scores for chronic heart disease
- Number of early discharges
- Daily physicians' routine
- Quality control links.

[33] Interviews with HMO management and doctors
[34] Interviews with primary care doctors
[35] Interviews with HMO management and doctors

3.1.3 Reaction and acceptance of users

Many healthcare professionals have adopted the HIN willingly. Many say that that they cannot imagine working without a HIN, especially young doctors who have no experience of working without it. They are also pushing increased utilisation of, and reliance on, information from the HIN. Some healthcare professionals are of the opinion that if the HIN fails some day, hospitals would stop working. This level of reliance could be a substantial burden for a centralised EHR solution, but is far less so for the virtual HIN with its decentralised virtual model with no single point of failure.

Some information, such as ECG traces, is currently not accessible via the HIN. Doctors have requested this type of expanded service, indicating acceptance of the system and a change in culture.

Patients also seem to like the HIN. During consultations, some ask doctors to check their details on the PC[36].

A substantial increase in activity rates occurred during the summer of 2006. The Lebanon Crisis resulted in military confrontation between Hezbollah and the Israel Defence Forces, and about one million Israelis living in the north temporarily evacuated to the south. Many left without taking their medication or prescriptions with them. During this period, the HIN page views increased sevenfold. Previously, the average usage statistics were at about half a million a month. During the conflict, the average was over one million (July 2007). The increase was about 120%.

This utilisation compares with a recent activity peak of 1,000 concurrent users in the community environment.[37] These levels of utilisation indicate a positive acceptance and reliance by users.

3.2 Timeline and milestones

1995:	New Insurance Law in Israel that enables competition between healthcare providers in Israel. Trade union control over Clalit Health Services stops. Incentives for Clalit and all other healthcare provider organisations to become more efficient
1999:	Failure of early project that involved exchange of digital files and faxes
	New Committee defines prerequisites
	Pilot at the Soroka Hospital (part of Clalit Health Services)
2001:	Decision by Clalit to implement Soroka's system nationwide
2003:	Sheba adopts initial HIN for internal use
2004:	Start of routine HIN operation and Sheba and Rambam Hospitals join the Clalit Network

3.3 Supporting take-up

During implementation, project managers were the main source of support. Their main responsibilities included training that comprised three steps[38]:

[36] Interviews with doctors
[37] Interviews with HMO management
[38] Interviews with HPO management

1. Presenting the system to each department
2. Group training for doctors and nurses in groups of four or five
3. Personal training of super-users, one or two people in each department trained over two days so they can help other users in their departments.

As the HIN became routine, the project managers' workloads gradually decreased.

An additional incentive was providing a new computer to each department. It helped to achieve a 90% rate of discharge letters written with the support of, and available on the HIN.

A key success factor for the HIN was that healthcare professionals at points of care wanted the solution more than the CIO.[39]

3.4 Benefits

This section of the report provides an overview of the benefits from using the HIN in Israel, identified by the EHR IMPACT study team during on-site visits. The qualitative nature of the analysis is supplemented by anecdotal quantified evidence illustrating the size and scope of the gains.

3.4.1 Patients, informal carers and other people

Patients and their carers benefit directly by healthcare professionals sharing their information with their colleagues across all parts of the healthcare sector. Throughout the HIN critical importance is attached to sharing medical information but it is recognised that sharing within one healthcare organisation is only part of the equation and that the sharing of information between healthcare professionals, whoever they work for, is more important from patients' perspectives.[40] The benefits have many dimensions. At its simplest, patients receive safer care, with a reduced exposure to risk.

Primary care

The HIN offers considerable benefits for visitors and new patients. These can account for about five to ten patients a day for each GP.[41] Their medical histories are available to GPs at the first consultation, so there is no delay in either starting or extending treatment, or deciding that there is no need for action.

Where the GP has prescribed drugs for patients, the HIN provides information about the drugs dispensed, confirming compliance with the clinical regime. It also reveals where patients have not complied with this next stage, indicating that patients may need further support. Patients also benefit with improved safety when their GPs have rapid access to comprehensive prescriptions by other doctors and so can avoid over-prescribing.

A similar benefit arises from GPs' access to diagnostic tests. Where these were completed recently in other settings, such as a hospital stay, GPs can use the HIN data instead of requesting duplicates, and patients then avoid the risks, discomfort and sometimes journeys to hospitals and laboratories.

[39] Interviews with HPO management
[40] Medical Information Sharing in Clalit Health Services, Israel, (2009) D. Mustacchi, Available at: http://inteliprojects.com/wp-content/uploads//MEDICAL_INFORMATION_SHARING_IN_CLALIT_HEALTH_SERVICES_ISRAEL.pdf (08-09-09)
[41] Interviews with primary care doctors

Some GPs show HIN information on their PC monitors to patients during consultation, creating a better dialogue between healthcare professionals and patients.[42] Patients can use this comprehensive, complete information to be better-informed and so participate more effectively in their own care.[43] This can be especially valuable where the HIN helps GPs to care for patients from multi-lingual patient communities, such as Ethiopian immigrants.[44]

Hospitals

As for patients in primary care, patients and their carers benefit directly by healthcare professionals sharing their information through the HIN with their colleagues across all parts of the healthcare sector. The benefits have many dimensions. At its simplest, patients receive safer care with a reduced exposure to risk by using comprehensive, current information in clinical decisions.[45] The main value of the HIN is providing healthcare professionals with the facility to obtain past medical information in real time, especially laboratory results.[46]

Some hospital inpatients experience sensitivities to several drugs. The HIN can provide alerts to these and so improve patient safety, sometimes avoiding an average of one extra day in hospital. The incidence of these events is about once every two weeks for each hospital.[47]

Where patients need emergency services and are semi-conscious, such as with head injuries and serious cardiovascular conditions, the HIN can provide information about their medical histories and sensitivities, and so inform healthcare professionals about treatment options, especially those to avoid.[48] Patients benefit from this improved safety. The same information can also quicken the pace of treatment by avoiding wasted time seeking information from hospital archives or phone calls to GPs. This time saved chasing missing paper increases the time available for patients. Information in the HIN can also help doctors to test and validate their decisions on treatments beyond 24 hours.[49]

Important benefits for the safety of patients arise from using the HIN and its messaging service to provide discharge and medication recommendations to GPs. Data transmitted electronically is legible and enables GPs to improve the continuity, precision and quality of care.[50]

The example of better communication in the case of language barriers illustrates further how the HIN helps health professionals provide safer care. In the catchment area of Soroka Hospital, 27% of the population is Bedouin. With each woman having an average of seven children, and being responsible for 55% of births, the Bedouin population is growing. There are significant cultural differences and language barriers between Bedouins and the rest of the population, making the provision of healthcare more difficult. Often, the only information doctors have about the medical histories of Bedouins is from the HIN, which helps to clarify facts[51]. Without this information, patients would be exposed to the risk of adverse events due to ill-informed decisions.

[42] Interviews with primary care doctors
[43] Interviews with HMO management and doctors
[44] Interviews with HMO management, and primary care and hospital doctors
[45] Interviews with hospital doctors
[46] Interviews with hospital doctors
[47] Interviews with hospital doctors
[48] Interviews with HMO management and doctors
[49] Interviews with hospital doctors and HMO management
[50] Interviews with hospital doctors and nurses
[51] Interviews with HPO management and doctors

3.4.2 Health service teams

The core benefits of the HIN for healthcare teams are from sharing information between healthcare professionals across the whole healthcare chain, leading to improved clinical decisions.

The HIN shares information across all healthcare sectors, thus supporting multi-disciplinary teams working across all healthcare and several professional boundaries. The main benefits from quick and easy access at the point of care to the patient's medical history are better communication, better decisions, safer care and efficient use of time. An example is nurses in primary care integrated with the work of hospital nurses, avoiding the need for them to reassess transferred patients.[52] The benefit extends across follow-up requirements and continuing care.

Pre-discharge letters from hospital nurses to community nurses provide information about the status of patients and enable preparations for a smooth continuous takeover by community services with minimal surprises on discharge.[53] Each primary care clinic receives at least one patient a day discharged from hospital, so community nurses check the HIN about three times a day to prepare for patients discharged into their care. This helps them to put in place a range of facilities that patients need, which can include oxygen in patients' homes, antibiotics, dressings, injections, physiotherapy and occupational therapy. If there is a problem with the required community services, community nurses can send a message back requesting that patients stay in hospital for longer so they can receive appropriate care a few days later then originally planned. Transfer is much smoother and better organised, especially when discharge from hospital is during weekends.[54]

GPs also know when women give birth and can immediately congratulate the parents, and make all necessary support arrangements. A national agency provides post-natal services, not primary care clinics, so midwives benefit from access to all test results from the hospital stay.[55]

A general, and significant, benefit is that the HIN improves healthcare professionals' working day and job satisfaction. Most of them cannot envisage their role without the information from the HIN. This is especially prevalent when doctors and nurses change their places of work permanently or temporarily covering for colleagues' absences, as they have access to the data they need.[56]

Primary care

GPs have about 1,500 patients each. Typically, a GP will access the HIN about a hundred times a day to seek information, especially laboratory results that arrive only post-discharge. Without the HIN, they would need to call laboratories or hospitals several times until the results are available and provided by the hospital nurse.[57] With the HIN, GPs' knowledge of patients test results is routine.

About 20 patients from each GP practice attend A&E each day.[58] For patients attending or admitted to hospital, GPs can track the services provided, the diagnosis, and the prognosis. One GP visiting a conference in Vancouver was still able to remotely track a patient's bilateral breast cancer treatment.[59] In this way, GPs are prepared to take up their role in

[52] Interviews with primary care doctors
[53] Interviews with doctors and nurses
[54] Interviews with doctors and nurses
[55] Interviews with primary care doctors and nurses
[56] Interviews with doctors and nurses
[57] Interviews with primary care doctors and nurses
[58] Interviews with primary care doctors and nurses
[59] Interviews with primary care doctors and nurses

continuing the treatment, healthcare and support of their patients on their discharge or transfer into primary care.

Effective primary care services should provide seamless services for many types of patients discharged from hospital, but this is a demanding goal to achieve consistently. With the HIN, the messaging services and the working links between nurses in hospitals and primary care have enabled improvements in planning and scheduling continuing services, which saves clerical and administrative time. Using the HIN replaces telephone calls, so avoids problems and delays from unavailability.[60]

Communications between doctors and nurses in primary care is also improved. With paper records and notes, nurses had to clarify instructions and requirements for patients about twice a day. A common factor was illegibility, a situation avoided with the HIN, saving time and disruption for both types of healthcare professionals.

Discharged patients and patients relying on primary care services often need home visits. Demand for this is increasing as Israel's elderly population is over 50% and likely to need regular monitoring and more healthcare. Before the HIN was introduced, home visits could turn out to be wasted, as the patient had been hospitalised. Using information from the HIN can save about five wasted visits a week to patients' homes, benefiting GPs and nurses.[61]

GPs benefit from better communications with their patients. Knowledge of all their patients' prescriptions, including those by doctors in other facilities, avoids reliance on patients' vague descriptions such as "small white pills", limited by a lack of clinical features.[62] At the same consultation, GPs can identify if patients have already had the prescriptions they need, and the timing of any follow-on prescription.[63] A valuable benefit is from the ability to check patients' medications dispensed by pharmacies. Some patients often fail to take their medications. About 6% to 7% of chronic patients and about 60% of diabetic patients stop taking the medications after about a year.[64] An initial indication of this failure is patients who do not take their prescriptions to pharmacies for dispensing, and the HIN shows this. However, the HIN cannot identify the patients who collect their drugs, take them home, but either do not take them or fail to complete the prescribed course. Only a direct entry from observation in patients' notes and records can identify this failure and potential future occurrences. A similar use of the HIN is reviewing patients' compliance with medication regimes with several prescribed drugs. Some patients have misunderstood the regime and taken these drugs in sequence, not in parallel. The HIN's dispensing information revealed an equivalent sequence and alerted GPs to the need to intervene.[65]

GPs can also monitor patients' compliance with referrals to hospital services via the HIN. Some patients fail to follow these referrals. They either do not attend initial hospital consultations, or do not complete the required sequence of attendances. GPs can begin to deal with these issues on patients' next consultations with them.

Perhaps the most constructive and demanding benefit of the HIN is that some doctors see the need to change and develop the way they provide information and advice to patients. Access to the shared information provides GPs with new and better knowledge, which they see as creating new opportunities to be both better and different GPs.[66] It seems likely that this benefit is not immediate, but comes to fruition over several years.

Hospitals

[60] Interviews with doctors and nurses
[61] Interviews with primary care doctors and nurses
[62] Interviews with primary care doctors and nurses
[63] Interviews with primary care doctors and nurses
[64] Interviews with primary care doctors and nurses
[65] Interviews with primary care doctors and nurses
[66] Interviews with primary care doctors and nurses

Generally, the HIN offers hospital teams more benefits in time savings and efficiency than impact on better clinical decisions. Typically, before the HIN it took about two hours to find patients' data, and about a day and a half to access data transferred to central archives, amounting to about 20% of a person's time dedicated to record retrieval. For some patients' records, transferred to the central archive, it takes about a month to retrieve the paper documents. Reducing these elapsed times can reduce risks and for some patients, reduce their length of stay by up to a day.[67] Overall improvements in discharge procedures have achieved savings of 10-15 min per patient where the use of existing hospital notes has replaced full re-typing of notes.[68] The HIN cannot reduce the needs of patients living alone, who may have extended hospital stays of up to two days to ensure satisfactory arrangements for discharge,[69] but it helps to ensure that arrangements are in place as rapidly as possible so that this extended length of stay is not extended further unnecessarily.

Admission procedures are more efficient when using the HIN. For patients needing admission from A&E, nurses used to call head nurses on each appropriate ward to locate an available bed. With the HIN, an available bed can be located directly, then assigned to transferring patients.[70] Using the HIN for admissions can save up to a day a week on clerking, and up to 25% of doctors' time. Where patients were inpatients before, admissions can use their previous data, saving further time.[71]

For emergency and planned admissions, when the admission summary is available in the HIN, the preparation of discharge letters begins using copy-paste-and-adapt, saving time. A major advantage is legibility of discharge recommendations and medication records.[72] Two out of three doctors say that discharge summaries are faster than before. Surgeons may be less sure of this than other hospital doctors.[73] Some pre-discharge letters for patients over 65 can include up to seven different drugs. Rationalising the completion of these documents benefits doctors as well as nurses. [74]

The HIN facilitates better bed management by providing near-time situations on information about discharges, admission and occupancy. Doctors take discharge decisions, and head nurses on each ward decide about the precise point in time when discharge is completed, reflecting factors such as the delivery of drugs to take home, the facilities required to be in place by primary care and the information needed to be completed before patients are discharged.[75] Bed management is especially critical because many wards in Israel operate near or at 100% occupancy.[76]

Whilst time saving and efficiency may offer the main benefits from the HIN for hospital teams, clinical decisions and treatments have improved by using more information. On wards, healthcare professionals review HIN records before patients arrive at the ward, including unplanned admissions of patients. This is a benefit in better preparation and care planning and faster and more reliable direction of treatment by physicians.[77] Access to patients' histories can be more important, and sometimes critical, for chronic patients. This includes direct access to laboratory and imaging test results that are viewable in chronological order of tests.[78]

These benefits may be greater for healthcare professionals in internal medicine compared to surgery. There are many perspectives to this difference.

[67] Interviews with hospital doctors
[68] Interviews with hospital doctors
[69] Interviews with hospital doctors
[70] Interviews with hospital nurses
[71] Interviews with hospital doctors
[72] Interviews with hospital doctors
[73] Interviews with hospital doctors
[74] Interviews with hospital doctors and nurses
[75] Interviews with hospital nurses
[76] Interviews with hospital nurses
[77] Interviews with hospital doctors
[78] Interviews with hospital doctors

"In the internal medicine departments, patients arrive at random and a spontaneous way while surgery is generally on an elective basis. Therefore, historical information is more important in the internal medicine departments. Sometimes it is the only source for historical information. In the surgical departments, the activity is more organised in advance and the historical information is collected and organised beforehand.

The results of a recent study indicated that the adoption of the information system at the hospital sector had led to improvements in the physician's ability to browse and gather historical information in a way that improves their outcomes. Results indicate that the importance and value of information is affected by several factors:

- The goal which the physician has to achieve, i.e. the decision he has to make. Results show that when diagnosis is the major concern, the physicians seek different information components from those used in situations of providing treatment or medical service.
- The subject's specialisation – specialised physicians and surgeons differ in the information components that they use from the patient's medical record. Results show that the need and uses of information by internal physicians are different from those of surgeons.
- The level of seniority and experience.

Results show that the utility of using historical information provided by the information system is measured as 0.0687 QALY."[79]

A&E services benefit more from the HIN than inpatient services. Regular use of the HIN is confirming decisions after setting up patients' treatment regimes. Approximately 40% of A&E patients benefit in this way from HIN, which compares to about 20% of inpatients who benefit.[80] The impact is mainly from hardly any loss of data, resulting in patients and healthcare professionals having a reduced exposure to risk.[81] Obstetrics services have experienced only limited benefit from improved communication and data sharing.[82]

Improved access to data with the HIN helps to improve the quality of decisions, especially information about patients' operations histories.[83] Access to laboratory test results is used extensively, especially their chronologies. Another example is the drug-to-drug sensitivity alarm that improves patient safety and typical avoided outcomes of an extra day in hospital and additional distress and inconvenience for patients and carers. This type of event occurs about once every two weeks.[84]

A general estimate of time savings is about three to four hours a week per doctor and avoided wasted time of about one to one and a half hours a day per doctor.[85] The main contributions to these improvements are stopping the practices of the previous paper-based system where doctors would spend about 15 to 30 minutes, three times a week, on telephone calls with GPs,[86] saving about an hour per shift by not copying medical summaries manually and doctors not having to sit by the phone waiting for information.[87] These convert into improved work satisfaction.

Nurses benefit from being better informed. They use the HIN to access information they need for patient care. This helps them to overcome positions where doctors' instructions may not

[79] Value of Information in the Decision Making Process in the Healthcare Environment. Shabtai, Leshno, Blondheim, Kornbluth (2007). Dissertation Abstract. Available at: http://recanati.tau.ac.il/Eng/_Uploads/368WP_24-2007_Leshno.pdf
[80] Interviews with hospital doctors
[81] Interviews with hospital doctors
[82] Interviews with hospital doctors
[83] Interviews with hospital doctors
[84] Interviews with hospital doctors
[85] Interviews with hospital doctors
[86] Interviews with hospital doctors
[87] Interviews with hospital doctors and HPO management

have been precise enough and need clarification. This health information exchange within wards saves each nurse a minimum of an hour a day, about 12% of a nurse's time[88].

On shift changes, handovers are more efficient. Each nurse saves about ten minutes a shift, with shift changes three times a day. The process for a fully occupied ward of 42 beds occurs for the morning shift, often of about five nurses, the day shift with about four nurses and the night shift with about three nurses.[89] A simple calculation estimates the time saving on this type of ward as about 2 hours a day, some 8% of the total nursing team.

Using the HIN to collect recent laboratory results avoids unproductive telephone calls to hospital wards. Using the HIN's messaging enhances this benefit by avoiding telephone calls.[90]

Generally, the use of the HIN compared to the previous manual systems realises more in internal medicine nursing services.[91]

In Israel, about 200 infectious diseases are reportable, including hepatitis A and B, HIV and TB. The HIN helps to improve infection control across all infection types. The infection control nurse uses the HIN to collect results on microbiology and bloodstream infections from all catheters used for patients. Information is available on the performance of all operations and surgical infections. Access is by seeking information about individual patients, not by asking for infection types, such as MRSA. The database provided by the HIN can be used to identify locations of viruses and where they are acquired, leading to rapid, effective action. If necessary, nurses can contact patients before admission as part of a response to hospital infection control.[92]

Infection control is one aspect of clinical risk management. Three to four clinical risk management activities are typical for a large hospital. Information is needed for each reported event, especially for sedation, and the HIN is used to collect information about patients' medical histories. Sedation nurses care for about ten sedated patients each day.[93]

Lack of information about patients can affect issues of liability and responsibility. This also applies where information does exist but is not clear. Despite some initial scepticism by some doctors, the HIN can help in this matter by ensuring that good recording is part of good risk management.[94] Without the HIN, knowledge about patients is more limited, especially slower to acquire. Risk management activities rely on the HIN for 75% of checks. A manual system within a hospital would need more than five full-time staff compared to fewer than two with access to the HIN.[95]

Information from the HIN has improved epidemiology services. Reports on public health are now immediate compared to about three months with paper systems. On some occasions, the information was too late for epidemiology decisions. In one hospital, the HIN enabled the redeployment of two to three full-time staff needed to analyse paper records to follow information in real-time and act when needed. The benefit is not in staffing reduction, but redeployment to immediate reaction, so avoiding extra treatment and suffering.[96] All information needed for the decision whether an infectious disease is a threat is in the HIN. Each day, the epidemiology nurse looks at all microbiology data and relevant procedures and matches procedures to laboratory results. The quality of epidemiology has improved with better traceability of patients and contacts. Achieving the same outcomes without the HIN would need another four full-time support staff.[97]

[88] Interviews with hospital nurses
[89] Interviews with hospital nurses
[90] Interviews with hospital doctors and nurses
[91] Interviews with hospital nurses
[92] Interviews with hospital nurses (infection control & risk management)
[93] Interviews with hospital nurses (infection control & risk management)
[94] Interviews with hospital HPO management
[95] Interviews with hospital nurses
[96] Interviews with hospital HPO management
[97] Interviews with hospital nurses (infection control & risk management)

3.4.3 Healthcare Provider Organisations (HPOs)

HPOs benefit from the HIN in several ways. Perhaps the most significant is the shift in focus away from discussions about the accuracy, reliability and availability of information. Now, people in HPOs trust the HIN data[98] leading to a paradigm shift in the focus of HPOs to using good clinical and patient information to seek continuous and sustainable improvements in the value of the healthcare provided. The HIN complies with the transparency and commitment needed for this more challenging and sophisticated management role, which is especially critical in large HPOs.

HPOs can secure improvements in the quality of the healthcare they provide, with a commensurate reduction in exposure to clinical risks. This leads to more satisfied patients and carers and improved job satisfaction of clinical staff. The impact on clinical staff increases by improvements in efficiency, leading to productivity gains, with HPOs able to streamline and improve their healthcare processes and so achieve better resource utilisation. Operational processes improve too, such as admission, discharge and transfers. The HIN also provides accurate and prompt information for billing.

Efficiency gains are considerable. HPOs in primary care use data from the HIN on previous laboratory tests and avoid the need for duplicative tests for about 50% of patients. Similarly, there are fewer repeat tests, especially in haematology, chemistry, imaging and colonoscopy.[99]

There are equivalent improvements by HPOs for hospital services, for example, avoiding laboratory tests when a test has already been ordered by a GP with the result now available to hospital doctors via the HIN. About three duplicate tests are avoided for each shift.[100]

The HIN also provides access to data needed for business intelligence models, although not all the data. Good business intelligence includes data from external sources, and information is available from the Israel Central Bureau of Statistics and the National Insurance Institute.[101] However, without data from the HIN, business intelligence is seriously impaired, with a limited emphasis on factors such as workloads, staffing and finance.

Further gains accrue from the accreditation requirement for information performance by insurance companies.[102] The HIN ensures that this is achieved.

3.4.4 Third parties

The HIN provides data for some research and has to comply with formal ethics policies. Research includes topics such as bone marrow and stem cells. Researchers can use the HIN to compile data on epidemiology and outcomes.[103]

Third party payers have reliable information available on the performance and workloads of their HPOs and can use this to develop policies, strategies, plans and projects for service development and improvement. These build from effective, constructive financial management and control activities.

[98] Interviews with hospital HPO and HMO management
[99] Interviews with doctors and nurses
[100] Interviews with hospital doctors
[101] Interviews with hospital HPO and HMO management
[102] Interviews with hospital HPO management
[103] Interviews with hospital HPO management

4 Conclusions

Critical success factors in the implementation of the HIN in Israel include:

- The HIN was developed from a clear understanding of the needs of all types of users, especially medical knowledge and medical needs, and clarity on what was possible and acceptable within organisations
- Ownership of data by those who created and stored it is maintained
- The HIN began with a minimal data set that was clearly defined and subsequently expanded, and avoided a model trying to create a complete, sophisticated solution in one attempt
- Detailed designs, such as patient lists and page views, are easily assimilated into healthcare professionals' workflows and support and enhance organisations' strategies for improved healthcare indicators and proactive and preventive healthcare
- Project teams included all important stakeholders and people with the authority and peer standing to bring the project out of the committee stages and to fruition
- ICT teams allowed the people working in the healthcare and business activities to lead, acting as technology enablers and facilitators, and iterating potential solutions with leaders and users
- The HIN was quick to implement, user-friendly and does not disrupt normal routine daily workflow
- Existing ICT infrastructure and investment is leveraged because the HIN is integrated with functions such as existing data, confidentiality, security and authentication standards
- The partnership relationship between healthcare executives and the vendor defines the processes for development, support and maintenance between local sites and continuous development
- The HIN is cost efficient with simple implementation at new sites and clinics and low cost operations for the scale of utilisation.

4.1 Future potential

The HIN is interoperable with mainstream clinical systems, so its potential is not constrained by future changes in these in its core role of providing healthcare professionals with access to, and sharing, clinical information. Current demand is for more access to clinical details and histories, for example, to be able to see the sequence of ECG results and PACS images, and the HIN's interoperability platform could help to compile access to these. Such developments will contribute to fulfilling the HIN's potential as a virtual EHR.

Ultimately, even greater benefits are expected by progressing towards semantic interoperability in which advanced aggregation and clinical logic is added. Using the semantic meaning of data allows information to be delivered, represented and viewed in a clinically relevant manner integrated within clinicians' workflows and enables advanced use for clinical reasoning. Furthermore, meaningful, unambiguous, actionable data provided in a coherent way to not only clinical and analytical systems but also to personal health records, population research and monitoring, tools supporting operational and managerial workflows and other

applications help realise the true value of data residing within and outside the healthcare enterprise.

In full alignment with the HIN requirement to "leave data to remain where it is and not interfere with existing systems", even greater future benefits are expected for the HIN as it upgrades the network and thereby enables the progression towards semantic interoperability in which advanced aggregation and clinical logic can be applied. The foundation for this semantic interoperability functionality is dbMotion's Unified Medial Schema (UMS) based on HL7 V3 and the Reference Information Model and its vocabulary domain, which leverages information architectures that do not share common terminologies, vocabularies, or code structures.

At UPMC, dbMotion has integrated and aggregated data from more than 15 major clinical systems, such as laboratory test results, problem lists, and documents into a unified information framework used to further "semantically harmonise essential patient information such as medications and allergies whose sources were diverse vocabularies and terminologies".[104]

An advanced Medical Ontology is being developed using OWL (Web Ontology Language) and based on standard terminologies and code systems. It defines a rich set of relations between concepts incorporated from different standard terminologies. This ontology builds the core of a comprehensive *Semantic Framework for Health Interoperability and Intelligence (HII)* offering a broad range of semantic services like providing the name of the therapeutic group a drug belongs to and all the associated medications in that group, providing associations between medications and diagnoses, problems and treatments, etc. Tools for semantic harmonisation of data from local terminologies into the medical ontology are also made available. The Semantic Framework addresses the needs of all key healthcare stakeholders (caregivers, quality managers, administrators, financial managers, researchers, decision support analysts, IT managers, etc.) by implementing a common vision - providing unified, harmonised, meaningful, computable, and consumable patient information.

The broad capabilities and flexibility of this advanced Semantic Framework further expand the possibilities for interoperability and intelligence over the long term.

4.2 Transferability

HIN equivalents are in use in several different healthcare systems in several countries. UPMC in the USA started using and developing its HIN equivalent in 2006, with a consequent investment interest in dbMotion. UPMC is the largest integrated healthcare enterprise in Pennsylvania and one of the leading non-profit medical centres in the United States. It has 48,000 employees, 20 tertiary, specialty and community hospitals, 400 outpatient sites and doctors' offices, retirement and long-term care facilities. There are almost 5,000 physicians affiliated with UPMC.[105] A HIN equivalent is also undergoing implementation at UMass Memorial Health Care, the largest integrated healthcare system in Central and Western Massachusetts with over 10,000 employees including 1,500 physicians and 2,500 nurses. The UMass Memorial Health Care is the clinical partner of the University of Massachusetts Medical School.[106]

[104] http://www.dbmotion.com/UPMC.aspx
[105] dbMotion Press Release, February 25, 2008
[106] UMass Memorial Health Care Selects dbMotion for Unified and Interoperable Patient Record. Advanced interoperability and portal solution to connect multiple hospitals, ambulatory care facilities and technology environments to improve care delivery (02-02-2009). Available at: http://www.dbmotion.com/webSite/Modules/News/NewsItem.aspx?ntype=2&pid=246&id=156

IRIS, a hospital network in Belgium, with its five hospitals across 11 sites in the Brussels region, including specialist hospitals for paediatrics and oncology, has chosen a system based on the same concept and technology as the Israel HIN. The IRIS network has 2,461 beds for more than 120,000 inpatient admissions a year with over 670,000 bed days and over one million outpatient admissions.[107]

dbMotion has used the concepts developed on the basis of the HIN to team up with Orange, to complete Orange Healthcare's solution offering for hospitals in France.[108] The presence in France includes cooperation with the Franche-Comté Regional Network.[109]

These examples confirm the transferability of the HIN model.

4.3 What it means for decision makers

The HIN model offers decision makers an eHealth option that builds on their existing ICT investments by providing healthcare professionals with access to virtual EHRs. Proven benefits are realisable and risks are manageable. The case study could not have access to economic cost information, so it is not possible to indicate the economic monetary value, or net benefit, of the Israel HIN, nor the time needed to realise a net benefit. It is not likely to be much shorter than other EHRI case studies. Decision makers need to estimate these themselves.

[107] dbMotion Press Release, July 1, 2008
[108] dbMotion Press Release, May 28, 2008
[109] dbMotion Press Release, October 2, 2007

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