e-Health: the case of Mexico

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Abstract

This paper describes the initiatives and programs on innovation and technological development in public and private sectors in Mexico, contributing to elaborate experiences on the e-Health area, as a way of improving healthcare services, mainly in rural communities facing problems to access hospital and specialized services.

Key-Words: *Health Services; Basic Health Services; Telemedicine; Telenursing; Remote Consultation; Mexico.*

Resumen

Salud-e: El caso de México

Este artículo describe las iniciativas y programas de innovación y desarrollo tecnológico dentro de los sectores público y privado en México, que dieron lugar a experiencias en el área de salud electrónica, como una forma de mejorar los servicios de atención sanitaria, sobre todo en las comunidades rurales que enfrentan problemas de acceso a servicios hospitalarios y especializados.

Palabras-clave: Servicios de Salud; Servicios Básicos de Salud; Telemedicina; Tele-enfermería; Consulta Remota; Telesalud; México.

Resumo

e-Saúde: O caso do México

O presente artigo descreve as iniciativas e programas de inovação e desenvolvimento tecnológico dentro dos setores público e privado, no México, que iniciaram experiências na área de e-Saúde, como uma forma de melhorar os serviços de atenção a saúde, sobretudo nas comunidades rurais que enfrentam problemas principalmente de acesso a serviços hospitalares e especializados.

Palavras-chave: Serviços de Saúde; Serviços Básicos de Saúde; Telemedicina; Telenfermagem; Consulta Remota; Telessaúde; México.

INTRODUCTION

Healthcare services in Mexico are provided by both the public and the private sectors. The public sector is made up of social security institutions (offering outpatient, inpatient and specialized health services, including medicines and other raw materials) – Mexican Institute of Social Security (IMSS), Security and Social Services Institute for State Employers (ISSSTE), Mexican state-owned petroleum company (PEMEX), Mexican defense secretary (SEDENA), The Mexican Navy (SEMAR) – providing coverage for the employees of the formal sector of the economy, such as companies, public services and federal government, for the retirees and their families; social security institutions of state

governments and services for the population without social security (Health Department, State Health Services, that offer heterogeneous services, basic outpatient services in rural health clinics and more complex services in capital cities), Popular Insurance (for low income people without institutional coverage from healthcare services) and the IMSS Oportunities (providing medical care in health clinics and hospitals mainly in rural areas).

The private sector, which is primarily based on a profitable scheme, is addressed to the population that can afford to pay and it is made up of private insurance companies, service providers in private doctor's offices, clinics and hospitals. This sector also includes some non government organizations, universities and academic centers that offer medical care services and/or social assistance. According to ENSANUT 2006, 25% of the population entitled to the services provided by the National Health System are unsatisfied and use private services regularly.

Although Mexico has a wide health infrastructure, health services received by the population depend on the institution they belong to. Hospital medical care, specialized care and high complexity care are concentrated in urban areas. Customers of social security institutions enjoy more benefits, whereas rural communities which are geographically scattered face problems to have access to hospital and specialized services.

On the other hand, Mexico faces a reality with a high concentration of physicians in urban areas and a limited availability of healthcare professionals in rural communities. In addition, public health services have long waiting time for accessing hospital service.

The presidency of the National Health System is held by the Health Department with the tasks of planning, designing and establishing policies, intersector coordination, health goods and services regulation, protection of the service users and evaluation of programs and policies.

The main healthcare problems of the Mexican population are related to chronic-degenerative diseases, such as: overweight, diabetes, ischemic heart diseases, high cholesterol levels, hypertension, brain-vascular diseases, cancer, liver diseases, and obstructive pulmonary disease and nephrology diseases.

Finally, there are also initiatives and programs on innovation and technological development in public and private sectors that have started to get involved in e-health activities. The main goal is to contribute towards the strengthening of medical care services and the improvement of health situation for the different communities of the country.

E-HEALTH IN MEXICO

Mexico has been present in e-health development for a long time. At the end of 1968 Dr. Ramiro Iglesias was finishing an advanced course in aerospace medicine at NASA Air Force when the medical control team of the Apollo 8 invited him to be the cardiologist for this mission. He received the first ECG and pneumogram sent from the orbit of the moon.[1]

The first Federal government program marking the inclusion of the health system in the use of communications goes back to the end of the 70´s when within the IMSS-COPLAMAR program (in 1993 this program changed its name to IMSS-*Solidaridad* and in 2002 to IMSS-*Oportunidades*), the Mexican Institute of Social Security (IMSS) developed the rural network of radio-communications to support communication among medical units. In 1985 this program was restructured limiting the network extension reach.

In 1985 due to the devastating impact of the earthquake in the City of Mexico, one of the first international experiences of the use of telemedicine in disasters took place. The National Aeronautics and Space Administration Agency (NASA) supported by the Advanced Technology-3 (ATS-3) satellite facilitates the American Red Cross and the Pan-American Health Organization (OPAS) to provide voice-based support. At this time, land communication media were collapsed, except for radio based lines. During the first 24 hours after the disaster the ATS-3 gave priority to communications required to assess damages and rescue operations.[2]

In 1985 the health education program on TV starts at the Children's Hospital Federico Gómez in Mexico called "Mexican Center for Health Education on Television" (CEMESATEL).[3]

In 1994 the Security and Social Services Institute for State Employees (ISSSTE) carries out the first analysis to apply telecommunication technologies on health and in 1995 the first telehealth program with institutional coverage came into operation.

On the other hand, there are also the surgery services at *Torre Médica Hospital* supported by surgical robots and telepresence allowing surgeons to carry out and direct distance procedures on the operating theatres and hospitalization areas. This type of resources and services are the result of the work done by Dr. Adrián Carbajal since 1996, a pioneering surgeon on robotic surgery in the world.

In 2001 the Health Department, considering the e-Mexico National System initiative and the national experiences

existing through the Inter-Institutional Committee, proposed the Action Program: Telemedicine e-Health 2001-2006.[4]

In 2007, the Telehealth Action Program 2007-2012 is published and put into operation with the aim of supporting and establishing a reference and integration framework of plans, programs and resources for the configuration of a Telehealth National System.[5]

The first areas to adopt information systems within health institutions in Mexico were the administrative and research areas. Later, the use of computing equipments was extended to epidemiologic surveillance, statistics preparation and teaching.

HEALTH DEPARTMENT

In 1970 the National Center for Health Information and Documentation (CENIDS) worked with the support of teleprocessing terminals to remotely consult the Medical Literature Analysis and Retrieval System (MEDLARS) system belonging to the National Library of Medicine (NLM) in Bethesda, Maryland, United States. This centralized consultation system was used for approximately 15 years and its main limiting factor was the cost per minute of the connection.[6] During 1977 and 1986, 13.029 connection hours were registered. MEDLINE was the most used database in 41.531 searches by 30.775 users.

In 1985 the data processing of the State System for Basic Information (SEIB) was centralized reaching 12 states, covering the 32 states of the country in 1989. In 1992 SEIB and the Universal Vaccination Program operations were automated and the first local networks were installed at the federative entities. The Year 2000 transition (Y2K) favors the creation of the Y2K Information National Center of the Health Sector.[7]

In 1995, the Health Statistics and Assistance Department (SSA) started a central Internet Portal offering statistic, administrative, legal and follow up information services on health programs with the aim of promoting its image and supporting the wide range of users of the institutions. In 1996, after one year of operation the *SSA Forum* and *Ask your doctor* services started, providing users with the opportunity to ask questions on different healthcare related topics. These questions were answered by a group of specialists.

The Informatics Development program at the SSA 1995-2000 (changed its name to Health Department in 2001) regarded information and communication technologies as strategic tools to increase the efficiency of the substantial and administrative tasks of the institution.

In 1995 the National Epidemiological Surveillance System (SINAVE) is created and the Single Information System on Epidemiological Surveillance (SUIVE) is created, with the support of the Single Automated System for Epidemiological Surveillance (SUAVE) for processing the Hospital Network on Epidemiological Surveillance (RHOVE), the Epidemiological Surveillance System for Addictions (SISVEA), the Automated System for following up tuberculosis cases (EPI-TB), the histopathology records of Malignant Neoplasia (RHNM) and the Epidemiological Surveillance System for External Causes Lesions (SVELECE), among others.[7] In 2000, the Action Program "National System of Epidemiological Surveillance" had five components: weekly notification of new cases of diseases (SUAVE): Hospital Network for Epidemiological Surveillance (RHOVE); Epidemiological and Statistic System of Deceases (SEED); Special Systems; and Single System of Laboratory Information (SUILAB).[8] In 2006, the diagnosis made on the National Health Information System identified the following opportunity areas: insufficient standardization of concepts and indicators, diverging views among the several actors involved for integrating and automating the system, heterogeneity among the sources, resources and information technology and a weak legal framework.[9]

The Single Automated System for Epidemiological Surveillance that concentrates information regarding events of epidemiological medical interest coming from institute units at national level, supported the weekly notification of new cases on: vaccine preventable diseases; intestinal and parasite infectious diseases, respiratory infectious diseases; sexual transmitted diseases; vector transmitted diseases; zoonoses; and other exanthemic and transmitted diseases.

In 2000 the Health Department had the aim of reducing the complexity to generate health information in Mexico resulting from the statistic information collection from several institutions supported by more than ten systems with different collection formats, glossary of terms and periods to collect information; since the Health Department identified different information gaps resulting in incomplete and deficient information, it proposed the creation of a National System on Health Information (SINAIS); it promoted the Mexican Official Standard NOM-040-SSA2-2004. This Standard was published in the Federation Official Gazette on March 8th, 2004 and it became operational in 2005. The Standard establishes the criteria to obtain, integrate, organize, process, analyze and disseminate health information,

regarding population and coverage, available resources, awarded services, damages to health and performance assessment of the National Health System.[10]

According to the Standard NOM-040-SSA2-2004, SINAIS is made up of five sub-systems: population and coverage; physical and human resources and financial resources; awarded services; damages to health; and performance assessment. Information for epidemiological surveillance is ruled by the Standard NOM-017-SSA2-1994.[10]

Also, in 2000 the Health Department program Coverage Extension Program (PAC) through the radio-communication network reaches the coverage of 19 federative entities of around eight million inhabitants. Within PAC, a distance graduate course addressed to Strengthening Managerial Capability for Healthcare Authority started.[4]

During 2000-2006 the Health Department General Direction of Information Technology (DGTI) established a policy to adopt free software systems including office tools. During this same period of time, it started to organize the Hospital Administration System (SAHO) with the creation of a community of developers that started at the same Health Department, the "Shared Institutional Software Program".[11]

The SAHO includes multiple processes gathered into four divisions: Medical Services, Administrative Services, Administration of catalogues, Administration of medical schedules by physician and specialty. At the end of 2005, around twenty hospitals were working with the first version of SAHO. With an estimated time of 18 months of implementation including training the staff and making adaptations.[11]

Some modules of the system were installed at the medical units called UNEMES, at Silao Hospital belonging to the Guanajuato Health Department and the Specialized Hospital Belisario Domínguez (HEBD), that belongs to the Federal District Health Department. At the moment the Social Work and Outpatient Consultation modules are in operation at the HEBD, they are also on the adaptation process of the medical urgency module.

The Federal Health Department identified consultancy and assessment of medical technology as an opportunity area and this is why it established the National Center for Technological Excellence in Health (CENETEC). This entity included among its activities the promotion of actions and meetings to exchange experiences related to the use of information and communication technologies on health. As a result of these actions there is an Annual e-Health Mexican Conference, which started in 2002, with the aim of collaborating with national and international experts and organizations.

The CENETEC was created in January 2004 and since then it officially coordinates, supports and looks for the alignment of the different telemedicine initiatives in Mexico through the incorporation of several actors and institutions that constitute the National Health System.

SYSTEM FOR SOCIAL PROTECTION IN HEALTH

The National Health Program 2001-2006 proposes financial protection in health as one of the central topics to protect people with limited access to medical care services from the costs of the diseases. Thus, it suggests to consolidate the basic protection of such population through the creation of a popular security scheme that promotes affiliation to social security and to look for the regulation of private insurance schemes.[11]

In 2003 the General Health Law (LGS) was modified and it incorporated the System for Social Protection in Health (SPSS) which operational entity is the Popular Health Insurance (SPS). This Insurance started to operate as a pilot program in 2001 and in 2004 its operation was extended to the rest of the states. At the end of 2007, it had almost 22 million people affiliated. In 2008 this Popular Health Insurance guaranteed access to 266 interventions including medicines, covering approximately 90% of causes of outpatient and inpatient care at public institutions in the country and access to a package of 49 medical interventions and 8 high cost diseases.[12]

With the aim of following up the affiliated population and the operation of the program, the Popular Health Insurance included as a technological platform the use of electronic clinical records and the TUSALUD (your health) card that started to be implemented in several levels in the 32 states of the Republic in 2005.

The TUSALUD initiative registered pharmacies into the Popular Insurance that provided prescriptions when people identified themselves with the card. In July 2006 it was estimated that the Popular Insurance had given 3.7 million family cards and had 2.078 pharmacies enrolled. In 2006, it was estimated that the Public Sector issued 180 million prescriptions per year with an average of three drugs and with the use of TUSALUD the estimates showed that expenses with drugs were reduced by 20%.[13]

Credentials were financed by the Treasury and Public Credit Department (SHCP) that created a fund to finance this single credential. Each card had an approximate cost of eight dollars.

However, interoperability and maintenance problems were reported in at least 15 states and the program was cancelled. At the same time, together with this initiative in the states of Durango and Jalisco some efforts started to provide an independent credential system.[14]

ISSSTE

The Security and Social Services Institute of the State Employees (ISSSTE) started using ICTs at the Automated Detection and Diagnosis Clinic (CLIDDA) that initiated its operations integrating the use of automated medical records in 1975. In November 1993 it started the updating process of computer services of CLIDDA that went into operation in 2006.

In 1995, the ISSSTE run the first telehealth program with institutional coverage considering a potential population of 4.2 million entitled citizens. This program is based on the use of satellite technology and its goal is to reduce the costs of the institution with patients having to travel to specialty and high complexity centers concentrated in the main cities of the country. Until 2007, specialty interconsultations were done between 11 General Hospitals and Clinics with six Regional Hospitals and the National Medical Center *20 de Noviembre*. During this same period distance learning services were provided. In the year 2000, 7,200 teleconsultations had been delivered, 93 monographic courses, three graduate courses and 1.200 administrative processes. During 2007 and 2009, 26 million pesos had been invested and it was estimated that 40 million pesos were invested by 2009.[15]

In 2007 a new stage of this institutional program started with the incorporation of digital technologies into medical units at the three levels of care extending the network to 177 units. Its main goal was to increase coverage of specialized services and to reduce unnecessary referrals of patients.

In 1995 the ISSSTE adopted a Hospital Information System (SIAH) at *Hospital 20 de Noviembre* offering services through 300 PC terminals and 280 Macintosh equipments. With these two technologies working together different databases were kept with a continuous release of new versions of the system.

In 1996, the ISSSTE started the project to automate family medicine clinics (CMF) called Automated System of Clinics, starting with the CMF in Xochimilco and installing 8 CMFs in the Federal District.

With regard to information systems automation and integration to support medical care services, the responsible organ for these projects is the Sub-Direction of Information Technology.

Since 1991, the Integral System of Medical Information SIIM is used to control the statistic information generated at the three levels of care at the ISSSTE. The SIIM integrates the following systems: Productivity of Outpatient Medical Services (SISPRO), Hospital Entries and Departures (SIEH), Preventive Medicine (SIMEP), Installed Physical Capacity (SICAFI) and Surgical Acts (SISACT). These systems were updated in the year 2000, and standard catalogues of coding were integrated. This same year, the Allowance System is adopted for the hospital network of the institute operating in nine Hospitals and at the temporary request for the sick people. At the same time, the institute established the institutional computing committee and the institutional program for computing and telecommunication development (PIDIT).

During the period of 1998-1999 the institute established its first National Voice and Data Network with the goal of providing support to communication and reduction of technological infrastructure expenses. In the year 2000 the network covered 31 state delegations and four metropolitan ones, the National Medical Center *20 de Noviembre*, with 1.804 points in the metropolitan area and 1.700 at the delegations.

Similarly to the IMSS, ISSSTE also has an information system on administrative management. In 2010 the ISSSTE was getting ready to implement a national adoption of electronic clinical records and the automated measuring operation of the performance in service provided at the healthcare services through the Internal System of Institutional Performance Assessment (SIEDI).[16]

IMSS-OPORTUNIDADES (OPPORTUNITIES)

The first program of the federal government marking the inclusion of the health system into the use of communications dates back to the end of the 70's when the Mexican Institute of Social Insurance developed the rural network of radio communications to support communications between medical units, within the IMSS-COPLAMAR program.

In 1997 the IMSS-*Oportunidades* together with the Public Education Department and the UNAM created a health education program for peasants and indigenous communities. This program managed to connect 1.373 points and

40.000 people. During 1999 and 2000, 240.000 teenagers were trained on a basic course on sexuality.

In 2001 the IMSS-*Solidaridad* Program had computing infrastructure at a central level and 1.369 computers distributed around administrative areas in 18 delegations in 17 states, 69 rural hospitals, 210 zone teams and 43 regional teams.

IMSS

In 1989, the IMSS started a program called Operative Medical Information System (SIMO), for the medical units to be able to register productivity by service and by physician. Thus, information collection and assessment were integrated at the place of origin in order to ensure its quality and the necessary opportunity for decision making.

In 2002, the usefulness of a nominal registration including variables of health promotion and attention to damage was identified. This registration considered coverage, prevalence, indicators and productivity, and the Information System on Health Integral Attention (SIAIS) came into operation with the purpose of having a statistic registration of medical care actions.

During the period between 1995 and 2000 the institute started to use a hospital administration system at the Oncology Hospital of the National Center *Siglo XXI* and two hospitals in Monterrey and Nuevo León. The goal was increase efficiency in hospital administration and medical care. The system included 28 modules on: hospital registration, appointments, clinical laboratory, operating theaters, infirmary and electronic clinical records.

At the same time with the support of the World Bank, the Family Medicine System *Siglo XXI* started in five units in the City of Mexico and another one in Monterrey. This system took into account the automation of the medical appointment request, the applicability of rights, the electronic clinical records, the control of disabilities and the prescription generation charged to the pharmacy warehouse. It supported the rights applicability services in 331 units of the first level. There were 23 clinical labs supported by different lab systems. Sixty nine percent of the institute hospitals had the patient classification system based on Diagnosis Related Groups. In 2000, the IMSS had 32,231 computers.

The IMSS has the Family Medicine System (SIMF) that supports medical care registration and administration at the first level units. This system was developed together with the Engineering School of the Mexico Autonomous University (UNAM) in 2002 and went into operation in 2003. The SIMF is addressed to family physicians, medical assistants, lab staff, X ray personnel, stomatologists and administrative personnel at the units. The main modules are appointment schedule, integral care, PREVENIMSS, stomatology and diagnosis assistant services. The SIMF enabled the integration of statistic information of first level units at the SIAIS. It was initially installed in 133 Family Medicine Units and in 2004 the second version of the system was released including improvements and the support of outpatient activities of second and third level hospital units.

In 2006, 1,184 Family Medicine Units used the SIMF, prescribing 70 million medical prescriptions during the period of 2005-2006, 4.5 million disabilities and containing 18 million electronic clinical records. In the white book “Family Medicine Improvement Process” an initial investment of 21.8 million pesos was identified for the SIMF project in 2002.

Medical care processes of hospital services including urgencies are supported by the Hospital Outpatient Information System (SICEH) and the Hospital Information System IMSS-VistA. This last initiative was initially done together with the Mexico Autonomous University and later consultancy and development services from national and international software companies got involved.

Also, in 2001 hospital and specialized medical care services at the four hospitals conforming to Raza National Medical Center were supported by the Digital Imaging System that facilitated the storage of medical images. After the beginning of the adaptation and development project of IMSS-VistA, the development of medical images visualization system is incorporated into the DICOM standard. The systems supporting the services of diagnosis and treatment assistants, such as clinical laboratories, blood banks and haemodialysis are integrated into the electronic clinical records through the use of a message system based on HL7 version 3.0.

In 2007, the IMSS electronic clinical record enabled the integration of the medical notes, the orders and results of diagnosis and treatment assistants, haemodialysis, disabilities, stomatology, pharmacy and medical appointments among others. Nowadays, the IMSS is facing the challenge of integrating several systems that support medical care into the several levels with the lowest costs and modifications to the operating applications.

In 2004, the estimated investment for the project of the electronic clinical record of the Institute to cover its entitled population of 46,813,307 was U$ 102 million.

In May 2006, the IMSS started the operation of the Digital Hospital, this project was carried out in collaboration

with partners from the information technology industry. It integrated electronically hospital services including the critical areas and infirmary. At the managing level, it enabled to follow up productivity and the daily activity of the hospital with control boards. The Digital Hospital of the IMSS represented an investment of 259 million pesos.

During the last years with the improvements made into the electronic clinical record systems, the IMSS obtained information to support the decision making process of the services management. At the moment, it is facing the challenge of using it for costs based on diagnosis related groups.

The IMSS has incorporated ICTs through the national and international market offer. The participation of the international market is higher with tailor-made solutions, especially in the case of information and technology systems for telehealth and telemedicine.

PEMEX

PEMEX has focused on the administrative control of sensitive areas of expenses and it has the Institutional System for Pharmacy Administration (SIAF) linked to the Institutional System for Hospital Administration (SIAH), that enables a centralized administration and it generates weekly orders to supply the pharmacy. In 2006, digital prescription was in operation in 44 medical units.

In 2003, the SIAH supported the functions of appointment control, medical care, disabilities control, hospitalization, payment to outside patients, operating theatres, control of pathological studies, health profile covering services in 109 occupational health units.

PEMEX has made investments to develop the institutional electronic clinical record that until 2006 reached 55.2 million pesos and with an estimated total cost of the project of 1,173 million pesos. In 2005, regarding information technology, the coverage, functionality and support of the Hospital Administration Integral System was approved and extended to 60 medical units with first level of care, in its reception and medical care modules with the generation of electronic prescription.

SEDENA

In 1997 the operations of the specialty units of the SEDENA started, incorporating the use of a computing administrative system. The unit of medical specialties and dentistry started its operation with the Computing Administrative System with Electronic Clinical Records based on the file manager PRO-IV that has 47 subprograms, seven subprograms are common and 12 and 18 are special sub-programs for the Unit of Dentistry Specialties and Medical Specialties respectively. This system was developed by the staff at the Informatics Section of ISSFAM with the participation of specialized physicians and surgeons.[15]

That same year, the SEDENA integrated the Digital Imaging Network at the Medical Specialty Unit that included two teams of basic radiology through a plate digitizer, two ultrasound teams, a team for contrasted studies, one CT scan team, two plate printers and three working stations. The imaging network was not interconnected to the electronic clinical record system, and the Medical Specialty Unit was made of two independent networks.[15]

Between 2006 and 2008 the SEDENA developed the Project Hospital Administration Computing System of the Clinic on Women's Specialties (SIAHCEM). The system is made up of 32 modules that support the administration of outpatient appointments, the control of drugs management at the general warehouse, pharmacy, hospitalization rooms, administrative procedures and the use of clinical records.

The Central Military Hospital has been the medical unit of SEDENA with special effort to install computing applications. In 2002 a committee to develop the project Integral Medical Administrative Computing System was included.

SEMAR

The Marine Department has a system for hospital control (SICOHOSP) that is used to automate the control of medical services offered by this institution to its staff, both active and retired, and also to all people entitled to these services. This system was developed by the staff at the Direction for Developing Computing Systems at SEMAR.

Such system has the following modules: administration, users allocation; reception, enabling to create electronic records, scheduling and appointments allocation; medical consultation, general consultation, consultation for specialties and dentistry; warehouse, it also supports the control of drug stock; lab and X rays studies; naval healthcare, it controls the consultation done to the records; and preventive medicine that supports physicians in prevention treatments of diabetes mellitus and obesity.[16]

SEP

In order to reduce the impact of hospitalization on education and school drop outs of boys, girls and teenagers who are at the hospital, on March 9th 2005, the Public Education Department, the Health Department and the National Institution for Adults Education with the collaboration from the private sector, started the program "Let´s carry on learning" at the hospital (SIGAMOS) through the Edusat network. In these hospitals, rooms were prepared at hospitalization floors and also on the outpatient area and classes were offered at hospital rooms for boys, girls and teenagers with difficulties to move around.

In 2006, the program was in operation in 22 federative entities, 52 hospitals and three lodgings and in the Federal District. Almost 182.200 services had been provided per year. The SIGAMOS program was extended to the inner part of the country in the states of Aguascalientes and Nuevo León, helping up to 13,000 boys and girls and more than 8,000 teenagers and adults with some educational difficulty.[17]

NATIONAL INSTITUTES, HIGH SPECIALTY REFERENCE AND HOSPITALS

General Hospital of Mexico

In 1993 the Project to implement the Integrated Hospital Information System was proposed at the General Hospital of Mexico. This Project had the goal of modernizing the infrastructure to facilitate the processing and consultation of statistic, epidemiological and administrative data. It also considered the management of X rays images and lab data. In 1995, after visiting several hospitals in France, the coordinator of the project selected and purchased French optical fiber and software infrastructure for the hospital. In 1996, the General Hospital of Mexico tried to inter-communicate and share resources between the hospital information system and the digital library services, however it faced the obsolescence of the system and equipment that supported the digital library limiting the benefits between the systems.[18]

The Teaching Direction at the General Hospital of Mexico in 2006 created the Department of Educational Technological Innovation with the aim of looking for new technologies that would benefit the medical area, having as a priority project the Virtual Education Center (CEV) at the General Hospital of Mexico. At the moment, the Hospital, through the CEV, offers services of virtual libraries consultations, anatomic-clinical sessions, diagnostic guides, videoconferences, electronic magazines, residents' thesis, electronic books and online courses.

NATIONAL REHABILITATION INSTITUTE

In 1997, the Orthopedics National Center that later changed its name to National Rehabilitation Institute started working with information technology projects applied to health. Initially it adopted an electronic clinical record system to enable the control of medical schedules facilitating the reduction of the waiting time in the office and the administrative control. The clinical and imaging areas were gradually integrated.

In 2002 the Institute had the Automated System of Hospital Information that had the following modules: Outpatient, Clinical Files, Urgency, Infirmary, Hospital Registration and the medical assistance, cashier operations, pharmacy, social work and warehouse modules were under development.[19]

Similarly, in the year of 2000, the former Orthopedics National Center incorporated telemedicine services, being a pioneer in supporting medical education through videoconferencing based education, a subject within the group of national health institutes due to its trend to become a Smart Hospital. In 2003, the systematization process of administrative areas started and at the moment the National Rehabilitation Institute continues its operations integrating information and communications technologies.

HIGH SPECIALTY REGIONAL HOSPITAL OF *EL BAJÍO*

In April 2007 the High Specialty Regional Hospital of *el Bajío* (HRAEB) opened the doors and from the beginning the Health Department included a management model supported by a hospital information system developed and used health services. This system is based on a ERP complemented with several business intelligence and clinical management modules, among others.

NATIONAL INSTITUTE OF RESPIRATORY DISEASES

Between July and September 2004, the National Institute of Respiratory Diseases (INER), finished the installa-

tion of its internal computing network. It implemented the Hospital Administration System, a project with the aim of having the total control of hospital operations reducing the operational cost and helping to increase the quality of the medical care services provided. The Institute also considered the integration of its administrative and substantial medical areas through the use of a Government Resource Planning (GRP).

In 2006 the Institute continued to implement the Hospital Administration System updating the web platform and it carried out the pilot test on the urgency service. The GRP, the hospital information system, the imaging services of RIS-PACS and the laboratory centralized its data into a single database.

DR. SALVADOR ZUBIRÁN'S NATIONAL INSTITUTE OF MEDICAL SCIENCES AND NUTRITION

The operation done at Dr. Salvador Zubirán's National Institute of Medical Sciences and Nutrition (INCMNSZ) is partially supported by the Hospital System that has been developed by the informatics area of this institution and it is mainly integrated by the following modules: surgery, operating theatres, interconsultation, electronic records, medical notes, lab and images.

NATIONAL INSTITUTE OF CANCEROLOGY

During 2003 and 2008 the National Institute of Cancerology (INCan) developed its system of electronic records called INCanet. In 2006, this system had 40 different modules and at the end of 2007, the INCan had approximately 400 connected computers to access electronic records including different levels of integration with laboratory, pathology and X rays services.

NATIONAL INSTITUTE OF PSYCHIATRY

In the year 2000 the Institute started using videoconferencing services supported by a dedicated link of 384 kbps with the DGSCA at UNAM. A program of distance courses started in 2003 focused on updating knowledge on the areas of mental health and psychiatry. Distance education is supported by the Moodle platform. In 2008 the Institute was broadcasting weekly bibliography sessions of analysis of the last publications on psychiatry and mental health; also, Master and PhD degree classes are delivered together with the School of Medicine of UNAM and the Neurobiology Center of UNAM in Querétaro.

NATIONAL INSTITUTE OF PERINATOLOGY

In 2009, the system and the database for the use of electronic clinical records were installed in the application server. 727 users were trained, including physicians, nurses, social workers, nutritionists and administrative personnel. The operation of the electronic clinical record system was expected from September that same year. At the moment INPer has the service to request Assessment Consultation on the internet.

NATIONAL INSTITUTE OF PEDIATRICS

In 2006, the National Institute of Pediatrics started the evaluation of possible technological solutions to integrate hospital administration and service systems. And in 2007 it started the process of using electronic clinical records including the 175 services offered by this institute.

GENERAL HOSPITAL DR. MANUEL GEA GONZÁLEZ

Since 1996, the General Hospital Dr. Manuel Gea González (HGMGG) started its transformation to incorporate information technology. During 1998-1999 some services for payroll payment and partial control systems of inventory on different warehouses were introduced, such as: general, pharmacy, clothes, stationery and supplies. During these years the hospital had a network of 20 computers. According to financial statement information, during the period of 2002-2007 the purchase of computing equipments in this institution has been continuous and it has increased approximately 54%.

The impact of systematization has been very specific and it enabled to reduce the waiting time at cash registers and the elaboration of admittance cards.

In 2005, the HGMGG started to use the SIGHO. In its first stage, it carried out adaptation tasks for the needs of the areas of pre-consultation, outpatient, social work, urgency, cashier operations and registration. Until 2006, this system was used to control the modules receiving general

data from patients, hospitalization date and the service into which patients were admitted. The medical care processes needed to be included to integrate the clinical records.

The HGMGG presents a relevant experience of using the electronic clinical records in emergencies. During the H1N1 event in Mexico, this was one of the hospitals that met the needs of the population and it managed to document electronically in real time the cases seen that may be related to the epidemics. The area of informatics, urgency and diagnosis and treatment assistants configured the SIGHO to register the cases and to do the mapping on a geographical information system.

NATIONAL CENTER OF TRANSPLANTS

Based on the experience of the transplant service of the INCMNSZ and the integration of the needs of the transplant centers in Mexico, in 2003 the National Center of Transplants (CNT) automated the national waiting list meeting the need of counting on timely and reliable information for the availability of organs for transplant at a national level.

MEXICO CHILDREN'S HOSPITAL "FEDERICO GÓMEZ"

The year of 1985 marked the beginning of the health education program on television at the Mexico Children's Hospital Federico Gómez called the "Mexican Center for Health Education on television" (CEMESATEL) with 18 Mexican institutions participating at the initial stage. This program had the active participation of the former Health and Assistance Department (now the Health Department), the Communication and Transport Department and the National Autonomous University of Mexico. The CEMESATEL tried to complement and keep healthcare professionals updated with free services on medical education, offering talks, monographic courses, programs on different medical topics and events on its programming. In 2006, it included digital services for broadcasting its different programs. Also in 2008 transmissions were made through the EDUSAT network. Currently it has national and Latin American coverage.

NATIONAL INSTITUTE OF CARDIOLOGY "IGNACIO CHÁVEZ"

In 2002 the National Institute of Cardiology was developing the hospital information system called Information Global System. It had more than 500 computers connected in a local network and it incorporated connection with some biomedical teams.

In the year 2000, the Institute had the following applications: Procurement, Warehouse, Social Work, Patients Accounts and Hospital Registration. It also started the operations of the Clinical Record Subsystem incorporating its use in outpatient and some hospitalization areas. The clinical notes are done with free text capture with some structured data such as anthropometry and vital signs.

The computerized project at the Institute tried to redesign processes, identify the added value of ICTs at the several services to raise awareness among decision makers and to increase resource allocation on computing infrastructure. In 2002, the main obstacles identified for the implementation were the lack of training in the use of computing tools.

In 2008 the Institute started to update this system with the aim of integrating it with the laboratory information system, GRP and incorporating the use of information exchange standards.

Table 1 - Gross Investment in equipments at HGMGG 2002-2007.

Gross Investments in equipments	2002	2003	2004	2005	2006	2007	Percentage Increase %
Surgical Equipment and devices	129.1	132.6	143.0	172.5	182.3	224.7	74.1%
Machinery and tools	29.6	29.5	31.1	32.5	34.2	35.4	19.5%
Computing Goods	13.0	13.4	14.9	17.1	19.0	20.1	53.9%
Furniture and office equipment	12.3	12.2	13.0	14.1	14.8	15.5	25.6%
Medical instrumentation	4.2	4.4	5.8	8.0	8.2	8.6	103.1%
Transport Equipment	3.1	3.2	3.4	4.2	4.3	4.4	45.1%

Source; HGMGG. Financial Statements 2003-2007

STATE SERVICES

In the state health services, similarly to what happens in the private sector and in the social security, ICTs application was initially implemented for administrative management. The use of electronic clinical records has been limited. In the field of telemedicine, several pilot programs had been used and some of them had even been established as integrated programs into health services. In the Southern region of Mexico, the telemedicine programs of Chiapas and Yucatán are good examples, as well as in the region of Northern Nuevo León.

AGUASCALIENTES

In the period between 2004 and 2006 the Health Institute of the State of Aguascalientes (ISEA) developed the project to improve processes called "Integrated System of Health Management" and, at the same time, they started to use the electronic clinical records. In this period, the second level hospital outpatient areas and 90% of urban first level clinics used the system of electronic clinical records. In 2006 they were doing the necessary adaptations of the existing application to use it in two specialty hospitals. The system integrated the federal health programs: Popular Insurance, life line, quality indicators, opportunities, COFEPRIS and SIS statistics.[20]

The system developed by the ISEA enabled to have a productivity and medicine supply report at the automated units. Among the reports generated were the following ones: main diagnosis detected, information on patients with diabetes and high blood pressure and pregnant women, information of studies and diagnosis assistants, administrative information, reports to patients entitled to IMSS or ISSSTE and the follow up of referred patients.

CHIHUAHUA

In 2004 the Coordination for Development and Modernization of the state of Chihuahua indicated that the electronic clinical record had been implemented at the following hospitals: Children's hospital, Central, General, Zubirán and Women's Hospitals in this entity. The health technological project had three fundamental parts: Electronic Records, Hospital Care System and Telehealth.

In 2002, the Women's Hospital in Ciudad Juárez started using an Electronic Record System in the consultation area. In 2006, this system used was changed for the Hospital Management System (SIGHO), due to its more friendly interface and improved support. In addition, its administration and support was done locally. At the moment, both systems are used, the ICHISAL at Hospital areas and the SIGHO in the outpatient areas".[21]

The Telehealth network of this state is focused on medical micro-units located at the mountains and serving the indigenous population. In 2004, they had a network connecting 64 health micro-units and they were trying to establish a call center including chat and forum with a group of physicians for consultancy.

NUEVO LEÓN

With the aim of mitigating the scarcity of specialized physicians, the Health Services of Nuevo León State, started the telemedicine program in 2001. In 2005 they started the prison telemedicine program including three state centers for social inclusion.

In 2003, the first efforts were made to offer distance medical care and tele-education in the state of Puebla, the initial network of services included 6 General Hospitals and four Integral Hospitals.

COLIMA

The state of Colima started to develop the Administration System for Electronic Records of Colima (SAECCOL) with the program Popular Insurance. It has four modules: first and second level outpatient; first and second level schedule; configuration and statistic management; and installation tools.

In January 2006, the process of adopting the electronic clinical records in hospitals started with the project Medical System and Hospital Administration (SIMAH). The Ciudad Guzmán Hospital started a pilot program and, in 2008, it was already operating at the Women's Hospital in Tala; in Tepatitlán, in Puerto Vallarta and in La Barca. The use of the electronic clinical records in this state will increase depending on the investments made on the necessary information technology equipments in the hospital units.

The system is addressed to capture and consult medical-hospital records and to facilitate administrative tasks at the hospitals. It is a tailor-made solution based on a web

platform. The system has three administrative modules and thirteen operational modules including Hospital Registration, Clinical File, Physician, Blood Bank, Cashier operations, Outpatient, Costs, Infirmary, Laboratory, Pharmacy, Operating Theater, Social Work, Urgency, Catalogues, Safety and Interfaces.

SINALOA AND SIGHO

Sinaloa is probably the state experience with the largest coverage and support of electronic clinical records in Mexico. The computing area of the State Health Department developed the Clinical Records System called SiEC that has been implemented and used in all first level units of that federative entity in 2003. This solution had the goal of reducing repetitive administrative tasks done by the medical staff from filling out multiple forms. Another goal was to help improving the quality of the institution.

In 2003 the General Health Information Direction (DGIS) belonging to the Health Department and responsible for the presidency of Health Information, encouraged the development and operation of the Information System for Hospital Management (SIGHO), together with the State Health Services in Sinaloa. SIGHO was the result of the evolution of the SiEC initiative. Until January 2008, the SIGHO had 13 modules: appointment, registration, hospitalization, labor and delivery surgery, surgery, social work, laboratory, pathology, blood bank, cashier operations, control board and pharmacy.

In 2005, based on the results obtained at the General Hospital of Culiacán, it was decided that the SIGHO should be the managerial information system to be used at Health Department hospitals nationally. The system was made available to the State Health Services including the code with the agreement that the State Health Services must invest in infrastructure and required services for its operation.

In January 2008, there were 1,519 healthcare units that had least one SIGHO module, of which 2% offered some hospitalization service and the rest corresponding mainly to first level healthcare units. Most units reported the limited use of the modules for appointment and outpatient.

In 2005, the state of Jalisco started to use the Information System for Hospital Management (SIGHO) at first level units and, at the moment, it is installed in five units.

In March 2010, the health services of the State of Guerrero reported on their website the use of SIGHO in seven state hospitals and five health centers. The modules that are in operation at the health services of this entity and at different levels are: appointment, outpatient, imaging and laboratory, registration, urgency, hospitalization, labor and delivery surgery and social work. Seventy percent of the hospitals have adopted the use of systems supporting 100% of their services with SIGHO.

VERACRUZ

The Health State Services in the state of Veracruz developed the Integral Managerial System for Medical Care (SIGAM). The aim of this system is to integrate the electronic clinical records of patients and to support the management of medical care. The experience developed from 2006 and implemented in 2008 concentrated the use in two hospitals and 36 primary care units located in the Jurisdiction of Coatzacoalcos and Poza Rica. In September 2008, the Department had 50.000 electronic clinical records.

SIGAM has the modules of appointment, outpatient, urgency, hospitalization, registration and social work. In addition, the system platform of health services in Veracruz includes the health intelligence system, the virtual office and the knowledge portal Web 2.0.

ZACATECAS

It started teleconferencing services with the interaction with the General Hospital of Mexico in 2006. Nowadays, they carry out tele-education sessions with BUAP, HGM and the National Psychiatry Institute, among others.

On the other hand, the Health Services of Zacatecas use SIGHO since 2007. At the moment, 30% of the medical care units operate using the SIGHO support, within this group of units there are four general hospitals of the five general hospitals included in the project. The module used in these medical units is Outpatient.

YUCATÁN

In 2007 telemedicine services started in this state. The Health Services of the State of Yucatán offer telemedicine services through: the General Hospital of O'Horán, Community Hospital of Ticul and the Community Hospital of Peto. During July and December 2007, 410 teleconsultations were performed.

PRIVATE SERVICES AND E-HEALTH

Private institutions in Mexico have generally incorporated ICTs as a way to improve the administrative management control and have developed tailor made solutions with the cost-benefit logic. The applications most commonly used in this type of organizations are laboratory information systems such as *Laboratory Information Systems* (LIS) - and medical images *Radiology Information Systems* (RIS).

Currently the market for Administration Systems of Laboratory Information (LIMS) in Mexico and Latin America are being served by: developing companies of local software with limited training on the areas of health and process analysis; and by distributors of systems developed abroad. Thus, functionality in these systems is limited to cover the basic needs at an operative level. They offer little flexibility of adaptation to particular processes of each laboratory and normally its development and implementation are complex, slow and expensive, even without having interaction with other systems.

CARPERMOR

Probably the most relevant experience regarding automation of laboratory services in the private sector is PROA Group that supports the operations of the reference lab CARPERMOR and the services of the Medical Laboratories el Chopo. In 1998, they started to develop their own LIS substituting the issues generated by an external providing system that had inconsistencies with high operational costs and were not ready for the year 2000 change. In addition, they had a foreign system developed in MUMPS language without a local technical support. As a result their maintenance and support services were expensive and had long response times. Also in the year 2000 they started to offer real time and online services.

ABC HOSPITAL

ABC Hospital can probably be considered one of the private institutions with high technological level where the use of telepathology among its units and digital medical imaging services can be mentioned as good examples. In 2005, they kept telemedicine services around their units in Observatorio and Santa Fe with MD Anderson Cancer Center, The Methodist Hospital and Cedars Sinai Medical Center. That same year they had services based on their portal for physicians, corporate customers and patients.[22]

TORRE MÉDICA

On the other hand, *Torre Médica* surgery services are very relevant since they are supported by surgical robots and telepresence, allowing surgeons to carry out and run distance procedures on the areas of operating theatres and hospitalization.

This type of resources and services are the result of the work done by Dr. Adrián Carbajal who in 1996 started his work and contributions towards the daily use of robotic surgery at *Torre Médica* Hospital and other hospitals in Mexico.

Zeus project consisting in a telepresence surgery system started in 1997 and it was implemented between September and November 2001 at *Torre Médica* hospital. The *da Vinci* project on surgical research was carried out in Mexico in 1998. It is important to mention the international collaboration between Mexican nurses and biomedical engineers and their peers in the United States and Africa, in this last project.

Finally, both universities and NGOs also provide health services using information technologies, practicing telemedicine and developing their own Systems for Electronic Clinical Records. They have infrastructure and generate technological models.

CUDI AND INTERNET 2

The University Corporation for Internet Development A.C. (CUDI) started in 1999, to encourage cooperation between national and international projects on Internet 2 network.

It incorporated several universities with Schools of Medicine and it created the working group on health. In 2006, the virtual network was created among 14 National Health Institutes, and health projects requiring the use of computing resources on I2 are encouraged among national and international universities and health institutes.

ANÁHUAC UNIVERSITY

The Telemedicine Program at the Anáhuac University (now Altius Foundation) started in 2002, using mobile units and providing services to marginalized communities of *Costa Chica de Guerrero* and la *Sierra Mixteca de Oaxaca*, including services during the natural disasters Stan and

Wilma. The specialties supported by telemedicine in this program are the following ones: gastroenterology, nutrition, internal medicine, surgery, pediatrics and gynecology. The initial investment of this project was 7.5 million pesos including infrastructure, equipments and services. Operational costs ranged between two and 3.7 million pesos.

BUAP

In the year 2002 the experience of the Meritorious Autonomous University of Puebla (BUAP) on telemedicine started with the establishment of a satellite network supporting several virtual health programs with national and international coverage. At the same time it established teleconsultation offices and operating theatres focused on telesurgery.

In 2004, the program of electronic clinical records is incorporated into the BUAP telemedicine program. Between 2002 and 2004 the telemedicine program of the University was in charge of the General Direction of Educational Innovation.

In 2005 the telemedicine program is integrated into the School of Medicine of the University. In 2006 it is integrated into the National Network of Videoconferences run by UNAM. Since 2007 it participates actively in the inter-institutional committee of e-Health and in 2009 it started the graduate course on telemedicine and telehealth together with the Open University of Catalonia (UOC).

Nowadays the University has three teleconsultation offices at the communities of Libres, Chignahuapan and Tehuacán that get linked for specialized teleconsultations with the reference telecenter at the School of Medicine of BUAP.

The services that are currently being provided by the School of Medicine of BUAP are telescreening, telemonitoring and Preventive Telemedicine and it had established an annual program on health tele-education based on videoconferencing.

UANL

The Autonomous University of Nuevo León (UANL) has developed its telemedicine program through the University Hospital and its University program on health. In 2007 it had cable, optical fiber, microwave, ISDN and IP telecommunication Systems. They are interconnected with five university clinics, four health centers, one family medicine unit of the IMSS and the state Children's Hospital, Psychiatric and Metropolitan Hospitals, a dental module, IMSS specialty clinic, two university auditoriums, the state network on telemedicine of the State Department, Esquipulas Clinic in Chiapas.

At the moment, they are interconnected to the national videoconferencing network, the videoconferencing network of the United States and the videoconferencing network of Central and South America.

In 2007 they carried out teleconsultations in 17 specialties offering teleconsultation services to three prisons.

It had established agreements with other states to offer distance education services on health, in particular with Chiapas where they train nurses at High Specialty Hospitals of the entity.

IPN

Since last decade the National Polytechnic Institute (IPN) has contributed towards the training of healthcare professionals with continuous education programs. Since 1999 the Direction of Continuous and Distance Learning (DECyD) started to offer distance medical education with the Distance Learning Program on Health that included graduate courses, conferences and certifications. Until 2008 more than 5.000 physicians and healthcare professionals had participated on their programs. Also, since the year 2000, they had the collaboration of the main Hospitals in Mexico as for example the continuous participation of the Society of Surgery at the Juarez Hospital in Mexico.

At the moment, the IPN has 30 offices participating in its continuous education program on health, making possible to access the sessions of its programs via streaming and the EDUSAT network.

CINVESTAV

In the last ten years, the generation of telehealth centers and information technology had been sought in Mexico. This is the case of the Center for Research and Advanced Studies at the National Polytechnic Institute (CINVESTAV) that works with the topic of the Information Society through the General Coordination of Information and Communication Technologies. It has also participated in the evaluation of electronic clinical records of the IMSS and in the first interoperability tests among electronic clinical records in Mexico.

UNAM

The most important academic establishment in Mexico, the Autonomous University of Mexico (UNAM) with the School of Medicine has taken part in the development of e-health through health teaching and research, and medical informatics. In 1979 the permanent open course on Medicine by mail was created, in 1984 it broadcasted medical dissemination programs on a TV open channel, in 1988 it started national seminars with the series on medical updating *"AliisVivere"* on TV via satellite. In 2002, the first online graduate course with the General Direction of Epidemiology; in 2003, it carried out the first Edition of the online medical updating course "Anxiety disturbs in medical general practice"; in 2004, the course " Clinical-Therapeutic Update" was delivered by Interactive videoconference; in 2006, video on demand is introduced with the Conferences of the Course of Medical Knowledge Systematization and, in 2006, the streaming services with the course on "Update on Gastroenterologist for the general practitioner" are introduced.[22]

In 2007 the School of Medicine had more than 1.000 connection points to the UNAM network with a bandwidth and Internet of 1GB and its development and evaluation platform of distance courses was based on Moodle. [22]

UNAM is a pioneer in driving forward the specialty on Medical Informatics and courses on decision analysis and Medicine computing in Mexico, defending that medicine and teaching should not stay behind in the use of technology.

In 1995 the University included Computing Studies in the syllabus of the Medicine graduate course for students that explored databases and databanks such as Medline, the newspaper library and the national digital medical library.

The project to create the specialty on medical informatics started in 1985 at Arturo Rosenblueth Foundation. As a result of this initiative there is a new specialty, Artificial Intelligence in medicine.

The first conference on Medical Informatics took place in 1990 at the UNAM School of Medicine and, in 1996, the first graduate course on applied informatics started on "Medical Decision Making".

The telemedicine and videoconference project started in 1996 with the following goals: to carry out distance conferences, to reduce expenses and to disseminate knowledge.

In 1995, the Jalapa University School of Medicine in Veracruz opened the Master's degree on Artificial Intelligence with a chapter dedicated to medicine and, in 1997, in Tepic, Nayarit the first Graduate Course in Informatics Applied to Health is opened with the participation of lecturers from UNAM.

In 1998, an investment of U$250,000 was made for the internet server and to start the "virtual hospital" Project, with the aim of having an online team of specialists to answer questions from medicine students, physicians and patients. The specialties considered were pediatrics, obstetrics, gynecology, surgery, internal medicine and control of toxic substances.

In 2001, the UNAM together with its Foundation equipped 43 hospitals with computing equipments. These hospitals belonged to teaching units of the School of Medicine and it offered the first connectivity services to Internet on the hospital setting.

In 2010, the UNAM School of Medicine, with the support from the General Direction of Academic Calculation Services (DGSCA), established the 3D Modeling Laboratory to provide the medical university community with tools of teaching-learning, research and diagnosis through the visual and cybernetic supporting material to facilitate the understanding of "concepts" that are hard to visualize. This was also useful to support the noninvasive diagnosis. Media for three-dimensional content presentation is prepared in this lab.

The School of Medicine has developed 46 models for the following departments: Anatomy, Cell and Tissue Biology, Biochemistry, Teaching and Training Surgical Center, Pharmacology, Physiology and Microbiology and Parasitology.

CONACYT

In 1979, the National Board for Science and Technology (CONACYT) received the proposal of developing a telemedicine system based on the experience of the indigenous reserve of Papago. This proposal was not successful because at that time the practice of distance medicine in the country was not considered feasible.

Over the last years the Federal and State Boards for Science and Technology had promoted the generation of technology innovation networks for e-Health and the generation of ICTs clusters, with the goal of making multi-sector agreements a common practice to generate research projects on the e-Health area.

MÉDICA SUR FOUNDATION

In 2004 *Médica Sur* Foundation started its work supported by the funds of CONACYT. The project presented

included three large sub-projects (teleassistance, teleconsultation and teleconferences) and three large pillars (teaching, research and assistance).

The goals included were to establish online programs for health education for the open population, medical and paramedical areas. The first pilot of telemedicine services started in the General Hospital of Valle de Chalco Dr. Fernando Quiroz Gutiérrez in 2006. Also, a telecare pilot with eight patients was carried out.

At the moment, it collaborates closely with the CICESE through the project "Technology Transfer in Telemedicine" that has the support of CONACYT. During 2007 and 2009 they developed a set of Med2VC software for integrating medical devices into specific videoconferencing equipment.

INSP

The National Institute of Public Health (INSP), founded in 1922, is one of the main centers for research and teaching in the field of health in Latin America. In August 2005, it started its first program on Virtual Education aligning its goals of generating knowledge and innovation on health systems with the training of human resources for Public Health. This program is concentrated on offering educational alternative solutions to professionals located in remote areas and who want to study a post-graduate degree or to take an updating course.

The INSP has a geographical information system which goal is to be the interface to access and visualize statistic information of the Center for Collection and Analysis of Health Information (NAAIS). Among other sources, the information used comes from demographic data coming from the national census, economic information from income-expense surveys, social information from marginalization indicators, INEGI information and the national surveys on health.

UAG

The operation of the medical informatics department started in March 1997, through its university center of Health Sciences together with the Civil Hospital of Guadalajara. And in 2010 the First International Conference on Telemedicine took place in Guadalajara.

UP

Its work on telemedicine telematic started in 2006 with the organization of the International Conference on Telemedicine and Innovation, and with the development of the Project called "Rural Generic Telemedicine Project" (PROTEGER) and the electronic clinical records used in a rural clinic in the State of Mexico. In 2009 UP organized the first International Conference on Virtual Medicine.

UAEM

The Autonomous University of the State of Mexico (UAEM) started working with Electronic clinical records in 2009 with the Virtual Directive Graduate Course on Electronic Clinical Records supported by a Trust to Encourage and Develop Scientific and Technological Integration at UAEM and the General Direction on Health Information at the Health Department.[23]

UCOL

Contributions made by the University of Colima in using ICTs on health are in the field of immersion learning objects in the medical area and online programs.

UAM

The Metropolitan Autonomous University participated in the development of ICTs on health with specialized research done at the National Research Center on medical instrumentation and imaging with the headquarters in the Iztapalapa unit. This center has a set of labs designed to host instruments and infrastructure related to medical instrumentations and imaging. Its goal is to strengthen research, training of human resources and to connect the academic, business and health sector in high impact projects inside the field of biomedical engineering.

ITESO - SHM

The company SHM designed, developed and financed a pilot Project called ZUMBIDO in 2007 with the goal of improving the response to the HIV/AIDS pandemics and with

special attention to improve the quality of life of people with HIV in the state of Jalisco. The aim of this project was to use technology to provide relevant information in order to improve the medical treatment; to improve the emotional state of people through communication; to develop people capabilities to access specialized health services. The Institute for Technological and Higher Studies from the West (ITESO), designed the evaluation of the project in its different stages.

The project was done in six municipalities in the state of Jalisco, Yahualica, Tequila, Puerto Vallarta, Lagos de Moreno, Zapotlanejo and the Metropolitan Area of Guadalajara. Mobile phones were used to build a social support network to increase people's knowledge on HIV, getting advice from people who were also living with the virus, reducing the isolation and the distress of living with the virus. Also, this project helped to acquire cognitive and emotional tools to face the situation. The project lasted three months.

TELETÓN FOUNDATION

The experience of Teletón foundation responsible for the System of Child Rehabilitation Centers Teletón (CRIT) shows a wide use of information technologies on the field of health services offered by a NGO. This foundation was opened in 1997 with the goal of providing rehabilitation services to children and young people with neuromuscular-skeletal disabilities and in 1999 they started their services supported by a computer platform including the use of electronic clinical records.

In 2007 the foundation made an evaluation of the needs for automating their units and it developed a system to support the mission and the substantive process of integral medical care. At the moment, the CRIT System has a knowledge administration system that supports directive and medical decision making oriented to integrating the network and workflows among the several collaborators participating in the services awarded. The CRIT System is made up of a network of 13 units and in January 2010 their electronic clinical record system and the knowledge platform were in operation in 11 units. During 2010 the use of this platform was integrated into all the units of the system.

It is important to point out the pioneers on telehealth and robotics in Mexico, with the extremely important contributions made by Dr. Ramiro Iglesias and Dr. Adrian Carbajal respectively. At the end of 1968, Dr. Ramiro Iglesias was finishing an advanced degree on airspace medicine at NASA Air Force, when he was invited to be the cardiologist for the Apollo 8 mission. He was the first cardiologist to receive the first ECG and pneumogram sent from the orbit of the moon.

E-MEXICO

In the year 2000, the government proposed a public policy to incorporate Mexico into the Information and Knowledge Society. The "National e-Mexico System" was established as part of the "Development National Plan" (2001-2006). The aim of this system was to reduce the existing digital gap and to increase the country competitiveness. Following the work line established by the e-Mexico System of the Communication and Transport Department (SCT), it signed intersectorial agreements on connectivity with the Departments of Public Education, Health, Social Development, and the National Institute for Adults Education and the Center for Municipal Development.

As a result of the public policy previously mentioned and taking into account the National Health Program 2001-2006, the Health Department an e-Mexico National System created an intersector working group to develop the first Action Program: e-Health. This group started the current interinstitutional e-Health Committee aiming to gather and integrate initiatives and actors from the public and private sectors interested in e-Health development.

The e-Health Action Program 2001-2006 considered the use of information and communication technologies in medical care, public health, research, training, teaching and medical care service management. The main goal of this program is to increase, through innovation and modernization processes, efficiency and coverage of the services, and to take them to remote regions with the same quality, as well as offering online specialized services for all population, regardless of their place of residence, their social, economic or ethnic-cultural condition".

The targets set in this program included the creation of telehealth systems to intercommunicate personnel at different levels of medical care; to offer online health information to everyone through the e-Health Portal; to strengthen staff capabilities through continuous distance training and education; to modernize the management and administration processes of health services, supported by telematic options and to implement the use of electronic medical records.

Collaboration among several institutions of the National Health System happens through the e-Health Interinstitu-

tional Committee that appeared in 2001 as the answer of the sector to the e-Health Action Program.

The mission of this Committee is to promote experiences and advances of health services based on Information and Communications Technologies on the sector in Mexico. It integrates the main social security institutions, state health services and institutions, academic organizations, non government organizations and the SCT as responsible for the e-Mexico program. Among its activities the Committee is in charge of the coordination and the annual organization of the National Conference on e-Health with an active participation in the national meetings for Health Technologies.[24]

The first actions of the e-Mexico National System were to establish internet connectivity to support the services of several initiatives and involved sectors through the network of Digital Community Centers (CCD). In the case of healthcare, the healthcare centers located in rural communities were incorporated into the network of internet satellite services, with an important participation of the medical units belonging to the IMSS-*Oportunidades* program. In 2007 the healthcare sector had 1025 Digital Community Centers.

In 2001 the Health Department, considering the initiative of the e-Mexico National System and the existing national experiencies through an Interinstitutional Committee, proposed the Action Program: Telemedicine e-Health.

This program identified a poor integration and fragmentation between the information systems and the information technologies in the sector; the lack of a strategic plan to run the adoption and use of technologies for the sector; heterogeneous advance of ICTs infrastructure at the different levels of medical care; ICTs initiatives in the sector addressed to management and administration with limited scope in the clinical setting; lack of knowledge on infrastructure conditions; lack of maintenance and obsolete infrastructure and heterogeneous technological platforms inside and outside institutions.

In 2007, the Telehealth Action Program 2007-2012 started with the aim of supporting and establishing a framework of reference and integration of plans, programs and resources for a National Telehealth System.

This program suggests the use of telehealth to increase accessibility, quality and timing of medical care services in the vulnerable population. It incorporates the development of technological standards and the definition of national data, to look for and guarantee investments on infrastructure, configuration of human capital, the incentive to research on this field and a reference framework to assess the impact of the use of telehealth. The e-Mexico National System did not limit itself to create the internet connectivity infrastructure, but it included within its mission to bring contents closer to citizens through the e-Mexico portal. This portal is made of four pillars: e-Government, e-Economics, e-Health and e-Learning, also including two large sub-sections: DiscapaciNET (for the disabled) and e-Migrants.

The e-Health Portal wants to keep general population informed on activities to promote and prevent damages to health. It also helps to carry out government procedures on health and it integrates information provided and endorsed by institutions of the sector, so that the population could trust the contents.[25]

The first stage of e-Health portal took place in 2003, during 2004 work was done on its restructure to improve the control of contents and in August 2005, the current version of the portal was finally launched.

In 2006 the e-health portal had become the portal of the e-Mexico National System with more pages shown and the second in number of available contents, with a total number of 602 in 2007. During 2005 and 2006 most seen contents were those related to: chronic problems, women, common diseases and those requiring community action for taking care of the disease.

In the year 2000, it was estimated that approximately 10 million Mexicans had some kind of disability. This is why the Office for Social Promotion and Integration for Disabled people (ORPIS) and the National Advisory Board for Social Integration of Disabled People (CODIS) were created. Also, the Action Program for Preventing and Rehabilitating Disabilities (Prever-Dis) was created establishing the commitment for developing the DiscapaciNET service with the support of the National Rehabilitation Center (CNR).

The CNR, ORPIS and CODIS, together with SCT, SEDENA, SEMAR, IMSS, ISSSTE, PEMEX, DIF, e-Mexico National System among others, developed the DiscapaciNET Portal with the aim of providing information and guidance for disabled people, their family and the general public on the several disabling conditions, its prevention and treatment, the existing services, specialized staff and places that sell or rent rehabilitation devices and equipments on the Internet.[26]

DiscapaciNET was launched on October 8th 2003 integrating in its first stage health and social security content. In its second stage in 2004, it incorporated contents by the Public Education Department with information on schools specialized on disabilities, reaching a volume of more than 1.600 contents.

DISCUSSION

During the last decade the Mexican government has incorporated into its agenda Information and Communications Technologies on the different services offered by the institutions. Mexico has been pioneer in Latin America on the use of information technologies on the healthcare sector. In particular, the experiences from 1985 started a few services that are still on operation. Although in some cases progress is slow, several efforts have been made to develop e-Health.

The first e-Health action program tried to use the experience from individual projects carried out by several organizations conforming the national health system, however the trend of individual initiatives has been kept. This is the main reason why heterogeneous impacts are identified. One of the factors favoring independent advances is the fragmentation of the national health system and the fact that access to technology has depended on the investment capacity and budget of the organizations.

The IMSS has gained a wide experience on designing and using electronic medical records and systems to improve the administrative management. The IMSS has not waited for a national judicial maturity, instead it has generated its own framework for the safety of patients and physicians alike.

A problem for Universities and NGOs is that they are not able to ensure medicine provision or to follow up patients, forcing them to sign cooperation agreements and to be operationally integrated into the health system.

ICTs infrastructure at medical care units in the private sector varies. There are hospitals with an intensive use of technology such as the Torre Medical Hospital, the ABC Hospital, and the *Médica Sur* Hospital among others. For the private sector ICT offer is in the international market. In very few cases there is a national offer. Part of this national offer is concentrated on the electronic medical record, which is used in a limited way on the network of private clinics and doctor's offices. This limitation is expressed in its use for medical care purposes, as well as for knowledge generation by the services.

In the private sector telehealth has been mainly adopted as teleradiology, telepathology and tele-education. These are mature applications of telemedicine, they are not very complex and they do not need a great interaction between professionals and patients.

The service offer on the ICTs and health areas by the Mexican industry is limited, organizations have chosen to develop human resources with technological profile and with a limited involvement of healthcare professionals.

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