may result in difficulties of rapidly implementing a system on a nationwide basis. If feasible, a one-stop-shop approach, where the same software is used by all users, is likely to avoid such complications.

- Sufficient resources need to be planned for to train the users of the software. This task has to be seen as part of a continuous maintenance effort, due to the large number of staff involved nationwide, the fluctuation and rotation within the staff and the changes in the system itself.

The particular characteristic of giving great importance to data security and privacy concerns, the flexibility of the underlying data structures, and adaptability to federal administrative structures combine to make Surv*Net*@RKI particularly attractive to multinational surveillance networks like the EU-wide infectious disease surveillance hosted by the European Centre for Disease Prevention and Control (ECDC), since it would allow participating member states to basically use their existing national systems and connect to the universal interface of Surv*Net*@RKI. Having proven itself able manage complex outbreaks reports from many independent states, Surv*Net*@RKI may also be the appropriate platform for the management of the complex data that the new International Health Regulations now require all states to report.

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ORIGINAL ARTICLES

Surveillance report

SmiNet-2: Description of an internet-based surveillance system for communicable diseases in Sweden

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Electronic systems for communicable diseases surveillance enhance quality by simplifying reporting, improving completeness, and increasing timeliness.

In this article we outline the ideas and technologies behind SmiNet-2, a new comprehensive regional/national system for communicable disease surveillance in Sweden. The system allows for reporting from physicians (web form) and laboratories (direct from lab data system) over the internet. Using a unique personal identification number, SmiNet-2 automatically merges clinical and laboratory notifications to case records. Privileged users, at national and county level, work against a common central server containing all notifications and case records. In addition, SmiNet-2 has separate county servers with tools for outbreak investigations, contact tracing and case management.

SmiNet-2 was first used in September 2004. Individual counties receive up to 90% of all notifications electronically. In its first year, SmiNet-2 received 54 980 clinical notifications and 32 765 laboratory notifications, which generated 58 891 case records.

Since most clinicians in Sweden have easy access to the internet, a general web-based reporting has been feasible, and it is anticipated that within a few years all reporting to SmiNet-2 will be over the internet. In this context, some of the major advantages of SmiNet-2 when compared with other systems are timeliness in the dataflow (up to national level), the full integration of clinical and laboratory notifications, and the capability to handle more than 50 diseases with tailor-made notification forms within one single system.

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Introduction

Communicable disease surveillance is an ongoing process involving the systematic collection, analysis, interpretation and dissemination of health data. It aims to detect outbreaks early on, to monitor and analyse trends, and define public health priorities in order to reduce morbidity and mortality and achieve improved health [1-3]. A well-designed and functional surveillance system is fundamental for providing the necessary information for appropriate and timely action and response. In recent years, electronic reporting has become increasingly widespread, incorporating internet-based data entry for the notifying physician and/or the county/state health department, and automated input of electronic laboratory results [4,5]. Electronic systems may enhance the quality of the system by simplifying the reporting for the end users, improving the sensitivity (completeness of reporting), and the timeliness within the system, from event to action [6-13].

In Sweden, a national electronic surveillance system (SmiNet-1) has been in place since 1997. For security reasons, SmiNet-1 was built on a Lotus Notes platform, with local servers in each county and a central server at the SMI. The notification reports were manually entered at the CMO offices (clinical notifications) and at the SMI (laboratory notifications). Some major laboratories had export routines for exporting data directly from the laboratory computer systems to SmiNet-1. For clinical notifications, fields for all information on the standard report forms were at hand, while for the laboratory notifications, more specific information, such as antimicrobial susceptibility and genetic typing information could only be reported as non-standardised information in free text fields. Each night, the central and local Notes servers exchanged information on the recently entered notification information. For further data cleaning and analysis, an SQL-database (EpiArk) was used at the SMI and a stand-alone Lotus Notes application was used in many of the CMO offices. As there was no communication between EpiArk and the local databases, changes and updates made by CMO users were not available for SMI users and vice versa. Furthermore, patients with chronic infections such as HIV or hepatitis C could have separate case records in several of the local databases, but only one in the central database. The incidence for these infections from the county statistics were therefore higher than the county-level statistics submitted from the SMI. After a technical revision of SmiNet-1 in 2001, the inherent weaknesses in the system and outmoded IT solutions prompted the development of an entirely new system (SmiNet2), built using the experience and insight gained from SmiNet-1.

The reporting system

The Swedish Communicable Disease Act [14] regulates the reporting of 59 statutory notifiable infectious diseases. Diseases are notified in parallel by both the patient's physician (clinical notification) and the laboratory that has diagnosed the causative agent (laboratory notification) to the 21 county medical officers (CMOs) and to the Department of Epidemiology, Swedish Institute for Infectious Disease Control (EPI/SMI). The clinical notifications must contain detailed epidemiological information and the laboratory notifications, the relevant microbiological information. With the exception of sexually transmitted infections, all notifications are made using full patient identity, including a unique personal identification number that is issued to all Swedish residents. This number is used to link clinical and laboratory notifications on the same patient and disease episode.

Data-entry close to the source

One of the important ideas behind SmiNet-2 is for data entry to be made as close to the source as possible. Since all hospitals and health centres and almost all private physicians in Sweden have internet access, data-entry over the internet is the preferred mode of clinical notification. The system also allows detailed data to be imported from the microbiological laboratories' computer systems without the need for manual data entry.

User groups

There are four groups of users in SmiNet-2, listed below. All users working within the same database.

Clinicians: There are about 30 000 clinicians in Sweden, working in approximately 5000 healthcare units (hospitals, health centres and private clinics). The clinician reports to the system using either a web interface or a paper form. The clinician may use the web interface to fill in the form and print it out before sending. The physician does not have access to any data within the system (one-way communication only).

Laboratories: There are about 50 routine microbiological laboratories in Sweden, including the reference laboratories. A laboratory has a choice of three reporting methods: through a direct connection from the laboratory data system to the SmiNet-2 using a web service; manually using a web interface; or using a paper form. All communication for the laboratories is one-way.

CMOs: The CMO has the overall responsibility for communicable disease surveillance and control within his county. The SmiNet-2 users at the CMO offices use a Java client for a two-way communication with SmiNet-2, for example, to enter additional information from clinicians and laboratories, to work with outbreak investigations and to get IT support when performing contact tracing.

EPI/SMI: The EPI/SMI is responsible for national surveillance of communicable diseases. The EPI/SMI staff use a Java client for a two-way communication with the system, for example, data cleaning and analysis.

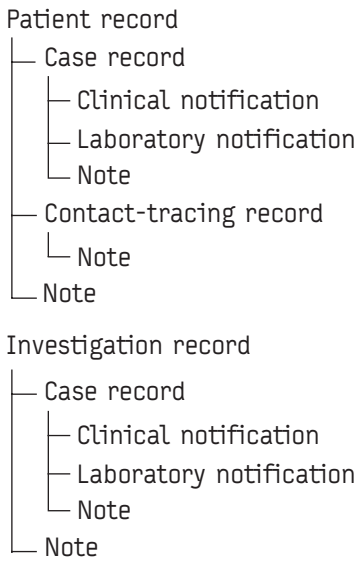
Basic entities in the system

There are six basic entities in SmiNet-2 (listed below and illustrated in Figure 1).

Notification: A notification (clinical or laboratory) contains both mandatory information (for example, patient ID, diagnosis and date of reporting) and optional information (such as country and date of infection). The EPI/SMI has access to all notifications, while the CMOs have access only to notifications reported from their county.

Figure 1

Illustration of the relationship between the basic units



Case record: A case record in SmiNet-2 summarises information from all notifications for the same individual related to a specific disease and within a specified timeframe (defined for all diseases). Each case record can be associated with a patient record and/or an investigation record (see below). The EPI/SMI has access to all case records, while the CMOs have access only to the case records for which they have received a notification. If a patient has moved between counties, and been notified with the same infection (typically chronic infections such as hepatitis C) in more than one county, several CMOs may access the

same case record. The case records form the basis for statistics, and a case record may therefore be active in only one county at a time.

Patient record: A patient record represents a unique individual within the system. Each patient record is linked to his or her case records and contact tracing records. The patient record contains personal information, such as contact details and specific instructions given to the patient by the clinician, and can only be accessed by the CMO who created it.

Investigation record: An investigation record is used to gather and analyse information from outbreaks and other health events. Each investigation record can be linked to the case records associated with the outbreak. The investigation record can only be accessed by the CMO who created it.

Contact tracing record: SmiNet-2 provides the tools necessary for follow up of contact tracing at the CMO offices. Each contact tracing record is linked to a patient and can only be accessed by the CMO who created it.

Note: A note is created for recording an administrative event, such as a phone call, a letter or a decision. Each CMO can create letter templates to write standard letters, such as letters containing instructions to a patient. Each note may be linked to one or more case record, patient record, investigation record or contact tracing record. A note can only be accessed by the CMO who created it.

Software and hardware

SmiNet-2 is written in Java 2 Standard Edition (J2SE). The web module uses Java 2 Enterprise Edition (J2EE) IntelliJ IDEA (version 3.0.5) was used to develop the system. Two database servers are used. The CMO local databases use a MySql database server (version 4.0.20) and the central server databases uses a Microsoft Server 2000 (version 8.00.194). Two Java Database Connectivity (JDBC) are used: a MySql JDBC Connector (version 3.0.6) and an i-net Merlia 2000 (version 1.03). Apache (version 2.0.46) is used as a web server, in conjunction with a Jakarta Tomcat (version 4.1.30) as application server and Apache Axis (version 1.1) for web services.. Communication between the clients and the server are achieved using Java Remote Method Invocation (Java RMI) and the distribution of the clients is done using Java Web Start (JWS). Java Runtime Environment (JRE) version 1.4.2 or higher are required to run either a client or a server. OpenSSL (version 0.9.7a) is used for client server encryption.

System architecture

Figure 2 illustrates SmiNet-2's system architecture.

Server: There are 22 different servers within the system, one central server (at SMI) and 21 local county servers. The central SmiNet server contains a number of databases. Each CMO has his or her own local SmiNet server, containing a local database with information that can only be accessed by the CMO (patient records, investigation records, contact tracing records and notes).

Central databases: The central server contains two databases: OrgArk (originals archive) and EpiArk (epidemiological archive). For legal reasons, OrgArk contains all notifications reported to SmiNet-2 in their original form. EpiArk contains all approved notifications (clinical and laboratory) and the corresponding case records. Either the CMO or the SMI must approve a notification to create it in EpiArk, and both must approve a notification to allow further processing. In EpiArk, a notification or a case record may be modified or supplemented (with full logs of all changes made, by whom and when). The central server also has separate administrative databases, for example, for user information and system logging.

Local databases: The local county databases contain patient records, investigation records, contact tracing records and notes. The information in these databases can only be accessed by the respective CMO (and his/her authorised staff). The local databases also store relational information, for example, to link a contact tracing record to a patient record, or a note to an investigation record.

Clients: Each group of SmiNet-2 users has its own specific way of interacting with the system. The clinicians log into the reporting form at the SmiNet website (http://www.sminet.se) using their workplace's specific healthcare unit code, issued by the CMO.

A laboratory with export routines to SmiNet-2 in place in its laboratory data system creates an export file in a specified XML format, which is transferred to SmiNet-2 through a web service. If a laboratory cannot make the proper system adjustments, the notifications may be entered and sent manually using a web client.

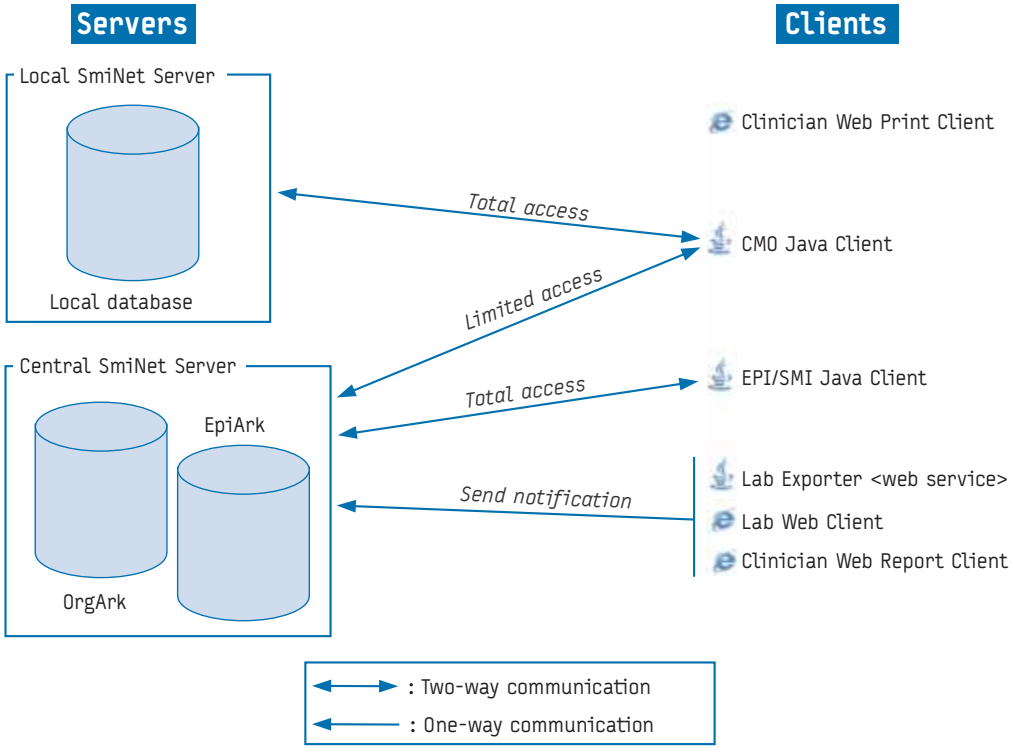
The CMOs and EPI/SMI have Java clients to communicate with the central and local servers.

Data security and safeguard of personal integrity

The two-way communications between SmiNet-2 and the Java clients of EPI/SMI and the CMOs run over a private internet

FIGURE 2

Overview of the SmiNet-2 architecture



(wide area network (WAN) with restricted access) used by the Swedish healthcare services. All other clients work over the internet, but the functionality is limited to reporting (one-way communication). Login is required for all users, and all communication between client and server is protected by a strong SSL (Secure Socket Layer) encryption (168 bit 3DES) [15].

Only authorised staff at the CMO offices and at EPI/SMI, with pre-installed Java clients, can access the central database, and authentication is required. All staff with access to SmiNet-2 work under the same strict confidentiality rules that apply for direct patient contacts within the healthcare sector. Under the Swedish Secrecy Act [16], access to any healthcare related data is restricted to staff who need this data to fulfill their duties, and it should be directly related to the purpose for which the data were collected.

Introduction of SmiNet-2

SmiNet-2 was first used in September 2004, when two pilot counties and EPI/SMI began to use the system. The final county is scheduled to enter the system by mid-2006. The two pilot counties now receive between 80% and 90 % of all notifications electronically. In its first year, SmiNet-2 received 54 980 clinical notifications (12% submitted electronically) reported by 1935 healthcare units and 32 765 laboratory notifications (78% submitted electronically) reported by 47 laboratories, which generated 58 891 case records. All case records from 1997–2005 stored in SmiNet-1 (approximately 390 000) have been migrated to SmiNet-2, and when the last county enters SmiNet-2, the old system will be closed down. Information on tuberculosis and HIV infections that have previously been stored in separate databases will also be fully integrated into SmiNet-2 during 2006.

Data output

EPI/SMI supplies web statistics on the communicable disease situation in Sweden, as tables, graphs and GIS maps for the SMI website [17].

Discussion

Other countries have implemented electronic web-based reporting mechanisms in their national surveillance, the Netherlands (Infectious Disease Surveillance Information System- ISIS) [7,18], the Republic of Ireland (Computerised Infectious Disease Reporting – CIDR) [19], and the United States (National Electronic Disease Surveillance System – NEDSS) [20,21]. In NEDSS, different states are using various computerised and web-based technologies. RODS (Real Time Outbreak and Disease Surveillance) is one of the latest technologies, and is increasingly being applied [5,22,23].

Each of these systems has its own profile and history, and any comparison between systems must take the local context into consideration. Sweden benefits from being a small country with a largely uniform organisation of health services, universal use of personal identification numbers, and a tradition of quality and comprehensiveness in reporting [9,10]. Since almost all clinicians have easy access to the internet, a general web-based reporting has been feasible, and it is anticipated that within a few years, almost all infectious disease reporting will be over the internet. In this context, some major advantages of SmiNet-2, compared to the old SmiNet-1 system and the systems in most other countries, include timeliness in the dataflow (up to national level), the full integration of clinical and laboratory notifications, and the capability to handle more than 50 diseases with tailor-made notification forms within one single system. The obvious gain in timeliness is due to direct entry of data at the source and therefore no delay in the mail process and data entry at the receiving end. We are planning a more formal evaluation in 2007, making use of the same methodology previously utilised when evaluating SmiNet-1 to more precisely quantitate this gain [9,10]. Another unique feature of SmiNet-2, to our knowledge, is that is has built-in administrative databases and tools for the daily public health work such as outbreak investigations and contact tracing.

Direct links from the patient record systems of the health centres to SmiNet-2 will be an important function and will decrease the workload of the reporting physician, increase data quality and obtain timelier data. This modification has been considered, but an obstacle has been the wide range of different patient record systems. SmiNet-2 is currently being prepared to directly import data from these systems, using the same technology as for communicating with the laboratories, but export routines in the patient record systems need to be implemented by patient record system manufacturers.

A current weakness of SmiNet-2, compared with some other web-based systems, such as the German SurvStat@RKI system [24], is limitations on the output side. The system includes a number of data retrieval tools and reporting forms for the privileged users with Java clients at the EPI/SMI and the CMO offices, and these tools will be further developed in the near future. However, for the non-privileged users, with no direct access to the system, data is presented on the SMI website in static format only. Despite a number of output options (maps, graphs and tables), there is currently no possibility of retrieving data using one's own search criteria [17]. A priority for the future is therefore to make the output functions also on the website more diverse and user friendly.

As yet, there is no alert system integrated in SmiNet-2. In order to optimise the capacity of the system to detect outbreaks and other unexpected events, data need to be timely and algorithms need to be in implemented to detect clusters of patients in time and space. To prepare SmiNet-2 for an early warning system, a study comparing three widely used algorithms have been conducted [25].

In 2005, the new European Centre for Disease Prevention and Control (ECDC) became operational [26]. One of the main tasks of the centre is to coordinate all European level surveillance activities on communicable diseases and to host the databases for this purpose [27], and the ECDC will need to evaluate closely the existing electronic surveillance networks in Europe and draw on the best practices available. The experiences from Sweden and those other countries that have recently been developing modern electronic surveillance systems will provide a good basis for this important future work.

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Author KE is former Deputy State Epidemiologist for Sweden and was working at the Department of Epidemiology, SMI (EPI/SMI), during the main part of the development phase of SmiNet-2. The SmiNet-2 system is the result of the joint work of many people, especially the staff of EPI/SMI, but also the user groups of stakeholders.

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ORIGINAL ARTICLES

Euroroundups

TRAVEL-ASSOCIATED LEGIONNAIRES' DISEASE IN EUROPE: 2004

KD Ricketts, B McNaught, CA Joseph
on behalf of the European Working Group for Legionella Infections*

Six hundred and fifty five cases of travel-associated legionnaires' disease with onset in 2004 have been reported to the EWGLINET surveillance scheme by 25 countries. A total of 84.9% of cases were diagnosed by the urinary antigen test, and 37 cultures were obtained. Thirty seven deaths were reported, giving a case fatality rate of 5.6%.

Eighty six new clusters were detected, 45% of which would not have been detected without the EWGLINET scheme. Ninety four accommodation sites were investigated and the names of four sites were published on the EWGLI website. Fifteen sites were associated with additional cases after a report was received to say that investigations and control measures had been satisfactorily carried out.

Further improvements could be made in the data collected on deaths due to travel-associated legionnaires' disease, and on the number of samples taken for culture throughout Europe.

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Key words: Europe, legionnaires' disease, travel

Introduction

In 1976, an outbreak of a pneumonic illness at a hotel in Philadelphia in the United States led to the identification and recognition of legionnaires' disease. By the late 1980s, it was clear that international collaboration would be required to facilitate exchange of information about this disease and to identify clusters of cases associated with individual accommodation sites. The European Working Group for Legionella Infections (EWGLI) was formed in 1986 and, in 1987, EWGLI established a surveillance scheme for travel-associated legionnaires' disease (EWGLINET) that aims to track all cases of the disease in European travellers. When a cluster of cases is suspected to be associated with an accommodation site, EWGLINET initiates and monitors immediate control measures and investigations at the site, and ensures that international standards are adhered to. The history and current activities of EWGLI are described further on its website (http://www.ewgli.org).

The number of cases reported to national surveillance schemes across Europe has been increasing. In 2004, 4588 cases were recorded in 35 countries [1] (including hospital-acquired and community-acquired cases, as well as travel-associated cases), compared with only 242 in 1993 from 19 countries. This increase in numbers can be attributed to an increasing awareness of the disease, a rise in the number of contributing countries, and strengthening of national and international surveillance systems. Of the total cases recorded in 2004, 396 (8.6%) died.

This paper provides results and commentary on cases of travel-associated legionnaires' disease with onset in 2004 reported to EWGLINET.

Methods

The addition of Andorra during 2004 brought the number of collaborators participating in EWGLINET to 59, representing 51 collaborating centres in 37 countries [FIGURE 1] which report all travel-associated cases fulfilling EWGLI's case definitions and detected by their national surveillance systems to the European database. Some countries host more than one collaborating centre. Collaborators are encouraged to report cases in people who travel within their own countries as well as those who travel abroad, and an increasing number are doing so.

Standard case definitions have been agreed by the collaborating countries in EWGLINET and are used for the purposes of international surveillance. A single case is defined as a person who, in the two to

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