9. Gierczynski R, Szych J, Cieslik A, Rastawiki W, and Jagielski M. The occurrence of the first two CTX-M-3 and TEM-1 producing isolates of *Salmonella enterica* serovar Oranienburg in Poland. Int J Antimicrob Agents. 2003;21(5): 497-9

10. Mulvey M R, Soule G, Boyd D, Demczuk W, Ahmed R, and the Multi-provincial *Salmonella Typhimurium* Case Control Study Group. Characterization of the First Extended-Spectrum Beta- Lactamase- Producing Salmonella Isolate Identified in Canada. J Clin Microbiol. 2003; 41(1): 460-2.

11. Baraniak A, Fiett J, Hryniewicz W, Nordmann P, and Gniadkowski M. Ceftazidime-hydrolysing CTX-M-15 extended-spectrum ß-lactamase (ESBL) in Poland. J Antimicrob Chemother. 2002;50(3):393-6.

12. Arlet G, Rouveau M, and Philippon A. Substitution of alanine for aspartate as position 179 in the SHV-6 extended-spectrum beta-lactamase. FEMS Microbiol Lett. 1997;152(1):163-7.

ORIGINAL ARTICLES

Surveillance report

SURVNET@RKI – A MULTISTATE ELECTRONIC REPORTING SYSTEM FOR COMMUNICABLE DISEASES

D Faensen, H Claus, J Benzler, A Ammon, T Pfoch, T Breuer, G Krause*

In 2001 Germany implemented a new electronic reporting system for surveillance of notifiable infectious diseases (Surv*N*et@RKI). The system is currently being used in all 431 local health departments (LHD), the 16 state health departments (SHD) and the Robert Koch-Institut (RKI), the national agency for infectious disease epidemiology. The Surv*N*et@RKI software is written in MS Access 97 and Visual Basic and it supports MS Access as well as MS SQL Server database management systems as a back-end. The database is designed as a distributed, dynamic database for 73 reporting categories with more than 600 fields and about 7000 predefined entry values. An integrated version management system documents deletion, undeletion, completion and correction of cases at any time and entry level and allows reproduction of previously conducted queries. Integrated algorithms and help functions support data quality and the application of case definitions. RKI makes the system available to all LHDs and SHDs free of charge. RKI receives an average of 300 000 case reports and 6240 outbreak reports per year through this system. A public web-based query interface, Surv*S*tat@RKI, assures extensive and timely publication of the data. During the 5 years that Surv*N*et@RKI has been running in all LHDs and SHDs in Germany it has coped well with a complex federal structure which makes this system particularly attractive to multinational surveillance networks. The system is currently being migrated to Microsoft C#/.NET and transport formats in XML. Based on our experiences, we provide recommendations for the design and implementation of national or international electronic surveillance systems.

Euro Surveill 2006;11(4): 100-3 Published online April 2006
Keywords: disease notification, electronic reporting, infectious diseases, surveillance

Introduction

In January 2001 a new law for the prevention and control of infectious diseases (*Infektionsschutzgesetz*, IfSG) was enacted in Germany. This has resulted in a modernisation of the national surveillance system for notifiable infectious diseases. In order to assure information flow between local, state and federal institutions we developed a new electronic reporting system (Surv*N*et@RKI) as the technical backbone of the new surveillance system. While various evaluations of the German surveillance system have already been published elsewhere [1-4], this report intends to present and critically discuss the technical aspects of the software and database architecture for electronic data transfer within the surveillance system.

* Robert Koch-Institut, Berlin, Germany

The objective of this paper is to present technical solutions developed in Germany which could be applicable in surveillance systems of other countries or international networks.

Methods

Background and requirements

Germany is a federal republic with 16 states (*Bundesländer*) and 439 counties (*Stadt-/Landkreise*). Typically, there is one local health department (LHD) per county, responsible for managing single cases and outbreaks of infectious diseases and carrying out necessary prevention and control activities. The IfSG defines 47 pathogens and 14 diseases that laboratories and clinicians, respectively, have to notify to the local health department. LHD complete and verify the case information based on national case definitions. These cases are then transmitted on a single case basis to the state health departments (SHD) and from there to the Robert Koch-Institut (RKI), the central national agency for infectious disease epidemiology. A requirement analysis revealed the need for an electronic reporting system with the following functional and non-functional features:

The system capacity needed to be sufficient for over 300 000 reported cases per year with 25 to 60 variables per case entered by 431 LHDs throughout the country. The system needed to take issues of data security of privacy-related patient data as well as specific additional requirements of individual states into account. For economic reasons the software had to run on common hardware without the need for additional software licenses and expensive back-end systems. As permanent internet connection was not available in all LHDs, the system needed to be operable offline as well. The system should incorporate reporting of complex outbreaks and be flexible enough to adapt quickly to unexpected changes caused by new emerging diseases (e.g., SARS).

In July 2000 the two legislative houses of representatives in Germany (*Bundestag* and *Bundesrat*) ratified the IfSG to be enacted by 1 January 2001. Within 6 months the RKI developed the electronic reporting system for the national surveillance system.

Software design

The architecture of the system was designed inhouse at the RKI. However, a major part of the programming was done by an external IT company. The newly developed system was called Surv*N*et@RKI.

The data flow is depicted in the figure. The front-end of Surv*N*et@RKI is written in MS Access 97 and Visual Basic. Depending on the data volume it supports MS Access as well as MS SQL Server database management systems as a back-end. Adding or removing reporting categories, fields or allowed values do not require changes to the programme structure, which is based on the fractal© concept of

picoware GmbH. Surv*Net*@RKI allows the reproduction of previously conducted queries and analyses by means of an integrated version management system: Any updates of a data record (case or outbreak) result in the creation of a complete new record in the database that is marked as valid beginning at the time when the record was created. The old record's validity period ends at that time. As shown above the data replication is organised by the transmission of transport files in a format specified by the RKI. The transmission format is text-based and allows the representation of complex data with possibly multiple nominations of a field. Online help functions provide additional information for the user (for example, the disease-specific case definition). Integrated algorithms that follow the national case definitions assure that case records are exported only if the case confirmation criteria are met.

Deletion is integrated into in the transport process by activation of a marker which makes retrieval of previously deleted records possible.

Data base design and management

The database is designed as a dynamic, relational database that currently consists of 73 reporting categories with more than 600 fields and about 7000 predefined entry values in look-up fields. All criteria formulated in the national case definitions are integrated into the data entry forms in order to facilitate application of and compliance with case definitions [5].

Furthermore, each record representing a case of an infectious disease can belong to one or more groups of cases representing an outbreak. The version management described above is also applied to outbreak records.

Results

Software design

The RKI provided the commercial software manufacturers with the final technical specifications for electronic case reporting in October 2000 and released its own software programme, Surv*Net*@RKI, in December 2000, free of charge. The new system was implemented nationwide on 1 January 2001. Within a few weeks, almost all LHDs were reporting at least weekly through the new system [2]. All state health departments use Surv*Net*@RKI. Among the 431 LHDs in 2005, 112 (26%) use Surv*Net*@RKI while 319 (74%) use one of five different commercially available software programmes for public health administration which include a case reporting module based on the specifications published by RKI. Public health nurses at the LHD enter the data into the reporting software and complete the records according to findings of subsequent investigations. When outbreaks occur, the LHD (or the SHD or the RKI) creates an electronic outbreak record, which groups the affected case reports and holds additional data regarding the outbreak, such as modes of transmission and evidence for this information. At least once a week each LHD creates a transport file containing all changes since the last export. Those data are automatically extracted by the system. Any information subject to data privacy remains physically in the database of the LHD. The transport file is sent via email to the SHD, where the data is imported into Surv*Net*@RKI, which in turn generates a confirmation file that is sent back to the LHD, also via email. In all SHD and in those LHD that use Surv*Net*@RKI changes and additions in field definitions and database structure are usually executed within one month after publication of the new specifications. New versions of Surv*Net*@RKI are fully downward compatible, which ensures that data generated by older software versions can still be imported and handled.

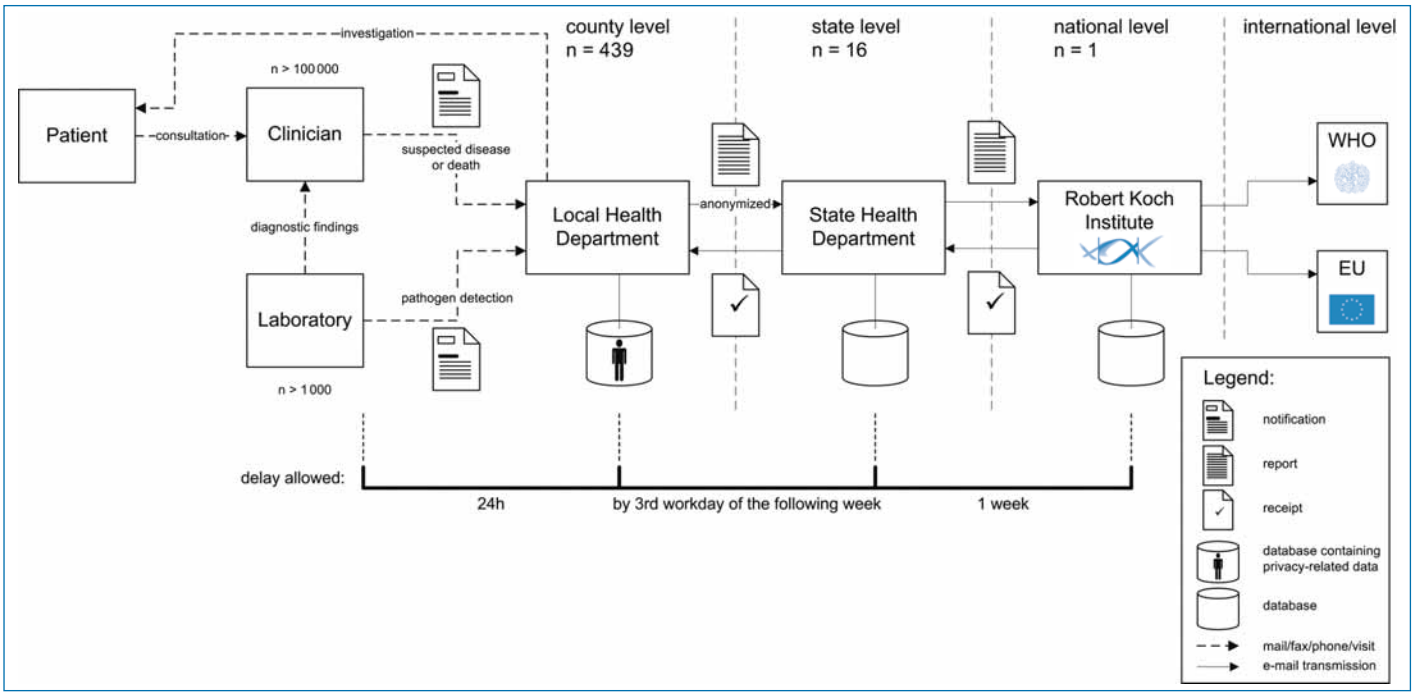
Data base design and management

The RKI receives an average of 300 000 reported cases per year. Thirty six per cent of the case reports are completed or corrected during the investigation process and are therefore transmitted in two or more different versions, which are all retrievable in the database. This results in a total of 490 000 datasets sent to the RKI each year. Based on the complex record versioning system, datasets are never frozen at any given deadline but can be continuously corrected, completed, deleted and undeleted if necessary. Historical case counts can therefore be performed for any state of knowledge in the past, which facilitates the generation of epidemiological reports and comparison of data.

Eight per cent of the fields in Surv*Net*@RKI, such as reporting week and year, are mandatory fields, and must be filled in ore the record cannot be saved. About 10% of the fields undergo an integrated plausibility algorithm (for example, the order of the timestamps for date of birth, onset of illness and date of diagnosis). This will generate error messages when data has not been entered or is in conflict with entries in other fields. Case reports of disease with a yearly incidence of approximately less than 1 case per 100 000 population undergo a manual quality control procedure at the RKI before they are released for publication;

Figure

Data flow in the German computerized reporting system



these cases made up 0.89% of the mean number of yearly reports (n= 1 212 482) from 2001-2004. Most data quality indicators have improved significantly over the past four years, but show variations depending on the state where the data is generated and the kind of software used to enter and manage the data at the LHD [2,4,6].

Development effort

The estimated cost for the development of the initial software prototype adds up to one year full time equivalent (FTE) for an IT scientist, one year full time equivalent for a medical epidemiologist and EURO 50 000 worth of external programming work. Furthermore, an estimated amount of 1 FTE for an IT scientist and 0.5 FTE medical epidemiologist in addition to EURO 60 000 for programming done externally been invested each year for maintenance and further improvement of the system. This comes to a total of approximately EURO 170 000 for the initial development, plus EURO 150 000 per year for improvements and maintenance. It does not include the actual epidemiological work for data quality control, system evaluation, scientific interpretation of the data, and the training of external users of the system.

Data release and publication

The national surveillance data collected at RKI are published periodically [6] or whenever required by RKI staff or external scientists. In order to improve data quality, implausibilities are fed back to the SHD, and are forwarded from there to the appropriate LHD requesting validation or correction. SurvStat@RKI, a web-based query interface, allows interested users to perform analyses on the national data [7]. Each spring following the reporting year, RKI releases an annual epidemiological report of over 170 pages. Germany contributes more case reports than any other country to the European Basic Surveillance Network, which is facilitated by the ability of Surv*Net*@RKI to automatically translate the German raw data to the European data formats [8]. RKI also reports surveillance data electronically to the World Health Organization and to various dedicated surveillance networks of the EU.

Outbreaks detected

Interlinked with the reported individual cases, RKI receives an average of 6240 outbreak reports per year, which generally have been primarily identified and investigated by the LHD. On average, 2047 (33%) of these outbreaks have five or more cases [9]. In addition to assessing outbreaks detected at the LHD level, Surv*Net*@RKI has also been able to report outbreaks and clusters that were not identifiable at the SHD or LHD level because of their rather diffuse geographical distribution. Examples for such outbreaks are an outbreak of *Salmonella* Agona from contaminated aniseed [10], an international outbreak of *Salmonella* Oranienburg due to German chocolate [11] and a large outbreak of hepatitis A among German tourists returning from a hotel in Egypt [12].

In 2003 Surv*Net*@RKI has also been adopted for internal use in the German Armed Forces, contributing to a better information exchange between civil and military health departments as shown in a large outbreak of epidemic conjunctivitis [13].

Discussion

Surv*Net*@RKI has proved to be a powerful reporting system for cases and outbreaks of notifiable infectious diseases.

Many national surveillance systems rely on or are moving towards electronic reporting systems (such as NEDSS in the United States [14], CIDR in Ireland [15], and SMINet in Sweden [16]). In comparison to these systems Surv*Net*@RKI provides some features of database and communication architecture that make the system particularly useful for surveillance networks of multiple states or countries and for environments in which requirements of data security and limitations to data sharing usually create major obstacles.

Surv*Net*@RKI addresses theses challenges by using a physically distributed database characterised by a highly standardised core database and variable branch subsets. Another remarkable, and to our knowledge unique, feature is the tight integration of case reporting and outbreak reporting.

During the five years that the system has been running in all Germany's LHDs and SHDs, it has coped well with a complex federal structure, which generally complicates or even impedes efficient information exchange between administrative levels.

We believe a key to the success of Surv*Net*@RKI was the very strong cooperation of epidemiologists from LHDs, SHDs and RKI, the in-house IT staff and the external company. The costs have been kept low.

However, we also experienced difficulties in implementing necessary changes rapidly throughout the country, particularly because manufacturers of commercial software at the LHD level took a long time to implement the changes, and in some cases were unable to implement the specifications at all. This puts LHDs who use such software programmes at a significant disadvantage, because the majority of the system changes aim to reduce the workload at the LHD level and to avoid data entry errors.

The use of MS Access 97 with Visual Basic programming proved to be an effective basis for finalising a stable prototype within a very short time. However, now after approximately five years of experience, recurring changes and amendments have resulted in a complexity of the system that is becoming hard to maintain with the current platform. For similar projects we recommend the use of professional development environments, object-oriented approaches, and data exchange technologies that are better at supporting team development, code reuse and change management.

We are currently migrating Surv*Net*@RKI to a new platform that better meets those requirements. It will be re-implemented in Microsoft C#/.NET. The former transport file format specification will be replaced by an XML schema. This allows, for instance, the manufacturers of third-party products to test their export files against the specification eliminating a frequent error source. The user interface will be multilingual.

In the framework of a federal government initiative (BundOnline 2005) to foster e-government solutions, we intend to develop an interface for the most commonly used laboratory software systems in order to enable laboratories to report automatically in electronic format to the respective LHDs.

Recommendations

Based on our findings and experience in designing and implementing Surv*Net*@RKI, we have come up with the following recommendations for future developments of multistate electronic reporting systems:

- Adhere to the best practices in software engineering. We recommend following an agile development process to keep costs low. Staff the team with both IT specialists and epidemiologists.
- The number of fields per case needs to be kept to a minimum. In contrast to the general tendency to expand the amount of data, revisions of the system should always aim to reduce complexity of the database. The more experience available on the quality of the incoming data and on its actual contribution to epidemiological conclusions, the easier it will be to keep the database simple.
- Drop-down menus presenting the choice of data field entries need to be formulated in clear, concise language that can be understood without advanced medical knowledge.
- Transport and interface formats should be based on XML.
- Software development should not be completely outsourced from the institution that will be in charge of the system. First, the epidemiological expertise needs to be included into the process from the beginning on, which is more efficiently done if the software design is done inhouse as well. Second, maintenance and improvement of the system requires inhouse IT expertise, otherwise sustainability is at risk or may become costly.
- Cooperation with multiple peripheral software manufacturers

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.

References

1. Krause G, Ropers G, Stark K. Notifiable disease surveillance and practicing physicians. Emerg Infect Dis. 2005;11(3):442-5.
2. Krause G, Altmann D, Claus H et al. Erste Bilanz des neuen Systems zur Überwachung meldepflichtiger Krankheiten nach dem Infektionsschutzgesetz [First evaluation of the surveillance systems of notifiable diseases under the infectious disease control law in Germany]. Gesundheitswesen. 2003; 65 Suppl 1:S8-12.
3. Krause G, Benzler J, Porten K, Buchholz U, Claus H, Ammon A. SARS-Surveillance - Wurde sie den Anforderungen an die Surveillance neu auftretender Infektionskrankheiten gerecht? [SARS Surveillance - Did it meet the demands made on the surveillance of new infectious diseases?]. Gesundheitswesen. 2003; 65(12):715-8.
4. Brodhun B, Kramer MH, Krause G. Befragung der Gesundheitsämter zur Umsetzung des Meldewesens nach dem Infektionsschutzgesetz [Survey among local health departments concerning the implementation of the new infectious disease reporting system]. Bundesgesundheitsbl - Gesundheitsforsch - Gesundheitsschutz. 2004; 47(8):755-761.
5. Benzler J, Krause G, Mitarbeiter der Abt.für Infektionsepidemiologie. Zur Ausgabe 2004 der Falldefinitionen für die Surveillance meldepflichtiger Infektionskrankheiten in Deutschland. Bundesgesundheitsbl - Gesundheitsforsch - Gesundheitsschutz. 2004; 47:141-6.
6. RKI. Infektionsepidemiologisches Jahrbuch meldepflichtiger Krankheiten für 2004. Berlin: Robert-Koch-Institut, 2005.
7. Faensen D, Krause G. SurvStat@RKI - a web-based solution to query surveillance data in Germany. Euro Surveill. 2004; 8(22):5-7. http://www.eurosurveillance.org/ew/2004/040527.asp#4
8. Ternhag A, Tegnell A, Lesko B, Skaerlund K, Penttinen P. Basic Surveillance Network, a European database for surveillance data on infectious diseases. Euro Surveill. 2004;9(7):19-22. http://www.eurosurveillance.org/em/v09n07/0907-221.asp
9. Krause G, Benzler J, Faensen D, Claus H. Electronic outbreak reporting system for outbreaks of foodborne infections in Germany [abstract]. 5th World Congress Foodborne Infections and Intoxications, 7-11 June 2004, Berlin, Germany.
10. Koch J, Schrauder A, Alpers K et al. Salmonella agona outbreak from contaminated aniseed, Germany. Emerg Infect Dis. 2005;11(7):1124-7.
11. Werber D, Dreesman J, Feil F et al. International outbreak of Salmonella Oranienburg due to German chocolate. BMC Infect Dis. 2005;5(1):7.
12. Frank C, Walter J, Muehlen M et al. Large outbreak of hepatitis A in tourists staying at a hotel in Hurghada, Egypt, 2004 – orange juice implicated. Euro Surveill. 2005;10(4),135-7. http://www.eurosurveillance.org/ew/2005/050609.asp#2
13. Wölfel R, Pfeffer M, Dobler G, Finke EJ. Virologische Untersuchung der Keratokonjunktivitis Epidemica. Wehrmedizin und Wehrpharmazie. 2004; 2:36-41.
14. National Electronic Disease Surveillance System (NEDSS): a standards-based approach to connect public health and clinical medicine. J Public Health Manag Pract. 2001;7(6):43-50.
15. National Disease Surveillance Centre. Computerised Infectious Disease Reporting (CIDR). http://www.ndsc.ie/WorkingGroups/NDSCWorkingGroups/ComputerisedInfectiousDiseaseReportingCIDR/ 2005.
16. Jansson A, Arneborn M, Ekdahl K. Sensitivity of the Swedish statutory surveillance system for communicable diseases 1998-2002, assessed by the capture-recapture method. Epidemiol Infect 2005;133(3):401-407.

ORIGINAL ARTICLES

Surveillance report

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

P Rolfhamre[1,4], A Jansson[2], M Arneborn[1], K Ekdahl[2,3,4]

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.

1. Department of Epidemiology, Swedish Institute for Infectious Disease Control (SMI), Solna, Sweden
2. Department of Medical Epidemiology and Biostatistics, Karolinska Institute, Stockholm, Sweden
3. European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden.
4. Stockholm Group for Epidemic Modelling (S-GEM), Stockholm, Sweden.

Euro Surveill 2006;11(5): 103-7 Published online May 2006

Keywords: epidemiology, communicable diseases, infectious diseases, surveillance