Key Technical Issues in

Developing and Implementing

TB E-R&R System

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WHO Expert Group for TB Electronic Recording and Reporting
Why computerization?

- Revised forms with increased analysis and reporting requirements;
- Under-utilization of existing data to improve TB control and epidemiological research;
- Requirement for closer integration with other diseases, such as HIV/AIDS, and integrated epidemiological analysis;
- Requirement to improve efficiency and control through better utilization of modern information and communication technologies.
Plan to develop or find a TB-specific computer application?
Key questions

- What data should be computerized?
- Where to computerize?
- Patient level (case-based) or aggregated data?
- Stand-alone vs. client-server or web application and key features of the application?
- How should data be transferred from lower levels to higher levels in the NTP?
- Which computer hardware (e.g. desktop PCs, handheld computers) and software (packaged vs custom-developed)?
- Technical development, implementation and maintenance options, including in-house vs commercial or open-source development?
Outline

• Benefits of e-R&R?
• Elements of e-R&R?
• Key considerations:
  – To choose the different elements of e-R&R
  – To implement the system
• Checklist
• Resources
Electronic Medical Record

Efficiency saving
(e.g. reducing hospital lengths-of-stay, nurses administrative time, drug usage in hospitals, and drug and radiology usage in the outpatient setting)

- Safety benefit
(e.g. reducing adverse drug events in in and outpatient settings)
- Health benefits
(e.g. disease prevention measures and chronic disease Management)

Net Potential Savings (Efficiency Benefits Over Adoption Costs) For Hospital And Physician Electronic Medical Record (EMR) Systems Adoption During A Fifteen-Year Adoption Period (2004–2018)

<table>
<thead>
<tr>
<th>Dollars</th>
<th>Cumulative inpatient</th>
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<th>Yearly inpatient</th>
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<td>350</td>
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SOURCE: F. Gitani et al., Extrapolating Evidence of Health Information Technology Savings and Costs (Santa Monica, Calif.: RAND, 2009), sec. 4.2.3.
TB electronic recording and reporting system

• Use of IT technology:
  – to facilitate the transfer of information needed for public health from clinical information systems in the health care industry;
  – to reduce provider burden in the provision of information;
  – to enhance both the timeliness and quality of information provided.
Potential benefits of e-R&R

• Assists and improves the efficiency of integration, aggregation, analysis and reporting,

• **To Share across** multiple sites and integrate with other patient and disease management systems

• Handles much **larger volumes of data** than paper-based systems

• Improves the **completeness and accuracy** of data

• Easier to **duplicate and safeguard** against natural catastrophes such as fires and floods.
Potential benefits of e-R&R

- Easier to **feed back** down the TB programme and, in some cases, may also be used as a basic patient and treatment record system with appropriate facility-level reports.

- Significantly **speed up the data reporting process** and result in more rapid response times.

- Strong role to play in enhancing the evidence based planning process.

- Using digital data **enhances human resources capacity** both in surveillance (mainly data management and analysis), and in computer skills.
Electronic vs. paper reporting in Netherlands

Median central delay for nine notifiable conditions by conventional (2001) and electronic (2003) reporting, The Netherlands

Results

- Electronic reports were received at the national level significantly quicker than conventional reports.
- Electronic reports contained more complete information; noted improvement in data quality.
- An estimated 50% reductions in administrative workload in relation to reporting infectious diseases.
Electronic vs. paper reporting in USA

Figure. Laboratory-Based Reports Received for 5 Notifiable Conditions by Reporting System, July 1–December 31, 1998

Results

• Electronic reporting more than **doubled the total number of** laboratory-based reports received.

• On average, the electronic reports were **more timely and more complete**, suggesting that electronic reporting may ultimately facilitate more rapid and comprehensive institution of disease control measures.
Elements of e-R&R system

• Data and information flow
• Application software\(^1\)
  – user interface
  – database
• Hardware
• Application architecture\(^2\)
• Training
• Technical support
• Other

1 Application software is a program or group of programs designed for end users.
2 Application architecture is the relation of the hardware, software and network components to one another
Data and information flow

Ask
1. If and how can the data flow in the existing paper-based system be optimized?
2. What should be computerized, i.e. the individual patient data or aggregated reports?
3. Where should the computer be introduced? i.e. facility level, BMUs, …

Do
1. A critical analysis of the data flow in the paper-based system.
2. A careful assessment of the available hardware, software, infrastructure and human resource capacity at the each level of data flow.
3. Based on 1 and 2 (above), answer the questions 1-3 in the left side.

Fundamental design decisions
understanding at what level data will be compiled electronically and whether the primary data will be used for uses other than TB Control programme reporting and needs to be shared with other systems and for patient management.
whether any existing applications exist that sufficiently match the core process such that they could be considered for implementation instead of developing a new system.
Generic NTP Data Integration, Aggregation and Reporting Process
Hardware

- Desktop Computers
- Handheld Computers (PDAs)
- Mobile (Cellular) Telephones
- Paper Scanning and Optical Character Recognition
- Tablet PC and Touch Screen Computers

Fundamental design decisions

The choice of hardware is driven mainly by data and information flow considerations, environmental considerations (eg clean power, technical support, local expertise etc), software application and network connectivity requirements and cost considerations.
Application software

Custom Software Development

- **Re-using of the existing application software**
  - A review of existing applications and implementation (TB catalogue)
  - Commercial and / or free and open source applications that can be implemented and/or configured

- **Developing an application software (de novo)**
  - an initial requirements definition and specification process followed by a Request for Proposals (RFP) and contract of work.
  - make use of a packaged relational database management system (RDBMS) as well as open source medical data capture applications, such as OpenMRS
  - Make sure that the standards are followed HL7 that can be useful for interfacing with other health information systems and XML (Extensible Markup Language) that is useful as a common standard for specifying the structure of data.

**Fundamental design decisions**

- the build-or-buy decision and consequently, the data process adjustments to be made or the procurement and development strategy to be followed.

- in the case of custom software development, the vendor or consultant to be appointed, the project management process and any standards that will be followed.
"Musts" in TB-specific application software?

- Obviously, easy data entry and data extraction

Plus

- NTP data manager (not programmer) should be able to
  - Change the reporting units and their grouping
  - Add new variables and set-up the data entry screen.
  - Generate new reports.
  - Produce or modify checking rules.
Re-using of the existing application software or developing from scratch

Balance

the inevitable compromises that will need to be made in adjusting part of the data and information management process to an existing software application and cost of the customization

against

factors such as the inherent risk of failure and potential slippage in time and cost in developing custom software to more closely match a particular process.
<table>
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<th>Year</th>
<th>Description</th>
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| 1994-6 | Denis Coulombier (CDC Atlanta) creates Electronic TB Register (ETR) and CDC Botusa Project (Botswana) implements it in Botswana (20-some users at midlevel borrow TB Register books on a quarterly basis to enter data on individual patients).  
1994-6 | CDC and WHO HQ (various persons including Tony Burton) create and implement IFA (Information for Action), an EpiInfo-based tool for managing aggregated data in national immunization programmes (i.e., disease and coverage data for various vaccine preventable diseases). This programme is subsequently adopted in all SEAR countries and also in several EMR countries and in China (site of earliest development) but is not adopted widely (at all?) in AFR or AMR.  
1997-8 | Ian Smith (WHO Nepal) sees IFA demonstrated, and engages Ros Walley (Int'l Nepal Fellowship) to make a TB equivalent to IFA (i.e., an EpiInfo application to manage TB quarterly reports, i.e., aggregated data). Called EpiCentre (acronym revolves around "National Tb Reporting"). Implemented in Western Province of Nepal (under INF support) and at central TB office during the 1990s.  
1997-99 | Peter Feenstra (WHO Ethiopia) engages Eric Brenner (North Carolina Dept Health) to design a software tool to manage TB quarterly reports, also in EpiInfo. Development stalls amidst admin changes in national programme and in WHO country office.  
1997-99 | KTB under development (like ETR, but more complicated: all culture results, Xrays, etc). History of implementation not followed. Closer to a patient management system than a TB register (tool for TB managers to monitor).  
1998   | A "software" meeting is held in WHO Geneva to discuss software. EpiCentre and ETR are revealed to unknowing respective parties. Some participants suggest writing guidelines or standards for software (standard methodology to making software, recommended field names, universal file structure, etc), while others suggest merging EpiCentre and ETR into one software tool.  
1999-2000 | The Botusa Project expands to include a team of 2 FT staff who offer customization and implementation of ETR in southern African countries. Visits made to several countries. South Africa implements in two provinces.  
1999-2000 | WHO TME supports SEAR in implementing EpiCentre. All SEAR countries involved in two week training, followed by country visits to help in implementation. Training and visits carried out by Ros Walley (eventually WHO Nepal) and Avijit Choudhury (WHO SEAR).  
2001-2002 | An ETR project review in 2001 reveals that few countries involved have implemented ETR or sustained its implementation. Peter Vranken (CDC) working with Denis, revamp some aspects of the tool, including outputs as HTML. South Africa expands use, and Tanzania starts using, plus Lesotho and perhaps other countries. |
<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>2001-2002</td>
<td>Ros Walley leaves WHO. Avijit Choudhury becomes involved almost exclusively in WHO India data management (manging NTP data via EpiCentre). Indian version of EpiCentre improved by export feature, additional menus.</td>
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<tr>
<td>2002</td>
<td>Jan van den Holmberg (WHO Ethiopia) revives project with Eric Brenner, naming it TULIP (TB &amp; Leprosy Pgm). Eric improves look of output by sending it to WordPad. Some features specific to Ethiopia added (search for duplicate reports). Meanwhile, the &quot;content&quot; of the Ethiopian R&amp;R system continues to evolve, and computerization is deferred.</td>
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<td>2001</td>
<td>Holger Sawert develops an Access database with Thai TB data. Discussed with Thai NTP but not used. Some doubt about computerizing reports versus TB registers.</td>
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<td>2001-2</td>
<td>Dan Bleed, working with Ros Walley, writes draft of &quot;FAQ re recording and reporting&quot;. Includes section on advice about computerization (addressing the 1998 recommendations to some extent). Document not well received by very few reviewers, probably based primarily on the &quot;sticky&quot; issues discussed in the R&amp;R content; no reactions to the computer-related discussion per se.</td>
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<td>2003-2004</td>
<td>ETR use in South Africa expands to most provinces, amidst many programmatic and bureaucratic changes. MRC review project with CDC, suggest alternatives to ETR. Discussion in CDC about making ETR into an EpiInfo Windows version, but progress on this issue not well followed.</td>
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<td>2003-2004</td>
<td>EpiCentre very successful in India. EpiMap component dropped in favor of ArcView. In Nepal, project revived by Christian Gutenberg (WHO Nepal) with plans to use a revised version (based on Indian version) nationwide in 2005. No other SEAR countries using EpiCentre. Avijit more free to devote time to regional issues (not just India).</td>
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<tr>
<td>2003</td>
<td>WHO EMR discussed software with TME. Interested in supporting computerized registers. Plans to promote Excel tool based on that used successfully in Syria.</td>
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<td>2003</td>
<td>December visit to Myanmar by Dan Bleed (WHO TME) to discuss data needs in relation to a tool being developed in Access for management of TB quarterly reports (called simply TB prototype database). Development continues during 2004.</td>
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<tr>
<td>2003-4</td>
<td>Amidst discussions of the need to evaluate impact of GDF contributions, PPM projects, and the performance of various partners sometimes involved in TB control within a given country (e.g., Bangladesh), and also amidst increasing evidence (in annual reports to WHO) that NTP managers cannot easily prepare their data stratified by DOTS versus non-DOTS, it would seem that the ability to group data by various strata would be important in a software tool.</td>
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<td>2004</td>
<td>Meetings in Geneva seal plans to revise the case-finding form and the treatment outcome form recommended for use in national programmes. This implies that NTP will eventually migrate their recording and reporting systems to comply (e.g., dividing case types by age instead of sex; listing outcomes for each re-treatment case type).</td>
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<tr>
<td>2004</td>
<td>WHO Ethiopia hires local programmer to make further revisions of TULIP, and a training session is held in fall of 2004 for the 12-15 zone's data staff who will use it.</td>
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<tr>
<td>2004</td>
<td>Thailand said to have developed a software tool in Access, called TB Light, that is similar to EpiCentre and ready to use. Some WHO SEAR staff have seen it demonstrated. But not discussed at a recent regional epi training workshop.</td>
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Customizable TB software
without need for a computer programmer

**ENRS/EMRO** [Microsoft Excel]; case-based;
developed by Syria packaged by WHO/EMRO; adopted in Egypt., Jordan, Sudan.

**STAR** [Microsoft Access] developed by WHO/HQ, in the course of pilot testing in Myanmar and Bangladesh.
Customizable TB software
with need for a computer programmer

• ETR (case-based) developed by CDC

• TBnet (web-based) developed by South Korea, adopted by China.

• Epicenter (DOS) – aggregated, developed in India, windows version is under development.

• More?
**Excel spreadsheets**

The **most common software** which is used at the NTP offices, but in most cases in not the most efficient way

<table>
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<th>Pros.</th>
<th>Cons.</th>
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<tr>
<td>Easy to set up and implement</td>
<td>Low security level despite of password protection feature.</td>
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<tr>
<td>Simple to use</td>
<td>In IT world it is not considered as a powerful integrated database.</td>
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<tr>
<td>Widely available (licence issue)</td>
<td>The limitation of 65 000 rows per sheet.</td>
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<tr>
<td>Many people know Excel to some extent and feel comfortable to use it</td>
<td>Re-grouping, contextual checking and trends analysis can be difficult</td>
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<td></td>
<td>Adding/modifying variables and reporting units can be tricky</td>
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whether to develop/implement a standalone or client-server model
whether to implement local or central database and data management and which product(s) to use at different levels in the system.
Training

• Training data management and data capture staff is critical for the success of the system.

• The data entry and caseload burden must not exceed the capacity of the available staff.

• Data management staff need to understand how to enter data, manage data, export data, make backups and run existing reports.

• TB coordinators need to understand the data and information flow and receive training on integrating data, running existing reports and, potentially, developing *ad hoc* reports.

Fundamental design decisions

the training plan to be followed and the strategy for ongoing skills development.
Technical support

• Technical support is a critical requirement for computerized e-R&R systems

• the level at which technical support can be provided will be an important determinant of the level at which electronic data capture is implemented and the system architecture that is decided.

• In general, the closer to primary data capture that the e-R&R system is implemented, the more stringent is the requirement for technical support.

Fundamental design decisions

the technical support that will be provided and the plan for providing support and attending to support issues.
Confidentiality, privacy and security

• Confidentiality and security of patient data is critically important and electronic TB recording and reporting applications

• at the (sub-) district level need to be capable of protecting data from unauthorized access by securing access to the computer, password protection of the database and/or data encryption.

• Even where the database contains only anonymized and/or aggregated data it is good practice to ensure the security and restrict access to this application and database as well.

• For standalone systems, data needs to be transported in a secure format and, for web-based systems, data needs to be transmitted securely. It is common to require data management personnel to sign confidentiality agreements and to receive training on standard operating procedures to ensure data confidentiality.

Fundamental design decisions

the data confidentiality and access control strategy(ies) to be implemented and the standard operating procedures to ensure that these are implemented correctly.
Data quality assurance

• Data quality is a critical requirement and requires both a well-functioning system and constant attention.

• It is often useful to implement routine checks against the paper forms to estimate the level of error in data compilation.

Data backup

• Adequate data backup and disaster recovery systems need to be in place to prevent loss of data.

• In the case of paper record systems, archives should be protected from fire and water hazards and, in the case, of electronic record systems, archives should be kept in more than one place.

• The configuration of the data backup and recovery system will depend to a large extent on the software and hardware implementation selections. One of the advantages of some client server implementations is that responsibility for data backup is centralized and the burden of responsibility for local data backup is reduced.

• Backup system should be tested regularly to ensure that they are working properly.
Cost?

Data flow in the German computerized reporting system

Legend:
- notification
- report
- receipt
- database containing privacy-related data
- database
- mail/fax/phone/visit
- e-mail transmission
The estimated cost for the development of the initial software prototype, Germany

- 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.

For maintenance and further improvement of the system

- 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.

**Total:** This comes to a total of approximately EURO 170 000 for the initial development, plus EURO 150 000 per year for improvements and maintenance.

Note:
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.
Where to computerize?

– Computers and infrastructure (e.g. security, clean power) to implement and maintain a computerized system;

– Computer skills and access to technical support and training (although this could be an opportunity for positive skills development);

– Effective data management and backup systems to protect data;

– Adequate communication systems to fully exploit electronic data interchange, although this can be reduced by system architectures such as web-based.
Case-based vs. aggregated

Case-based is the ideal solution ONLY the infrastructure and human resource are or will be available and sufficient.
Patient data available at national level

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement. © WHO 2005. All rights reserved
Stand-alone vs. web-based

Ideal solution is web-based systems, but ONLY where the internet connection is available and sustainable at the level of computerization.
How to transfer data?

Depends on software architecture, one or a combination of different means can be used.

Web environment in web-based systems and email in stand-alone.
Conclusions

1. National TB database is a MUST.

2. National database that receives data electronically from the provincial centres is feasible and recommended in most countries.

3. Before adopting or development a new TB-specific software make sure that the minimum features are incorporated in the database.
Welcome to the WHO TB e-R&R portal, a site dedicated to sharing knowledge about electronic recording and reporting (e-R&R). We invite you to view a catalogue of e-R&R software currently in use in several countries. A technical analysis for those interested in implementing an electronic system is in preparation.

What is e-R&R? Computerized implementations of TB Recording and Reporting registers and quarterly reports. In other words, entering data into some kind of computer which generates various analyses or reports.

- **TB SOFTWARE CATALOGUE**
  - Please view a more detailed catalogue of the IT solutions

- **COUNTRY SURVEYS**
  - (in preparation)

- **EXPERT GROUP MEETINGS**

- **DOCUMENTS**
  - Revised TB recording and reporting forms and registers - version 2006
    - English [doc.2.28Mb]
    - English [pdf.1.53Mb]
  - Formulaires et registres d'enregistrement et de notification des cas de tuberculose
    - Français [doc.2.40Mb]
    - Français [pdf.1.51Mb]
  - Field testing survey and lessons learnt on the shift to a revised TB...
Key Technical Issues in Developing and Implementing Electronic Recording and Reporting Systems for TB Programmes
Thank you
**Epi-Centre**

*Used by:* India  
*Developed by:* WHO/SEARO

*Case based:* no  
*Aggregated:* yes

*Runs online:* no  
*Runs offline:* yes  
*Requires installation on user’s computer:* yes

*Technology:* DOS version based on EpiInfo (moving to Windows).

**Kenya PDA System**

*Used by:* Kenya  
*Developed by:* 

*Case based:* yes  
*Aggregated:* no

*Runs online:* no  
*Runs offline:* yes  
*Requires installation on user’s computer:* yes

*Technology:* Handheld PDA with Microsoft Visual CE.
TBnet
Korean TB Surveillance System (KTBS)

Used by: Korea, Japan, China (planned)
Developed by: Korean Institute of Tuberculosis

Website: http://tbnet.cdc.go.kr/ktbs/

Case based: yes
Aggregated: no

Runs online: yes
Runs offline: no
Requires installation on user’s computer: no

Technology: Web application in ASP.

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STAR
Software Tool for Analysis and Reporting

Used by: Myanmar (pilot), Bangladesh (pilot)
Developed by: WHO HQ

Case based: no
Aggregated: yes

Runs online: no
Runs offline: yes
Requires installation on user’s computer: yes

Technology: Access database frontend and backend.
ETR.NET
Electronic TB Register DotNet

Used by: South Africa (in use), Botswana, Mozambique, Tanzania (in progress)
Developed by: CDC South Africa

Case based: yes
Aggregated: no

Runs online: no
Runs offline: yes
Requires installation on user's computer: yes

Technology: Dotnet WinForms (C#) with Access database or SQL backend.
TBNet is an Internet-based web application for TB surveillance implemented in Korea by the Korean Institute of Tuberculosis (KITA) in July 2000. The application comprises desktop PCs connected through an Internet-based virtual private network (VPN) and a firewall to a central server. The peripheral PCs require Windows 98, or later, and the central server requires Windows 2000, or later. Security is maintained through personal user and passwords. The application was developed to provide more timely estimates of prevalence and to improve case notification by the private sector. The data collection system comprises a TB Reporter and Primary Checker at the peripheral level, a Data Rechecker at the intermediate level and supervision by doctors and nurses. Basic data comprises demographic characteristics, treatment history, BCG vaccination, results of examination for diagnosis, ICD of Tuberculosis, case definition and treatment outcomes (for the public sector, only). From the website, it is possible to perform basic analyses and generate tables and graphs (incidence and cohort) and simple geographic information system (GIS) analysis. The main limitations of the system are related to the accuracy of the data (missing or illogical data and poor computer skills of operators) and the lack of completeness of the system (incomplete notification by the private sector and incomplete surveillance coverage). The data accuracy issue is being addressed by implementing quality control procedures and training. The completeness issue is being addressed by improving the convenience of the system (1-page form) and through information dissemination and promoting the system.

Structure and Information Flow

TB notification forms are entered in the internet-based system directly at facilities level (both public and private sectors) to make up a national database. When data cannot be entered directly in the internet-based system, they are collected through medical association and entered within the 7 days after reporting. Data are checked twice, at peripheral and intermediate level, for confidentiality, personnel is required.
Downloads

**ETR.NET**
Electronic TB Register DotNet

- **Used by:** South Africa (in use), Botswana, Mozambique, Tanzania (in progress)
- **Developed by:** CDC South Africa
- **Case based:** yes
- **Aggregated:** no
- **Runs online:** no
- **Runs offline:** yes
- **Requires installation on user’s computer:** yes
- **Technology:** Dotnet WinForms (C#) with Access database or SQL backend

**Downloads**

- [Presentation of ETR.NET.pdf](https://www.who.int/tb/err) (1.33 Mb)

[www.who.int/tb/err](https://www.who.int/tb/err)
Thank you

Send content updates, feedback and requests to contact product owners to:

TBrecordingreporting@who.int

Portal Homepage:

www.who.int/tb/err
Thank you