

***Three Interlinked
Electronic Registers
(TIER.Net)
Project***

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TIER.Net (formally known as the HIV Electronic Register or eRegister)

Background

Due to scale-up of antiretroviral therapy in high HIV burden countries, many treatment sites are no longer able to cope with the monitoring of large cohorts of patients with paper based systems only. However, these same sites do not all have the necessary infrastructure and resources to implement full electronic medical record (EMR) systems. This realization has led to the articulation of a 3-tier approach to monitoring which includes a paper-based system making up tier 1, an electronic version of the paper register as the middle tier or tier 2, and full electronic medical record software at the 3rd tier.

The 3-tier approach allows the departments or ministries of health to strategically implement one of the three tiers in each of their facilities offering ART services. The choice of tier is based on context and resources at the time of implementation, however as resources become available and infrastructure improves, more and more facilities will transition to the next tier. The three tiers need to complement each other in order to easily facilitate such movements between tiers. It is considered a flexible solution, as any one health region could be running one or a combination of the three tiers at any given time. The 3 systems all produce the same monthly and quarterly reports needed for long-term routine monitoring of people on ART. Aggregating these reports from the 3 different tiers results in a single dataset of essential elements and indicators needed for monitoring the programme and providing feedback to districts, sub-districts and facilities. One of the major benefits of the middle tier is that well maintained paper registers can be rapidly digitized for later export into EMR systems, whereas back capturing from original paper records is a major burden for mature sites implementing EMR systems for the first time.

The 3-tiered approach provides a relatively quick and inexpensive way to evolve towards electronic solutions. Another example of a middle tier system already working in 8 countries is ETR.Net which is an electronic register for patients receiving treatment for tuberculosis. It is easy to see that this approach would also provide huge benefits in health services such as maternal & child health (MCH) in developing countries as well, where longitudinal outcome data is necessary but rolling out EMR software to all facilities offering these services would be too expensive and resource intensive. It is in this context that UCT, in discussions with collaborators from the WHO, CDC, MSF and South African government departments, extended the vision for TIER.Net to a single electronic register software implementation covering all three priority programmes (HIV, TB, MCH). This could support the interlinked paper-based tools for these programmes which have already been well proposed.¹ The expanded project is termed Three Interlinked Electronic Register (TIER) project.

The TIER.Net software application

The University of Cape Town's (UCT) Centre for Infectious Diseases, Epidemiology and Research (CIDER) have been involved since 2003 in collaboration with government in developing and

¹ *Three Interlinked Patient Monitoring Systems for HIV care/ART, MCH/PMTCT and TB/HIV: Standardized Minimum Data Set and Illustrative Tools*. Geneva: WHO; May 2009. Available from: http://www.who.int/hiv/pub/imaj/pmq_form_booklet_090907.pdf [accessed on 16 October 2010].

supporting both paper-based cohort monitoring systems for ART,^{2,3} and EMR-type systems for use in large sites.⁴ The monthly and cohort reports from paper registers and reports from the EMR system have always been the same and have been aggregated at a Provincial level in the Western Cape Province of South Africa. It became apparent with time however that even in this relatively well resourced province, and with the continued pace of scale-up, the infrastructure, connectivity, support and human resource challenges were such that it was not possible to transition all mature sites straight from the paper-based registers to the EMR system. The Centre at UCT was also supporting projects in other provinces and countries where full EMR systems are unlikely to be feasible in the medium term.

The TIER.Net software has been built to easily and effectively capture the minimum data elements and resulting indicators (ascertained by systems based on the WHO paper registers) required to monitor the HIV and ART services. Monthly and quarterly reports are generated by a 'push of the button' as are encrypted back-ups and dispatches for transferring of data to higher levels of management such as sub-districts, districts and provinces. A standardized format for exchange of data between other software and TIER.Net has been implemented, allowing for an easy migration solution from this middle tier to EMR software, based on a modified version of the HICDEP format⁵ as implemented by the leDEA Southern African cohort collaboration.⁶ In instances where the majority of sites are on the electronic register and a minority on EMR systems, TIER.Net can also import data in this format from EMR systems (provided they export in the same format) to enable all available electronic patient data to be in the TIER.Net database.

TIER.Net has been successfully piloted in 5 sites over a nine month period and has since been fully implemented in another 8 sites during the third quarter of 2010 (with an additional 10 sites in various stages of implementation). The software is currently operational in sites that have anywhere from 100 patients to 3400 patients started on ART. The major bottle necks to implementation seem to revolve around operational or structural issues such as staff not being in place, space and security issues, moving services to newly constructed areas within clinics and procurement of equipment. Benefits seem to be more accurate reporting of monthly retention, easily extracted reports, defaulter lists than can be passed onto community treatment supporters as well as enthusiastic staff who are benefitting from individual capacity development.

² Boulle A, Bock P, Osler M, Cohen K, Channing L, Hildebrand K, Mothibi E, Zweigenthal V, Slingers N, Cloete K, Abdullah F. Antiretroviral Therapy and early Mortality in South Africa. *Bull World Health Organ.* 2008;86(9):p678-87.

³ Patient monitoring guidelines for HIV care and antiretroviral therapy (ART). Geneva: WHO; 2006. Available from: <http://www.who.int/3by5/capacity/ptmonguidelinesfinalv1.PDF> [accessed on 16 October 2007].

⁴ Boulle A, Van Custem G, Hilderbrand K, Cragg C, Abrahams M, Mathee S, Ford N, Knight L, Osler M, Myers J, Goemaere E, Coetzee D, Maartens G. Seven-year experience of a primary care antiretroviral treatment programme in Khayelitsha, South Africa. *AIDS.* 2010 Feb 20;24(4)563-72

⁵ HICDEP; HIV Cohorts Data Exchange Protocol. Copenhagen: CHIP – Copenhagen HIV Programme. 2008. Available from: http://www.cphiv.dk/Portals/_default/pdf_folder/HICDEP.pdf [accessed on 22 October 2010]

⁶ Cornell M, Technau K, Fairall L, Wood R, Moultrie H, et al. Monitoring the South African National Antiretroviral Treatment Programme, 2003 - 2007: the leDEA Southern Africa collaboration. *South African Medical Journal.* 2009;99:653–660.

Current Features of the TIER.Net

The main features of TIER.Net currently include:

- A consolidated HIV record with pre-ART and ART centric views
- INH, Cotrimoxazole and TB symptoms and treatment elements
- Monthly and quarterly cohort reports
- Data Exchange Standard (DES) exports
- Encrypted dispatch files for transfer of patient level data to higher levels of health
- Multiple user profiles for confidentiality and security
- Easily installed and updated software

The Software

TIER.Net is a stand-alone system based on a VB.Net front-end and a Microsoft Access or SQL Server backend. The MS Access database is embedded within the application, therefore it is not necessary to procure and install MS Access in order to use the software. If using SQL Server as the backend, SQL Server Express can be installed. No software licenses are specifically required to run the application, and the application is provided free of charge by the University of Cape Town who have paid for and guided its development. Limited computer experience is required for a person to effectively use this software application; however as in any monitoring system routine support is required to ensure high quality entry of data and in order to maximize the benefits of such software.

The Developers

A software development company (WAMTech) has been retained to do the development of the TIER.Net software in collaboration with UCT. WAMTech are the developers of the National Electronic Tuberculosis Register (ETR.Net) used in South Africa and several other countries. WAMTech comes with tremendous credibility having built the most successful example of a national disease-specific patient information system in South Africa. WAMTech have also facilitated the use of ETR.Net in other countries, translating the software into different languages and implementing elements specific to each countries, while retaining a single source code base. The TIER.Net has benefited from their wealth of experience in building disease-register software and many components have been re-used between the systems.

Capturing Data

The user-interface was built for direct capture from paper-registers to manage the burden of back-capturing at sites that have been offering ART services for many years. Therefore, a person does not have to retrieve or re-file folders in order to capture the ART patient records into this electronic software.

1. Back log
 - a. If paper registers are in use and up to date, 150 patients can easily be back-captured per full day by one data capturer (750 patients per week, or 2-3 minutes per mature patient)
 - b. If the paper registers are so incomplete that they cannot be used for back-capture, it takes about 8-10 minutes to back-capture a mature patient from standardized patient clinical records and most likely double to triple that time if capturing from free-text hand-written clinical notes.

2. Real time (same day) data capturing

- a. The experience from the pilot and implementation and subsequent roll out of TIER.Net is that a single data capturer can reasonably capture 100 patient visits a day in prospective mode working 3 hours a day (at busier clinics with 2 data capturers, both tend to help during the morning with front reception duties, retrieving folders and filing laboratory results – in the afternoon one continues with filing and the second captures data)

Implementation model

A separate *Implementers Guide to TIER.Net* has been developed and has more detailed suggestions for rolling out TIER.Net within a single facility. This guide is appended.

A. The fast track sub-district/rural district (SD/RD) roll out model:

Implementing a second tier such as an eRegister will require additional resources but can be done relatively quickly if one adopts a workshop style implementation plan. If logistics, time or money don't allow, bullets number 3 and 4 can be skipped or addressed at a later date.

Staff needed

Implementation team: 1 Implementer

2 SWAT team members

Facility level:

1 dedicated data capturer at each site (at minimum, if >1000 patients or if the data capturer has other responsibilities than an additional data capturer would be required).

1. Invite all staff from a SD/RD to a buy-in and introduction training meeting
2. Plan one to a few days to do site assessments at all clinics within SD/RD (it should be possible to do five per day but depends on distance between sites)
3. Plan a one day clinical record keeping workshop for the whole SD/RD (for pharmacists, nurses, and doctors – once the team knows what is needing to be captured the documentation by staff is usually more complete and neater)

Roll out in stages, using a 'SWAT' team to capture back log and bring the sites up to date for M&E (roll out to two sites at once, leaving one SWAT team member at each site, each with their own laptop connected to the sites computer via a cross-over network cable or other local networking solution). During back-log capture, the SWAT team member should be training the data capturer and closely monitoring their progress with the software (note: the back-log could be captured in a workshop setting if there was a central space available with enough extension cords and table space and, all data capturers could bring their computers and up to date registers with them for a multi-day workshop, instead of SWAT teams going to sites).

4. Once all sites in SD/RD are caught up with back-log, hold another training session for data capturers/ programme managers and facility managers on how to use TIER.Net to better manage their site (attendance of clinical meetings by data capturers and their responsibility in those meetings should be discussed at this training session)

B. Fully operational SD/RD

Once a SD/RD is fully operational (all ART services are using one of the three tiers), the provincial SD/RD staff should take over (with continued supervision and support from implementer for up to six months).

Staff needed

Facility level: data capturer/s

SD/RD level: 1 dedicated HIV/TB/PMTCT Information Officer
(training, validation, analysis, feedback)

District level: 1 information officer to analyse and feedback to sub-districts

Provincial level: 1 M&E Coordinator to tackle operational challenges, improve policy, train trainers
1 information officer to analyse data and feedback

Hardware needed

- A computer (PC or Laptop)
 - In larger sites (>1500 patients) two computers can be connected via a cross-over network cable or other local networking solution, with one computer acting as the master database. This way multiple people can capture data at one time if necessary.
- A memory stick or re-writable CDs to back-up data
 - we usually recommend the data to be backed-up daily onto the memory stick and for the memory stick or CD to be locked in the facility manager's office
- Access to a laser printer
 - To print reports in order to fax or courier them to the next higher level of management

When to choose a paper-based system, an eRegister or an EMR system (the 3 tiers)

There are several factors that contribute to making this decision including the size of the clinic, the resources available and the infrastructure in the region.

- A paper-based system will most likely always be in use at some clinics in a developing country. Paper-based systems are immediate and easy to use at small and even medium sized sites. A new service should not be held up while awaiting procurement of hardware and training on a software system. Sites with unreliable or no electricity will necessitate paper-based register systems.
- The move to an eRegister will be based on the availability of hardware for the system and the ability to quickly replace a stolen or broken computer. From our experience, facilities with less than 700 patients can still easily maintain a paper register and extract cohort reports. However, as ART is for life, even small facilities may benefit from a middle tier system after a few years of ART provision, as paper registers become dirty, torn and difficult to manage.

- The decision to move to an EMR system is multi-factorial but should at the very least be dependent on the following:
 - Infrastructure available to hold and sustain EMR systems (robust networks with quick response times when networks go down, enough available bandwidth to support an additional EMR software package, an IT help desk for end-user questions and support)
 - the equity of clinics in need of electronic systems - if wanting to digitalize a national health programme, middle tier solutions are less expensive, more rapid to roll out and require less routine support and training. It is arguably more valuable to scale-up patient registration systems in primary care that can share a unique identifier than to invest a large amount of resources in online EMR systems, given that ART will in future be provided in an increasing proportion of facilities. At least when sharing an identifier, data can be easily linked and merged across systems that are not reliant on constant connectivity.
 - If a facility is supported by academic institutions, research affiliates, or NGO partners who are willing to contribute the extra resources needed to support and sustain an EMR system, these sites should be encouraged to do so. Tier 3 systems with closely interrogated and monitored data are important to at a national level in order to answer clinical and sometimes operational questions which cannot be answered via routine monitoring systems. These tier 3 systems should only be recommended if they meet the basic requirements and standards as stipulated by a geographically based health authority (for example, software which in future is free for use by the government, the ability of the software to produce accurate nationally required reports and the ability to export and import data using a nationally stipulated standardized data exchange format).

In short, there is likely to always be a mix of system across tiers, and the focus should be on achieving scale and balance rather than a one-size fits all solution. There is likely to be an evolution over time in the proportion of sites that are using electronic monitoring systems (Figure 1).

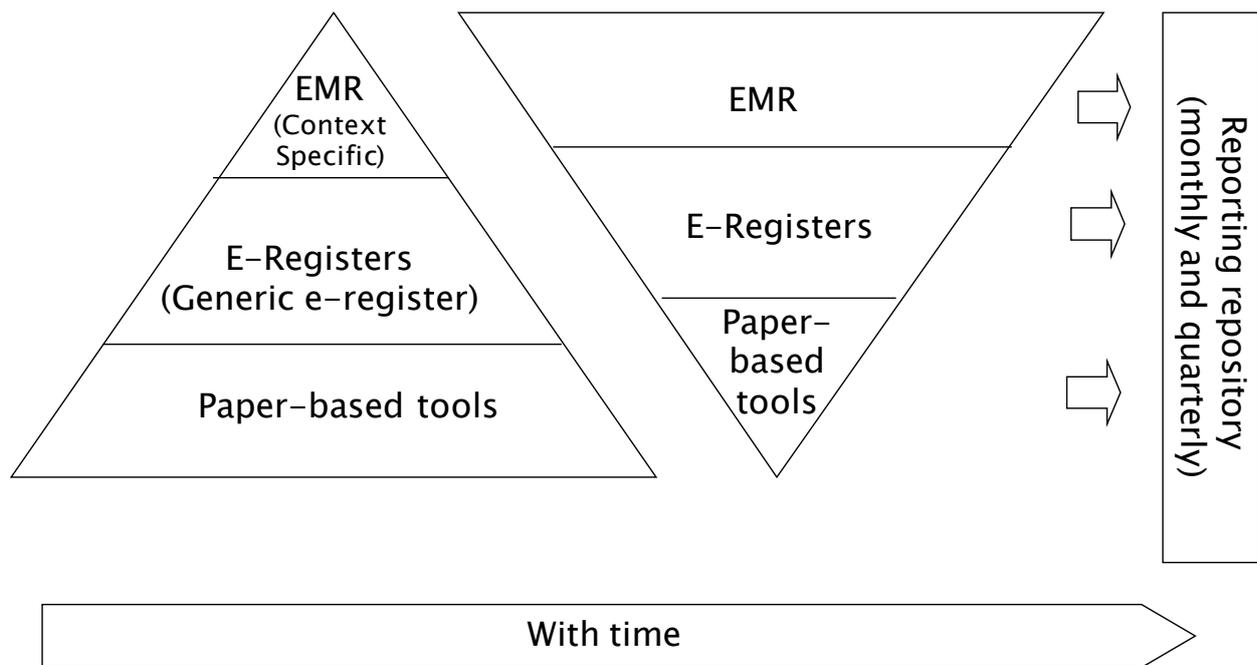


Figure 1: Evolution from paper systems to full EMRs

Costs of implementing each of the three tiers

Costs of implementation will be highly variable depending on the cost of each level of staff and hardware costs within the country. However, a comparison of costs based on the South African experience may be useful.

- The basics - All sites need the standardized patient clinical records, data capturers, and M&E support staff at the different levels of health.
- Tier 1 – the paper based system in addition to the above basics needs a paper register for adults and one for children per year.
- Tier 2 – TIER.Net in addition to the basics requires a computer, a memory stick and a laser printer (which can be shared across the site). The region will also probably need a support person to procure and liaise with the company providing maintenance on the equipment via warranty. The cost of the above hardware, including a PC with a 3 year warranty, was USD 2,500 in 2008.
- Tier 3 – the EMR systems in addition to the basics requires at least 3 computers (one in pharmacy, one in reception and one for capturing data), two label printers (one for reception and one for medication labels), three scanners (for scanning bar codes), a laser printer, local networking infrastructure, and, if working with a central server, data lines. The region would also require a help desk team to trouble shoot computer and software related questions, a network health and maintenance team and to maximize benefits, a central audit team for data quality assurance. The data capturing staff needed at the site also increases slightly due to the extra variables being collected. The hardware costs alone, without considering the cabling to the sites, was just under \$10,000 in 2008.

Migration solution

TIER.Net has been built for easy capture straight from a WHO recommended paper register, making the digitalization of the HIV/ART service less daunting when considering capturing a back-log of patient data. In addition, in large clinics that have the additional resources to launch an EMR system, TIER.Net can be used as a stepping stone. Using TIER.Net to back-capture patient data is far simpler and less time consuming in comparison to capturing from patient folders. Once a clinic's back-log is fully captured, these clinics can take advantage of the standardized data exchange (DES) template used in TIER.Net to import the data straight into an EMR system. Although some data that the EMR is capable of capturing will be missing (eg. opportunistic infections), the minimum data required for standard reporting will be transferred, and the extended data elements can then be prospectively captured.

What will the future eRegister look like?

TIER.Net, in the near future, will be able to capture both TB and MCH information along with the already available HIV/ART application. The patient demographics and important information such as CD4 tests dates and results will be shared across all modules without a data capturer needing to re-enter for each service. As MCH and TB services are for a defined period, TIER.Net could sit at the facility for direct entry or at sub-district level with carbonated copies sent routinely to the sub-district office for capture (as is currently happening with the TB programme in South Africa). Over time, as more sites have access to computers, more direct entry of data will occur, allowing the rollout of this middle tier to happen as slowly or quickly as the context and resources allow.

The following development priorities have been set:

TIER Phase II

- Merging of the TB module into TIER.Net
 - TB Registrations
 - Smear Results
 - Culture Results
 - DST Results
 - Standard national TB reports
- Standard installation to offer MS Access or SQL Server as the back-end database

TIER Phase III

- Developing an MCH module for TIER.Net
 - Antenatal VCT and PMTCT register
 - Labour and Delivery PMTCT register
 - HIV-exposed Infant Register

TIER Phase IV

- Introduction of hybrid technology to allow for bi-directional synchronization with a central repository where appropriate network infrastructure is available