Systematic Review of eCRVS and mCRVS Interventions in Low and Middle Income Countries

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
APAI-CRVS	Africa Programme on Accelerated Improvement of CRVS
BIRDS	Birth and death registration system
BRIS	Birth registration information system
CAPMAS	Central Agency for Public Mobilization and Statistics
CDC	Centers for Disease Control and Prevention
COD	Cause(s) of death
CoIA	Commission of Information Accountability for Women's and Children's Health
CPR	Central Person Registry
CR	civil registration
CRO	civil registry office
CRS	civil registration system
CRVS	civil registration and vital statistics
CS	civil status
CSB	Citizen Service Bureau
eBDM	electronic birth death and marriage
eCRVS	electronic computer technologies for CRVS
eIMMR	electronic Indoor Morbidity and Mortality Reporting system
ERP	enterprise resource planning
HDSS	Health and Demographic Surveillance System
HIS	health information system(s)
HISP	Health Information Systems Programme
HMIS	health management information system(s)
HMN	Health Metrics Network
HRS	Household Registration System
ICD	International Classification of Diseases
ICT	information and communication technology
ID	identification number
INSTAT	Institute of Statistics
IS	information system(s)
IT	information technology
ITU	International Telecommunication Union
MBR	mobile birth registration
MCD	Municipal Corporation of Delhi
mCRVS	mobile phone technologies for CRVS
MCTS	Mother and Child Tracking System

MDR	maternal death review
MOVE IT	monitoring of vital events using information technology
MVG-Net	Millennium Villages Global Network
MVP	Millennium Village Project
NCR	National Civil Register
NDG	Nokia data gathering
NORAD	Norwegian Agency for Development Cooperation
NRHM	National Rural Health Mission
OLIR	online institutional registration
SAISE	State Automated Information System "Elections"
SRS	Sample Registration System
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
VA	verbal autopsy
VS	vital statistics
WHO	World Health Organization

SECTION 1. **BACKGROUND**

1.1 DESCRIPTION OF THE PROBLEM

The problem addressed in this systematic review is concerned with the broad domain of information systems (IS) for Civil Registration and Vital Statistics (CRVS), and how they have been influenced, or have the potential to be influenced, by information and communication technology (ICT)-based interventions. Civil Registration (CR) is defined by the United Nations as the universal, continuous, permanent and compulsory recording of vital events provided through decree or regulation in accordance with the legal requirements of each country *(1)*. Vital Statistics (VS) represents the statistical output of a well-functioning CR system *(2)*. CR includes births, deaths, marriage, divorce, fetal death, annulment, judicial separation, adoption, and through the registration process these events are made legitimate. The focus of this report is on births and deaths, their registration and generation of VS.

There are three broad parameters which define the scope of this study. One, we define ICT interventions as those based primarily on computer or mobile technologies, called **eCRVS** and **mCRVS** interventions respectively. Two, while CRVS includes systems for births, deaths, marriages, divorces and other events, in this review, the focus of this report is primarily on births and deaths. Three, the focus is primarily on low and middle income countries to study these interventions.

In the context of low and middle income countries, CRVS systems have traditionally been weak, in terms of both coverage and quality of data. This weakness has led to CRVS systems being described as a "scandal of invisibility" *(1)* adversely affecting both systems of mortality and more broadly of poverty reduction. It is further argued by Setel et al. *(1)* that various affordable remedies potentially exist for addressing the identified challenges, and these need to be urgently implemented. Amongst these identified remedies, are technology-based interventions for developing alternative registration systems and sources of data for vital events and causes of death (COD). As a result, globally, there have been various technology-based interventions that have been initiated seeking to strengthen CRVS systems. As an example, the Health Metrics Network (HMN) has initiated in 2008, a number of pilot projects under the framework of MOVE IT (Monitoring of Vital Events using Information Technology) to test the efficacy of strengthening CRVS using IT.

The problem addressed in this review is to specifically understand the potential and its materialization practically of applying eCRVS and mCRVS initiatives to strengthen CRVS

systems. This leads to understanding examples of innovations, what characterizes them as innovations, and the potential they have for being scaled from pilot to national systems, and further across countries.

1.2 DESCRIPTION OF THE INTERVENTION

eCRVS and **mCRVS** represent technology-based interventions seeking to improve the quality and coverage of CRVS systems. In understanding the scope of what eCRVS or mCRVS covers, two dimensions are important – technology and the domain of application. With respect to technology, the "e" refers broadly to electronic computer-based applications, but extended to also include digitization and scanning technologies. The "m" refers to mobile phone-based interventions. The distinction between eCRVS and mCRVS is important to understand, as the latter is a much more recent phenomenon, and thus our knowledge and experience in this domain are relatively limited compared with eCRVS. Often, eCRVS and mCRVS are spoken of in the same breath under the umbrella of "ICT-based systems". While computerization of CRVS has been around for years, even in the context of low and middle income countries, what is new today is how systems are becoming increasingly interlinked with databases that are able to speak to each other, for example in Albania where the population register and CR databases are linked. Such interlinking was not technically possible in the time of stand-alone systems. The possibility of server-based deployment and interlinking of databases also then allows national databases to connect with registration offices in districts and sub-districts, creating the technical ability for the sub-national offices to register and issue certificates. Furthermore, health institutions recording births can now potentially transmit the name-based records pertaining to a birth or a death electronically to the civil registry offices to register the event.

Mobile technology further brings in new possibilities in terms of extending the geographical and temporal access to databases, and enabling events taking place in remote areas to directly communicate with databases located elsewhere. The possibilities that are being created through these technologies and their interlinking represent not merely a simple automation of a paper-based birth or death registration system, but potentially a radical transformation of the business processes of how births and deaths registration takes place. Harnessing the potential of these technologies will also require the legal processes to be redefined, for example to enable the acceptance of SMS-based notifications of a birth or a death-related event.

Concerning the domain of application, this review is primarily focused on understanding the use of technology in how births and deaths are recorded, notified to the relevant authorities, registered, and then compiled and consolidated into VS. For analytical purposes, it is important to distinguish between technology applications in births and deaths, as they arguably have different levels of complexity from the perspective of applicability of technology. A significant

proportion of all new initiatives of technology in the CRVS domain, especially those involving the application of mobile technology, are almost entirely in relation to births. It is also important to deal with causes of death separately because techniques such as verbal autopsy (VA) which lend themselves to ICT solutions are not primarily about death registration and issuance of death certificates but about generating information on COD.

There are various other systems and processes that relate to of birth and death registration, COD systems including for VA, national population registers, identification systems, sample registration surveys, demographic surveys and various others. While these all shape the birth and death registration systems in direct and indirect ways, for the purposes of focus, we emphasize only those interventions seen as being directly linked to CRVS. To the extent, these other systems can usefully inform issues around birth and death registration systems, we have considered them for the analysis. For example, the Universal Identification system currently being implemented in India is currently not directly linked to the CRVS system. However, the system is interesting to look at because of the use of technological innovations such as related to biometrics and de-duplication algorithms. These can potentially be useful also for strengthening CRVS.

Another important dimension to assess the efficacy of technology interventions in the CRVS domain relates to the issue of scale. For the government to make every citizen count, or every mother and child count, as the Commission on Information Accountability for Women's and Children's Health mandates, the need is for the technology to help the CRVS systems to achieve full coverage. This requires systems to be scalable both geographically and functionally. Geographical scaling implies full coverage of the whole population. Functional scaling in our context would involve the ability of the CRVS system to be able to speak to other associated systems. For example, VA systems collecting COD information should be able to speak to the CR system dealing with death registration. This involves a functional scaling of the CR system by its ability to expand its scope through linking with other databases. In a majority of the cases studied, technology-based interventions in the CRVS domain have been applied in pilot or small-scale settings, and focused towards one aspect of the system, such as birth notification without considering how that speaks to other components like the registration system. Typically, interventions tend to be focused on one or more of these three areas: (a) at the point of occurrence of the event (of birth or death); (b) at the point of creation of the legal document (birth or death certificate); and (c) at the point of consolidation of the VS. Two broad kinds of challenges can be seen to characterize these interventions. One, these interventions focus on a limited component of the overall CRVS system, and are thus arguably limited to bring in systemic improvements. Two, these interventions by design are focused towards pilot efforts and not to the larger scale of national systems. The scaling challenge gets further magnified, because the pilot initiatives are donor funded and not state owned, and tend to wither away once external donor attention and funds are withdrawn. These design and implementation limitations are reflective of challenges faced in information systems and

health information systems more broadly, leading to a crisis of sustainability and scalability of systems *(3)*.

While trying to understand the potential of technology to strengthen the CRVS domain, it is important to place the technology within the broader sociopolitical–legal multisectoral context within which the CRVS application unfolds. History shows that we tend to adopt a technological deterministic approach, assuming that technology can be posited as the silver bullet that can solve particular developmental challenges *(4)*. While acknowledging the tremendous potential that new technologies like the mobile phone provide to the domain of CRVS *(5)*, putting it within the framework of the businesses processes, other technological systems in operation, and broader context is essential. IS research, for example *(6)*, has historically and emphatically argued for the fundamental need for sensitivity to context and a sociotechnical form of thinking to design and implementation, as contrasted to a technology deterministic approach.

In summary, some key dimensions along which the intervention will be analysed will include the following.

- The type of technology, while acknowledging that mobile-based interventions are a new kind of intervention as compared to computer-based efforts, and thus far little is known about if they work or not in practical settings.
- The differences in the processes of birth and death registration, where the latter is inherently more complex because of the difficulties in generating COD information.
- The ability of computers to speak to each other, and to link with mobile phones which enhance the reach of access, technology creates a potential that far transcends mere automation of systems, but a more radical transformation. This ability is also a function of adherence to a multiplicity of global standards (e.g. the International Classification of Diseases (ICD) for COD, unique IDs for individuals and facilities to include registries, data transmission (XML, SDMX, etc.)
- Scale – geographical and functional – is an important consideration to understand the value of technology, and the challenges in achieving it.

Our intervention, in the form of a "systematic review" *(7)* will systematically analyse the evidence published relating to examples of eCRVS and mCRVS interventions applied broadly in the context of low and middle income countries, keeping the above analytical dimensions in mind. This analysis would help to identify examples of innovative interventions, and how and why they may demonstrate the potential to be scaled to national and global levels.

1.3 HOW THE INTERVENTION MIGHT WORK

eCRVS and **mCRVS** interventions undoubtedly carry the potential to enable innovations in the CRVS domain, and in breaking the inertia and stagnation that has characterized CRVS systems for over 30 years *(1)*. However, while the potential for innovations undoubtedly may be enabled by technology, materializing this potential requires a sensitive embedding to the sociotechnical–legal context. Furthermore, interventions by design need to be well directed to addressing the problem at hand, not just representing an effort of trying out a technology for the sake of the technology, for them to be successful *(8)*.

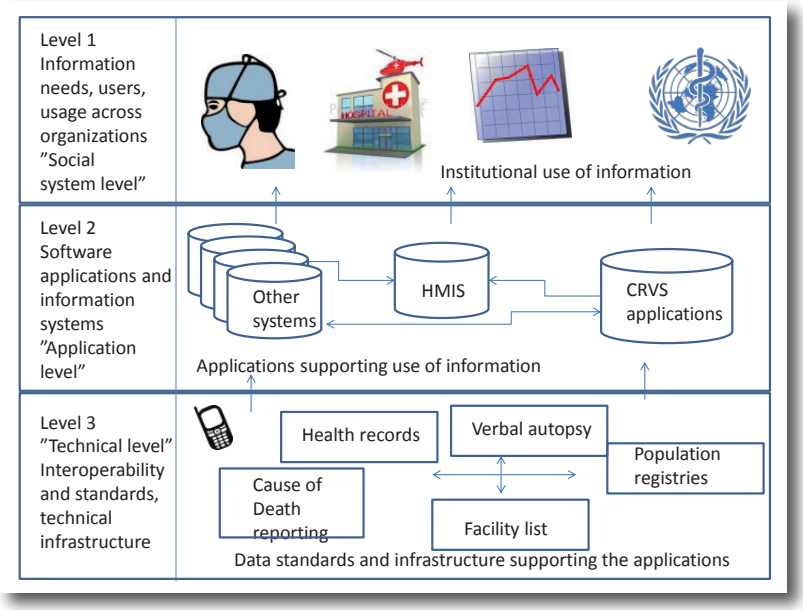
A systems approach has been long advocated for understanding design, implementation and use issues around IS *(9)*. A system, very simply, represents a set of interacting parts, which involves a set of inputs, throughputs which help to convert the input to desired outputs, and the process of feedback which goes into redefining inputs and throughputs to improve the outputs. Within the CRVS domain, conceptualized as a system, we can conceptualize various relevant sub-systems, such as those related to birth registration, death registration, VA, identification systems, population registers, and many others. There are various data sources that the CRVS systems deal with, such as births, child mortality, adult mortality, COD, and each of them may provide different affordances for the use of ICTs and for different functions of data registering, storing, integrating, transmitting and use. In strengthening the overall CRVS system, it is important to develop a perspective of a "system of systems" emphasizing how the different systems "speak" to each other. For example, there may exist a strong VA system for the identification of COD, but if it does not link with the system for death registration, it will not contribute to strengthen the overall CRVS system. This linkage across systems is not just a mere matter of technical connecting, but involves the coming together of social, political and legal conditions, which are by definition more complex to connect as they involve people and institutions that are historically and institutionally embedded. For example, we could use mobile phones to notify the event of a birth from a remote area to the district office. However, if the district registration office will only issue a birth certificate based on a signature or a thumbprint, this raises the requirement of the legal system to also change to accept a different form of notification that is not based on face to face.

In the domain of health and also other social development domains, IS to support CRVS represent just one amongst a multiplicity of other flows that intersect the CRVS domain. For example, the HMN technical framework described CRVS as one of the five data sources *(10)* which also includes surveys, census, health and disease records, health service records, as well as input sources related to resources, and finances. The various data systems have their own logics of use, and are typically supported by a range of IS including also paper-based, and involving the application of technologies in diverse ways. For example, VA systems are grounded in logic of medicine to generate COD information, while VS systems are oriented

towards generating consolidated indicators based on a statistical logic, while census systems come with a decadal frequency. The system of systems perspective being argued for, represent what is popularly called an "enterprise architecture" approach that emphasizes linkages across systems, grounded within a social systems approach. An architecture approach, as conceptualized in this study, is much more than just the technology and the nuts, bolts and wires that connect them. Rather, seen from a sociotechnical framework, in addition to the technology and supporting infrastructure, there is importantly the historical and political–institutional–legal context. This helps to understand the challenges in getting technologies to work on the ground, and the unintended consequences that typically occur, as people and institutions always provide surprises with the unexpected ways in which they respond to technology.

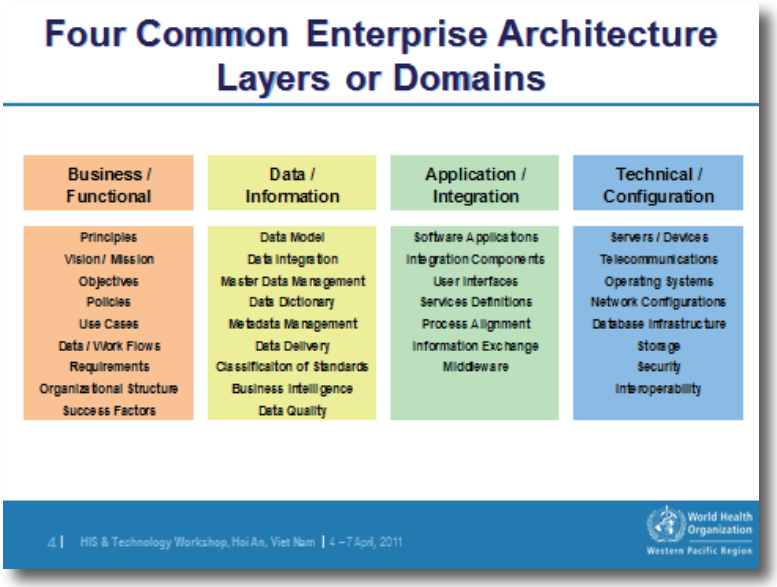
This systematic review is not explicitly studying institutional and organization issues surrounding CRVS systems, for example related to the legal processes surrounding registration, as the focus is primarily on the technological interventions. However, the analysis is developed within an architectural framework that is sensitive to the influences from the institutional and social context. The conceptual approach to the systematic analysis review is presented through the schematic diagram in Figure 1 involving three interconnected layers of the architecture. These include firstly the social systems level representing the political agreements that need to be reached to enable systems to institutionally speak to others. For example, the health and justice departments firstly need to come to an agreement at the political level so that they share the data on births and deaths that they respectively capture and own. Secondly, the application or semantic level involves developing semantic linkages between the systems, such as relating to nomenclature of data being collected, their periodicity, and the logics of how they are collected and combined. Thirdly is the technical or syntactic level, which involves the protocols and technical conditions within which systems integrate or interoperate. This three-level interaction can be nicely illustrated through an example of a cellular system. At the first technical or syntactic level, two people on the phone should possess handsets that enable the conversation. At the second level, if one person can only speak Chinese and the other only an Indian language, then there is not the semantic basis for communication to take place. Finally, at the social system level, the two people need to have the desire and the need for the conversation, for the linkage to take place. Important to note is the interconnected nature of these levels, as without a political agreement, syntactic linkages are largely irrelevant. Often, the focus of interventions is on only the technical level, rendering the overall effort ineffective. While this three-level model of an enterprise architecture has drawn conceptually from the domain of health information systems *(11),* we argue this also has direct relevance to understand the role of technology in CRVS, and how it can be effectively implemented. There will be necessary modifications that will be required to this model, arising from the particularities and multisectoral nature of the CRVS domain. This systematic review will seek to develop this revised model based on the evidence collected.

Figure 1. **Three-level model of enterprise architecture for CRVS system**



This model can also be viewed through the lens of "enterprise architecture", composed of four domains and their respective interlinkages , shown in the slide reproduced as Figure 2 by Mark Landry on enterprise architecture overview *(12)*. The "enterprise" representing the highest level of organization or trans-organization, which in the CRVS case can be t justice, home or health ministry, would need to lead the process of analysis, design, development and implementation of the architecture and systems.

Figure 2. **Four common enterprise architecture layers of domain**



CRVS systems are by definition multisectoral, spanning domains of health, law, development, statistics and various others. In the public health domain, while health information systems (HIS) have gained in importance over the years as an object of research *(13)*, CRVS systems, arguably due to their multisectoral nature, have slipped between the cracks and not been systematically studied within one domain – be it public health or IS. As a result, research findings

in the IS domain such as those emphasizing the architecture approach *(11)*, sociotechnical networks *(14)* and flexible standards *(3)* have not been applied to the understanding of the domain of CRVS systems. Arguably, this review drawing from the domains of IS, health and CRVS can help to apply some of these learning to CRVS-based IS. For example, to understand the innovative potential of eCRVS and mCRVS interventions, and strategies by which they can be scaled up – both functionally and geographically.

1.4 WHY IT IS IMPORTANT TO DO THE REVIEW

Arguably, little is known about information systems supporting CRVS systems from a systemic and architecture perspective. For example, there has been limited research on how computers and mobile supported IS can strengthen the entire process of CRVS from recording the event, its notification and registering, the issuing of the legal document surrounding the event, to its consolidation into vital statistics. The literature presents various examples of descriptions of particular ICT interventions relating to limited parts of the overall whole, such as on birth notification *(15)*, death registration *(16)*, COD recording *(17, 18)* and compilation of VS *(19)*. While these specific examples provide stories of both successes, for example *(18)*, and failures, for example *(15)*, for the particular interventions they report, they do not and cannot by design help to illuminate issues relating to the transformation and scalability of the overall CRVS system, as they do not address issues of relations with other flows and with the broader context. For example, Kariyawasam *(17)* describes a system for automating the process of COD identification. However, while this example provides an interesting insight on how ICT can help to provide more accurate COD information, it does not describe how this links up with systems for death registration, and thus has limited value in understanding the role of ICTs in strengthening the overall CRVS system. Similarly, from Liberia, Toivanen *(20)* describes a mobile birth registration system using GPRS technology and smartphones. Though it arguably appears technologically sleek, and also potentially a cost-effective solution for registration of births, it is not discussed how this system can be scaled beyond the pilot to a national level where naturally the complexities involved will be significantly different.

Our knowledge of understanding the role of eCRVS and mCRVS interventions in transforming CRVS currently thus remains insufficient and limited largely to small and piecemeal efforts. If we consider CRVS IS to primarily lie within the intersection of broad research domains of HIS, the governance of public health and public systems more broadly, arguably the CRVS and technology domain has not received appropriate attention. While the IS domain has until the present not considered CRVS systems as an object of study, literature representing the CRVS domain has primarily focused on limited examples. Arguably, there is a positive potential of bringing together these two research domains, because by combining knowledge and learning from the field of IS and the substantive content of the CRVS systems, we can draw valuable inferences about how eCRVS and mCRVS can transform CRVS systems.

SECTION 2. OBJECTIVES OF THE STUDY

The objective of the systematic/landscape review is to document, identify and categorize eCRVS and mCRVS solutions and other innovations and to consider available evidence on outputs, outcomes, impact (including unintended effects) and costs. In addition to the systematic review of grey and published literature, the study has involved consultation with knowledgeable persons and organizations in this area. Through these consultations, various project documents information and description from initiatives focusing on CRVS were obtained. Furthermore, through extensive IInternet searches various articles were obtained which involved both the development of standards and field applications within the CRVS domain. The articles were then selected by criteria of inclusion, and categorized and summarized around different relevant dimensions. The material selected to be included in the review through literature and consultations were then analysed to develop a summary of results covering the nature, scale quality and potential of eCRVS and mCRVS interventions to replicate or scale up. Some best practice case-studies were identified to emphasize interventions, interpreted as having taken an architecture approach, and also which have indicated positive results. This then provided the basis to make recommendations for the future interventions or research on eCRVS and mCRVS.

SECTION 3. **METHODS**

The primary method employed was of a systematic review which is based on a literature analysis focused on the research questions that had been identified. Data was collected from published high quality research, which related to the research question. This data was then appraised, selected and synthesized to help address the identified research question. A total of 58 studies were included in the study (see Annex 1 for a listing of these articles). The review is systematic because it is based on clearly formulated questions, identification and selection of relevant studies based on prior defined criteria, and a summarizing of the evidence with respect to the research questions. The evidence gathered through the literature review was complemented by consultations carried out with experts in the domain of CRVS. This list of experts was provided by the HMN, and in many cases names of other people were proposed by the experts, who were also spoken to. Some other persons were identified through the personal contacts of the authors. Annex 2 provides a list of all the persons who were consulted, and also the mode of consultation – whether through face to face meeting, telephone interview or e-mail contact. Furthermore, since the authors of this review have been associated in working with HIS in several countries under the framework of the Health Information Systems Programme (HISP) of the University of Oslo, they have also leveraged their experience and contacts in some of these countries to gather more specific information on CRVS systems nationally.

The information collected through the literature review, supplemented with the expert consultation notes and the HISP-supported information gathering, was subject to an interpretive process of analysis. The interpretations were then organized along the four key dimensions, representing CRVS interventions by:

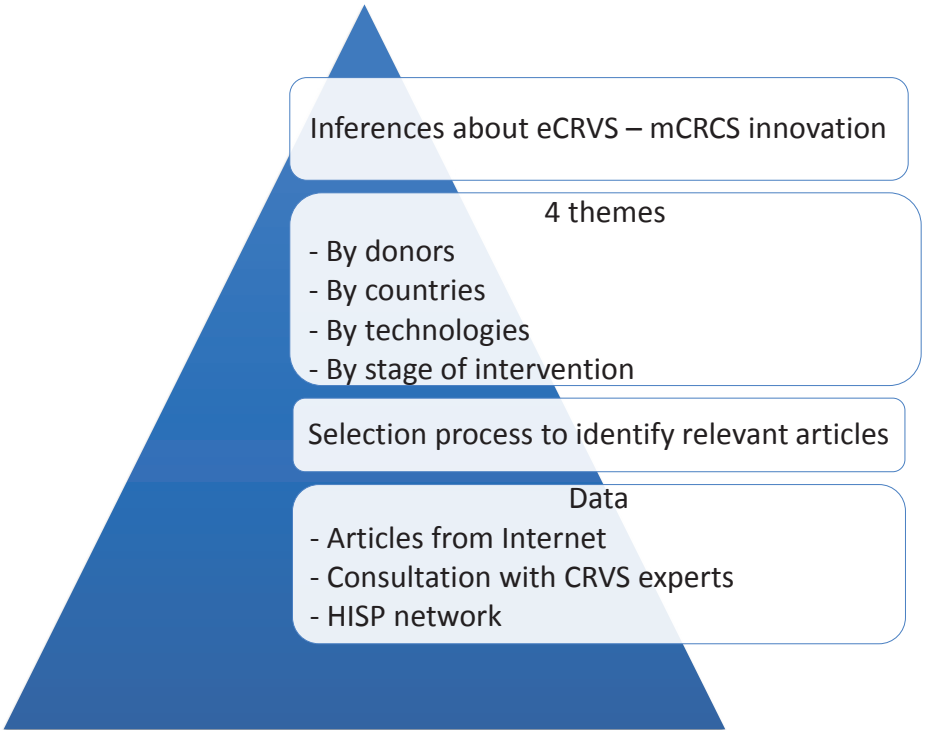
– technologies;
– countries;
– donors;
– stage of intervention in the CRVS process.

The report was then developed across two levels of synthesis. At the first level, which was descriptive, the articles were summarized across the above four dimensions. Following this, at the second and more analytical level the effort was towards developing more abstracted and generalized inferences that sought to address the formulated research questions.

At an interim stage of the process, roughly when the first-level synthesis was completed, a draft of the report was sent out to at least four experts who provided extremely valuable inputs into the organization and content of the report. These comments were then incorporated in the report to make a second and then a subsequent third draft. The final report was prepared after responding to the comments received on the third draft.

In Figure 3, a broad schematic is provided of the approach adopted with respect to the methods in this review.

Figure 3. **Process of methods adopted**



3.1 FRAMING QUESTIONS FOR THE REVIEW

The systematic review targeted answering three well-structured questions, which had been identified prior to starting the review. The basis for developing these questions was the Terms of Reference provided by the HMN for this study, which were then formulated based on discussions and clarifications with HMN right at the start of the study. The questions which were framed so as to be structured and clearly interpreted are provided below:

a. What is the nature and landscape of eCRVS and mCRVS interventions taking place in the context of low and middle income countries ?

b. What are the discernible outputs and outcomes of these interventions?

c. What is the potential for scaling or replicating these interventions to other settings?

Answering these questions also helped to identify some future directions for development of efforts in technology-based interventions in the CRVS domain.

3.2 IDENTIFYING RELEVANT WORK

A systematic review was carried out firstly in order to identify articles that involved descriptions of interesting applications of eCRVS and mCRVS. PUBMED and web searches were carried out using the following keywords in different combinations: innovation, information technology, mobile technology, civil registration, vital statistics systems, and electronic civil registration system. Furthermore, some United Nations sites were searched and also personal websites of some of the experts who had been identified. This helped to discern some of the contemporary work being done in this area by relevant institutions and also identified experts. The review covered published, semi-published and grey literature on ICT and innovations in CRVS in low and middle income countries and also in other settings (in developed countries such as Australia) that were deemed applicable to the subject environment. Studies from high-income countries where seen to be of potential relevance to low and middle income countries were included, with an analysis focus that considered also challenges of their adaptation.

The review also included evidence for existing legal mandates that allowed electronic collection and transmission of CRVS data. Some contemporary discussions around cloud computing were tapped into to help understand issues related to privacy and security that necessarily come to the fore when dealing with individual name-based information on servers – physical and virtual. In some cases, we studied technology applications not directly related to CRVS (such as the Universal Identification project ongoing in India), to try and analyse how particular technological approaches used could be useful for CRVS. A visit was also made to the MOVE IT project in Bangladesh to gain some first-hand experience. A visit to the Cause of Death meeting on HIV/AIDS in Cape Town, in November 2012, enabled meetings with key experts in the area (such as Dr Raj Mitra from the United Nations Economic Commission for Africa (UNECA), Ethiopia) and to also hear presentations on some of the MOVE IT projects from Africa.

In terms of limits of the data collection, the entire search was carried out in English language which automatically led to the exclusion of relevant articles published in non-English languages. Potentially, we could not access many relevant and interesting experiences from Latin American countries. The Internet-based search was primarily carried out during the period of 1 November 2012 to 5 December 2012. After this period, some focused Internet searches were carried out to obtain specific information in the process of the finalization of the report.

3.3 ASSESSING THE QUALITY OF STUDIES

We defined the inclusion and exclusion criteria for identifying the relevant work so that they would relate to the study questions around eCRVS and mCRVS interventions in low and middle income countries.

We included articles that provided a reasonable level of detail to be able to understand the intervention, thus excluding very scantily detailed articles. This was not an easy guideline to implement, as there were many articles in which the technical details of the intervention were not described, beyond for example saying a database was used. Such a description makes it challenging to develop inferences around the nature of the intervention and its potential for scaling. This challenge of technology being treated as a "black box" and not clearly described has been identified also in the IS research, which impedes our understanding of how the materiality of the technology shapes use processes. A review entitled 'Desperately seeking the IT artefact' *(21)* identified the extremely high percentage of research articles that made limited effort to be explicit about the technology. A large number of the CRVS articles studied arguably reflected the same weakness.

There were a number of articles that were picked up by the search which dealt with general level of CRVS issues, such as institutional and organizational, and not directly on technology related to eCRVS and mCRVS interventions. Such articles were largely excluded from the analysis, as the mandate for the study was primarily to focus on the technologies, how they are being applied, their impact, the reported challenges, and potential for scaling. Broadly, the articles selected were those that were directly dealing with low and middle income countries, and a few were considered from the developed countries where the intervention was seen to have relevance for the target context.

The identified articles were summarized and compiled into a single document. Each article was thoroughly reviewed to identify information about the type of study, key problem addressed, the nature of intervention, the stage at which the intervention has been applied (at point of event, the generation of the legal document of the event, and the consolidation of the VS), the technology used, and an interpretation of the strengths and weaknesses of the intervention. In Annex 3, a sample sheet is provided of how a particular article was summarized.

3.4 SUMMARIZING THE EVIDENCE

A summary sheet was designed which could capture key aspects of the evidence related to the study questions. This sheet was then used to summarize evidence of a few articles and some modifications were made based on our understanding of how well the articles could be summarized. Using this individual article summary sheet as a reference, a further four domain-specific summaries were created related to:

- interventions by the stage of intervention;
- donor-supported interventions;
- interventions by technology types;
- country-specific interventions.

The motivation to cut the evidence across these four dimensions was that it would help to situate the CRVS intervention within the relevant socioinstitutional–political context (of donors and countries) related to the problem to which the intervention is applied (the stage of intervention), and also the specificities of the technology (by technology types). These dimensions were crucial in understanding the impact of the intervention, and also in determining the potential for scaling. These four summaries are written as thematic notes in the section on findings. These were largely descriptive in nature, which helped to develop the basis to create the more analytical summary subsequently. Summary tables were developed including the articles representing each of the themes. Some of the articles contributed to more than one theme.

3.5 INTERPRETING THE FINDINGS

We have in this review relied primarily on secondary data; research papers, reports and interviews on various CRVS systems and projects, without being in a position to study them directly ourselves. We see our data as the interpretations of the various authors and individuals who have created these documents, rather than our empirical observations of the interventions. We would also stress that this report is in turn our interpretation of this data, seen in light of our academic and professional experience coming mainly from wider HIS design and implementation which has spanned multiple low and middle income countries. We are first and foremost interpretive researchers *(6)* who believe "truth" is a social construction, and in the research process try to understand the subjective meaning of the research respondents, and the inter-subjective processes through which these subjective meanings are constructed. Building interpretations was not always easy, given that the primary source of data is text

collected through secondary means. The principles of interpretive research applied to this analysis of this text included the following.

- Data are value laden, being shaped by the researcher's world view. The researcher does not stand outside the phenomenon being studied, but by the very act of studying it, shapes the same. In our case, our world view was primarily of HIS researchers.
- What is being presented in this report is one interpretation of "a truth", which is that of the researchers' interpretation, rather than "the truth."
- The aim from this analysis is not to make statistical generalizations to larger populations, but to develop insights and concepts that may be applied to other settings.

What was very crucial in understanding our interpretations is the extensive experience of more than a decade in the domain of HIS. This may have "biased" our approach to look at CRVS with an HIS lens. This can be both a strength and weakness, as while HIS share many common features with CRVS systems, they are also quite qualitatively different. For example, the legal requirements of the CRVS in most cases do not apply to HIS, and CRVS undoubtedly is more intersectoral than HIS. This emphasizes the point that while it is important to draw on the learning from different domains in order to not reinvent the wheel, it is also critical to look at CRVS systems in their own right with respect to the particularities they possess. The interpretive approach adopted encourages us to be reflexive to our individual conditions and experiences which may shape our understandings of the phenomenon. Part of this reflexive process was discussing the interpretations with others, for example receiving feedback on the draft document, discussing contrasting viewpoints and trying to bring this diversity into the construction of our overall analysis. Sharing drafts of the report with experts, getting their questions and viewpoints on the text, and responding to these in the course of making the revisions, represents a crucial part of the reflexive aspects of our interpretive analysis.

SECTION 4. **RESULTS**

In this section, the results are presented in two parts. The first involves an analysis of individual studies, organized by the following four themes. At the end of each thematic analysis, the second part consists of an overall summary of the in relation to the research questions.

Theme 1: eCRVS and mCRVS by countries.

Theme 2: eCRVS and mCRVS by stage of intervention.

Theme 3: eCRVS and mCRVS by donor agency initiatives.

Theme 4: eCRVS and mCRVS by technologies.

4.1 THEME 1: ECRVS AND MCRVS BY COUNTRIES

Articles relating to 23 countries were examined through reports, research papers, consultation with experts and contacts with representatives from the HISP network working in particular countries. A list of the countries reported on is provided in Annex 4, and Annex 5 contains a tabular summary of key characteristics of the CRVS systems across some of the countries.

A few issues were revealed as common across the countries, though there are also exceptions. The first is that most countries still primarily rely on paper for a bulk of their recording and reporting of births and deaths. In strengthening these systems, there have been initiatives to scan the paper records, because much historical data only appear in paper, and also because paper has been found to be a reliable technology in the lack of other solutions. As an example, the Registrar General Department of Sri Lanka started a process of digitization of birth and death certificates from 2006 *(22)*. The COD data were extracted from the death certificate for all deaths available from 2008 for analysis. Ghana is another example of a country that has focused on scanning birth records.

The second issue is that, in many low and middle income countries, a high percentage of births is not taking place in a health facility. These births are often left unrecorded not only because of lack of proper routines and technology at the facility, but also because they happen outside the formal health system. A recent study by Kanjo *(23)* examines reasons for "missing data" relating to births. Interestingly, in Malawi there is a policy directive that prohibits traditional birth attendants from supervising deliveries, which should only be carried out by skilled birth attendants in facilities. A consequence of this policy directive has been that while the traditional attendants have continued to assist deliveries at home, they have stopped reporting them, escalating immensely the problem of low birth registration.

Even if children are eventually brought to a facility for other reasons such as immunization, data on details of birth, such as birth weight, tend to be left unrecorded. For this common scenario, mobile technologies have started to be implemented as a way of catching these data by community health workers or equivalent. For example, it is reported that in Uganda, where 43% of births occur outside health facilities, a mobile solution is being piloted for enhancing notification of births *(24)*. In this intervention, community health workers are given access to the central database using mobile phones to update birth information. Once this birth information is verified, birth certificates can be printed at the registration offices.

Lastly, where there is generation of statistics from birth and death registries, these are more often than not produced in separate CRVS statistical subsystems, rather than fed into an HMIS together with other health-related data. An exception may be in Egypt, where the Central Agency for Public Mobilization and Statistics (CAPMAS) system *(25)* is reported to capture all CR and also non-health-related data, which together are analysed in the national data warehouse.

The electronic birth death and marriage (eBDM) system in Fiji has reported to have helped to eliminate duplication in data entry by integrating information flows of the health department, Civil Registry and the Bureau of Statistics. The system links health recording and birth registration, and supports direct checking of the database by authorised government officers including the Registrar General's Office *(26*). Mobile technologies are also being drawn upon by various countries to strengthen CRVS, especially related to birth registration systems. In Liberia, birth registration was estimated at 5% in 2007 *(20)*, and to face up to this challenge a pilot project was initiated in one county, using a Nokia Data Gathering (NDG) mobile phones solution to collect birth registration data. While the results were deemed promising in the pilot Bomi county, issues of scaling including challenges of physical infrastructure and capacity building were not directly taken into acount. In Uganda, despite early positive results in the use of mobile phone for birth registration, the Director of Civil Registration has stated that there are still challenges to be dealt with relating to outdated laws and lack of integration with health work.

In India, since 2009 a massive effort was initiated at full national scale to develop a mother and child tracking system (MCTS), where a pregnant mother is to be tracked by name over time during the course of her pregnancy from her first antenatal registration to birth and postnatal care *(27)*. Furthermore, the child is also tracked by name from his/her first BCG vaccination dose to when full immunization has been completed. The government has invested significant resources to operationalize this system, including the purchase of high end servers for each state. This system, when implemented in totality, should be able to provide very extensive details to the CRVS system given that nearly 200 million babies are potentially to be reported by the health department annually. Unfortunately, such a linkage has not been conceptualized in design, and in fact this name-based system does not also speak to the aggregate facility-

based HIS. This implies that the field nurse has to enter details of all births in her registers, in the MCTS and then also in the facility-based system for aggregate details. Many states in the country have also linked the mobile phone to the MCTS, but this is primarily used to send SMS to senior managers on the total number of women registered in a day or babies that were born. The point is that a whole infrastructure t has been created by the health department – software, hardware, training, mobile linkage, policy direction, etc. – which could potentially have been used to strengthen the CR system, but the linkages have not been provided.

Another problem arising from the lack of integration, in this case largely institutional, is also cited from the state of Punjab in India. The Punjab Health Department provided mobile phones to all their 5000 health workers for reporting of data around the routine primary health services given. It was then suggested to them that this mobile infrastructure could also be used for supporting the process of births and deaths registration, but this suggestion could not be followed through because the process of registration was carried out by a different department, using a different flow of information. This is another example of a missed opportunity where an available infrastructure that could have been very relevant to strengthen CRVS was not exploited because of institutional constraints.

While challenges faced in CRVS systems share a lot of commonality across countries, there are marked differences in the strategies employed to tackle them. For example, Namibia saw a significant decline in coverage of birth certification from the period 2000 to 2007. This to some extent was attributed to particular characteristics arising from geography and communications, contributing to by the low population density and the long distances people had to travel to get the certificates. To counter this challenge of physical distance, sub-regional offices of the registrar were created, supported with technology to allow video conference and distance training of the staff there. A web-based national registration system could be accessed from these district offices, making access simple. Further, these systems were made interoperable with systems of other government departments, such as those responsible for creating passports *(28)*. Namibia thus provides a good example of how different technologies could be sensitively adapted to the context and applied to improve the CRVS through decentralizing registration, decreasing travel distance and hence improving the service to poor people by reducing the financial burden of travel. In addition to the web-based access to the registration system, video conferencing system was used to sensitively and in a cost-effective manner help build capacity in the newly formed sub-regional registration offices. A set of sociotechnical–institutional reforms thus helped to strengthen the overall CRVS system in Namibia. Similarly, Botswana which faces similar challenges of communication and geography as Namibia *(29)*, including a thinly populated country and long distances, has also decentralized birth registration and adopted the strategy of issuing national ID numbers through hospitals. Botswana, too, now boasts an advanced CRVS system.

In India, the Birth and Death Registration System (BIRDS) is reportedly being implemented in the Union Territory of Andaman and Nicobar Islands and has been made operational since 2010 *(12)*. This web-based system is developed on an open source software platform complying to open standards. Birth and death registration is mediated through 26 registration centres in the island, and citizens are enabled to freely download their birth certificates. Data are shared between the CRVS and other government departments through the Internet.

Kenya provides an example of combining existing structures with new technology, allowing rapid decentralization through utilizing the capacity already present at the village level *(30)*. Using an SMS-based reporting system, village elders, who were knowledgeable about health events taking place at the village level, were enrolled into the initiative to assist in reporting the events. This project, in the Western Province, took place in a situation where 60% of births occurred at home. Over a year and a half, the recording of birth weight was reported to have increased from 47% to 97%, which has since been sustained. Introducing cellular phones and infant weighing scales, village elders were given training to make measurements and record pregnancies, births, infant or maternal deaths, and infant weight in their areas. This information was then sent to registry administrators, linking the village level to the established routines of CRVS. The Kenya example is interesting as it focuses on leveraging upon the inherent capacity and traditional knowledge in the village, which can potentially be an appropriate strategy for tackling challenges of scale and sustainability. The MOVE IT initiative in Kenya is also interesting, in that it limits the use of the mobile phones to notify or inform an event, which is then expected to trigger action by the authorities to investigate and register the event. This triggering was seen as a way to counter the inertia encountered at the registration offices where, earlier, staff would often say that they did not have the required information.

In Cambodia, birth registration coverage was only 5% before 2004. After the introduction of the birth registration campaign, the coverage is reported to have increased to 95 % in 2011. But in the current context, the system is still weak with respect to data quality, workload in dealing with manual records, difficulties in producing automated reports, limited use of data for decision-making and planning at all levels, and the high costs involved in the printing of registration books and related papers. In 2012, the Ministry of Interior introduced a web-based system for CRVS reporting in 11 communes to capture individual birth and death records, print birth and death certificates, produce monthly reports and, most importantly, to capture additional data relating to place of birth and death, COD, and the photo and fingerprint scan of the reporter. This system is reported to have a positive potential to strengthen CRVS systems nationally.

Tajikistan has a well-established and robust system for CRVS, though almost totally without support of ICTs *(31)*. Here, the CR is handled by Civil Registry Offices (CROs) which are located in all the 68 districts of the country under the Ministry of Justice. This example has strong

routines and an institutionalized system, still relying on paper, which was also reported to be adequate during an earlier HMN-supported assessment. Later assessments, however, have reported serious shortcomings, one being that a significant portion of neonatal deaths is not being recorded, as these typically happen in Ministry of Health facilities. As a result, the data then end up in a different system; since the CRVS system relies mainly on paper records, there is no easy way of accessing and sharing these data. There are also other challenges, such as disincentives to report early deaths and payment requirements for patients, not related to the technology itself. There are plans for computerizing the system, and starting from 2013, support for CRVS will be included in the new health management information system (HMIS) supported by the European Commission that is going to use the DHIS2 as a web-based database. The aim is that the data warehousing approach enabled through the DHIS2 should support the integration of the health and judiciary systems and data as both will be using the same software. This example also emphasizes that while new technologies are adopted in different ways to tackle each country's particular challenges, they are part of the larger systems and infrastructures in the country that makes scaling of projects a complex task.

Figure 4 depicts the existing manual registration process currently being followed in Tajikistan, and Figure 5 shows the proposed integration strategy of HMIS and CRO under the proposed European Commission funded project *(32)*.

Figure 4. **Manual registration and reporting process of civil registry offices, Tajikistan**

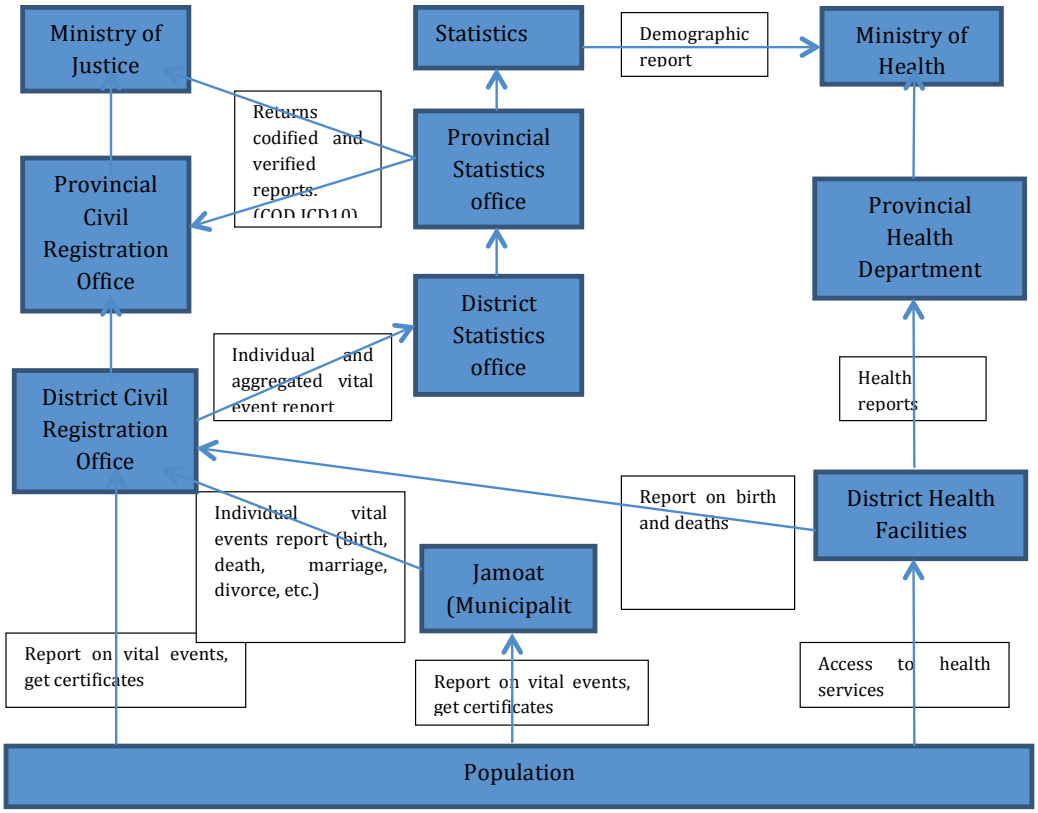
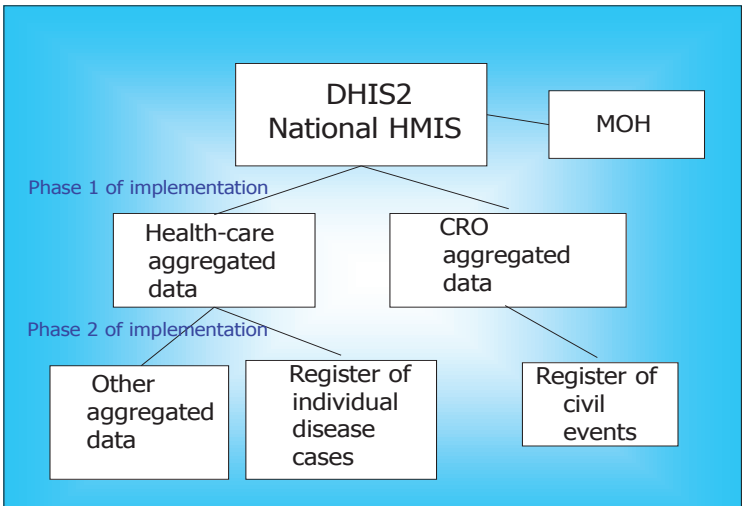


Figure 5. **Proposed strategy for integration of HMIS and CRO, Tajikistan**

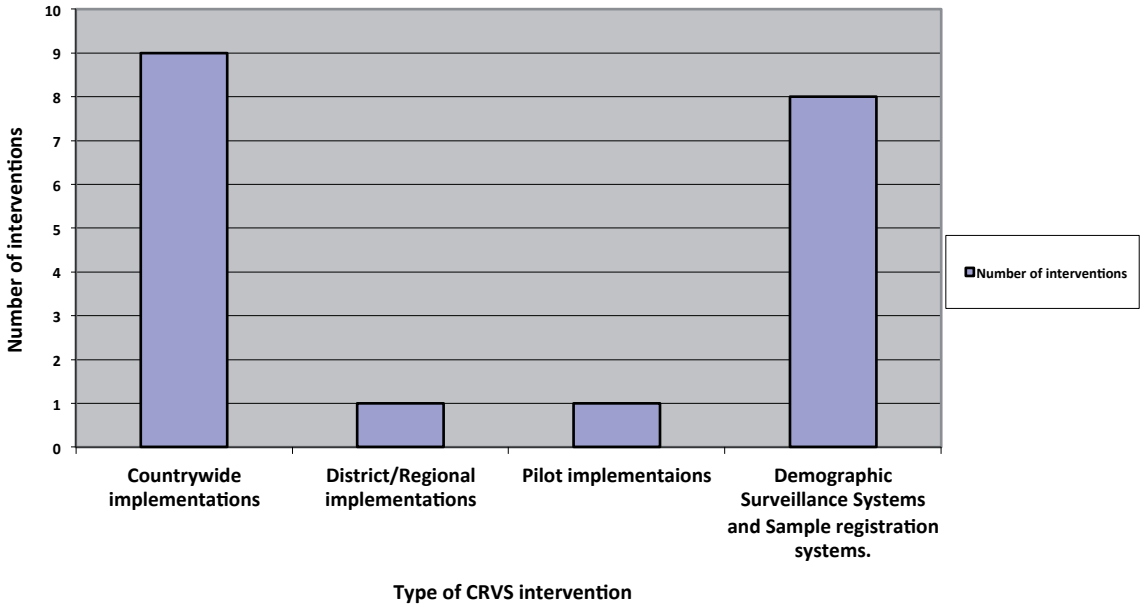


The literature contains many examples of pilot projects, or systems limited to just single districts, that are not easily scaled to national levels. For instance, Nouna district in Burkina Faso *(33)* is an example of a home-grown vital events registration system, using MS Access. The Nouna Demographic Surveillance System includes household survey data on births and deaths, which are collected on paper forms. This information is quality checked at several layers before it is entered into the database for longitudinal records and the generation of statistics. Such small systems as in Nouna district have typically grown out of single surveys, and the technology used has not been designed to scale.

Summary

Across countries, some similar trends are evident with respect to technology-based interventions in the CRVS domain. The majority of interventions reported are related to births, with systems for death registration being more limited. Existing infrastructure, for example related to the health department, are not being adequately leveraged by CRVS systems. CRVS systems in some countries have been implemented countrywide or at regional level and some have well-established demographic and sample registration systems such as those found in China and India, while other interventions are limited to pilot studies restricted to a single geographical area. Distribution of computerized CRVS systems is represented in Figure 6.

Figure 6. **Availability of CRVS systems across countries**



The health infrastructures in many countries have well-developed web-based structure right down to the facility level. These, arguably, can be leveraged upon to report on CRVS events as well. For this to happen, however, institutional mechanisms for integration need to be considered, and agreements achieved at a higher level of departments and ministries. There are opportunities created by technology to link databases and also to enable access from remote areas. The example from Namibia is a case in point, where effectively national databases have been linked with sub-registry offices, and these have arguably contributed to enhancing coverage of birth registration.

The Albania example illustrates how technology interventions are possibly more effective when the existing paper-based system is strong. The new system was implemented countrywide and the background for modernization was set up by the strong and well-established paper based registration system. The computerization contributed to accelerate the registration coverage, although the generation of vital statistics remained a main concern. The Egypt example illustrates the power of a data warehouse effort, enabled through CAPMAS. This warehouse enabled the integration of different data streams including the CRVS system. Coupled with the use of data-mining tools, this integration enabled the capability to identify hidden patterns of mortality data and its correlation with other socioeconomic factors.

While various countries show the usual problems of inadequate infrastructure, weak human resources capacity, funding constraints and the existence of a multitude of systems, there are also positive examples. Three important elements contributing to positive gains were identified: the ability to link databases to obtain synergies; the positive gains of building upon a well-functioning paper-based system; and the adoption of a data warehouse approach, including integration of data streams and the use of data mining capabilities.

4.2 THEME 2: ECRVS AND MCRVS BY STAGE OF INTERVENTION

Three key stages of technological interventions are identified with respect to CRVS. These include: at the point of event of the birth or death; the point of generation of the legal document around the event which will be the birth or the death certificate; and where the VS are generated. Arguably, it is important for us to understand at which point the technologies are being broadly applied, and with this are there some gaps that can be identified. In the literature studied, it was often not clear at which stage the intervention described was being addressed. However, we attempted to carry out this categorization based on information provided in the articles.

4.2.1 AT THE POINT OF EVENT OF BIRTH OR DEATH

This review identified a significant proportion of the technology-based initiatives to be taking place at the point of the event of birth or death, especially related to births. Technically, we can see technological interventions to support three different kinds of activities at the point of event which relate to ***recording***, ***notification*** and ***registering*** of the event. We define ***recording*** as the noting down of all the details relating to the event, for example with respect to a birth, the name, place, type of birth, etc. This has typically taken place historically on paper, and in some cases is now being supported through a technological intervention such as the mobile phone. However, this does not tend to replace the paper record, but only complements it. ***Notification*** is the act of official communication of the details of the event to the authorities who are responsible for the issuance of the legal document relating to the event. Formal notification can be the basis for the act of registration which by definition is a legal act. It is important to distinguish between formal notifications of, say, birth details compared with ordinary reporting of these details. A birth certificate will only be issued in most contexts based on a formal notification. So, while a mobile phone can technically send through SMS the details of a birth, for the authorities to act on it for registration the SMS needs to be accorded a notification status.

Finally, ***registration*** represents, arguably, a higher-level function in which the event is legally registered within the CRVS system. This can be in the province or national-level database – electronic or paper based, and made ready for the compilation of the VS. In the papers reviewed, often these three functions are not clearly demarcated, as everything is said to involve a "registration." Despite it being difficult to separate the interventions described in these three categories, we have tried to do so, as we believe it is important as certain technologies may have features that lend them better to certain functionalities than to others. For example, mobile phones intuitively seem more suited to functions of notification than registration, which could be better carried out in an electronic data warehouse. Also, the systems approach which we advocate requires us to look at technical changes in conjunction

with other systems, such as legal ones. As legal systems change much more slowly than technical ones, the use value of technological interventions needs to be assessed accordingly.

We first provide some examples of these three different types of interventions, before discussing some broader patterns.

RECORDING. Some examples explicitly state how technologies are used to facilitate real-time birth recording. Examples of death recording for registration are far more limited, although there are various research-based and experimental efforts towards recording of death details. Systems for VA typically record COD-related information, but are rarely linked to death registration. The Agincourt Health and Demographic Surveillance System (HDSS) in South Africa, based on a stand-alone database being populated manually with vital events data, also focus largely on the recording of the event *(19)*. With respect to birth recording, for example, Ohemeng-Dapaah and co-workers *(16)* write that in Ghana, an OpenMRS based system called MGV-net is used to record real-time birth information in a pilot project that took place from 2007 to 2009. Burkina Faso, Ethiopia, the Gambia, Mozambique, Senegal and the United Republic of Tanzania have all reported the introduction of stand-alone CR systems, often based on the Household Registration System (HRS) to register births, deaths and migrations *(34)*. However, it is unclear whether these systems are doing only the recording of the event or also carrying out the actual registration. Similarly, in Iraq, a system has been developed to record population-based mortality survey data *(35)*, but again not linked to registration.

There are various surveys, such as the Sample Registration System (SRS) in India, introduced first as an interim measure, still continuing strong more than 50 years later, also recording data on births and deaths. While this SRS is being strengthened by computer-assisted VA to improve quality of COD reporting, these surveys are not linked to death registration systems. The same seems to be the case with the example reported from Brazil *(36)* in the use of computer-assisted VA to improve the quality of COD reporting. There are various efforts by countries to use ICD-10-based classification for mortality information, in order to compls with WHO standards, but they suffer from weak linkages with CR systems. The ICD-based system is rather complex to implement in a low or middle income country context. Latifov *(31)* reports on the efforts to adopt such a system in Tajikistan and the challenges experienced. Challenges include implementing a system of about 14 000 codes in a primarily manual paper-based system, the lack of capacity in the peripheral areas to do the coding, and the challenge of coding when there is high patient load. Campione at al. *(18)* provide a more positive example of the use of ICD codes in reporting hospital deaths in Mozambique using the stand-alone SIS-ROH software system. Maybe these two examples point to the fact that such ICD coding is more suited to the environment of tertiary hospitals than to primary health-care facilities. Moreover, both these examples do not explicitly discuss integration with the CR system for registering deaths.

NOTIFICATION. Technological interventions, such as through the use of mobile phones, may be especially suited for low and middle income countries where a significant proportion of the birth and death events take place typically outside the jurisdiction of the health facility. Examples of Malawi and Uganda have already been provided to make this point. In such contexts, as the example provided from Uganda describes, the CR database can be accessed, or in our terms be "notified", and updated by mobile phone, which can then allow the generation of the birth certificate at the community level (Taylor) *(24)*. However, notification would involve legal mechanisms to be so created, but in the absence of that, the SMS from the mobile phone can be used to trigger the process of notification. Adams *(5)* describes such experiments where SMS on births and deaths from the community level to the local health centre level helps to trigger an actual investigation of the incident through a supervisor who is expected to travel to the place of occurrence of the event. Similarly, Ngoma et al. *(15)* describe mobile interventions seeking to improve vital registration in Malawi and the United Republic of Tanzania. These efforts focus on recording the event and transferring data about it to the district level. Toivanen and colleagues report a similar effort from Liberia *(20)*.

A set of MOVE IT projects to strengthen CRVS IS were initiated by HMN. Many of these, for example in Kenya and Rwanda, focused primarily on the notification aspect of the process. In both these countries, the details of the event are appropriately coded and entered in a paper form, taken then into a form on the mobile phone and sent by SMS to the district level which is expected to register the event. In both these cases, the technology used involves low-end phones and Rapid-SMS technology to transmit the information by SMS. Linkages of this SMS with CR are relatively unclear, other than possibly triggering information about the event. In Kenya, in a personal interview, it was told that this sending of SMS is not treated as a formal notification of an event, but merely as a trigger for the district to initiate action so as to complete the process of registration. In Rwanda, too, the aim seems to be of triggering a process of registration rather than carrying out the CR itself. Legal processes need to be established where the SMS can be treated as a formal notification, something which is not currently in place.

REGISTRATION. Examples of the use of technology to facilitate registration of the birth or death event are far more limited. In Albania, for each citizen an individual record was created in the CRVS database, also treated as a population registry, and issued a unique ID *(37)*. A limitation here is the proprietary nature of software used to develop the web-based system which, firstly, made it expensive to develop and, secondly, involved costs in enabling data-sharing processes with other systems. Despite these shortcomings, the system is reported to have achieved national scale, and is capable of generating national-level VS. A similar example is seen in Thailand, where a system, based on open source software, issues a unique ID and does the CR. The open source nature of this system enables integration with other government departments, and integration makes registration mandatory in order to access

other welfare services provided by the government, in turn improving the CR coverage. Egypt also reports an innovative approach in using an Enterprise Data warehouse approach to gather CR information *(25)* implemented through CAPMAS. Since CAPMAS represents the institutional authority to manage all the public information, including CR data, sharing across departments is enabled and strengthens the registration coverage.

The Government of Fiji has introduced a web-based system that integrates information from Health, Registrar General and Statistical departments, eliminating duplication of data entry and coding. This allows the Registrar General department to legally register the event, while the health department provides the information necessary for registration. In the Latin American country of Chile, there is the use of a computerized central database for CR and each citizen is issued with a unique ID. This system is supposed to register birth, death and marriages and is capable of generating VS reports as well *(38)*.

Bangladesh has introduced the Birth Registration Information System (BRIS) on a pilot basis with the aim to record individual birth information, automatically issue birth certificates, and retrieve and report birth data when required by storing them centrally in an electronic database *(39)*. This system connects with other software systems and furthermore is expected to provide more accurate information for the immunization programme. However, we understand that new initiatives currently taking place in the CRVS domain in Bangladesh are not being designed to speak with such existing systems. Muzzi provides also another account from the Gambia *(38)* relating to the strengthening of birth registration by automation and linking it with growth monitoring cards. Automation is one component of a larger systemic initiative to strengthen birth registration, through its decentralization and enforcement of a legal framework.

India's e-District Project, being implemented from May 2012 onwards, provides a facility to register births and deaths online and to issue birth and death certificates easily. In rural areas, government officers collect birth and death data from health workers, village caretakers or heads of families and enter the information electronically, using the e-District system for issuing the certificates *(40)*. The objective is to ensure that the defined process of service delivery of birth and death certificates is followed in an adequate and timely manner.

An online birth registration system is implemented in the Municipal Corporation of Delhi (MCD), India *(39)*, connecting institutions in the municipality. The system is supposed to cover the information processing all births and deaths in institutions as well as in homes though this online system. In addition to registration, there is the provision for obtaining births and death certificated through the system. A similar example is seen in the Andaman state of India. Using BIRDS, the registration offices have the capability of registering births and deaths online on the Internet, through which and citizens may download their valid birth certificates free of charge *(12)*.

Further, it has been reported that India's National Rural Health Mission (NRHM) has implemented an online Maternal Death Review (MDR) system to review and reduce maternal deaths, which are estimated at about 67 000 annually in the country. The MDR provides detailed information on various factors at facility, district, community, regional and national levels, which can help analysing the factors contributing to the maternal deaths and how to take measures to correct these. The MDR monitoring system of the Punjab NRHM ensures registration of every maternal and infant death, and the state is taking various measures to strengthen capacities for data collection, assessment and review of maternal deaths. A single-window software system is being used, which seeks to reduce delays in transferring information on maternal and infant death. However, details of how this system links up with that for CRVS are not provided.

Namibia is experimenting with a CR system that will provide a birth certificate to all babies before they leave the health facility *(28)*, which can subsequently serve as the foundation to develop linkages between the CR system and other government information systems. Similarly, in Botswana, there is reported an experimental initiative of registering a birth or death real-time where it occurs and integrating this CR system with other governmental information flows, allowing cross-country information updates *(29)*. The South African electronic system to manage CRVS data is reported to have successfully registered 86% of births and 83% of deaths. In Sierra Leone, the birth registration system, severely hampered by its civil war, is now gradually being modernized *(41)*. Under the Universal Birth Registration initiative, computerization of the National Office of Birth and Death Registry has been initiated, also involving a decentralization of the registration process using mobile and Internet technology. These reforms are expected to enhance registration coverage, facilitating the issuing of birth certificates and strengthening demographic data analysis.

There are various other examples identified in the review which were not very clear-cut in terms of the functions carried out. UNECA *(42)* reports that Mauritius is operating a new system to manage CR registrations and generate VS under the e-Business plan. More details are not given of the technological intervention involved. Similarly, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) *(43)* reports Mongolia has automated all CR activities, enabling coverage of 97.8% of its population. The CR system is reportedly linked with other government information sources, including Mongolian embassies in other parts of the world. In Moldova, technological intervention is in the form of a voter registration system which is used to generating the voters list and VS. The State Automated Information System "Elections" (SAISE) is expected to be implemented countrywide by 2014, according to the Organization for Security and Co-operation in Europe (OSCE) *(44)*.

4.2.2 AT THE POINT OF GENERATION OF THE LEGAL DOCUMENT – THE BIRTH OR DEATH CERTIFICATE

There were limited examples provided of countries having fully automated systems with capabilities of generating also the legal documentation required for the completion of the act of CR. Positive examples come from Albania, Egypt, Fiji, India (MCD), Thailand and some others. In Albania, every citizen has a separate record in the population database containing his or her birth information, residential and civil status information. This web-based system facilitates generation of legal documents at the local setting accessing the information stored in a central location, and individuals are identified by their unique ID number *(36)*. This registered information is shared with other government departments, for example facilitating the issuance of passports and other documents based on the registered birth certificate. The legitimacy of the individual is confirmed through the system when the person accesses other government welfare services. A common government web portal is used for many eGovernment services including vital registration. In this system, each citizen is registered with a birth registration number issued by the Registrar General's department. A citizen can obtain birth, death and marriage certificates and register marriages online. Similarly in Mauritius, under the e-Business plan, in addition to registering vital events and generating vital statistics information the system also produces legal documents locally by accessing the central database *(42)*. Similar examples are also available from Egypt, Moldova, Mongolia and South Africa.

As contrasted to national implementations, the initiative of Andaman and Nicobar in India is at the state level. Once the birth registration is carried out at the registration centres, a citizen can freely download legally the valid birth certificate through the Internet. The citizen kiosks provide a convenient mechanism for the dissemination of birth certificates. In many of the other examples, such convenient methods of generation and dissemination of certificates is not described. This includes Ghana *(16)* and also Burkina Faso, Ethiopia and the United Republic of Tanzania where the stand-alone CR systems do not appear to be equipped with the facility for generation of the legal documents. Possibly because these are mostly pilot systems, they may not be entrusted with this responsibility of generating legal documents. Similarly, the Agnicourt system being largely survey based, does not have the capability to issue legal documents. In her examples from Malawi and the United Republic of Tanzania, Ngoma and co-workers *(15)* describe how the system can generate the legal documents locally while accessing the data in the central data repository. A similar arrangement seems to exist in Liberia as well, though the details are less clear *(20)*. The Namibia case explicitly describes how a birth certificate is provided to all babies before they leave the health facility *(28)*, which then enables integration with other government information systems. The case is reported to be the same in Uganda, where the baby is supposed to receive the birth certificate before leaving the hospital.

Obtaining a copy of the birth certificate has been simplified in Sri Lanka, where there has been an initiative to digitize all the existing birth certificates by scanning them. Though electronic registration has not been introduced in the country, this digitization has enabled the obtaining of the birth certificate at the registration office using the government information system. Brazil seems to have gone a step further as birth certificates have been microfilmed, which allows its citizens to request delivery of birth certificates to their doorstep. In the Philippines, the National Statistics Office provides the facility to obtain birth certificates online, since all CR documents are digitized and available in a database.

4.2.3 AT THE POINT OF CONSOLIDATION OF VITAL STATISTICS

While some countries are reported to have integrated CR and VS systems, for example Albania, Egypt, Mauritius, Moldova, Mongolia, South Africa and Thailand, most other countries seem to have separate systems. Integrated systems enhance the capability of generating vital information statistics reports, and are also able to carry out data analysis such as profiling of deaths by causes and geography. Some of these systems store individual records of life events, from which statistical reports can technically be generated to help formulate demographic and other indicators. In Fiji, the CR system is integrated with the health and statistics department, making full use of birth information which is entered at the time of birth at the health facility. This robust integration facilitates extraction of VS data and each citizen is identified by the birth registration number issued by the Registrar General's department at the time of birth. From the SRS in India, statistical reports can be also generated. So, also from some of the Demographic Surveillance Systems, basic demographic indicators are being generated (34). The Chinese disease surveillance point system collects COD data based on ICD-10 codes and generates statistics *(45)*.

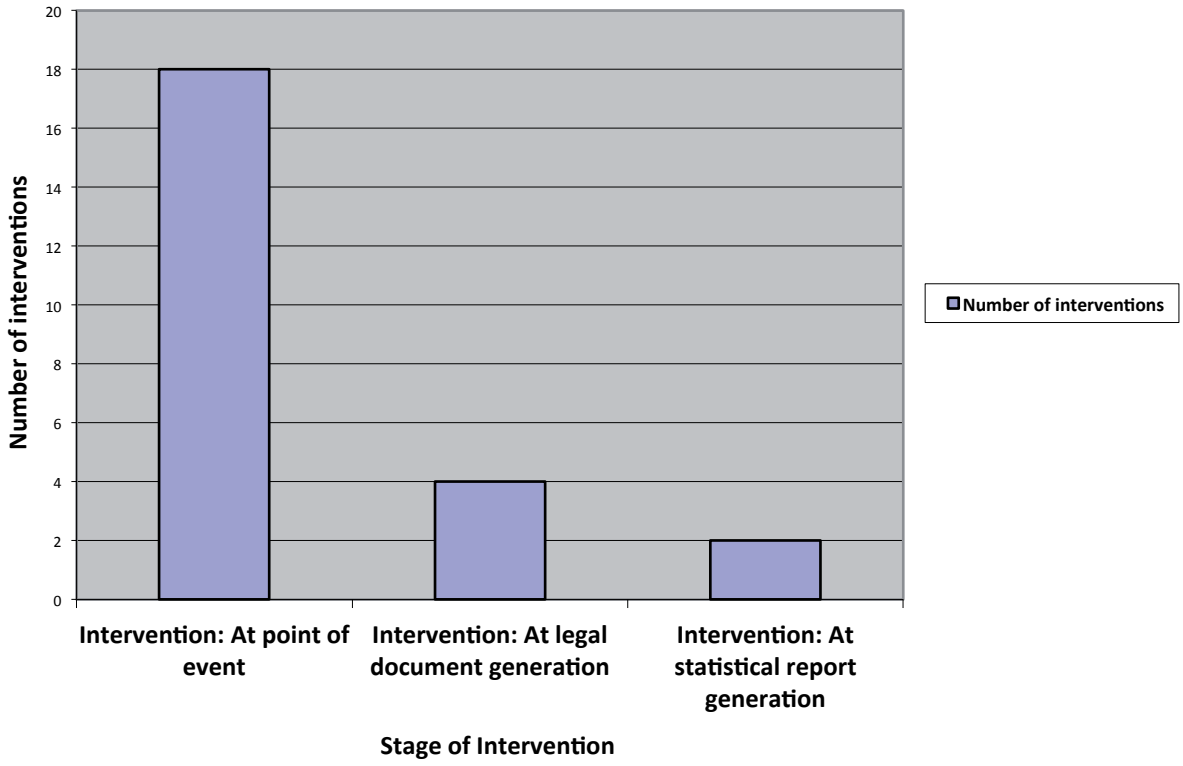
In the MCD, India, the system is capable of producing statistical reports related to births as well as deaths. On the other hand, the BRIS from Bangladesh is reported only to have the capacity to aggregate birth information. Some of the surveillance systems, such as HDSS in rural South Africa, are updated annually with resident and vital events, and are capable of generating statistical reports. The Ghana system is described to be capable of generating VS reports for the cluster of villages where the system is operational *(16)*.

Various systems have been described as capable of generating statistics from individual data such as the ones in Iraq *(35)*, Malawi and the United Republic of Tanzania *(15)*, but it is unclear whether they represent the formal VS systems of the area. Similarly, the electronic Indoor Morbidity and Mortality Reporting system (eIMMR) of Sri Lanka reports cause of death information for deaths occurring in hospitals. Though it doesn't contribute to death registrations this system is capable of generating statistical reports at facility, regional and national levels regarding hospital deaths, cause of death and age specific mortality rates *(17)*. These do not necessarily relate to VS.

A general comment that can be made in this regard is that there is limited information provided in the articles related explicitly to the production of VS.

SUMMARY. A few general comments can be made on the theme of technological initiatives by the stage of intervention. Firstly, a majority of the interventions seem to be taking place at the level of where the event occurs, and these are mostly concerned with the recording of the details of the events and transmitting theme using SMS. In many cases, this transmission does not serve as a formal notification of the event, because that requires additional legal requirements to be in place, for example the thumb impression of the citizen. In the absence of this, the details transmitted can at least serve as a trigger for actions leading to notification and registration. In many cases, the use of a stand-alone system impedes the local setting to link up with central databases and is thus restricted in issuing legal documents. Processes of death registration and also VS generation are seen to be generally poor, and much more emphasis seems to be given to modernizing birth-related systems. There are limited examples of national systems for the generation of VS in low and middle income countries, such as in Cambodia and Sri Lanka.

Figure 7. **CRVS systems by stage of intervention**



Another key learning here is the importance of adoption of a holistic approach to modernization which includes the processes of registration, legal document generation and the production of VS within an integrated perspective. Examples of Albania, Egypt and Thailand are important to realize the benefits of an integrated approach. In systems that concentrate on one or two

aspects of the overall process, as do many in Africa, the results of modernization appear to be not so promising. Many African countries are experimenting with CRVS systems that can collect relevant details at the point of event and are capable of generating VS reports, but they most often lack the capacity to generate legal documents. Furthermore, since efforts are confined to a small geographical area and carried out in a research mode with limited capacity and intention to scale up, they are not equipped with the legal authorizations required. The same is often the case with survey-based systems when a vicious circle is created: because of their pilot status they cannot fully impact on the CRVS system, and without its legal capacity they are not able to scale up.

Another important learning is about the synergies obtained when the CRVS system can link with others, especially in the health sector. The Bangladesh example shows the CRVS system being linked to child immunization, and so too in Namibia. Integrated systems in Albania, Egypt and Thailand allow the CRVS system to share data (often being mandatory) with other government departments such as passports and immigration. This linking has positive effects in enhancing the CRVS coverage.

Experiences of systems being able to generate VS directly from the CR systems are more limited. Maybe this is because CR systems are typically not covering full scale, and VS should by definition cover the full population area for which the statistics are being generated. There is lack of integration between the CR and VS systems, such as in Moldova, where only processes of registration and legal document generation, and not VS, are automated. In Sri Lanka, where the focus is only on digitization of paper forms, or in Cambodia where technology is used to store and reproduce legal documents, the systems are by design not geared to generate VS.

4.3 THEME 3: ECRVS AND MCRVS BY DONOR AGENCY INITIATIVES

Under this thematic discussion, we develop an overview of some of eCRVS and mCRVS initiatives being supported by donor agencies in different countries and also regionally. The aim is to understand the nature of their efforts, what have been the outcomes, and what are their specifically stated plans for the future. This does not represent a comprehensive overview of all initiatives, but is only representative of the types of efforts being supported.

4.3.1 UNFPA

The United Nations Population Fund (UNFPA) has similar objectives across countries, supporting broadly initiatives in two domains of CRVS and population and development. Initiatives in

population and development do not typically include CRVS initiatives, and can be seen to cover efforts to operationalize in nations a population policy to help support maintaining basic sociodemographic data while emphasizing a gender-based approach to planning. Further, they support countries to strengthen institutional capacities and human resources to carry out population and development work, including particular initiatives in reproductive health and strengthening country responses to HIV/AIDS. They support advocacy specific initiatives to strengthen country efforts to elaborate a national strategy for population and development and to fight against all forms of discrimination against women.

Padmanabha *(46)* describes a number of UNFPA country-based support initiatives in the CRVS and population development domains. Despite being dated, the article provides a useful overview of projects being supported. Some of the country-based initiatives are summarized below.

In Lesotho, a project for strengthening the CRVS started in 1980 in two phases. Initially, a model area was selected to strengthen the CR system by supporting field organizations and procedures, producing estimates of demographic variables, and helping in the development of uniform laws regarding registration. When the project was concluded in 1988, some good results were achieved, but could not be scaled across the pilot area because of funding bottlenecks, an absence of a legislative framework to support registration, untrained staff and poor IS. There was no explicit mention of the use of ICTs to support the implementation of the project.

In Syria, UNFPA supported two projects. The first was a consultancy assignment that sought to review the need for improvements. This project concluded that while registration coverage at 99% was adequate, information utilization for planning was weak because of poor organization of data processing and records preservation. Recommendations to improve this situation included the use of microcomputers and the provision of ICT training for the staff. The second project concerned improvements to the registration system by strengthening coverage, timeliness and accuracy of information, and the generation of better quality VS. UNFPA provided technical assistance in terms and equipment from 1992 towards meeting these aims.

In the United Republic of Tanzania, UNFPA had a four-year project to develop a compulsory CR system in a sample area. Various problems were encountered, attributable to delays in release of government funds, recruitment of persons and delivery of equipment, and the chronic shortage of paper and forms, which were also rather complicated to understand. Further, there were difficulties in conducting training, limited transport facilities, and the absence of a central supervision unit. Combined with this was the inadequate testing of forms and the system, which contributed to unsuccessful outcomes from this project. There was also a UNFPA-supported project in Nigeria which aimed to strengthen broadly the overall

CR system and the development of comprehensive population policies. The project included various tactical interventions related to the testing of registration forms and manuals, training of staff, understanding reasons for low registration, and developing recommendations for scaling nationally. The project was adversely affected by funding constraints, and the project objectives were only partially achieved. On a smaller scale, there were positive achievements in establishing some form of a core unit for CR activities, drafting of a uniform law, some training of higher officials, and the establishment of a training facility. However, these achievements could never be scaled, as they had not been assessed with scaling and ICTs in mind.

In Kenya, the UNFPA project conceptualized over four years and starting in 1981 was primarily towards the demonstration of an effective CR and VS system and creating awareness. The first year of the project involved a study of the conditions, the second a pilot over four districts, the third a consolidation phase followed by an extension to four more districts in the fourth year where, however, severe financial and logistic problems were encountered. The project was able to achieve some of its main objectives in helping to establish a national organization including a statistical data processing unit responsible for activities related to CR and the generation of statistics. Furthermore, recommendations of best practice were made, including the use of motorcycles in place of other vehicles for transport to boost registration, simplification and decentralization of registration procedures, better training of staff, and building more awareness about the importance of CR systems for broader planning purposes.

In Myanmar, the UNFPA-supported project was towards the improvement of CRVS systems more generally, with short-term objectives of extending the CR system nationally and providing training to ministry staff on data utilization. Project delays were considerable, contributed to by the shortage of paper and other logistic and political issues. There were some positive achievements with respect to central-level capacity building. At the end of the project term, the total coverage was still only 33.7%. After an assessment, the second phase of the project was initiated, which involved the redesign of the forms and strengthening attention to improve the VS system. Modification of the forms was not successful, attributable to lack of contribution from the government. At the end of the project period in 1992, the project had achieved partial success by covering a considerable population. In general, the project could not bring in systemic operation, and no provisions were made to revise data collection forms.

In Botswana, a UNFPA-supported project from 1983 was towards strengthening of CRVS systems in demonstration areas, including efficiency and timeliness which could potentially be scaled to the entire population. This involved developing a methodology for the demonstration area, and building awareness and training staff. The project continued until 1993 with limited success including the plans of establishing a microfilming unit and linking it to other government departments. Another UNFPA-supported project in Yemen was explicitly concerned with computerization of the CRVS systems, including also marriages and divorces, in six pilot areas. Partial success was achieved, as a legal basis was established for creating a

law (in 1991), forms and content for recording vital events were developed, and procedures for registration of births, deaths, marriages and divorces was established. Initial steps for computerization of the system were made, but it was not effective in producing reliable statistics from these areas.

In a subsequent document published by the United Nations in 2004 *(47)* some further country-specific CRVS projects were described.

In Nicaragua, the United Nations Development Assistance Framework (CCA/UNDAF) identified the need to improve the systems of CRVS as a tool for national and local planning and evaluation processes. This would help agencies to provide a coherent response to complex problems, involving sociodemographic and cultural perspectives, and strengthening aspects of good governance and decentralization. It would also strengthen the work of the United Nations Children's Fund (UNICEF) on registering children and monitoring human rights, while WHO could generate more accurate statistics on mortality, and UNFPA could create a reliable national statistics system, including the census every ten years.

4.3.2 **UNICEF**

A working paper on good practices in integrating birth registration into health systems describes some UNICEF-supported efforts in the domain of CRVS in Bangladesh, Brazil, the Gambia and Delhi, India between 2000 and 2009 *(39)*.

In Bangladesh, BRIS was envisaged to support UNICEF national activities of strengthening government and nongovernmental bodies in preparation of national plans for children, and child rights implementation and monitoring. The system involved multiple activities including legal reforms, integrating birth registration with the Expanded Programme on Immunization, and strengthening the routine birth registration system. In 2002, in order to introduce electronic birth registration in the country, the Government developed BRIS, which was first applied on a pilot basis in two local government bodies of Rajshahi City Corporation and Gazipur Paurashava. BRIS aimed to store birth information of every individual in a database, automatically issue birth certificates and retrieve information on the birth record as and when required. The database would help to generate periodical reports on implementation progress of the registration system for monitoring purposes, and the central database would be able to be linked with other services. At the time of writing, BRIS was being subjected to a revision, including the development of a web-interface, to deal with emerging issues of interoperability. Deployment was planned from a central server, reducing both the need to install software on local machines and support requirements.

It was reported that BRIS, supported by the centralized and automated searching features, has helped to remove duplication and redundancy from birth registration records, and also make

the process faster by reducing error rates, with a combined ID and bar-coding system. A CD-ROM of BRIS data has been created; in addition to providing backup, it also allows the transfer and reuse of registration data outside the LAN system. The direct costs of system development were less than US$ 20 000 and operational costs around US$ 200 per month. BRIS is also undergoing a process of expansion to include the electronic immunization administration system. In Rajshahi, where this expansion was carried out, it was reported that there was now available more accurate and readily accessible information on birth and death registration. This has helped to strengthen enhanced monitoring of individual child immunization status, Vitamin A supplementation and post-natal care. It was reported that both registration and immunization rates have increased since the system was introduced.

Brazil

UNICEF has supported a strong initiative in Brazil to improve the birth registration rates over the last 12 years. Support has come from UNICEF in the form of advocacy and technical assistance to the government at the central and state levels. In 1997, the government took a key step to amend existing laws, rendering the registration of births and the issuance of birth certificates free of charge. Other efforts have included providing monetary incentives for birth registration, integrating civil registrar and maternity wards, and strengthening the engagement of civil society. Integrating birth registration into health services has required extensive field testing prior to creating a national model. A model system for this was introduced in the state of Pernambuco involving an online birth registration system linked to the health system, based on several prior pilots. Monetary incentives, while useful, need to be conceptualized within a framework of a comprehensive national policy, long-term budget allocations, and joint collaboration at all levels (central, state and local) between CR authorities and the health sector.

The Gambia

The Gambia adopted the strategy of decentralizing and integrating birth registration into reproductive and child health services, as a UNICEF-supported strategy to enhance birth registration. This strategy was enabled through the Ministry of Health's mandate to register children, decentralization of the process of birth registration, integrating birth registration into maternal and child health clinics, and computerization of the system.

Reform efforts have included computerization at the Ministry of Health of the birth registration system which helped the production of draft digitized birth certificates. Funding for this initial establishment of the computerized birth registration system and its subsequent maintenance remains a constraint. However, recent developments in 2009 included the delivery of computer software to the Ministry of Health to help facilitate the storage and retrieval of birth registration data, provided by Gambian philanthropists. Another positive enabler for birth registration has been the linking of birth registration and growth monitoring cards, known in the Gambia as Under-5 Clinic Cards. It was reported that about 90% of babies have such cards, despite the

fee attached to obtaining them. The rationale would be that the fee for the clinic card would incorporate the cost for the issuance of birth certificates. The card records the date of birth of the child or the date first seen at the health centre. The birth registration process then uses this as evidence of date of birth and transfers the information to the birth register. However, automatic registration of births following the issuance of a clinic card is pending.

Delhi, India

The MCD has been in the process of computerizing birth and death registrations since 2003, involving three components: digitization of vital records from previous years for better preservation; launching the Online Institutional Registration (OLIR) in 2004; and setting up a computerized Citizen Service Bureau (CSB) in each zone to support dissemination of the certificates. The digitization project started in February 2003, followed by the launch of OLIR in January 2004 and the setting up of a computerized CSB in each zone. Under the OLIR scheme, all government and private hospitals and other institutions were provided with user ID and passwords. Each vital event (birth or death) occurring in the institution was registered online. The article reported that nearly 400 hospitals had been integrated with the MCD for online institutional registration of births and deaths. Because the scheme primarily covers institutional births, the head of the family or the relative living nearest to the registration centre registers the births or deaths that have taken place at home. There are 191 centres spread across 12 zones, with 137 centres in urban areas, 50 in rural areas and 4 in municipal hospitals. This online registration system manages nearly 1200 entries and generates some 3000 birth and death certificates every day.

The CSB serves as a single-window port for citizens to access different services, including the issuance of birth certificates. Any citizen who needs a certificate can go to the CSB and ask for a printed copy, or else use the online ordering facility, paying by credit card and receiving the certificate at the doorstep upon payment of courier charges. Computerization has also facilitated the process of generating a unique reference number for each child, which helps processes of data management, speeding up the generation of reports and enhanced online monitoring. It has also helped in the monitoring of births by sex and zone.

Furthermore, a pilot project was launched in 2006 to link immunization to birth registration called Linking Immunization to Birth Registration (LIBRE). This covered 32 maternity homes in the MCD area with the aim of integrating basic services for children. This was implemented within the framework of a tripartite partnership involving the MCD, the Office of Registrar General and UNICEF, which provided nominal monetary support to the extent of US$ 13 071. Immunization and birth registration are two services provided for children by the MCD and handled by two separate sections within the Health Department. At the time the pilot was initiated, the birth registration system was already computerized, while the immunization programme involved a manual process, with a fair degree of overlap in data collection and next to no synchronization. There were obvious advantages to be had through integration,

as it would help to track a child from birth to the cycle of completing full immunization (or not) in addition to reducing duplication of work and information flows. Data entered once while registering births would also be used for immunization and the compilation of a database on children by area, which would be used for planning and supervision at the facility level, including the generation of electronic registers. It was envisaged that the system would help to strengthen reporting of events (births/deaths) occurring in the community covered by outreach staff of the immunization programme (called Auxiliary Nurse Midwife/Basti Sevikas), including unregistered children born outside the MCD area. This information would be sent to the Office of the Registrar General of India for forwarding to respective states (provinces).

As a part of the preparatory phase of the project, a feasibility study was conducted, some basic hardware including broadband connectivity was provided and health staff were trained on computer basics and data entry. An external agency was contracted for the development of the software, which was first pilot tested in two maternity homes, after which further changes were incorporated. The software was developed in Java with Windows as the backend, and made available on the Internet in July 2007 followed by user testing in August 2007, including issues of user IDs and passwords for uploading information. A MIS cell for data compilation, analysis and publication of reports was set up, and from September 2007 the software was used by all 32 maternity homes covered under the pilot project. UNICEF supported two components of this pilot project, namely staff training and software development, and the project was scaled to cover the entire MCD area from April 2008 onwards.

4.3.3 AFRICAN DEVELOPMENT BANK

UNECA, together with the African Union Commission, the African Development Bank and the Republic of South Africa published a report on reforming and improving civil registration and vital statistics systems in Africa in 2011 *(48)*. This report described efforts to support African governments to build modern and accountable public administration and measure and monitor their respective development efforts. Key to this were the objectives of strengthening the capacity of national governments to manage the recording and service provision of vital events, and of the national VS compiling offices in the production and dissemination of flow of demographic and health statistics for national, sub-national, regional and international consumption. The tangible targets for improvements envisaged included for the member countries were as follows.

- Improve coverage and completeness of CR in member states:
  - two thirds of member states with current coverage level below 40% reach over 50% by the end of the plan period;
  - two thirds of the member states with current coverage level between 40–60% reach over 60% by the end of the plan period;

  - two thirds of the member states with current coverage level between 60–80% reach over 80% by the end of the plan period.

- Improve timeliness and completeness of VS in member states:
  - two thirds of the member states with current coverage level below 40 % reach over 50% by the end of the plan period;
  - two thirds of the member states with current coverage level between 40–60 % reach over 60% by the end of the plan period;
  - two thirds of the member states with current coverage level between 60–80% reach over 80% by the end of the plan period.
- Improve timeliness, quality and use of VS in member states:to reduce the time lag in the release of annual VS reports to below six months, and increase by more than 50% the number of member states producing VS reports, using VS from CR, and using death records for compiling COD statistics.
- Establish integrated population registers/databases: at least half of the member states to initiate the creation of population register/database by the end of the plan period.

The strategies to reach these targets involved: (a) conducting comprehensive assessment of the status of CRVS; (b) ensuring country ownership and leadership; (c) updating and improving methodologies, operational and monitoring mechanisms and tools; (d) strengthening collaboration and integration of the organs of CR and VS; (e) harmonising initiatives and approaches; (f) promoting data use and quality assurance mechanisms; and (g) building sub-regional, regional and international partnerships. It is important to note that no explicit mention was made of strengthening technology-based interventions.

4.3.4. **NORAD**

Skiri and co-workers, for the Norwegian Agency for Development Cooperation (NORAD) describe the web-based system to modernize CR in a multi-party collaboration in Albania *(37)*. This system uses a central population registry, where each citizen is issued a unique ID. This registry is based on proprietary software, and despite its high cost is reported to be implemented countrywide and well established. The system has not been adapted to other countries, possibly due to restrictions imposed by the proprietary nature of the software.

4.3.5. **UNECA**

UNECA is currently hosting the Africa Programme on Accelerated Improvement of CRVS (APAI-CRVS), a medium-term plan adopted in 2010 by countries in the African region to face the challenges related to CRVS systems *(48)*. This strategy was directed towards bringing

various on-going CRVS initiatives and activities in Africa into a consolidated policy and advocacy framework. The programme is developed on the basis of United Nations principles and recommendations on CRVS, in order to inspire policy-makers and programme managers at the country levels. A consortium called the CRVS Core Group was formed to support the implementation of APAI-CRVS consisting of various international partners including the HMN, with UNECA being the coordinating entity. Countries are expected to come with their plans based on systematic assessment of the CRVS systems. UNECA is putting together a resource pool of experts to support the countries implement their plans.

4.3.6. **HMN**

Strengthening of CRVS IS one of the main focus areas of the HMN MOVE-IT initiative. HMN has been supporting countries to improve their CRVS systems by providing assistance to develop guidelines for policy, legislation and infrastructure. Further, HMN has been facilitating the development of country case-study reports and work plans for CRVS, including various other technical products. In its corporate plan (2012–2013) *(49)* HMN allocated 22% and 11% of its total budget, respectively, for HIS strengthening through support for catalytic activities and key innovations.

Summary. It seems clear that donors have been very active in this domain for over two decades. Especially active seems to be UNFPA and UNICEF. There have also been a whole range of countries from Africa, Asia and the Americas that have been supported, and positive results have also been achieved. Various approaches to strengthen CRVS systems have been adopted, including institutional reforms, data management and, to more limited degree, computerization efforts. UNFPA has supported computerization of CRVS systems in Syria and Yemen while providing assistance for strengthening institutional and legal systems in general in Botswana, Kenya, Lesotho, Myanmar and the United Republic of Tanzania.

The UNICEF approach is interesting as it seeks to strengthen birth registration in conjunction with systems for child health management, such as immunization and child growth. BRIS of Bangladesh, which has integrated birth registration with the immunization IS, is one such initiative. Monetary incentives in Brazil and legal reforms in the Gambia have shown success in improving birth registration. Birth registration in the Gambia and India is supported by computerization. The MCD example in India is interesting as it links the birth recording in maternity clinics with birth registration in the registrar office. The MCD case is discussed later in this report as a best practice case-study. The African Development Bank initiatives seem to focus on strengthening CRVS systems generally in its member countries. Computerization is not explicitly mentioned in the various reform efforts. The modernization of the CRVS system of Albania was jointly supported by NORAD and the European Union, with positive results. This too is discussed as a best practice case example later in the report.

As with our other inferences at the end of the two previous themes, it does appear that initiatives to support death registration and COD are far more limited. The same case is also found with donor initiatives, where the emphasis is more related to birth processes and not death.

4.4 THEME 4: CRVS INTERVENTIONS BY TECHNOLOGIES

The focus of this report is primarily to analyse the application of mobile and computer-based technologies in the CRVS domain. These are discussed respectively in the following two sections. We also briefly discuss interventions based on digitization and scanning, and provide a short overview of some of the computer-based tools available for CRVS.

4.4.1 MOBILES FOR CRVS INTERVENTIONS

The review identified various examples of interventions based on mobile technology to strengthen CRVS systems, discussed below.

Ngoma and co-workers *(15)* describe examples from Malawi and the United Republic of Tanzania to apply mobile phones to strengthen birth registration. While it is reported that the intervention helped to improve the registration rate and the flow of birth information from the community level to the district level, no tangible benchmarks were provided. In post-conflict Liberia, the Liberia Mobile Birth Registration (MBR) project utilizes low-cost mobile solutions, including GPRS technology to support birth registration. Data capturing was done using the open source NDG tool developed by Nokia. Data collected by the mobile phone is transferred to a central server and stored in a MySQL database. Mapping of data is done using a GPS-based system, which has the capability of transmitting data directly to the national as well as regional levels. The MBR has reportedly demonstrated the potential of employing ICT as vehicle to strengthen the realization of basic civil rights in a post-conflict society *(20)*.

Ghana has experimented with using mobile technology for reporting births and deaths from the community to the local health centre level *(5)*. Actual investigation of the incident is supposed to be carried out by a supervisor who will travel to the place of occurrence, after having received the information of the event through the phone. This represents a good example of using computer and mobile technology in conjunction. In countries such as Malawi and Uganda, where a high proportion of births occur outside health facilities and the registration rate of these births remains low, mobile technology holds particular promise to improve access and reach. It is reported that the CR database of Uganda s accessed and updated by mobile phone, which facilitates the generation of birth certificate at the community level (Taylor) *(24)*.

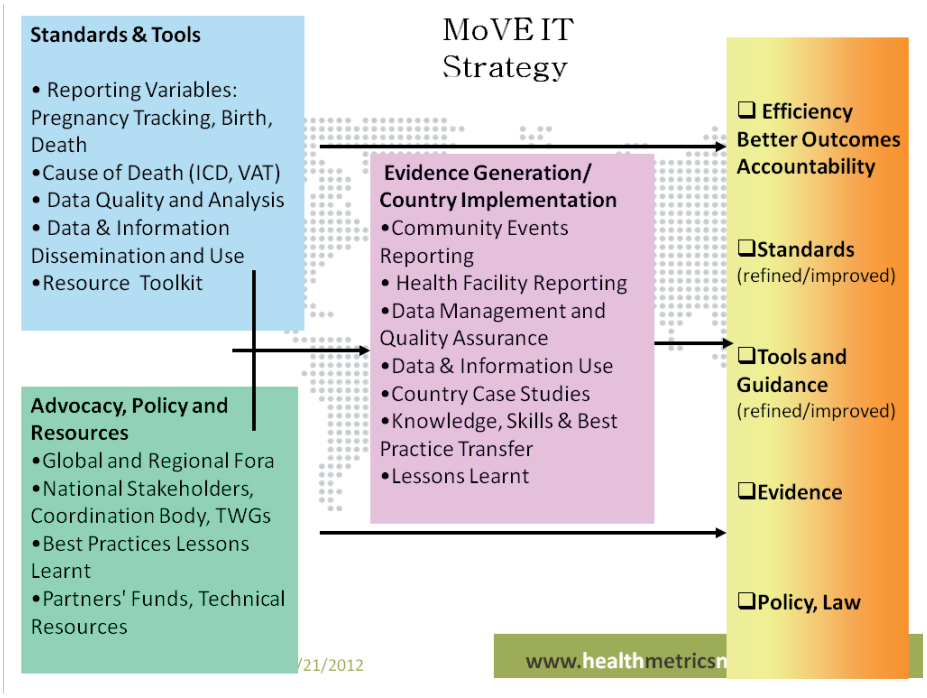
Strengthening systems for CRVS is an important global agenda. For example, the Commission of Information Accountability for Women's and Children's Health (CoIA) was established by the United Nations Secretary General's global strategy to save the lives of 16 million women and children. In operationalizing this strategy, nine working groups were established. The International Telecommunication Union (ITU), mHealth Alliance, NORAD and WHO put together an Innovation and eHealth working group, and made a set of recommendations to incorporate integrated ICT solutions to the national health infrastructure by 2015. In this accountability framework, the assessment of 11 indicators and the strengthening of births and deaths were identified as priority areas. The MOVE IT initiative was also supporting this strengthening process of births and deaths systems. The use of innovative technologies is seen as an important component of this strengthening process.

In operationalizing the above vision, HMNinitiated the MOVE IT project *(50)* to explore how vital events can be more effectively monitored using IT, especially involving the use of mobile technologies. This initiative was inspired by the commitment of various countries and development partners, to make the monitoring of vital events a priority. MOVE IT sought to harness innovation and advances in IT in a drive to record every birth, death and COD, reversing the global and national neglect of this issue. In 2007, HMN's MOVE IT initiative brought together WHO, the World Bank, Centers for Diseases Control and Prevention (CDC), academic institutions and others to set out a strategy for strengthening CRVS systems in countries. This effort culminated in a series of papers in The Lancet, launched during the Global Forum for Health Research held in Beijing, where the potential of CRVS systems to strengthen accountability, equity and continuity of care were emphasized.

This initiative emphasized a central role for technology in enabling innovations, for example of how smartphones can provide real-time data access from remote areas, including the sending of reminders and alerts to health service providers and patients. It was to be explored whether mobile technologies could enable community ownership of reporting of pregnancies, births and deaths. Also, it was to be seen how telephone service providers could contribute to better community reporting and improving access to emergency services, and how incentives could be provided to families to report vital events and access life-saving services, such as cell time or free calls for reporting pregnancies, births, deaths and emergencies. The project in Kenya, for example, includes an experiment with the use of the open source Rapid-SMS technology to send birth information to the district level, whichis piloted successfully.

The MOVE IT strategy has three different work streams of advocacy, provision of standards and tools including mobile technologies, and they generate evidence of what makes things work *(51).* In this way, technology application and its assessment was built into the design of the initiative. The framework of the project is summarized in Figure 8.

Figure 8. **The Health Metrics Network MOVE IT framework**



Source. Monitoring of vital events through leveraging innovations including IT advances (http://ecastats.uneca.org/acsweb/Portals/0/ASSD/3/MoVEIT%20ASSD%20Cape%20Town_MA_final%20ppt.ppt).

Within the HMN framework, 20 projects in different countries were initiated including the following: in Africa, Botswana, Egypt, Ethiopia, Ghana, Kenya, Mozambique, Rwanda, Senegal, South Africa and the United Republic of Tanzania; in Asia, Bangladesh, Cambodia, India (one region in Bihar), Indonesia and Thailand. The initiative received funds of US$ 3 666 000, contributed by the Bill and Melinda Gates Foundation, the Netherlands Ministry of Foreign Affairs, the United States Agency for International Development, CDC and the World Bank *(49)*.

MoTech *(52)* represents another mobile technology-based initiative, though not explicitly supporting CRVS systems. The focus here is on care processes for pregnant women and new mothers. This initiative is ongoing in the Upper East Region of Ghana where Internet access is virtually non-existent, literacy rates are low, and travel distances significant. Local beliefs and superstitions often guide women on health-seeking behaviour. For example in Kassena-Nankana West, elder female relatives encourage young pregnant women to deliver at home rather than in a clinic as this reflects a mark of strength and willpower. MoTech seeks to integrate the mobile phone into the rural health system, enabling pregnant women and new mothers who own or have access to a phone to receive relevant and personalized health information, such as messages for patients who are overdue for routine check-up. Individual level data can also be aggregated to generate statistics for the health catchment area. Such information is useful for both the service providers and the pregnant women receiving services. Currently, MoTech includes sixteen different types of data entry forms pertaining to various

client encounters, such as patient registration, antenatal care visits, postnatal care visits, and delivery information. The mobile phone application also includes various query forms that allow real-time retrieval of information, such as patients overdue to receive a service, and the system can thus generate an overdue report and send to the nurse for action. Data captured by MoTech (via mobile phones) can be aggregated to generate the monthly reports, a task previously done manually by health workers scanning paper registers. The mobile phone data collection system is based on openXData, significantly based on the W3C xForm standard (http://www.w3.org/MarkUp/Forms/).

Dimagi, a privately held software consultancy founded in 2002 in the USA, has been working nearly exclusively in the domain of mHealth. Commcare, a free and open source mHealth application, is one of Dimagi's products being used as a job aid for community health workers. Commcare supports, amongst other processes, the tracking of mother and child. The application also supports users with lower levels of literacy using audio clips and images to reinforce each prompt, creating a simple interface. Commcare applications are used in over 25 countries for various purposes from health promotion to disease surveillance activities. Commcare is supported by the United Nations Foundation, the United States Agency for International Development (USAID) and many other support agencies. In India, the National Rural Health Mission is using this application for community health care. In the United Republic of Tanzania, this application is used in home-based care, neonatal care and emergency case management. Meanwhile in Zambia, Commcare is used as a stand-alone database to store individual patient records. In this way, Commcare as an open source application has the potential to be used for CRVS applications, but currently is not doing that. In India, many of the states have initiated mHhealth-related projects in conjunction with theMCTS, which is used for tracking pregnant mothers and children for immunization. The mobile application typically sends SMS from the server to the state administrators informing the number of women registered for the day and similar such information. Some other states also do the name-based registration and service updating on the phone and send the data to the server, and the service providers receive acknowledgements and activity schedules on the phone from the server. However, since the MCTS is not linked to CRVS systems, it does not make an impact there.

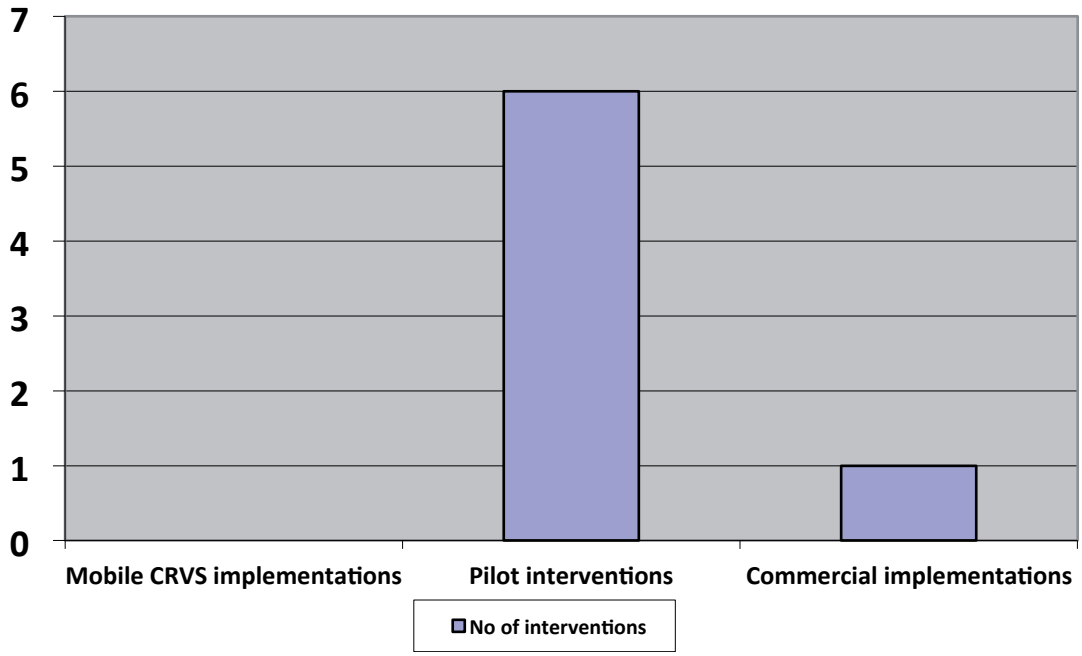
Another notable mHealth application is that in Punjab State, involving 5000 health workers who have been given mobile phones from the government. The phones are used by the health workers to send monthly reports of the routine data to the state server which is the HMIS application on the DHIS2 (District Health Information Software). The state wanted to take advantage of the fact that the health staff had phones and were trained to report data on it, to have them to also report on birth and death data. However, since that data went to the state registrar and not to the health department, the application could not go further. Despite the technical infrastructure being in place, the advantage to use it for CRVS was missed because of institutional considerations. Nevertheless, from this same state we

have an innovative example of how another wing of the health department used the same infrastructure to carry out a household survey to identify cases of cancer. Survey forms were filled on the mobile and sent into an application called the DHIS2 Tracker at the state level.

While it is positive that new technology is being harnessed to improve IS, including relating to CRVS and health, there is a tendency for pilot projects to be established with little coordination among them, nor with the aim or ability to scale. This has become known as "pilotitis" and represents a risk for CRVS initiatives.

Summary. There are many efforts globally to use mobile-based applications for strengthening mother and child care related information, including tracking of pregnant mothers and children for immunization. By definition, these applications would also capture data related to birth of the child. However, there are no examples published relating to the linkage of the systems with CRVS. Some mobile applications have been used at the pilot level to register births, but limited published examples exist of their scaling beyond the pilot.

Figure 9. **Mobile CRVS implementations**



The MOVE IT sets of applications are by definition supposed to be oriented to vital events. In some of the projects, such as those in Kenya and Rwanda, Rapid SMS-based applications are used to transmit information from the peripheral area to the district about the event of a birth and death. These are used more as triggers to initiate registration action. We also find other innovative uses of technology in other countries, but these are not linked to CRVS. For example, in Ghana a health education and health promotion campaign is supported through the mobile phone oriented towards reducing maternal and infant mortality. This application

helps to provide health advice through the mobile phone using the MoTech program. In another application in India, the phone is used to deliver multimedia training programmes to pregnant mothers on how best to manage their pregnancy. In Uttar Pradesh state in India, an interactive voice recording system is used to allow more than 100 000 schools to report on a daily basis the number of meals given to children under the midday meals programme. The mHealth Alliance has reported on a number of interventions, although none are directly related to CRVS, but concern initiatives such as healthier ageing, promoting maternal and newborn health, improving health education, and supporting the fight against TB. Technologically, the multimedia and also the interactive voice recording applications, though not directly related to CRVS, provide innovative examples that could potentially be adapted to the CRVS domain. Broadly, it could be concluded that the potential which mobile technology has for CRVS not been fully leveraged as of yet.

4.4.2 CRVS INTERVENTIONS BASED ON COMPUTERIZATION

Many countries in the world have initiated efforts to computerize their CRVS-based IS. Countries such as Albania, Egypt, Mauritius, Moldova Mongolia, South Africa and Thailand have developed comprehensive national CR systems, some of which are using population registers. For example, Albania has used a population register that issues a unique ID for each citizen, and the system registers all vital events from birth to death and also generates VS *(37)*. This is a web-based system and it is developed based on proprietary software at a high cost, but is reported to be successful. Currently, the system has weak protocols and standards to link up with other governmental systems.

The Ministry of Public Health in Thailand is coordinating a project setting priorities using information on cost–effectiveness analysis (SPICE), which has a similar approach to the Albanian system for registering its individuals. This CRVS system also issues a unique ID. Compared with the Albanian project, the Thailand one shows more openness as the system readily shares CR information with other government departments and other service providers in the country, such as with the Department of Local Administration and Ministry of Interior. Such integration limits redundancy as it involves data sharing between different entities dealing with patient diagnosis, in-patient financing and insurance schemes. This sharing supports the annual reimbursement to hospitals using diagnosis-related groups involving 5 million in-patients (7 million admissions). The system provides standard data sets for health insurance, patient demographics including citizen ID, diagnosis and ICD-coded patient discharge status.

Similarly UNECA *(42)* has reported that Mauritius is operating a new system to manage CR under the eBusiness plan. This system registers vital events and generates VS information as well as generating statistical reports at regular intervals. Mongolia is reported to have automated all CR registration activities, covering 97.8% of its population *(43)*. The CR system

is linked with other government information sources and also with Mongolian embassies in other parts of the world. From Latin America, a good example of computerization is found from Chile. The Registrar service offices are linked with a single computerized network and each citizen is issued with a unique ID *(38)*. Information collected at services offices are sent to the national level every six months to generate statistical reports. Though it is considered as a less sophisticated system, it is seen to be functionally effective.

Egypt is described to have a different approach to register its individuals. While Albania and Thailand use a population register, Egypt has utilized an enterprise data warehouse to gather CR information that is reported to be implemented countrywide *(25)* through CAPMAS, which has the authority to manage all public information and CR data, and actively share it with other departments. Since registration has become mandatory to access other public services, it has helped to significantly improve registration coverage. The eGovernment plan of Fiji has modernized its CR system through a common government portal, and is also integrated with the health and statistics departments. Moldova provides an alternative approach based on the Voter Registration System whose primary aim is to generate the voters list. The SAISE election system is expected to be implemented countrywide by 2014 according to the OSCE *(44)*.

The Millennium Village Project (MVP) is offering an innovative integrated approach to rural development, including the overlapping areas of agriculture, education, health, infrastructure, gender equality, and business development. The MVP has covered 12 villages in Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Uganda and the United Republic of Tanzania. In the health sector, key MVP activities include renovating health facilities and hiring health personnel to strengthen early detection and referral for treatment. The interventions have involved the development of the Millennium Villages Global Network (MVG-Net) as a comprehensive open source eHealth architecture and service delivery platform based on OpenMRS. This has reportedly helped to generate data to track individual progress and also support facility level aggregate data-based management. MVG-Net currently has two main components: ChildCount+ and OpenMRS. ChildCount+ (http://www.childcount.org) is a point-of-care SMS-based mobile phone system that enables data collection, reporting and feedback for health workers, including on all local births and deaths. The OpenMRS is an open source electronic medical record platform that uses a centralized concept dictionary to collect person-level health information from different technologies, including the Childcount+ mobile system. OpenMRS is used by MVP as the core of MVG-Net as well as for collecting data directly from facilities in the MVP villages. Furthermore, the system is reported to be capable of generating VS for a cluster of villages *(16)*.

South Africa also uses an electronic system to manage CRVS data, which supports registration of 86% of births and 83% of deaths. There are various other initiatives to strengthen CR in developing and rural communities through the Agincourt HDSS in South Africa *(19)*. This system is based on a stand-alone database populated manually by the data collected on vital

events, and can also map them to facilitate spatial analysis. A similar system is reported from Iraq *(35)*, based on a two-stage cluster sampling method of grid-based population data, a GIS, and Google EarthTM imagery. This has helped to survey population-based mortality, carried out in 2011 on a one-time basis, in contrast to Agincourt which is ongoing.

Burkina Faso, Ethiopia, the Gambia, Mozambique, Senegal and the United Republic of Tanzania are all reported to have introduced stand-alone CR systems based on HRS to register births, deaths and migrations. These demographic surveillance systems have largely been limited to pilot areas *(34)*. In Namibia, there is an ongoing experiment to provide a birth certificate to all babies before they leave the health facility, and also to try and link the CR system with other government systems such as relating to the issuing of ID cards and passports *(28)*. Similarly, in Botswana, there is an initiative to register a birth or death as and when it occurs, and to enable integration with other government information flows nationally *(28)*. Sri Lanka is using a web-based system to improve VS reporting from hospitals by transferring morbidity and COD data based on ICD codes to the national level. This system currently covers about 30% of hospital deaths, with plans to scale it nationwide *(16)*.

Computerization has also supported systems for COD and VA information, such as with the Mortality Information System in Brazil. This system records ill-defined COD based on data collected in a simple questionnaire *(36)*. Similarly, in India, the Prospective Study of One Million Deaths investigated COD recorded by SRS. This system is supposed to track 14 million individuals from 1998 to 2014 and to investigate COD by VA. These COD are planned to be coded by physicians by gender, age, socioeconomic status and geographical region *(53)*. In Mozambique, there have been experiments reported for ICD-10 based hospital information system for mortality notification, based on an open source SI–ROH software developed locally. It is reported to be currently under a process of national adoption *(18)*.

Important in the development of eCRVS and mCRVS computer-based systems is the use of data standards, for example the minimum data and the format on which a birth or death registration is to be captured. There are efforts ongoing in WHO, Geneva, for the development of such minimum data standards, but which will need to be adapted by countries to suit their individual contexts. We can conceptualize a hierarchy of standards *(11)*, where there is some kind of accepted core set of data standards to which all levels of a national system must adhere, but with flexibility to the different levels to add on to their local list based on their needs.

The District Health Information Software (DHIS2), which inscribes the design principle of the hierarchy of standards, contains two modules that can support birth and death registration. The first is a "line listing" module that can take details for a particular event of a birth or death in a line list. In India, it is being used by many states to list by lines a birth, a death or a maternal death. Screen shots are provided in Figures 10–12 for each of these three cases.

Figure 10. **Line listing of births in DHIS2**

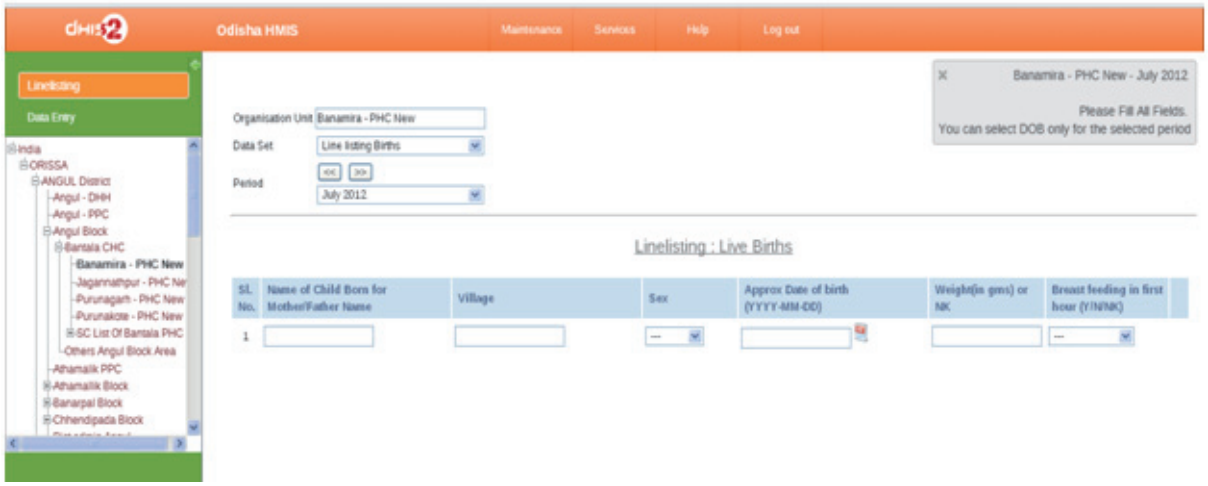


Figure 11. **Line listing of maternal deaths in DHIS2**

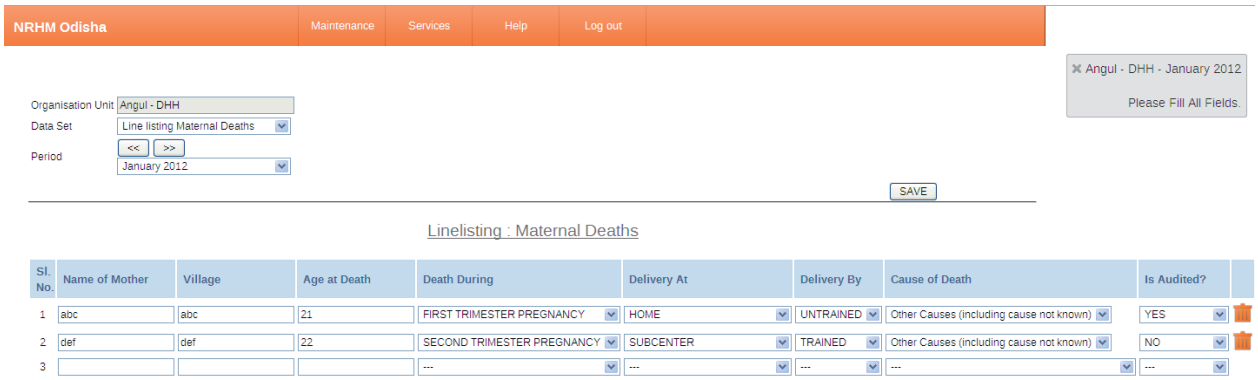
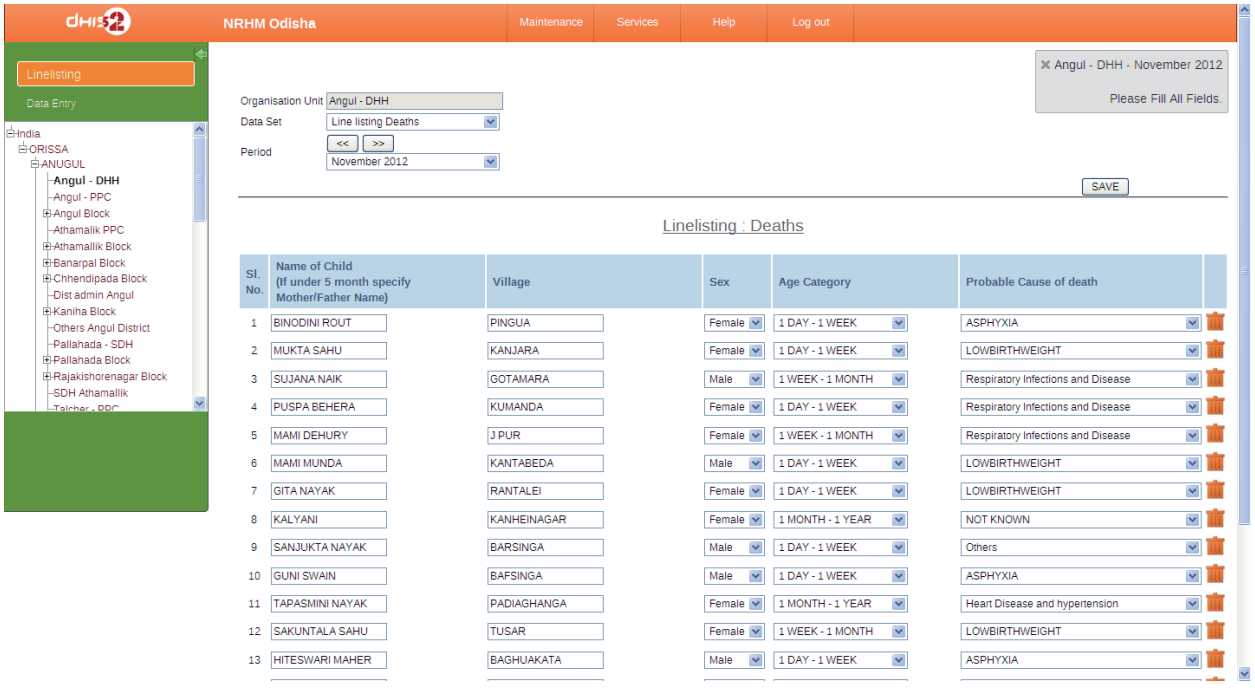


Figure 12. **Line listing of deaths in DHIS2**



The other module of relevance is the DHIS Tracker, which provides the functionality to track by names an individual registered for a health programme with fixed stages such as antenatal care, or for a single event like a birth or death, and also cases under longitudinal treatment for diseases such as tuberculosis and HIV. Uganda is using the DHIS2 Tracker for recording maternal and neonatal death audits: these consist of both a one-page notification form and a more detailed five-page audit form. Similarly, Ghana is using the tracker for three sets of programmes –deliveries, inpatient admissions including deaths, and generating death certificates. Currently, all of these are anonymous, so they do not represent a tracking functionality. But they are all case-based, and data are being collected for statistical purposes. Since these programmes have been rolled out in April 2012, about 80 000 deliveries and 220 000 admissions have been recorded. Screen shots are provided in Figures 13–15 on the tracker use in Ghana. The advantage of using the line list or the tracker module is that the DHIS provides the functionality to directly generate VS from the name-based lists. However, in the absence of these modules being linked to the CRVS system, their potential remains unutilized. Similarly, in the DHIS in Indian states, we have the following numbers available in the database, which have never been made available to the CRVS.

- Madhya Pradesh State
  - 3638 line-listing deaths (last entry in September 2012)
- Punjab State
  - 81 697 line-listing deaths; 530 line-listing maternal deaths; 86 371 line listing births
- Odisha State
  - 41 934 line-listing deaths; 484 line-listing maternal deaths
- Kerala State
  - 14 711 line-listing deaths; 244 line-listing maternal deaths; 9402 line-listing births
- Haryana State
  - 10 990 line-listing deaths; 237 line-listing maternal deaths

Figure 13. **Registration of death in DHIS2, Ghana**

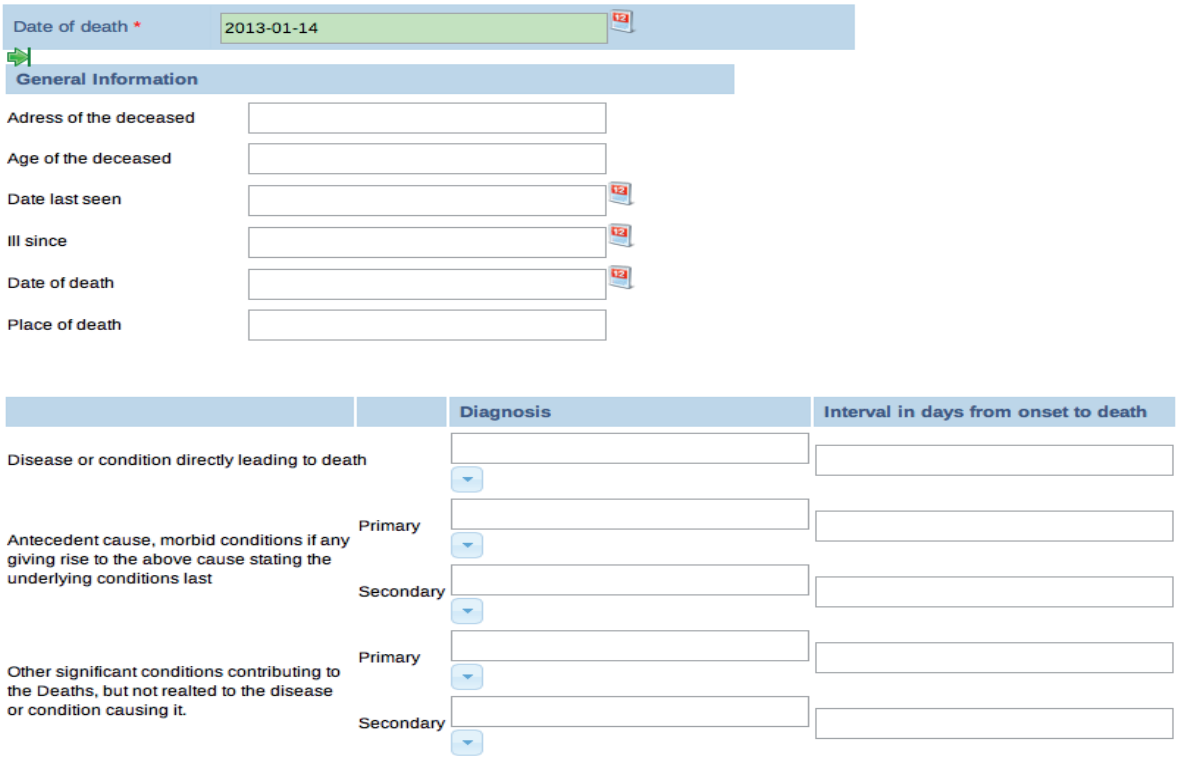


Figure 14. **Deliveries data capture in DHIS2, Ghana**

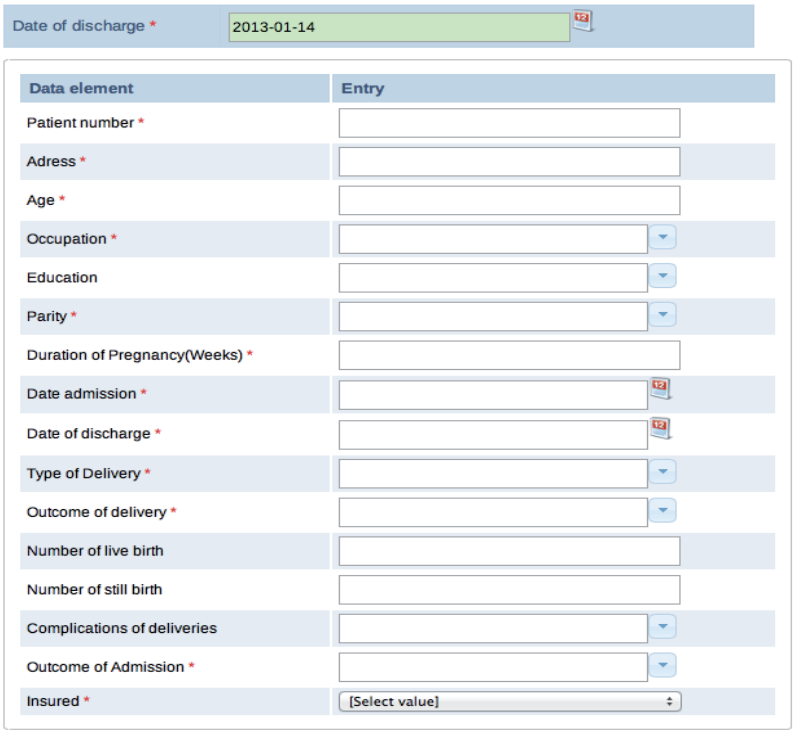
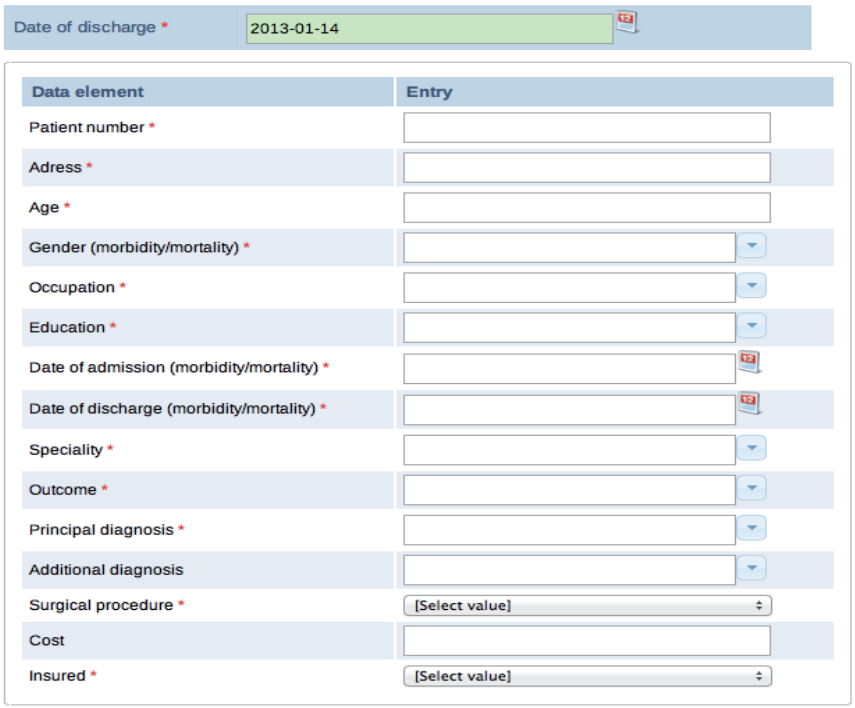


Figure 15. **Admissions data capture, DHIS2 Ghana**



Some other electronic tools

The IRIS software is emerging as an important tool for the independent coding of mortality data based on ICD-10 classification (54) (http://apps.who.int/classifications/apps/icd/meetings/tokyomeeting/B_6-2%20IRIS%20A%20language%20independent%20coding%20system.pdf).

Typically, in the selection of codes for a particular cause, there tend to be significant variations across trained medical coders, attributable to different interpretations. The IRIS software tries to solve this problem by trying to reduce the errors through the assumption that most ICD codes can be mapped to a single Entity Reference Number.

Furthermore, CDC(55) explains that Mortality Medical Data System (MMDS) automates the selection of underlying cause as it receives death data through Mortality Medical Indexing, Classification, and Retrieval (MICAR) and Automated Classification of Medical Entities (ACME). Up to now the language dependence of ICD codes has limited the use of MICAR for the same purpose. IRIS functions as a bridge between language-dependent ICD codes and the MICAR system. Local language ICD codes are stored in a dictionary and these individual codes are mapped in to an ERN. By this approach language dependent ICD code is translated in to language independent ERN's, so language aspect is only present in the ICD dictionary and, furthermore, this provides the necessary input for the MICAR system. Vitalware is another software being used to capture mortality and mortality details, including consultations on

clinical details, investigations and radiological images. For example, this software has been used in a telemedicine project in North India to capture consultations with children *(56)*.

Summary. Computerization is the most widely used tool in the CRVS domain, with its use going back to the 1960s. Broadly, there are two types of computer applications in use: one is individual based and other uses aggregate-based statistics, with more examples seen of the latter. Individual-based systems are again of two types – one similar to Electronic Medical Records, like the systems being used in Ghana and Mozambique under MOVE IT. There are also individual systems that are focused on community care (while OpenMRS is more facility or hospital based), like the tracker and line list modules in DHIS2. There are many instances of these applications being deployed alone – such as in Burkina Faso and Ethiopia – while there are others using web-based deployment. Applications from Albania and Thailand have demonstrated the implications of using proprietary versus open source applications for the CRVS applications. Albania has used a proprietary system, which has restricted the linkages between the CRVS and other government data. In Thailand, in contrast, the open source platform used for the CRVS has enabled more robust linkages with other government departments. The use of a data warehouse approach to the CRVS system, as has been the case in Egypt, has clearly demonstrated the benefits of having integrated data in one place as an enabler of linkages across departments.

Inter-departmental linkages can be facilitated through computerized systems, as the MCD India case demonstrates through the connections between the maternity clinics and registration offices. This has helped to have a very efficient system for generation and dissemination of birth certificates. The use of biometrics is one of the many tools being used to try and provide security and privacy to personal information. In India, the National Population Registry is a comprehensive identity database to register all of its usual residents; itis being mobilized in a phased manner, based on a house listing of residents being done since 2011 using a household survey. Information is being collected on every resident, in paper-based forms, which is then scanned and digitized and a textual record for each resident is created. These records are consolidated with a biometric identification consisting of the Iris of both eyes, fingerprints of both hands, and a photograph. The verification of biometrics can eliminate duplicated records and each person is to be issued a unique ID called "Aadhaar" along with a smart card for each resident containing a microchip with selected demographic and biometric attributes *(57)*. There are also other examples of use of biometric identification as a measure of ensuring data security and for access control. Albania, Mongolia and Thailand are examples where biometric identification and passports are being used. While there are various technological measures for security, often these are not effective in the absence of a strong data security policy *(58)*.

4.4.3 EXPERIENCE FROM DEVELOPED COUNTRY CONTEXTS SEEN AS RELEVANT FOR LOW AND MIDDLE INCOME COUNTRIES

In this section, we present CRVS-related experiences from the context of two industrialized countries – Australia and Denmark – which are seen to be relevant also for low and middle income countries. These are now briefly presented.

Denmark. There are experiences from developed countries which may be useful for low and middle income countries to gain from. One such is Denmark, where the electronic Civil Registration System (CRS) has evolved since its establishment in 1968, and is considered one of Europe's oldest electronic systems *(59)*. Registration starts with the notification of birth to the national birth registry, and covers 99% of births in the country. All live births are registered in the Medical Birth Registry and each birth record is linked to the mother's personnel ID in the CRS. Still births are exempted from registration. For each citizen, the CR system maintains a record containing the Central Person Registry (CPR) number, name, gender, date of birth, place of birth, place of residence, citizenship, vital status, CPR-number of parents and spouses, along with an additional 150 variables. At present these records are updated on a daily basis. The CPR number assigned to each individual is unique and the same CPR number is used in all national registers. The CPR-number has ten digits, where the first six digits indicate the date of birth (day two digits, month two digits, year two digits), the next three digits indicate a serial number to distinguish between persons born on the same day, and the last digit is a control digit introduced to minimize recording errors and also indicates the sex. Once a person has been assigned a CPR number, the same will not be assigned to another, and stays with the person forever. The vital status and the parent CPR number is continuously updated and on registration of marriage, the CPR number of the spouse is linked to the CRS record along with the date of marriage, while the historical data remain unchanged. Change in residential address must be notified within five days, and is changed.

The CRS was established initially for administrative purposes, independently of health and social factors. The CRS which contained all sensitive personnel information is linked with the Medical Birth Registry and the National Register of Hospital Discharges (NRHD) which contains all the sensitive health information of the particular individual. The CPR number does not contain any personally attributable data other than the date of birth and the sex *(59)*. It has been reported by Pedersen *(60)* that the information recorded is of very high quality, and various reasons could be attributed to it. First, information in the CRS is used continuously by the administrative system in Denmark, which corrects errors whenever they are encountered. Second, high quality is ensured by the ongoing validation of information recorded. Third, when the CRS was established, all residents obtained a civil registration number certificate including their own personal information so that potential errors could be corrected. Fourth, registration in the CRS is required by law. Fifth, there is a positive public attitude towards registration in the CRS. Sixth, the CPR number includes easily accessible information on date of birth and gender of each individual, thus ensuring good quality.

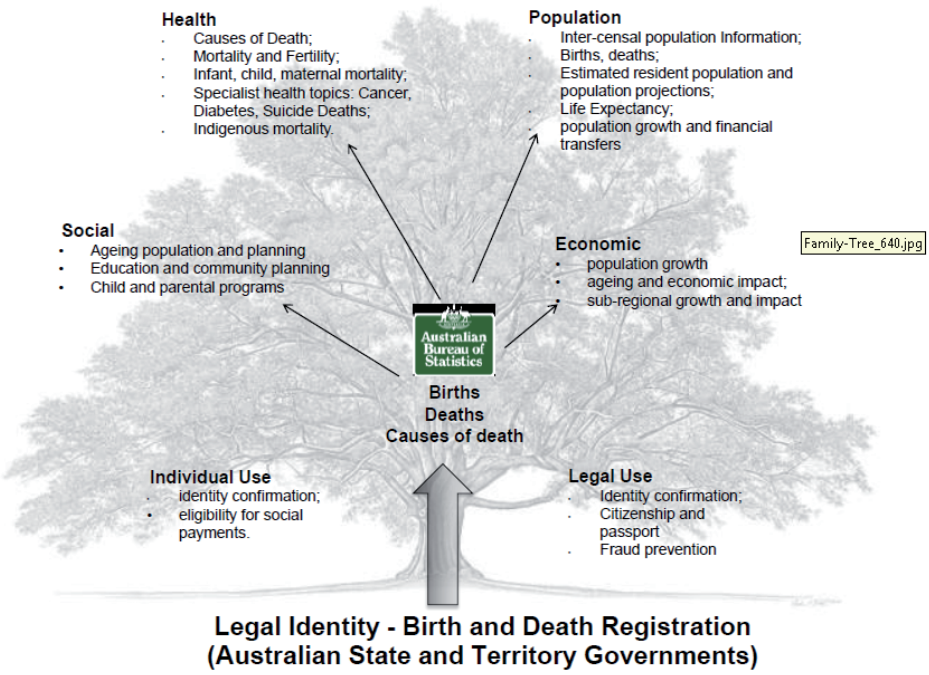
The Danish system reflects a good architecture, where there is a central number that is linked to various other systems, health and administrative, which ensures privacy is maintained while still having a central system of linkage. Security and privacy concerns are important when we are dealing with CRVS, as computerization increases vulnerability of the information as sensitive and vital information is available in electronic format *(58)*. The challenge is to secure information from unauthorized access, while maintaining integrity and ensuring authorized access. The increasing prevalence of cloud computing, while wonderful in expanding access, is especially vulnerable to risks: attacking the cloud can have mal effects on the thousands of computers that may be linked to it.

Australia. Another important example from a developed country context is the Australian CRVS system. A key feature of the system is the manner in which health information is treated as an essential component of the registration process, and birth notifications and medical certification of death must be received before a birth or death can be registered. This creates a very strong incentive in the system for deaths in particular to be properly certified. The Australian system adopts a very holistic approach with the CRVS system playing three key functions:

– providing individuals with a legal identity, which underpins citizenship;
– supporting a variety of government functions, across social, health and economic areas;
– supporting a wide and valuable body of research, especially in the health domain.

These functions are summarized in Figure 16.

Figure 16. **Legal identity – birth and death registration**



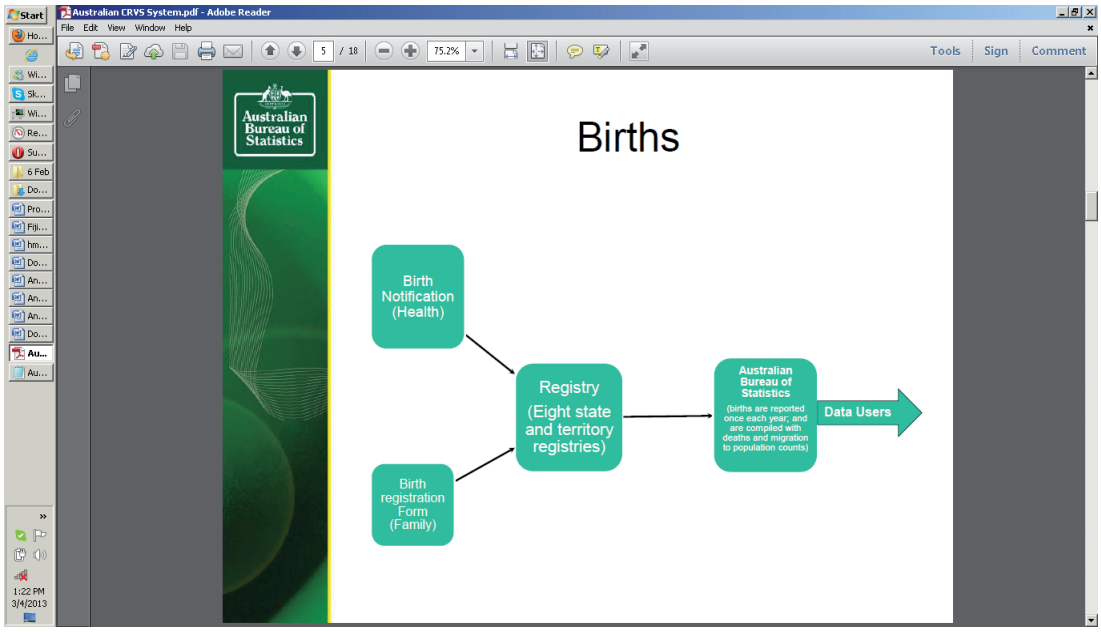
Source. Provided by Australian Bureau of Statistics , Australia.

A key feature of the Australian system is the strong coordination which exists between the different agencies involved in the CRVS, including the establishment of good data collection practices, as well as inter-agency cooperation between people and agencies to achieve good quality data on births, deaths and COD. Some of the agencies involved in the CR data include the health facilities (for births, death certificates), the Registries of Births, Deaths and Marriages, Justice Agencies and courts (for coroner deaths), and various private agencies (such as hospitals and funeral directors). The Australian Bureau of Statistics (ABS) serves as the point of consolidation of data from these different sources, and to ensure completeness and coverage. The registration of deaths is the responsibility of the eight states and territory Registrars of Births, Deaths and Marriages, who receive the confirmation of a birth or death from the health system. Information on COD is supplied by the medical practitioner or a coroner to the registrar, who then forwards it to the ABS for coding and compilation into aggregate statistics. ABS supplements this data with information from the National Coroners Information System (NCIS). Data quality assurance, through the use of the ABS Quality framework, is provided at every point in the production of statistics, including receipt from registries, editing, coding and publication. Care is taken to ensure quality through vigilance and working with the registries.

A strong legal framework governs these processes, including the maintenance and update of registers kept at the office of the registrars. ABS collects death registration information and performs the central function for ICD coding. ABS is estimated to carry out complete ICD coding for all deaths in Australia (around 140 000 each year). It is reported that 85% of deaths are automatically coded using MMDS, based on electronic information received by ABS, while 15% are specially investigated by coroners, and require special collection of information prior to coding. There are various publications generated by ABS to be used for statistics, research and policy. Excel spreadsheets accompany publications, and the births, deaths and population data generated are used widely for government planning and financial transfers.

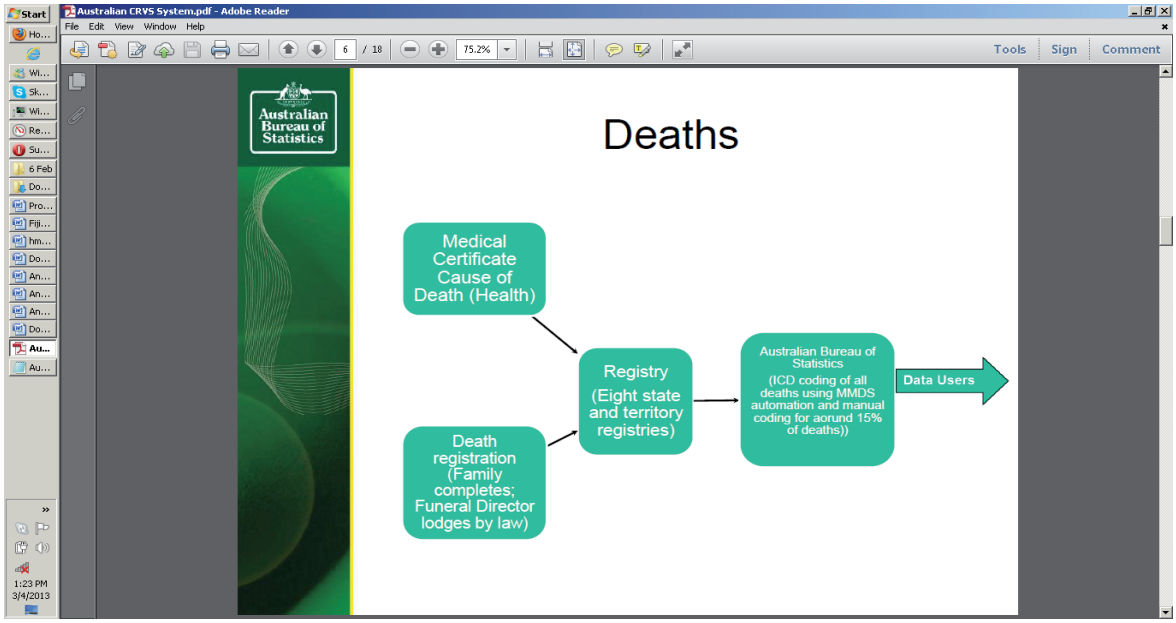
Figures 17 and 18 illustrate the process of information flow for births and death, respectively; Figure 19 shows a detailed flow of death-related information.

Figure 17. **Births**



Source. Provided by Australian Bureau of Statistics, Australia.

Figure 18. **Deaths**

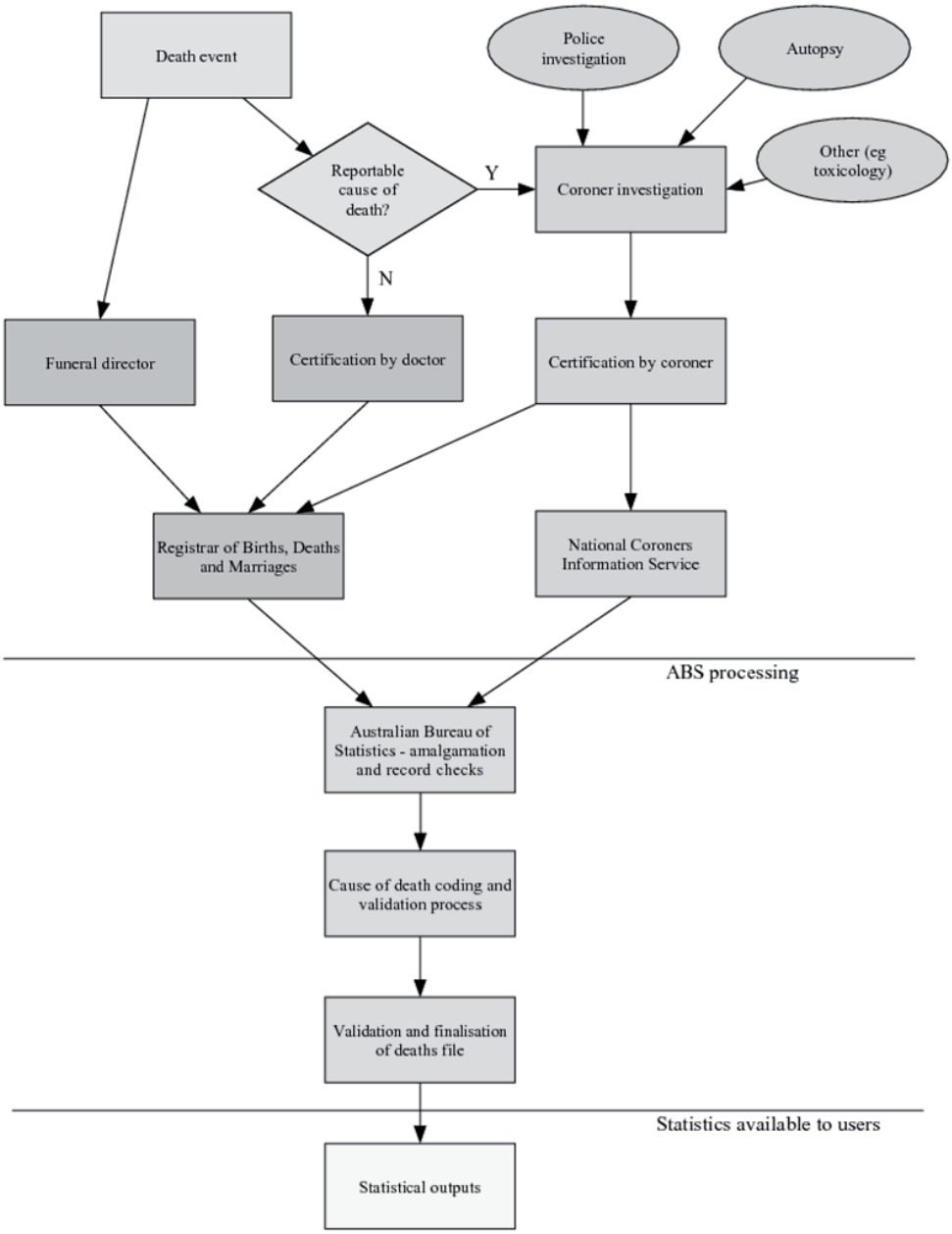


Source. Provided by Australian Bureau of Statistics, Australia

A key learning from the Australian system is the adoption of a holistic approach which pays attention to the different aspects of the data life cycle, from collection to publication and use, and the establishment of strong technical and institutional mechanisms to coordinate the processes. Multiple agencies coordinate their work including eight state and territory registries, eight health systems which look after hundreds of hospitals, eight coroners who deal with "external cause" deaths such as homicides and suicide deaths, one ABS, and many users of the data. ABS, as the apex body, plays the coordinating function for data collection,

consolidation, quality assurance and other aspects to ensure coverage and quality. While there is an increasing adoption of technology, it is being carried out within the institutional processes in place. For example, all hospital information is being provided to the registries electronically. Registries are also beginning to use IT systems to collect death registrations from funeral directors, and are looking into collecting birth registration information electronically through web-based systems. This is expected to help address some of the earlier challenges experienced of collecting forms from rural and remote areas. Electronic media are also used extensively for publishing, including reports and excel spreadsheets (datacubes containing aggregate statistics and information).

Figure 19. **Australian cause of death statistics system**



Source. Australian Bureau of Statistics, Causes of Death 2011, Cat 3303 www.abs.gov.au

4.4.4 CRVS SYSTEMS SUPPORTED BY DIGITIZATION AND SCANNING TECHNOLOGIES

Digitization and scanning technologies seem to have natural application in the CRVS domain which comes through a system historically dominated by existing paper-based records.

In Ghana, the CR forms are scanned, digitized and transferred to the national server through a computer network. This digitization is currently running parallel to the paper-based system. The new digitized forms are indexed so they can be searched and retrieved easily. Plans are being drawn to implement this system countrywide, together with the paper-based system *(61)*.

The Family History Library has microfilmed the CR records of many municipalities in Brazil. Records are dated in some cases from the late 1800s to the 1920s and 1930s, and often up to the 1990s. Similarly to Brazil, Argentina is also using the Family search library *(62)*. These family history records are searchable. Microfilming is considered as an interim measure to bridge the transformation to an electronic information management system *(63)*. The Philippines National Statistics Office is also reported to have digitized and archived available CR forms. It offers the facility of delivering certificates upon online payment, making reproduction of certificates easy *(62)*. The ministries of interior and health and the National Statistics Office are steering actions in CR and COD certification by undergoing a comprehensive assessment and planning process for improving their CRVS system. As the initial step, scanning technology is being used to digitize CR documents *(63)*. In this system, the CR documents of the previous year are collected and scanned at a central registration office. Further, there is a plan to provide scanning facilities to regional registration offices in the near future. In the United Republic of Tanzania, there is reported to be an Under Five Birth Registration Initiative (U5BRI) which uses a combination of mobile and scanning technology for birth registration and certification. From July 2012, U5BRI is being scaled up to the five regions ofGeita, Mbeya, Mwanza, Shinyanga and Simiyu. These efforts are geared towards increasing national coverage and the government's target of 80% registration by 2016 as reported by Registration, Insolvency and Trusteeship Agency (RITA).

In low resource settings, scanning, digitization and microfilming of registration documents can be considered as cost-effective alternative solutions to fully fledged computerization. Scanning technology has been utilized in Cambodia and Ghana, while the Philippines have successfully used a similar approach by microfilming of documents. In Sri Lanka, the birth and death certificates are scanned from the registration offices and the COD information extracted and used for the generation of VS reports.

BEST CASE EXAMPLES

Based on the review carried out, in this section we discuss three examples which we characterize as "best cases", with respect to technological interventions in the CRVS domain.

CAPMAS – enterprise data warehouse

CAPMAS, the Central Agency for Public Mobilization and Statistics, was established in 1964 by Egyptian Presidential Declaration No. 2915. Its mission is to collect, own, analyse and distribute all statistical data for Egypt, including census data. The objective of CAPMAS is to standardize statistical measures and create information that supports strategic and developmental decisions.

CAPMAS was experiencing difficulties fulfilling its mission because it relied on multiple data sources that were not easily linked together, making it difficult also to generate reports. In addition, there was a need to mine data from different sources to gain information to support decision-making. As a response to these challenges and needs, the CAPMAS management decided to invest in an enterprise data warehouse and data mining tools to support the storage and analysis of data. CAPMAS selected Teradata Corporation as a partner for the development of the system. The objective of the data warehouse was to provide accurate, up-to-date information to support decision-makers at the various government agencies across levels to enhance the decision quality and planning efficacy.

With the data warehouse in place, CAPMAS provides important services to Egypt including management of its census data, publishing important indicators for government decision-making, providing necessary information to government and private organizations and on demand to those who may need it. CAPMAS now maintains a large repository of data that are collected from various sources, and information is provided to government agencies either periodically or through on-demand reports. Data collection is done using 100 different static and dynamic forms, which are stored in multiple databases; in turn, these are integrated into the data warehouse to enable information sharing. With this data warehouse in place, a data mining unit was subsequently effectively established.

The CAPMAS data warehouse is connected to the CAPMAS network which is responsible for high-level analysis and data mining. The network is equipped with data analysis tools for data-mining techniques to enable the analysis of important national problems, for example the relation between diseases and COD is of extreme importance to the Ministry of Health. This analysis helps to drill down to issues such as job–disease–death: are there geographical associations? Data-mining techniques help to make the data relevant for government departments and to support planning processes. Such processes of supporting analysis and use would potentially contribute to strengthen the CRVS systems as data would be subject to healthy demand pulls.

Albania – Population Database

The Republic of Albania is a country in south-eastern Europe, bordered by Montenegro to the north-west, Kosovo to the north-east, Republic of Macedonia to the east and Greece to the south and south-east. Albania has a population of 3 260 000 and a density of 113.4 population/km^2. Albania is one of the most mountainous countries in Europe, with a rugged mountain terrain which covers 75% of the territory. Although Albania's economy continues to grow, the country is still one of the poorest in Europe, hampered by a large informal economy and an inadequate energy and transport infrastructure. The general improvement of health conditions in the country is reflected in the lower mortality rate, down to an estimated 6.49 deaths per 1000 in 2000, compared with 17.8 per 1000 in 1998. In 2000, average life expectancy was estimated at 74 years.

In a generally underdeveloped infrastructure, an old-fashioned CRVS was unable to provide satisfactory citizen-based services. To reform this situation, a project called the Modernization of the Civil Registration System in Albania was initiated. Today, this is considered as a successful project, as is reported to have improved periodicity, quality, reliability and comparability of data and indicators, especially on demography and vital statistics. Statistics Norway has supported the project with technical expertise, including giving the recommendation to purchase software for the National Civil Register (NCR) which has licences as Open source. This enabled the General Directorate of Civil Status (GDCS), Institute of Statistics (INSTAT) and Statistics Norway to maintain the system and to develop it further.

The aim of this project was to develop a population register, a database of individual information of its citizens, to be implemented in three phases. The first phase involved strengthening the ability and capacity of the CR system by establishing a central administrative unit, a central national register and the necessary legislation. The second phase aimed at actually carrying out computerization of 2–4 local civil registration offices, to gain valuable experience. The third phase involved scaling nationally through modernizing the CR offices, including the transition from paper to digital records. Other donors and agencies were invited to participate and support this very resource-demanding task. The model for change adopted was the Nordic model of population registration adapted to Albanian conditions, called the Civil Status (CS) system.

Later, a fourth phase was added aimed at strengthening the ability and capacity of the modernized CS offices to utilize old archive information by securing the material for the future. The proposal was developed by Statistics Norway and the Ministry of Local Government and Decentralization (MLGD). In 2006, an agreement was signed between the European Commission, providing the necessary funding through the Organization for Security and Co-operation in Europe, Statistics Norway, United States Government, Council of Europe and the Government of Albania.

In 2008 all the registration offices were connected through the Internet and all citizens were registered in the digital register based on their register books. This digital register was also used for creating the voters list and to issue biometric passports and identification cards. During the initial stages, the focus was on scanning and archiving of register books and sharing of information with third parties. Statistics Albania utilized this shared information to generate register-based statistics. Even though open source software was used, the vendor developed a system based on OSS but did not give access to the source code, which restricted the freedom for the Ministry of Local Government and Decentralization and Statistics Albania to further develop the application. The vendor would charge for the additional developments.

While the project was under way, INSTAT needed to compare the data collected during the Population and Housing Census of October 2011 with the civil registry data from the NCR. Based on the combination of data from census and CR, INSTAT aims to create a statistical population register, which would support the continuous recording of demographic and socioeconomic characteristics of a population. This combination has required additional developments on the software, involving increased costs, as it required data sharing to take place between the two systems to enable the comparison. Further in to the project, INSTAT needed to compare its own population register with the NCR. The INSTAT population register was created by the 2001 Census, while the NCR database is daily updated by the local CS offices. Matching these data in both registers will serve to create a more reliable source of information. Statistics Norway has developed the web interface in order to allow INSTAT to perform matching of its own data with the NCR. When the system was operational there were new requirements to exchange information through the NCR on births, marriages, deaths and, in particular, infant deaths with INSTAT. After the NCR was established, INSTAT asked the General Directorate of Civil Status to provide such information electronically. This was not possible because the NCR was not designed to collect these data fields needed by INSTAT, soadditional functionalities had to be developed to enable the transfer of NCR data to INSTAT. A €40 000 cost was incurred to develop this functionality for the transfer of NCR data to INSTAT, including additional VS fields required to check the census file.

Despite some delays, arguably, the overall objective of a modernized CR system for all Albania was achieved in cooperation with international and other national agencies. This has helped in strengthening the CRVS system nationally. The system can give users and producers of statistics more relevant and updated data. This was achieved through making historical material accessible in an electronic format, and through the production of register-based statistics. An important achievement, especially with relation to Albanian authorities, was that since 2008 the project has delivered an improved and indisputable basis for voters lists at elections.

MCD, New Delhi

The Municipal Corporation of Delhi (MCD) is a big organization that fulfils various kinds of needs to 14 million customers occupying every single area of Delhi territory. The MCD Health Department has computerized birth and death registrations since 2003 using a good enterprise resource planning (ERP) model of implementation *(64)* with the aim of reducing errors, improvimg speed and efficiency, improving management of human resources, and ensuring more complete access to information and real time transparency. ERP systems integrate all facets of the business enterprise under one suite of software applications (65), and are thus highly complex IS. The implementation of these systems is a difficult and high-cost proposition that places tremendous demands on corporate time and resources. By modernizing the birth and death registration with an ERP solution solves many business problems of the existing birth registration system by reducing paperwork, enabling faster information processing and generating speedy reports on such aspects as material shortages, productivity enhancements, customer service, cash management, inventory problems, quality problems and prompt delivery.

The MCD established its CSB in 2004, which serves as a single-window port for the citizens to access different services, including the issuance of birth certificates. Any citizen who needs a certificate can go to the CSB and ask for a printed copy, or else use the online ordering facility, paying by credit card and receiving the certificate at the doorstep upon payment of courier charges. Computerization has also facilitated the process of generating a unique reference number for each child. It has helped in improving data management, sped up the generation of reports and enhanced online monitoring. It has also helped in the monitoring of births by sex and zone.

The CSB launched OLIR in 2004 and incorporated the health department's birth and death registration system with it. This was followed by establishing computerized CSB in each zone. Under the OLIR scheme all government and private hospitals/institutions have been provided with user ID and passwords. Each vital event (birth or death) occurring in the hospitals/nursing homes is registered online by the institutions themselves. At present, nearly 400 hospitals have been integrated with the municipality for online institutional registration of births and deaths. Because the scheme primarily covers institutional births, the head of the family or the relative living nearest to the registration centre registers births or deaths that have taken place at home. There are 191 centres spread across 12 zones, with 137 centres in urban areas, 50 in rural areas and 4 in municipal hospitals. The online birth and death registration system manages nearly 1200 entries and generates some 3000 birth and death certificates every day.

SECTION 5. DISCUSSION AND RECOMMENDATIONS

In the previous sections, which are primarily descriptive, the different themes were elaborated upon by drawing upon the articles that were selected from the review. In this section we move to a higher level of abstraction: in the first part on discussion we develop inferences, and in the second part make some overall recommendations on how to approach the challenge of leveraging technological interventions more effectively in the CRVS domain.

5.1 POINTS OF DISCUSSION

5.1.1 CRVS INFORMATION SYSTEMS TEND TO BE STAND-ALONE AND FRAGMENTED

While there are various efforts towards building and strengthening CRVS-supporting IS, both through the use of technology and by streamlining the processes and creating guidelines, they have tended to be in a stand-alone mode. By definition, CRVS systems are multisectoral, naturally requiring linkages with other systems such as health, research, population registers, etc. However, the IS by design do not tend to support such linkages, implying that significant proportions of birth and death events being recorded under the purview of these other systems do not link with CRVS. A classic example in this regard is birth and death events being captured separately by the health sector for facility-based events and by local registration when compulsory for home or community-based events. For example, in India national guidelines have been established on MDR, and all states have started to carry out this function. However, and unfortunately, none of these guidelines leans towards establishing linkages between the MDRs and the CRVS. The MDR system is independent of other information flows, as reflected in its guidelines. Community-based maternal death review (CBMDR) and the facility-based maternal death review (FBMDR) are primary sources of information for the national MDR system. According to the guidelines, the MDR system is directed at reporting and notification of maternal deaths without actually registering the death, representing a vertical flow of information, where information is summarized at each level. The information collected in the MDR system includes name age, address, religion and caste, representing demographic information with no identifier that can link these details to the CRVS record. Lack of such a unique identifier makes it impossible share information between different systems, although this very fact secures the privacy of the data more strongly.

In addition to the fragmentation across different sectors, there are further divisions within the CRVA domain itself. There are at least two clear examples of this. The first relates to COD studies. While there are many examples of such studies being carried out, they tend to stay

typically in a research mode, for example the VA studies, and not linked with the CRVS system itself. The second example concerns the generation of VS, which ideally should be aggregated from the various case-based registrations of births and deaths to generate the VS. From the examples that were studied, there were very few of such cases, for example in Albania. In most other cases, it appears as if the VS systems are stand-alone, and generating the statistics not directly from the CR systems.

The clear implication from the stand-alone and fragmented nature of the CRVS systems is that there are births and death-related events that are being captured by these other systems such as health, which do not feed into the CRVS domain, and these challenges are further amplified by the internal fragmentation within the CRVS domain. At one level, for the citizens, who for example may have already participated in the MDR, it requires a duplicate effort in getting the death registered and obtaining the certificate. At the level of institutions, the concerned entities (health and CRVS in this case) lose the opportunity of being able to correlate their figures and mutually strengthen their respective IS. Thirdly, there are clear challenges in data quality, if for example the VS are not generated from an automatic aggregation of the CR data.

5.1.2 LIMITED EXAMPLES OF TECHNOLOGICAL INNOVATIONS IN THE CRVS SPACE

Very briefly, we start by defining some key characteristics of a technological innovation. A technological innovation would be one where through the use of the technology, the user finds a new way of doing an existing work, or to do a new piece of work that was not possible prior to the introduction of the technology. These technological interventions should contribute to cope with a practical problem that the user was facing; in this case we say the problem of poor coverage and quality of CRVS registration. Another important characteristic of an innovation, especially within the domain of applying IT for development problems, is its scalability over both vertical and horizontal dimensions. The vertical dimension implies how the innovation can become increasingly deep rooted and owned by the local environment, and build its ability to survive after the external injection of resources and money is withdrawn, as is typically the case with donor-supported pilot projects. The horizontal dimension involves the capability of the innovation to be taken from one setting or domain to others, for example from the safe setting of a pilot area to the national level. Although some systems become well established in their pilot setting, they lack the ability to scale either vertically or horizontally.

An important point to note in our understanding of an innovation is that a technological breakthrough, for example, new Android mHealth applications, by virtue of the technology does not by itself become an innovation. For it to qualify as an effective innovation, it must be able to solve practical problems on the ground.

The above backdrop and definition of innovation are important to keep in mind within the CRVS domain, as they are relevant to many discussions on new technology types that have demonstrated limited success on the ground. Further, we find multiple examples of small-scale pilot studies, which do not survive beyond their pilot status. A classic example in this regard is mobile technology, which is being positioned by many as a silver bullet to respond to CRVS-related challenges. Despite the significant investments being made in pilot projects, including also the HMN-supported MOVE IT initiative, the phenomenon of "pilotitis" dominates, where projects tend to die at the end of the pilot period and funding. For example, the Yemen project that took place in six pilot areas was never able to go beyond these locations after termination of funding.

There are nevertheless some interesting and innovative approaches to CRVS systems seen in the context of both low and middle income and higher income countries. In the section of best case examples, we have discussed a few interesting approaches. The cases of Australia and Denmark and Australia that are provided from developed contexts also reflect innovative approaches and use of technologies.

5.1.3 DATA WAREHOUSING APPROACHES TEND TO HOLD MORE PROMISE FOR INNOVATION

A data warehousing approach, in simple terms, implies the creation of a data repository that is capable of accessing data from different disparate sources, facilities for extracting and transforming data to a common format, and furthermore provides tools for "business analysis intelligence" in order to be able to carry out analysis and visualization of the data to be able to provide maps, charts and graphs. With respect to national health systems strengthening, the HMN had proposed a data warehousing approach back in 2005. This model was used by various countries, for example Bangladesh, Ghana and Kenya, in order to reform and strengthen their national systems. The development and evolution of the District Health Information Software (DHIS2) under the HISP initiative was inspired by the HMN model *(9)*, albeit with at least three points of difference. The first was that, unlike the one national data warehouse approach advocated by HMN, HISP argued for the possibility of multiple data warehouses, which followed similar principles. An example to this was in Sierra Leone, where because of challenges of Internet access and electricity supply, the architecture adopted was of multiple district-based data warehouses, rather than one national warehouse as was the case, for example, in Kenya. The second point of departure was in adopting a more decentralized approach as contrasted to the central one implied by the HMN model. This is again illustrated by the Sierra Leone case. Also, in India, HISP has supported states to use DHIS2 to develop their respective data warehouses, with a built-in interoperability to the national data repository. This approach was necessitated by the scale in India, and also by the fact that the states did not feel their informational needs were satisfied by the national model.

From the various CRVS examples studied, we find those that have employed data warehousing kinds of approaches have reported a significant degree of success. Two clear examples in this regard are from Albania and Egypt, which have both consciously adopted a data warehouse approach to enable creating these inter-system informational linkages. As an example, CAPMAS system of Egypt has integrated all the state databases into a single enterprise data warehouse, where different government departments share data with one another. The CR department registers its citizens and issues IDs, which are also drawn upon by the ministries of health and social welfare for more effective provision of health and social services.

A data warehousing approach, by design, encourages more integrative thinking. For example, if the same database is used by the CRVS authorities for issuing the birth certificate, and is also used by the passport office to issue the passport, then both the departments have an incentive to keep the database of good quality and up to date. Since one department also suffers if the other does not maintain the database, it is in their mutual interest to keep the database current and of proper quality. Population databases in Albania, Mongolia and Thailand have each been integrated with their respective CRVS databases to facilitate the issue of biometric passports and ID cards. These systems make civil data available to other government agencies that can coordinate their respective services, plus dynamic details such as transfer and change of residence, which are directly related to social benefits, can be better updated by the concerned department.

5.1.4 MISSED OPPORTUNITIES IN USING EXISTING INFRASTRUCTURE

Various low and middle income countries, during the course of their efforts on strengthening health reforms and in trying to establish national population registers, have spent extensive resources in creating national web-based infrastructures. To give examples of few such efforts, in India in 2008 when HMIS reforms were initiated, data could be entered into the national portal only at the district level. Some years on, now 100% of the sub-district units called blocks can enter data from their local facility, and another approximately 50% of the country can also enter data at the lower level of the primary health centre. Furthermore, many states like Punjab have also introduced reporting through mobile phones *(66)*, where health workers from outreach areas can directly send through SMS their reports to the state or national database. In short, in a country as large as India, an ICT-based infrastructure has been established that can support web-based access and reporting from the community to the national level.

A striking example on web infrastructure development from Africa can be seen in Kenya, where since 2010 the entire HMIS reporting is taking place through the cloud. The application running on the national server is being accessed by all facilities in the country to report their monthly data in a timely manner. Facilities are using mobile Internet to be able to establish

connection, and carry out their reporting. The Kenya example, maybe the first in Africa toestablish a national web-based infrastructure on the cloud, is indeed a case in point that such infrastructure is possible. Even in Sierra Leone, a country whose infrastructure was ravaged by civil war, has established a similar infrastructure which allows web access. And where such access is not possible, the data warehousing software can be made to have various ways to allow offline reporting and to be able to synchronize with the web applications. Many countries have also gone through extensive training efforts in making the health staff competent in using the web-based infrastructure.

Through these examples, the point being made is that given that a web-based national infrastructure and the human resources capacity are being established – which already have been in many countries – there is the opportunity for the established CRVS to leverage upon and use this infrastructure to enable the reporting of births and death. Many of the CRVS examples studied indicate that after the pilot, the projects could not scale because of infrastructure limitations. There are various other barriers to sustainability and the scaling of eCRVS and mCRVS. These include issues of multisectoral governance and leadership which is required for these systems and is often not in place. There is also weak understanding of what is the total cost of ownership of eCRVS and mCRVS systems when they are taken to full scale over time. Furthermore, principles of enterprise architecture discussed earlier – which look at issues of technology, data and business requirements in a holistic manner – are not taken into account, implying that the different pieces of the system do not work together. As a result, systems are not able to absorb operation and maintenance phases of the efforts. The lack of standards and weak compliance to what exists further impede the uptake of these systems.

Given these challenges, however, if there is an existing infrastructure in the health department and it is not used by the CRVS authorities, it is surely a case of a missed opportunity. However, there are points of caution to this. While the availability of an infrastructure is a necessary condition for it being used, it is surely not sufficient. For achieving the condition of sufficiency, as our three-level framework introduced in the start of the report argues, technical linkages by themselves are insufficient, and need to be interlinked with political agreements for sharing. In this case, it would mean that the health department and CRVS authorities, for example the department of justice or home affairs as the case may be in different countries, would need to develop institutional agreements for sharing infrastructure and data. The history of integration projects in both industrialized and developing countries have demonstrated that developing institutional integration is far more complex and subject to failures, as compared to building technical linkages.

5.1.5 ANOTHER MISSED OPPORTUNITY: DONOR PROJECTS DO NOT EXPLICITLY ADDRESS TECHNOLOGY ISSUES

Various donor agencies are active in the CRVS domain, including UNFPA, UNICEF, UNECA, the United Nations Development Programme (UNDP) and various others, and since more than three decades, they have supported projects in different low and middle income countries. Examples of some of these projects have been presented also in this study. It is striking to note that in very few cases has the use of ICTs been targeted in design, so as to be able to experiment and learn about how technologies can strengthen CRVS systems. Where technology comes in these efforts, it is largely incidental rather than by design. An exception to this is the HMN-supported MOVE IT efforts, where the focus has been explicitly towards applying and learning about the potential of mobile technology primarily. However, in the MOVE IT projects, two years since they were initiated, it has been observed that many of the initiatives were not explicitly towards births and deaths, but in many cases were focused on tracking of pregnant mothers and child immunization. Further, these projects did not work with the whole CRVS system, but only a small part of it. For example, some of the projects focused on notifying births, but not the next step of how this notification is translated to a birth registration. While technically these efforts are useful to understand the efficacy of the technology, they are not able to take into account the institutional complexity associated with CRVS, and how these shape the technology efforts.

Another significant challenge in donor supported projects is its pilot nature, involving limited geography, functionality and aims. While small-scale experimentations are indeed important to and learn from, before its expansion to larger scale, however it is important to note that this scaling will not happen on its own, but would need to be designed for and planned. It is important to build in the perspective of a total cost of ownership in the design of such systems, so that the efforts required operating, managing and supporting the systems over time if firmly budgeted in the process. In HIS, scaling of IS has been identified as one of the biggest challenges, leading to the demise of many projects before they became useful to the managers. There are various strategies and approaches that have been identified for scaling *(11)* and need to be explicitly considered. Furthermore, donor projects should explicitly build in mechanisms of funding and resources to support these scaling processes.

Introducing technology into development efforts is a complex task, and there are more examples of failures than successes. In the health sector, it has been reported that about 90% of projects are either partial or complete failures. The point made is that learning about design, implementing and scaling technology projects is a specialist job and cannot be taken as a secondary effort. Often in the health sector it is found that there are medical doctors who design software systems, because they believe it is a relatively trivial job which even they as doctors can create. These systems most often do not progress beyond the limited individual efforts, as they have ignored basic principles of systems design, of creating linkages with other systems, and taking into account various institutional complexities. Thus, it is

important that the design, development, implementation and evaluation of ICT projects for CRVS strengthening be made an explicit agenda in donor-supported projects, as has been the case in MOVE IT. The fact that this has not been done in the three decades of donor projects signifies a large case of missed opportunities, and something that needs to be rectified in the future. Even the recent UNECA Accelerated Programmes on CRVS Improvements, does not explicitly take into account ICTs. This can be a serious omission, as there is simultaneously a definite agenda to leverage upon the potential of ICTs to strengthen CRVS systems. With the resources that the donors put into these efforts, they can be leveraged more effectively to impact on CRVS.

5.2 RECOMMENDATIONS

The strengthening of CRVS systems drawing upon the power and potential of ICTs is now a global priority. The CoIA has described its efforts to support 75 CoIA countries drawing upon recommendations of strengthening CRVS systems using an integrated approach with HIS, and drawing upon ICT-based innovations. By 2015, CoIA recommends for all countries to have taken significant steps to establish a system for registration of births, deaths and COD and to have well-functioning HIS that combine data from facilities, administrative sources and surveys. This recommendation recognizes the great potential of ICTs, such as mobile phones, to overcome persistent obstacles in developing birth and death registration systems and rapid reporting of vital events.

Further, CoIA recommends all countries to have integrated the use of ICTs in their national HIS and health infrastructure by 2015. The materiality of ICTs offers functionalities towards speedy sharing of information on results and resources for women's and children's health. Constructing nam-based individual records, collecting data remotely, and their transmission for central storage and analysis are functionalities now available with modern technologies that combine Internet and mobile communications, even from remote areas. New social networking technologies coupled with increasing broadband connectivity create the potential of redefining both the channel and content of communication relating to mother and child health. In order to capitalize on the potential of ICTs, it will be critical to agree on standards and mechanisms for their compliance and to ensure interoperability of systems. This includes the creation of agreements on common terminologies and minimum data sets so that information can be collected consistently, easily shared and not misinterpreted. These need to be operationalized within frameworks of national policies on health-data sharing that ensure data protection, privacy and consent.

The recommendations presented in this section seek to meet these broader mandates established by CoIA, specifically relating to strengthening of information systems through integration, and identifying strategies and mechanisms of innovation. We draw from our

analysis and discussion to develop recommendations, especially relating to how to leverage eCRVS and mCRVS innovations more effectively. The recommendations are described at two levels. The first is at the level of meta design principles which could be adopted for building new CRVS technological interventions. At the second level, we discuss an overall architecture approach that incorporates these design principles within an integrated framework. Finally, we discuss some business cases that could be taken up by countries and donors to try and implement the recommendations being framed in this study.

5.2.1 DESIGN PRINCIPLES

The United Nations Statistics Department has developed a checklist of items representing nine decision points with regard to computerization of CRVS, as follows.

- Defining the framework for CRVS, including which vital events are included and their phasing for computerization.
- Defining the unique key (including the unique ID) to be used in the system to ensure seamless communication between the CR and VS systems.
- Defining the objectives and purposes of computerization.
- Establishing the organization that will handle computerization.
- Deciding overall development and operational strategy.
- Selecting hardware configuration and procurement.
- Inviting external contractors.
- Choosing conversion/initialization strategy, including relating to population status.
- Defining system functionality, including decisions on:
  - events and tabulations to be included;
  - definition of the logical entities and their data items;
  - functions to be included;
  - validation rules, business rules and procedures;
  - (e) utilities to be included, notably security requirements.

On a general note, most design principles that hold for HIS will hold for CRVS although, in the CRVS, we may find some additional requirements coming from the legal nature of the registration process. The design principles are discussed at two levels. The first relates to the development of the CRVS IS, while the second relates to ICT support in the development of the system. While there are obvious overlaps between the two sets of principles, for analytical purposes they are described independently.

Related to ICT-supported CRVS systems

- The principle of "save once and use multiple times". Any electronic birth or vital event record notification, registration or certification should only be captured and stored in a database once with the capacity to be shared between relevant databases and applications as necessary. Institutionally, this requires that in any geographical area, there is only one agency that will record the vital event and be responsible for its registration.
- Any birth or death, if being recorded by an agency other than the CRVS authorities, should explicitly elaborate on the process and system by which it links up – technically and institutionally – with the CRVS system.
- VS must be generated through an automatic process of aggregation from the individual case-based transactions of the birth or death. The VS system should not be a parallel system of recounting the individual vital events.
- Initiatives to identify COD, such as VA or MDR, in its design must ensure linkages with death registration within the CRVS framework.
- Surveys relating to births and deaths must remain just that – surveys – that can be used as a basis to triangulate CRVS data, but should in no event be allowed to become the default CRVS system. They must be withdrawn once the key purpose is met.
- Recording of COD, for example in hospitals, must become the basis for the generation of death certificates.
- Efforts to develop population registries or provide universal identification systems, for example as currently being done in India, by design and a legal mandate, must have a primary key to link it with the CRVS system.
- Scaling of systems, geographically and functionally, must be an explicit aspect of consideration in the design of any new system or intervention.

Related to technology support

- Any technological intervention cannot be designed from scratch, and would need to consider and take into account the existing systems and institutional ways of doing things. Within the CRVS domain this "installed base" is typically in the form of paper-based systems, guided by the strong legal framework that would be in place in the particular country. This installed base cannot be just eliminated through the introduction of new technologies, but will need to be sensitively cultivated, evolved and linked with the new initiative.
- The technology must be designed to support all types of existing systems, for example the current systems can be based on paper, using computers, entering data through mobile phones or any other. Sometimes the assumption made is that all data are electronic, and only provision of electronic import of data is provided. This may then exclude many existing ways in which the work is currently taking place.

- The CRVS system needs to be designed within an "information infrastructure" framework which assumes no finite start and end date to the system, nor a confined set of users. In short, it implies it is designed with evolution in mind, for example the need to incorporate new users which were not originally planned for. The Internet is a classic case of such an information infrastructure which has evolved over time to support a multiplicity of users and applications, starting from a defense application. A similar approach would need to be adopted for CRVS systems, as not only would they support the process of registering a birth or death, but in future could be used to support the process of issuing a passport or maintaining an Electronic Health Record of citizens. In the IS research domain, various principles have been developed to support the design of such infrastructures, including related to design with modularity, a cultivation approach, use of gateways, and bootstrapping, and these can be explicitly drawn into the CRVS domain.
- Various strategies of hedging risks can be adopted in building interconnected systems to prevent overall failure of a system if a component or piece of the whole breaks down. For example, the use of a loose coupling strategy with a gateway can help to allow parts to function independently while contributing to the totality.
- An incremental approach to implementation and scaling, where the system is introduced in a gradual manner particularly to be able to gain initial success in relatively easier areas, and then slowly be able to move to more complex domains. This is preferred over the big bang approach which seeks to change over the complete system in one go, as it minimizes risk, and ensures a gradual buy in to the systems. For example, in Tajikistan the plan is first to computerize the aggregate statistics, and then in the next step move to the individual records and the issuance of birth and death certificates.

After elaborating on a set of meta-level design principles or guidelines, we discuss the architecture approach already introduced in the start of the report, as a framework to strengthen the broader CRVS agenda. This architecture approach broadly encapsulates the different design principles elaborated above.

5.2.2 TOWARDS AN ARCHITECTURE APPROACH FOR CRVS

A CRVS system is comprised of a multiplicity of information flows from different sources and agencies, including:

1. Birth and death records from health department.
2. COD studies, e.g. VA.
3. Systems for birth and death notification, such as being provided through MOVE IT or donor projects, or through community-based systems.

4. Surveys of births and deaths.
5. Population registries.
6. Unique identification schemes.
7. Infant and maternal death review systems.
8. Systems of passport, electoral identification etc.
9. Various others.

Each of these different inputs will have unique relations with the CRVS system, and will need to be explicitly mapped out. For examples, birth records from health registers may provide the source of registration in CRVS, while surveys of births and deaths can provide a framework for triangulation and strengthening data quality and coverage. These relations will be shaped very much by the legal and political framework within the country. To deal with this multiplicity, an architecture approach is advocated.

An architecture approach, put very simply, represents a design approach where explicitly by design we attempt to see how systems – both technical and institutional – can speak to each other. The metaphor of architecture comes from city planning, where it is important that systems of utility, water, power, sanitation, sewage and others are synchronized with each other, for the city to work effectively. Despite city planning efforts, cities, especially megacities in the developing world, are in a state of chaos because they have not been able to anticipate migrations, purchase of cars, natural shocks like earthquakes, and various others. However, most people will agree that without city planning efforts, the conditions of cities would be worse than they currently are. We can adopt a similar perspective for CRVS systems, we need architecture planning efforts, but despite this we are not able to fully anticipate the future. For example, due to security regulations, privacy laws and the advent of new technologies therein, the whole system for CRVS would be under continuous processes of change in the future.

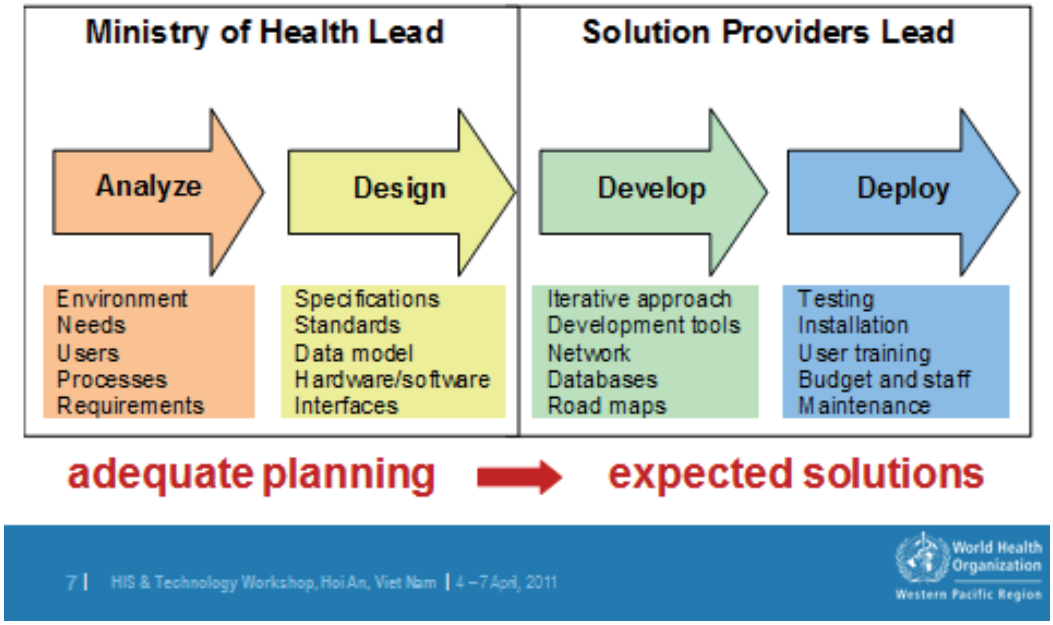
The other important aspect of an architecture approach is that it represents something "which is always in the making, always evolving" rather than a finished product. Given the unknown nature of the future, and our own state of incomplete knowledge, the architecture approach recommends taking decisions which do not block of or make irreversible certain paths in the future. For example, investing in a proprietary system which does not allow the possibility of making changes in the software or being able to link up with new systems that will come up in the future will not be a recommended approach. An open standard and open software approach which allows the potential for change, even if we are unsure of the nature of change, is strongly recommended. An open source approach is free from licence restrictions and allows the possibility to make changes. The organizations involved, however, need to build

capacity to carry out the changes, and establish policies to identify who and how changes can be made. As has been now clearly established in the literature, proprietary systems have often contributed to the failure of many HIS in low and middle income countries, as they create vendor lock-ins and require enabling contractual conditions, often not easy to create in the bureaucracies of these countries. Furthermore, often the prohibitive costs involved of licences of proprietary systems make them a rather unviable option for large-scale deployment.

An architecture approach based on open source software and standards enables more effectively (as contrasted with proprietary systems) the scope for combining technologies and applying them to different uses. It allows a modular approach to scaling, and to manage complexity by mindfully isolating distinct subsystems that can be dealt with independently. In summary, the architecture approach represents a strategy or road map for good design, based on an approach that is always evolving, but within a metatemplate which enshrines the design principles documented in section 5.1.

The basic building block of an architecture approach is a data warehouse, enabling the creation of a data repository capable of receiving data from different disparate sources. The other building block concerns standards – both semantic and syntactic – that allow data to have shared meanings through which they can communicate, and technical protocols for data exchange. The enterprise architecture approach as adopted in the development of health information architectures provides a useful framework to approach the development of CRVS-related architectures (see Figure 20).

Figure 20. **Enterprise architectural approach**

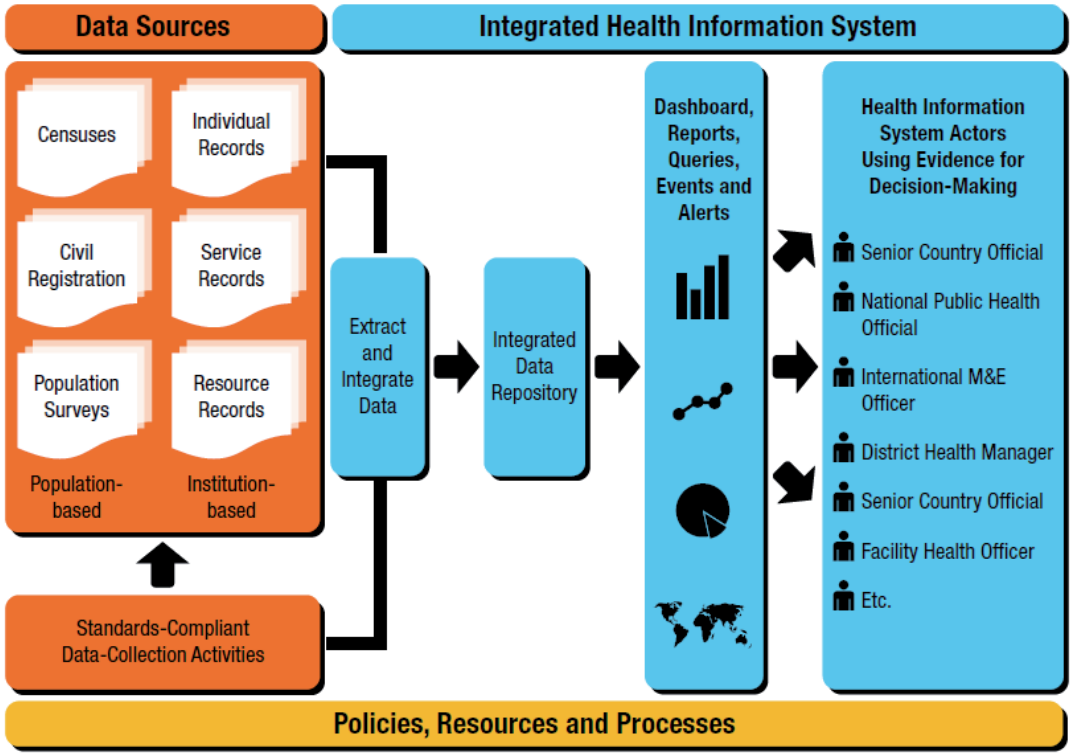


Source: (12).

In the health sector, the significance of this data warehousing approach was promoted by HMN in 2005, through the framework depicted in Figure 21. Core operating principles were of providing flexibility of customized information systems for different needs and data sources, and the ability to create outputs of different forms for various users deploying business intelligence tools.

On the output side, there are of course the core functions of registrations of births and deaths, and the VS that are generated from the CR records. Further to that, there would be specific kind of outputs that can be required and tailored for passport office, internal security, insurance, universal health coverage and others. The data warehouse should provide the functionalities to provide these outputs in reports, tables, charts, graphs, maps and others as desired by the users. In this way, there are two key roles of CRVS. One, CR should be handled by expert systems with core functionality towards registration of births, deaths, marriages, divorces and the like. Two, the aggregate statistics of such activity should be shared with a central data repository, for use within the larger health sector and other interested actors. The architecture approach then embodies a clear vision for CRVS within the architecture, specifying which data should be handled by what subsystem, and standards and definitions

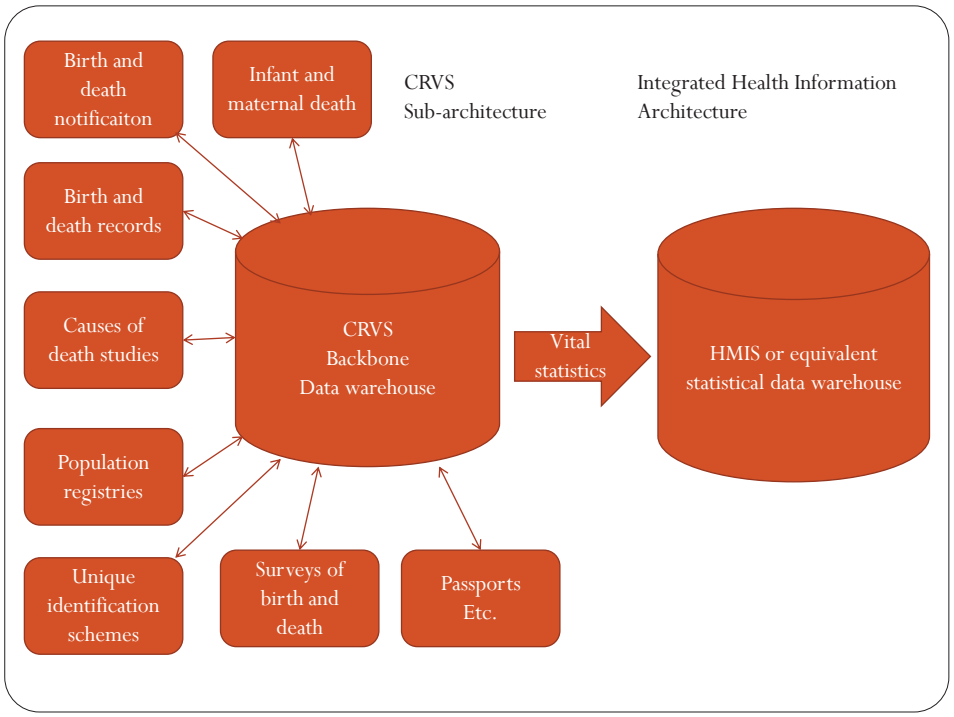
Figure 21. **Integrated health information system framework**



that allow this to take place. Furthermore, such architecture should be supported by policies, resources and processes, representing an institutional framework around the technological solutions adopted. The proposed architecture is then potentially reflected in the schematic in Figure 22.

The architecture approach supports the use of different technologies for multiple uses, such as within different sub-programmes. CR and VS systems are among these, partly based within ministries of health, and partly outside, with other government organizations. These systems are again using different technologies, which have evolved, and continue to evolve, with different technological strategies and resources. As such, in any one country one might find a co-existence of paper-based systems and others relying on a wide array of digital technologies and platforms. Architecture is necessary not to ensure uniform technologies being applied, but to handle the boundaries between them to ensure standards for data exchange and interoperability and the compliance to them.

Figure 22. **Integrated health information architecture**



An architecture approach also helps to mitigate challenges of scaling, by providing an integrated solution of systems for the life-span of the CRVS data. Registries containing data on individuals should be able to share VS with a wider user-group through an accessible central data repository. An architecture approach should thus spell out the hierarchies of use and provide a blueprint for how subsystems work together in providing this. By delegating CRVS on aggregate forms to a central data repository, the subsystems can be leaner. If infrastructure for architecture is already in place countrywide, CRVS subsystems that can easily be attached to this can scale more easily and rapidly than if a backbone infrastructure has to be developed as part of the CRVS. The approach suggested helps to manage complexity, based on well-defined principles to manage system interaction. Subsystems can be treated in isolation as long as they adhere to the standards of the architecture.

The architecture sketched out is proposed in a modular structure, enabling other systems to be plugged in or out from the architecture. As we had argued in the introduction, we have taken a three layered and social systems approach to its design, implementation and use. These include agreements at the user level, the semantic level of meanings, and the technical syntactic level of data sharing. The social systems approach urges us to situate this architecture in a historical and institutional context, where people and institutional practices are emphasized. This approach draws our attention to the challenges of change management, and why action outcomes are often unintended.

5.2.3 OPERATIONALIZING THE RECOMMENDATIONS

Our key recommendation would be to build on the learning from the different best practices examined in this review, and see how they can be adapted within a CRVS-based architecture approach. This would need to be supported more broadly with establishing foundational components such as ICT policies, including issues of security, privacy and confidentiality, institutional processes for establishing requirements, data sharing and ownership agreements between sectors and systems owners.

The aim would be to create CRVS systems that can draw upon the design approaches which can be inferred to have been followed in settings such as Albania, Egypt and MCD India, so as to learn from and adopt the best practices which have empirically worked. This includes the need for a central data warehouse to form the backbone for building multisectoral CRVS systems. We see mainly four strategies to reach the aim of a well-functioning CRVS system within a larger architecture, each applicable for different constellations of existing systems: (a) where there is no existing national data warehouse structure, but a promising initiative related to CRVS; (b) where there is a national data warehouse in place, sharing data and giving access to a range of various actors interested in health-related data; (c) where neither exists, or is of very limited scale and scope; and (d) where both exist, but are not linked to each other.

Arguably, the complexity of using already existing infrastructure, institutions and technology, and "plugging in" a subsystem for CRVS, seems to be much less than the other way around. Our recommendation is thus to focus efforts on new technologies for CRVS where there exists an adequate backbone these technologies can utilize. This corresponds to alternatives (b) and (d) above, exemplified by the cases of Ghana, India and Kenya. Here, an online, national data warehouse that is already collecting health data is in place, used routinely even at district and sub-district levels. Not ignoring the institutional agreements that must be in place, the opportunity to synergize from these ministry of health driven data warehouses, are many. Two main benefits, outlined below, will be to fully take advantage of mobile technologies to reach even community level with electronic CR, and to utilize the existing system to reach national scale more easily.

These two main benefits are related. The first is that new technology can be added for CR only, providing VS through the existing data warehouse. For example, mCRVS applications can be used where they are suitable, while at the same time fulfilling the requirements for VS by providing this to the data warehouse. This will allow developments of such applications to focus on the areas where the mobile technology has the most to offer, such as recording vital events taking place outside health facilities or in facilities not connected to the backbone infrastructure. Several projects were identified where the production of VS was included as a new development, even where there was already existing adequate infrastructure, technology, trained staff, and support for this within the institution-based HIS. If the existing infrastructure can be utilized, the sustainability of mCRVS-based systems will increase, and the efforts can be focused on CRVS only, while at the same time VS will be available for a wider range of users.

The other benefit is that of scaling up the CRVS systems, as they, once developed, can be used all places where the existing national data warehouse is in use. For instance, the project in Liberia using NDG mobile phone solution was efficient in increasing birth registration in the pilot county, but could not be scaled as it lacked the technical backbone to be implemented in other counties. All county health offices in Liberia are connected through mobile Internet connection and desktop computers to the national HMIS data warehouse, and this presents an opportunity in terms of infrastructure that could make the NDG solution nationally scalable. The development of sub-architecture for CRVS, where only VS is shared with an existing architecture, can also benefit from the infrastructure. To run such a solution, one is dependent not only on the physical hardware, but also the support structures of skilled staff that can do training and maintain and keep the system operational. In many cases, a structure of support has been created around national HIS, even at lower levels, that can be utilized when scaling CRVS subsystems. The centralization of such tasks within one unit can also be beneficial as it professionalizes this as a cadre, making possible the hiring of dedicated ICT support that serve the wider health sector.

To sum up, mCRVS and eCRVS efforts have tremendous potential for strengthening CRVS systems. However, what is important is that these initiatives are sensitively linked to other systems defined within an architecture approach. Another point in conclusion is the need to emphasize a social systems approach in the design, development, use and scaling of the systems, which emphasize equally the institutional and the technical. We can conceptualize certain initiatives as examples where the above designed approach and principles can be tested out and verified.

- The example of the MCD described earlier, has demonstrated success in a limited geographical area covering a limited set of facilities. Based on the principles of success but explicitly focusing on scaling challenges, a project could be initiated to scale to the entire state of Delhi.

- Tajikistan is currently embarking on a process to computerize its HIS in the Ministry of Health and the CRVS system in the Ministry of Justice using the same software – DHIS2. A project can be further initiated to ensure how principles of architecture are explicitly built into the projects to ensure the synergies are obtained through integration.
- In Africa, Kenya is working with a full scale web-based HIS being operated from the peripheral areas. A project can be initiated to see how the CRVS system can latch onto the HMIS so as to take advantage of the existing infrastructure and trained capacity.
- An assessment of the MOVE IT initiative is currently taking place. The most promising of the projects can be taken up to see how they may be scaled from pilots to a national system, building on innovative uses of mobile technology linked to a national backbone.

In conclusion, this systematic review has tried to understand the state of art in the use of eCRVS and mCRVS systems, identify challenges that exist in making them operational to scale, examine in more detail successful initiatives, and develop some guidelines and principles of how the eCRVS and mCRVS agenda can be systematically strengthened.

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ANNEX 1. LIST OF ARTICLES INCLUDED IN THE SYSTEMATIC REVIEW

1. Adams I. Volunteers vital for counting births and deaths in Ghana. Bulletin of the World Health Organization. 2011;89(5):322–3.
2. Helping babies breathe: collecting neonatal outcome measures and vital statistics. Elk Grove Village, IL: American Academy of Pediatrics; 2010 (http://www.helpingbabiesbreathe.org/docs/IG_pdfs/4D.pdf, accessed 11 January 2013).
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ANNEX 2. LIST OF EXPERT CONSULTATIONS

Name of expert	Designation	Mode of consultation
Alan Lopez	HMN Executive Board Chair	Phone
Jane Thomason	HMN	
Lene Birgitte Bjorklund Mikkelsen	HMN Technical Subcommittee	Phone
Carla AbouZhar	HMN Technical Subcommittee	Phone
Mark Landry	HMN Technical Subcommittee	Phone
Rafael Lozano	HMN Technical Subcommittee	Attempted to discuss, could not establish phone contact
Ties Boerma	HMN Technical Subcommittee	Face to face meeting in Geneva
Doris Ma Fat	WHO Health Statistics and MOVE IT technical lead for Ghana	Face to face meeting in Geneva
Don De Savigny	HMN Technical SubcCommittee	Attempted to discuss, could not establish phone contact
Ramesh S. Krishnamurthy	WHO Knowledge Management and Sharing	Face to face meeting in Geneva
Anneke Schmider	CRVS Expert, MOVE IT Bangladesh Principal Investigator	Phone
Véronique-Inès Thouvenot	e-health Adviser, ITU, Geneva	Phone
Paul William Delorme	Orange Telecom, Paris, France	Phone
Bruno Piotti	European Union HMIS Project, Viet Nam	Phone
T. Sundararaman	Executive Director, National Health Systems Resource Centre, New Delhi, India	Face to face meeting in Delhi
A. Malabika	MOVE IT Project, Bangladesh, BRAC.	Face to face meeting in Dhaka, Bangladesh
MOVE IT Project Representatives from Ghana, Kenya and Rwanda	Meeting of Cause of Death, November, Cape Town, South Africa	Face to face in Cape Town
Raj Mitra	UNECA, Addis Ababa, Ethiopia	Face to face in Cape Town
Bhaskar Mishra	Director, Registrar General Office, New Delhi	Phone

ANNEX 3. COUNTRY-WISE SUMMARY SHEET – AN EXAMPLE

Ghana – Combining vital events registration, verbal autopsy and electronic medical records in rural Ghana for improved health services delivery

Name of article: Combining vital events registration, verbal autopsy and electronic medical records in rural Ghana for improved health services delivery.

Name of author(s): Ohemeng-Dapaah S, Pronyk P, Akosa E, Nemser B, Kanter AS

Year of publication: 2010

Publisher: PubMed

Page No: NA

URL downloaded: http://www.ncbi.nlm.nih.gov/pubmed/20841720

Country, When, Name of system: Ghana, 2007, MGV-Net (Open MRS platform)

Description of IT/ mobile intervention: This paper describes the process of implementing a low-cost 'real-time' vital registration and verbal autopsy system integrated within an electronic medical record in the Millennium Village cluster in rural Ghana. Using MGV-Net, an open source health information architecture built around the OpenMRS platform, a total of 2378 births were registered between January 2007 and June 2009. The percentage of births registered in the health facility under supervision of a skilled attendant increased substantially over the course of the project from median of 35% in 2007 to 64% in 2008 and 85% midway through 2009. Building additional clinics to reduce distance to facility and using the community health workers to refer women for delivery in the clinics are possible explanations for the success in the vital registration.

Intervention stage:

At point of event: Birth, Death

At point where legal document is given: NA

At point where consolidated statistics are generated: Country

Comments: The integration of vital registration and verbal autopsies with the MGV-Net information system makes it possible for rapid assessment of effectiveness and provides important feedback to local providers and the MVP.

ANNEX 4. ARTICLE-WISE SUMMARY SHEET – AN EXAMPLE

Name of article: Use of verbal autopsy in a national health information system: Effects of the investigation of ill-defined causes of death on proportional mortality due to injury in small municipalities in Brazil

Name of author(s): Elisabeth França, Deise Campos, Mark DC Guimarães and Maria de Fátima M Souza.

Year of Publication: 2011 Publisher: Population Health Metrics Page No: NA

URL downloaded: http://www.pophealthmetrics.com/content/9/1/39

Country, When, Name of System: Brazil, Mortality Information System (MIS)

Description of IT/ mobile intervention: The Mortality Information System (MIS) in Brazil records mortality data in hospitals and civil registries with the responsibility of compiling underlying cause of death. Despite continuous improvements in the MIS, some areas still maintain a high proportion of deaths assigned to ill-defined causes. The aim of this study was to investigate ill-defined causes of death using the verbal autopsy (VA) method to estimate injury-specific mortality fraction in small municipalities in northeastern Minas Gerais, Brazil. Of 202 eligible ill-defined deaths, 151 were investigated using the VA methodology, and 12.6% had injury as the underlying cause of death. The proportional mortality fraction from injury among all causes of death increases from 4.4% to 8.2% after investigation. Different specific injury category causes were observed between recorded injury causes and those detected by VA. Drowning was the top specific injury cause detected after investigation

Intervention stage:

At point of event: Death

At point when legal document is given: Death Certificate

At point when consolidated statistics are generated: NA

Comments: This study provides evidence that the use of VA in the investigation of registered ill-defined conditions in an existing MIS can furnish information on the relevance of injury as a priority health problem in small municipalities of Minas Gerais.

ANNEX 5. LIST OF COUNTRIES INCLUDED IN THE REVIEW

Albania

Argentina

Azerbaijan

Botswana

Brazil

Burkina Faso

Cambodia

Chile

China

Egypt

Ethiopia

Fiji

Gambia

Ghana

India

Iraq

Kenya

Liberia

Malawi

Mauritius

Moldova

Mongolia

Mozambique

Namibia

Philippines

Senegal

Sierra Leone

South Africa

Sri Lanka

Tajikistan

Thailand

Uganda

ANNEX 6. **COMPARISON OF CRVS SYSTEMS INCLUDED IN THE SYSTEMATIC REVIEW**

Different CRVS interventions are compared each other to identify characteristics of each system. Scalability, level of implementation, point of intervention and limiting factors of each system are identified to help the analysis.

Country	Short description	Intervention stage	Legal documents	Statistics report generation	Inter-operability	Scalability	Restrictions and limiting factors	Level of implemen-tation	Acceptability
Albania	Web-based population registry	All events	All	All	Limited	Implemented throughout the country	Source code owned by a third party	Countrywide	Accepted witching the country. Not available for free use in other countries
Argentina	Digitized documents	All events	All	N/A	N/A	Yes	Digitization	Countrywide	Implemented
Azerbaijan	Collects monthly reports of the population vital statistics	Birth, death			Yes	Scaled countrywide. Not scaled beyond district level	Reporting is done district level upwards – rest paper-based	Countrywide	Countrywide
Botswana	Personnel ID number and registration was combined in to one system and when a child is born it is issued with a birth certificate and an ID number that remains for life	Birth	Hospital and community levels	No clear evidence	Not clear	Not clear	Research oriented	Pilot	
Brazil	Microfilmed the civil registration records	All registration events	Regional level	N/A	N/A	Scalable	Digitization process only	Implemented in selected urban area	Does not cover the whole country; scalable with availability of infrastructure
Burkina Faso	Vital event registration and the census data recording at the local level by 5 data entry operators and an admin.	All events	N/A	N/A	N/A	No	Stand-alone system	Limited to research sites	Successful at pilot level
Cambodia	Documents are scanned at regional level	All events				Scalable	No VS/COD arm	Countrywide	Successful
Chile	Web-based system	All events	All	National	Not known	Scalable	Not obvious	Countrywide	
China	DSS	All events			Not known	Scalability limited	Covers only surveillance sites	Implemented to cover sample population	Successful
Egypt	Enterprise Data warehouse (CAPMAS System) for CRVS along with other government information flows	All events	Local level	Local, regional and national	Interoperable	Scalable	Not known	Countrywide	Successful
Ethiopia	Registration and ID issuing is done by a unified system and vital event data are extracted (HRS)	Birth, death	Local level	Local and national	No	Limited	Stand-alone system	DSS sites	Successful at pilot level
Fiji	Computerized system for all ego services	All	National level	Local and national	Yes	Scaled countrywide	Web-based system	Country	Successfu
Gambia	HRS system	Birth, death	No	Regional	No	Limited	Stand-alone system	DSS sites	Successful at pilot level

Ghana	(MGV-net) Real-time vital registration and VA system based on Openers platform	All events			Interoperable – Open MRS based	Scalable	Web based – mediated by the MVP	MVP sites	No evidence of scaling beyond MVP
India – MCD New Delhi	A sample registration system with COD reporting through a well-validated (VA) instrument	All events	Birth, death certificates, ID cards	Regional	Integrated platform to manage all information	Scalable	Infrastructure support	New Delhi	Implementation cost and infrastructure
India - DSS	DSS to cover the whole country (14 million)	All events	N/A	Countrywide DSS	N/A	N/A	Covers inlay sample population	Countrywide DSS	Countrywide
India – BIRDs	Computerized system for registration	All events	Birth certificates	Regional implemen-tation	Integrated	??		State-wide	Accepted
India – Punjab	Mobile system for birth/death reporting	Can use for all events	Can use for documents	Not implemented	Can integrate	Scalable	Can cover all citizens in pilot area	Can start as a pilot	Restricted with institutional interests
Iraq	Two-stage cluster sampling method for application in population-based mortality surveys. The sampling method utilizes girded population data and a geographical information system	All events			No	No		Survey – for research purpose	Not an ongoing project
Kenya	Mobile phones for notifying births and deaths by Community Health Workers to Assistant Chiefs	Birth, death	Local level	Regional	N/A	N/A	Using mobile phones for notification. No intervention on data collection, V/S	Pilot	Accepted at pilot level
Liberia	Collects birth registration information through tailor-made information collection forms, transmits it via GPRS to the main birth registration service	Birth	Generate birth certificate at rural level	Regional and national	No evidence	Scaled countrywide	Not adopted	Scaled countrywide	Pilot accepted with some level of sustain-ability
Malawi	Mobiles used for reporting	All events	No	Regional	No evidence	Pilot	Research purpose only	Pilot level	Pilot accepted
Mauritius	Application architecture has been developed for the processing of data on vital events	Birth, death	Local and national level	Local and national	Integrated	Countrywide		Countrywide	Implemented
Moldova	Voter registration is done. No VS arm	Birth, death	N/A	Regional and national	Integrated	Countrywide	No VS arm	Countrywide	Implemented
Mongolia	Births, deaths, migration data, number of population, marriages are recorded in an electronic system	Birth, death	Local and national level	Local and national	Integrated			Countrywide	Implemented
Mozambique	Birth and death data collected in paper forms transferred to stand-alone system in Visual FoxPro.	Birth, death	N/A	Regional	No	No	Stand-alone system	Pilot	Pilot suites
Mozambique	ICD-10 based system for reporting hospital deaths	Death	NA	National	N/A	Countrywide	No CR arm	Implemented	Accepted as countrywide
Namibia	Information technology used for video conferencing, training and web-based national registration system that could be accessed via the Internet.	Birth	Birth certificate	Regional	Integrated	No evidence – not adopted yet	N/A	Regional	Pilot
Philippines	Microfilming documents	All events	All	No	No	Scaled	VS data not processed	Countrywide	Implemented

Senegal	At the field level, data are processed using portable computers, are then used for analysis of demographic indicators, fertility and child mortality trends	Birth, death	N/A	Local	No	No	Stand-alone system	DSS sites	Pilot
Sierra Leon	Proposes to computerize the CRVS system	All events	All	All	Yes	Yes	Web-based system with mobile arm	Countrywide	Proposed
South Africa	This system is based on an annual update of resident status and vital events, now supports multiple investigations into the causes and consequences of complex health, population and social transitions	All events	N/A	N/A	No	No	Stand-alone system	DSS site	Pilot accepted and sustained
Sri Lanka	Digitization of CR documents	Birth, death	N/A	Local and national	No	Yes	Data reported from district level	Countrywide	Adopted countrywide; COD reported
Sri Lanka	eIMMR	Death	No	Local and national	No	Yes	No CR arm	Being implemented countrywide	Accepted for reporting of hospital deaths
Tajikistan	Proposal to adopt a DHIS2 based web-based system	Birth, death	All	National	Yes	Yes		Countrywide	Proposed
Thailand	Population database for the entire population of the country, and issues identity cards and household booklets Citizen ID issues at the of birth registration Called 13 Digits number	Birth, death	Local level	Local, regional and national	Yes	Yes		Countrywide	Countrywide
Uganda	Mobile system feeds birth information into a database and is accessed via cell phone. This information is then validated by a registrar and a certificate is immediately issued	Birth	Birth certificate		No	No	No evidence	Pilot	Pilot
Africa - MOVE-IT	Regional implementation – using mobile, computerization, legislative support	Birth, death							Pilot
Compare (India, United Republic of Tanzania, Zambia)									