CareConnect — A Waypoint for the Electronic Health Record in 2002

Part 1: Conceptual Models

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INTRODUCTION

Discussions concerning the electronic health record (EHR) are often erudite and theoretical, in part because the EHR is less a destination than a journey (Denis Protti, University of Victoria, personal communication). At one level, it is a compendium of health data repositories. This level of complexity may require a "view only" functionality. At another level, the EHR is an element of a complex clinical decision support system that is at the core of processes to improve patient safety and quality of care. At this level, a "view and do" functionality may be required.

In this discussion, we will concentrate on the practical approaches to the construction of an electronic health record for the Vancouver Coastal Health Authority (VCHA). This pragmatic plan is centred on a series of realities: the particular mandate of the health agency, the sources of data and applications that are available, the use of that information by the caregivers and the types of integration architecture that are currently available.

MANDATE OF THE HEALTH AUTHORITY

The Vancouver Coastal Health Authority was created in December 2001. It encompasses the geographic entities of Richmond, Vancouver, North Vancouver and West Vancouver. It extends north along the Sea to Sky corridor to include Squamish, Whistler and Pemberton and along the Sunshine Coast to include Powell River. In addition, its geographic mandate includes the remote northern communities of Bella Bella and Bella Coola and environs. The population is one million.

It is a heterogeneous region, with one area, the North Shore, achieving the top of *Maclean's* magazine's annual review of health regions. On the other hand, the Downtown East End of Vancouver has one of Canada's biggest drug and HIV problems. The region hosts most of the teaching resources for the province's only medical school. Two of the largest hospitals, St. Paul's Hospital and Vancouver General Hospital, deliver a significant amount of care to individuals who reside outside the authority. The VCHA has an annual budget of $1.89 billion – the information systems budget is 2.6% of this figure.

SOURCES OF EXISTING DATA AND THEIR USE

Healthcare entities, large and small, have a wide variety of data sources, ranging from registries to complex applications. Many of these would be classified as Electronic Patient Records (EPR). Providing a way to link these resources is a fundamental goal in the creation of the EHR. The current shortage of healthcare resources makes it imperative to make the best use of those extant resources. Caregivers currently have limited access to useful EHR data sources such as private laboratory and radiology data and provincially held pharmacy data. This lack of access to information results not only in suboptimal care decisions and timeliness, but also wasted resources – for example, emergency staff in the public hospitals may order tests that might not have been necessary had the clinician been aware that the same tests had been ordered recently through a private lab. Similarly, access to information on currently used medications could pre-

vent adverse drug-drug interactions. These sources of information can enhance the quality of care just through the fact that they are accessible. There is, therefore, a benefit to "viewing" data in a passive manner.

The VCHA structure includes a wide variety of clinical information systems (for example, it includes major hospital information systems (HIS) from four different vendors – McKesson, IDX, Eclipsys and Meditech). In certain cases there are other systems which feed data including images into the HIS. In cases where clinicians do have access to these systems, there is significant complexity and time involved in learning how to use each system, navigating between the systems, remembering several user IDs and passwords, logging on and off, etc. Caregivers require easy-to-use, integrated access to the information systems within the regional institutions to which they have privileges, as well as to other information sources such as private lab data and pharmacy data. These data sources also exist in British Columbia: PharmaNet®, the provincial pharmaceutical tracking system, containing information on all medications dispensed in British Columbia's community and outpatient pharmacies, and PathNET®, the private lab service containing approximately 80% of all private lab results in the province. In addition, the authority is implementing an integrated regional community/mental health system (In4tek PARIS®).

A cornerstone of the clinical information systems strategy in most entities is the move towards physician order entry and clinical decision support. This certainly is the outcome envisaged by the VCHA. Any EHR solution, therefore, needs to provide the ability to enact orders (particularly pharmacy, diagnostic and nursing orders), and provide the ability to apply robust clinical decision support rules to those orders. Thus, the EHR, will need to provide caregivers with active "view and do" functionality, not simply passive "view only" access to data.

CAREGIVERS AND THE UTILITY OF THE EHR

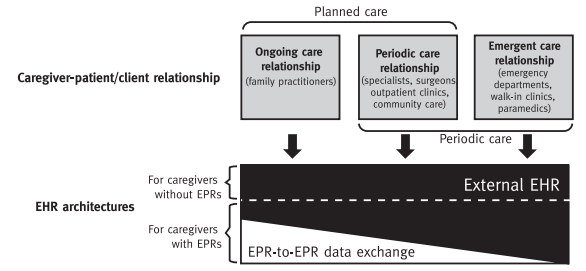
The nature of the caregiver-patient/client relationship and the level of electronic patient record sophistication of the two groups will determine, in part, the structure of the EHR. The relationship that caregivers have with the patient or client – ranging from a long-term relationship, exemplified by the family practitioner, where the caregiver has a relatively good ongoing understanding of the patient's history and needs, to an episodic care relationship, exemplified by hospital emergency departments, where the caregiver's knowledge of the patient's history typically is limited to whatever information the patient can provide at the encounter – is illustrated in Figure 1. This figure also identifies the EHR architectural models that best support each caregiver role.

Caregivers providing ongoing care, particularly family practitioners, already maintain their own longitudinal health records, typically in paper form. This health record is populated from data provided by the practitioner, and by external sources such as labs, specialists, hospitals, etc. There is a long-established protocol for the exchange and management of this information. In certain jurisdictions such as the Kaiser Permanente environment, or the National Health Service in Britain, virtually all physicians have access to computers for patient care (Feachem et al. 2002). However, in British Columbia, although the majority of physicians may have access to computers in the hospital system, and the majority use computers to bill and schedule, it is estimated that only 5% of family doctors use computers for active patient care in the office environment.

Caregivers providing periodic care, such as specialists, physicians in walk-in clinics and surgeons, maintain periodic health records. Caregivers operating in a hospital environment will typically maintain this information electronically – other caregivers such as specialists typically keep it in paper form. This latter health record is usually populated from data provided by the referring caregiver, and information related by the patient.

Caregivers providing emergent care typically have little or no historical information about the patient, in any form. Most hospital emergency departments (ED) have access to their own hospital EPR, which may contain historical information for the patient. Most EDs in

Figure 1: The nature of the caregiver-patient/client relationship and the level of sophistication with EPRs determine the optimal EHR architecture.



British Columbia also have access to PharmaNet. Walk-in clinics typically do not have an EPR, and have access to no clinical information other than that provided by the patient.

What types of EHR models are most appropriate for these categories of caregivers? There are two main approaches:

- An "EPR-to-EPR" approach (the lower yellow portion of Figure 1), where information requirements are supported through the electronic exchange of information between EPRs – for example, lab orders and results, referrals, discharge summaries, etc. This is essentially a "B2B" (business to business) model as practised in other industries. Based on typical B2B architectures, a "B2B hub" (as contrasted with point-to-point interfaces throughout) would appear to be an important component of a well-designed EPR-to-EPR architecture.
- An "external EHR" approach (the upper red portion of Figure 1), where the EHR is supported by a (preferably virtual) service that is external to the caregiver's EPR(s), providing integrated access to clinical information drawn from EPRs across the continuum of care. A wide variety of architectures are conceivable under this umbrella, including purely repository-based architectures, "index/pointer" architectures (e.g., the "Napster model"), visual integration architectures, and blends of the above.

The "EPR-to-EPR" approach is well-suited to caregivers having ongoing care relationships and who already use EPRs. Having data integrated into their EPRs makes it much easier to support order entry and automated clinical decision support – computerized physician order entry is so important as a patient safety matter that legislation in California mandated that most hospitals develop plans by January 2002 to substantially reduce medication-related errors using CPOE strategies and other IT strategies (Kywi 2002). Also, having the core of the longitudinal health record embedded in the caregiver's local EPR is consistent with the historical "local ownership" of the health record by family practitioners. Caregivers in British Columbia who already have an EPR tend to be early adopters of technology and will be enthusiastic supporters of EHR initiatives. These caregivers will also obtain value from the external EHR, which will include more information than will be available in the local EPR.

However, the "EPR-to-EPR" approach does not support emergent caregivers, because the information will be required immediately when the patient presents to the caregiver, and it would be technically impossible (certainly for the foreseeable future) to "pull" all this information from a wide range of sources into the local EPR in real time. The "external EHR" approach is a much more practical approach in these situations. Obviously, the "EPR-to-EPR" approach cannot support caregivers without EPRs, so again in these cases the "external EHR" approach is needed.

Periodic care providers could be supported by either or both approaches depending on the circumstances. For example, for large outpatient organizations such as the B.C. Cancer Agency, the EPR-to-EPR model may make more sense. For specialists without an EPR, the external EHR will be more applicable. For physicians whose work entails hospital and clinic time, a blend of both approaches may be suitable.

Overall, the external EHR has the potential to support all caregivers' needs to some extent. By contrast, the EPR-to-EPR approach supports only some types of caregivers. In the long term, clearly both architectures will be needed. In the shorter term, we believe that the highest clinical value can be obtained more quickly from an external EHR approach.

FUNCTIONAL ELEMENTS OF THE EXTERNAL EHR

What types of functionality will caregivers expect of the external EHR? We anticipate that the following types of functionality will be required:

- Easy, secure sign-on, supported by two-factor authentication where necessary.
- Highly visible flagging of patient-related alerts that require action (e.g., notifying the caregiver that lab results are now available for the patient).
- Core patient data, including demographics, allergies, problem lists, current medications, care providers, family history, immunizations and consent.
- Health encounter history, giving a list of healthcare encounters over time, showing summary information and also providing the ability to drill down for more information on each encounter (e.g., consult notes, operative reports, medications, diagnostic test results, discharge summaries, assessment reports, etc.).
- Longitudinal flowcharting of lab results and other values over time, showing related events such as the administration of medications.
- Ordering, including lab tests, radiology exams, medications, etc.
- Clinical decision support tightly integrated with ordering, such that the clinical decision support rules can reason across the patient's entire longitudinal health record.
- Links to Internet medical references specific to the patient's problems etc.

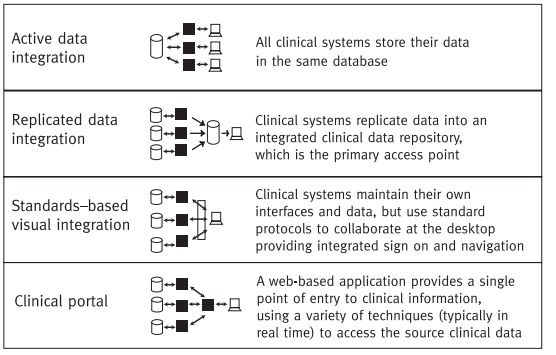
EHR ARCHITECTURAL MODELS

In order to move forward, we first need to agree on which types of caregiver needs we will address first. As discussed above, a "one-size-fits-all" solution is not applicable. The main clinical value of the EHR appears to be for "unplanned, periodic care" providers (in ED, walk-in clinics, etc.), where the EHR can provide invaluable information that is basically unavailable today. Assuming that we start in this area, as shown above, an "external EHR" approach is the only practical solution – this is shown in the red portion of Figure 1.

How would we architect an external EHR for these caregivers? We have identified four main external EHR integration architectures, as shown in Figure 2. Each of these integration architectures has its unique strengths and weaknesses:

- **Active data integration:** this is the ideal architectural solution. However, in the real world of legacy clinical systems investments, proprietary vendor solutions and limited capital funds, it is often not practical to implement on a large scale. No single solution can optimally address all clinical needs in acute, community, primary care and secondary/tertiary care.
- **Replicated data integration:** this provides an integrated view of clinical data, but is limited to offering passive "view only" access to the information; hence it cannot support ordering and integrated clinical decision support. Caregivers must access their local systems for active functionality such as ordering, which raises the issue of how to integrate caregivers' local systems with the EHR. Data standardization and transformation can be very challenging.
- **Standards-based visual integration:** this technique uses HL7 CCOW (Clinical Context Object Workgroup) to provide a standards-based bridge between applications, allowing for integrated "view and do" (physician order entry) functionality. This allows existing CCOW-compliant application to be "plug and play" integrated, making it possible to leverage existing systems investments. It allows a single sign-on to all enabled application with simultaneous searching for patient data across all

Figure 2: The four main external EHR integration architectures.



applications, saving the user the time and effort to search in non-integrated applications. With CCOW, applications are able to work together in ways that enable them to behave more like a single system from the caregiver's perspective. Several types of application links are supported by CCOW, including:

- *User link* – caregivers' system access privileges are linked from application to application through a "chain of trust." Once the caregiver has logged on to one healthcare application, his/her permissions are automatically passed along to other applications without the need to manually log on to each individual system.
- *Patient link* – caregivers can call up data about one patient via multiple applications with a single selection. When the user selects a patient of interest in one application, all of the other active applications automatically tune their data displays to this patient. As most clinical applications provide the capability to select a patient, any application may be used to establish the patient of interest on behalf of all of the applications.
- *Observation link* – enables caregivers to select a particular observation (e.g., a diagnostic imaging report) in any application and all other applications simultaneously display data pertinent to the observation (e.g., a series of ECG reports).

The CCOW approach is very pragmatic and highly effective, but it does have some limitations: it is not a seamlessly integrated view (applications will have somewhat different "look and feel" and different navigation); it will not necessarily appear to the end-user as a single application; it cannot provide integrated views of data (e.g., graphing of lab test values from multiple sources); and not all vendors have yet committed to the CCOW standard.

- **Clinical portal:** this is an attractive solution for the future, but vendor-provided portal solutions are highly proprietary at this time. Clinical systems vendors tend to focus their energies on their own portal solutions. The clinical portal marketplace is immature, so organizations take a risk when committing to a portal vendor. It is very difficult to implement full "view and do" functionality through a portal, except perhaps where the portal is provided by the same vendor as the back-end clinical systems. In order to implement functional portal solutions, vendors and developers often must rely on non-standards-based interfaces into legacy applications. As a result, the solutions are often technically complex and potentially brittle. The emerging adoption of standards-based web services (e.g., SOAP) should make portal-based solutions much more appealing (Patil and Saigal 2002).

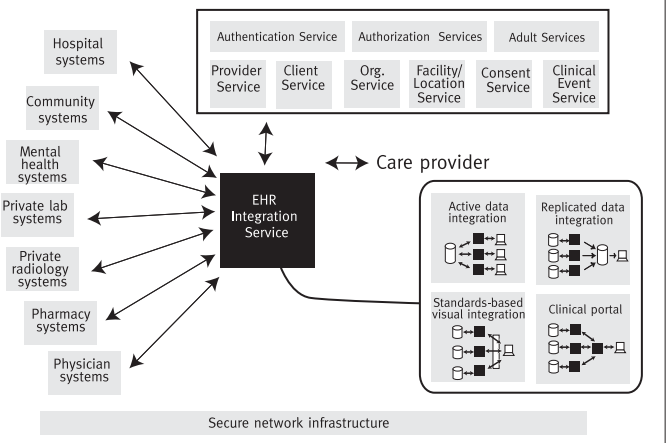
It is our view that none of the EHR integration architectures discussed above can, by themselves, fully address the EHR integration needs of caregivers and the realities of clinical systems implementations today. The overall solution will inevitably use elements of all four of these architectures, as shown in Figure 3.

There are many examples within the VCHA and across British Columbia of how these architectures have been applied. For instance, the IDX LastWord® hospital information system implementation within the VCHA uses elements of the active data integration architecture (by providing an integrated data repository that supports core hospital system functionality) and of the replicated data integration architecture (by receiving and integrating data from laboratory, radiology and transcription systems). The In4tek PARIS® community health system uses active data integration to support community care workers across Vancouver and Richmond, and eventually all of the VCHA. The PathNET® private laboratory results service in British Columbia uses replicated data integration to pull together data from the two main private laboratories in the province. And the PharmaNet® implementation in British Columbia uses active data integration to store data on medications dispensed in all community and outpatient pharmacies in a single provincial database. It should also be noted that EPR-to-EPR data exchanges are also implemented throughout British Columbia – for example, using the HL7-based Lab Test Standard.

All of the integration strategies will need a

number of infrastructure services including an Authentication Service, an Authorization Service, a Client Service, an Audit Service, a Provider Service, an Organization Service, a Facility/Location Service, a Consent Service and a Clinical Event Service. In addition, a secure, remote access methodology employing two-factor authentication and encryption is essential to assure the public that their data are being protected in transmission. We will discuss these infrastructure services in a subsequent article, "Part 2: Implementation Strategies."

Figure 3: Blending the four EHR integration architectures to support care.



CARECONNECT

The project that integrates VCHA and B.C. assets into an EHR for VCHA caregivers is called CareConnect (Figure 4). When installed, it will provide caregivers with improved access to clinical information, by (a) providing more useful clinical information, (b) making it easy for caregivers to access this information in an integrated way, and (c) enabling off-site access to information, for example at clinicians' offices and homes. Discussions with physicians in VCHA Emergency Departments, for example, have suggested that the information they are most interested in having access to is:

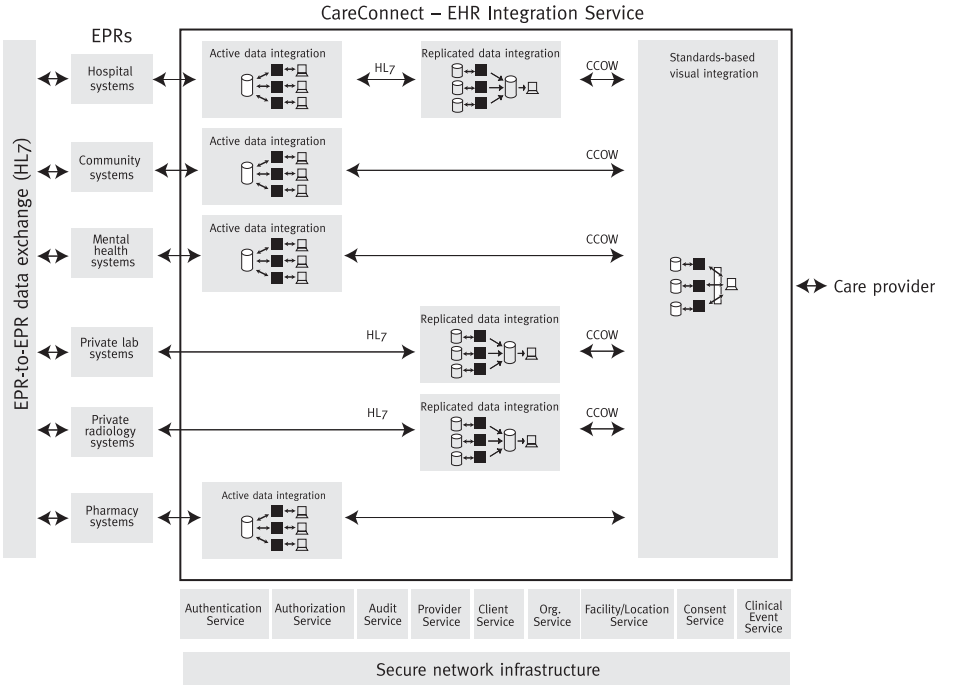
- pharmacy information
- private lab information
- information from other hospitals where their patients have been, in addition to
- information from community health services including the family physician

Pharmacy information is already available in an integrated form in PharmaNet®. Approximately 80% of private lab information is available in an integrated form in PathNET®. Three of the hospital systems in the health authority, Eclipsys, IDX and McKesson, have CCOW-enabled their products. Also, the B.C. Cancer Agency operates a document management system that integrates cancer-related documents from hospitals across the province. It appears feasible to adapt this system to include a wider range of hospital documents (discharge summaries, operative reports, etc.). An integrated community information system is currently being installed but very little information is available electronically from family physicians at this time or for the near future.

We believe that we can make progress quickly, and relatively inexpensively, getting an integrated EHR into the hands of caregivers for evaluation and feedback, by:

- Using existing hospital, community and mental health information systems as active data integrators.
- Using the existing PharmaNet® system as an active data integrator.
- Using the existing PathNET® system as a replicated data integrator.
- Leveraging the B.C. Cancer Agency's document management system as a replicated data integrator to provide core hospital information – information on patients, their hospital encounters, and hospital reports such as discharge summaries, procedure reports, consult notes and operative reports.
- Using standards-based visual integration (HL7 CCOW) as an "integrator of integrators" for caregiver access.

Figure 4: CareConnect demonstrates the variety of integration techniques that will be used across the VCHA. Integration architecture decisions have not yet been finalized in some areas (e.g., private outpatient radiology), but the diagram generally illustrates the techniques that we expect to use.



Furthermore, through visual integration, caregivers already using a CCOW-enabled EPR would also be able to use CCOW to visually integrate their local EPR with the systems described above with a single log-on, and a single patient selection.

We expect that the approach we have described will be an early phase of a larger provincial (and for certain citizens, a national) Electronic Health Record. The rationale for this extension beyond the VCHA is that for at least two of the facilities in the organization, St. Paul's Hospital and Vancouver General Hospital, almost 50% of patients are from postal codes outside of the VCHA. Thus, information from those areas must be brought in for caregivers and distributed out once care is provided. A subsequent phase of the project would be to link the systems of the other Health Authorities in British Columbia, namely the Northern, Vancouver Island, Fraser and the Interior Health Authorities, into the established EHR model.

There are some clear-cut benefits of this approach to caregivers and patients:

- Quality of care will be improved through prompt access to all information required.
- Speed of care will be improved by reducing delays in information availability, and providing more useful information, allowing care planning and delivery to proceed faster.
- Cost and effort of care will be reduced by not repeating tests and procedures, reducing length of stay through better clinical decisions, and improving caregiver and administrative productivity.
- Security and privacy of patient records will be improved by reducing the complexity of access to multiple systems, limiting caregivers to access only the systems and information they require, and auditing all system accesses.
- Flexibility of the healthcare system will be improved by allowing services to be more easily provided at diverse sites across the region, supported by integrated electronic access to information.

The types of patients who will particularly benefit include patients presenting at emergency departments or visiting a walk-in clinic, patients without an established family practitioner, patients with a complex medical history (e.g., elderly patients), and patients who have difficulty recounting their problems, medications, etc.

There are significant advantages to our approach. Elapsed time is short – because visual integration is standards-based and does not require new databases or systems to be developed, it can be implemented relatively quickly by comparison with "data integration" approaches. It is relatively low risk – the approach obtains clinical information directly from existing EPRs and integrated data assets that have already been implemented; and visual integration itself is a proven technology that has been successfully implemented in dozens of sites across the United States. It leverages the significant clinical information systems investments that have been made across the VCHA, in the private sector, and in government over the past decade, providing integrated access without requiring new systems to be developed or existing systems to be retired. It allows us to evaluate the value of the EHR by putting an integrated EHR in the hands of healthcare providers, providing an opportunity to assess provider feedback and address issues before moving further ahead with further EHR initiatives – as a result, reducing overall EHR risk and long-term costs. And it engages caregivers, providing a tangible demonstrator of the value of the integrated EHR, building caregiver enthusiasm and support.

CONCLUSION

We believe that the VCHA can obtain significant value from moving forward with an "external EHR" approach. This will particularly benefit patients and care providers in emergency departments and walk-in clinics, where the EHR can provide invaluable information that is basically unavailable today, but it will also facilitate family practice and specialist care.

No single integration architecture can address the external EHR needs of caregivers. We are convinced that the most cost-effective, pragmatic approach uses a blend of the four architectures discussed in this article. Immediately, the standards-based visual integration architecture will allow us to quickly leverage and bring together the clinical systems assets that we already have in place, putting an integrated EHR into the hands of our healthcare providers. e

More information on the CareConnect strategy can be found at: www.careconnect.ca, or by contacting Colin King at cking@vanhosp.bc.ca.

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References

Feachem, R.G.A, N.K. Sekhri and K.L. White. 2002. "Getting More for Their Dollar: A Comparison of the NHS with Permanente" *British Medical Journal* 324:135–43.

Kywi, A.. 2002. "Context Management: A Catalyst for Patient Safety Initiatives at a California Health System Streamlines and Simplifies Caregiver's Use of Diverse Applications. www.advanceforhie.com (7/29/2002).

Patil, S. and S. Saigal. 2002. "When Computers Learn to Talk: A Web Services Primer." *ElectronicHealthcare* 1(3): 63-70.