

# Pathology Results in the Electronic Health Record

John F Hamblin<sup>1,2</sup>, Phillip T Bwititi<sup>2</sup>, Helen T Moriarty<sup>2</sup>

<sup>1</sup>Southern Health Pathology, Monash Medical Centre, Clayton, Victoria, Australia

<sup>2</sup>School of Biomedical Sciences, Faculty of Science, Charles Sturt University, Wagga Wagga, NSW, Australia

## Abstract

*This paper examines the issues that arise when transferring and displaying pathology data in electronic health records and determines strategies available to mitigate any risks involved in data transfer. A review was undertaken of the English-speaking literature on Australian government policy concerning electronic health records, the processes for transferring data to these systems, the ownership of pathology results once data leaves the domain of the laboratory information system and the types of failures encountered in data transfer and display of results. Published data indicates that the benefits of electronic health records outweigh the disadvantages. However, transferring pathology data using the standard Health Level 7 communication protocol can lead to errors in the translation of data and alter the subsequent display of pathology results and reference intervals. The responsible entity for assuring the accuracy of the display of pathology results in these applications is not always clear. Patient health information will increasingly be accessed from electronic health records. Some of the problems encountered with the transfer of pathology data can be eliminated or minimized if the intended use of the data in the electronic health record is considered when designing interfaced systems. However, the transference of pathology data in the electronic health record within a context that facilitates accurate interpretation remains challenging.*

**Keywords:** Pathology, HL7, Electronic Health Record, Laboratory Information Systems

## 1. Introduction

While some studies have concluded that Australia has an efficient health care system [1-2], others have indicated that it is not as productive as some countries at a similar level of economic development [3]. It has been estimated that there is up to 20 percent inefficiency within the Australian health system [4]. A desire to increase the effectiveness in achieving Australian Government health objectives has been one of the drivers for health care reform [5].

Inefficient processes in Australian health care have been partly attributed to the lack of or inappropriate electronic information systems [6]. One type of information system seen as a critical enabler of health care reform is the electronic health record (EHR) [7]. The adoption of EHRs by health services has been associated with improved quality of service [8-9].

Pathology services are large stakeholders in the successful implementation of EHRs with considerable content held within an EHR database consisting of pathology data [10].

EHRs require pathology data to be in a form that supports decision support and trend analysis. Australia's adoption of the Health Level 7 (HL7) communication protocol to manage the transfer of data between health IT applications will see the majority of health data transferred in this format.

This paper examines the issues that arise when transferring and displaying pathology data in EHRs and determines strategies available to mitigate any risks involved in data transfer. The paper also identifies examples of faults that can be found in the design of pathology systems, implementation of the HL7 standard and the appropriate display in the EHR.

## 2. Methods

A search of the published literature between 1986 and 2009 was performed using PubMed and Australian government reports produced by the responsible authorities. The following search terms were used: Pathology, HL7, Electronic Health Record, Laboratory Information Systems, alone and in combination. The articles selected for analysis included those that presented primary data on Australian government policy concerning EHRs, the processes for transferring data to these systems, the ownership of pathology results once data leaves the domain of the laboratory information system and the types of failures encountered in data transfer and display of results.

From the reference lists of these studies other similar literature was located. Inclusion criteria were used for peer-reviewed journal articles, opinion pieces and reviews, and reports by Australian governments including: English language and articles that primarily identified issues with data transfer between health information technology applications.

Faults identified during the development of an interface linking a laboratory information system and an EHR in our laboratory were used as examples to illustrate some of the problems that may be encountered with data transfer.

## 3. Results

### 3.1. Electronic Health Records

Standards Australia defines an EHR as a repository of information regarding the health status of an individual in computer processable form [11]. EHRs nomenclature includes variants such as the electronic health care record, electronic patient record, computerised patient record, and electronic medical record [11]. These terms are sometimes given different meanings in various health settings but for the purposes of this paper will be considered equivalent.

The primary intent of an EHR is to support the provision of health care of the individual. EHRs provide real-time access to cross-disciplinary patient results and information thus promoting time efficient clinical decision making [12]. Data within the EHR can also be used for secondary purposes that benefit the wider community such as the investigation of disease prevalence [13], to aid in the analysis of procedural outcomes [14], clinical research and development of health policy [15].

The National Health and Hospitals Reform Commission (NHHRC), formed to develop a long-term health reform plan for Australia [16], recommended the establishment of personal EHRs owned and controlled by the individual. A personal EHR gives greater control by the individual in the release and use of data. This addresses some of the privacy concerns, which may be associated with EHRs. Additionally, the NHHRC advocated giving the individual a choice of EHR provider implying there

will be more than one. The practicality of individuals having the power to release their health information selectively to health providers has yet to be demonstrated.

Under the NHHRC's recommendations, Commonwealth government payment of benefits to pathology providers will be linked to their ability to send pathology data to these EHR providers [17].

The NHHRC also recommended the adoption of electronic information storage, exchange and decision support software by health providers [17]. A national approach to the creation of EHRs has been an objective of the State and Territory Governments since 2006 [18], with each State and Territory implementing EHRs within their public health systems [19]. It is important to note that these EHRs are not the same as personal EHRs and will offer no direct access by the individual to their records. The primary focus of EHRs in this context has been sharing of electronic health data between health care providers [20].

Other types of more specialised EHRs exist in many health services including:

- hospital medical records applications [21],
- EHRs catering for specific disease states for example cystic fibrosis patients [22],
- clinical systems designed for specific units such as accident and emergency departments [23] and
- general practitioner's (GP) practice software [24].

Pathology providers are required to create clear and unambiguous reports [25]. Adhering to this requirement can be challenging especially when data is transferred from a laboratory information system to another application. Transferring pathology data can alter the subsequent display of results in the EHR and potentially create errors in interpretation. This article explores some of the difficulties that can be encountered with the transfer of pathology data from laboratory information system to EHR.

### 3.2. Ownership of Pathology Data

An important question arises when pathology results are accessed from applications not under the direct control of the pathology provider. Who is responsible for or "owns" the data is an issue that must be considered. The entity legally responsible for the appropriate display of pathology results in these applications needs to be clearly established.

There are at least two situations that need to be considered with the transfer of pathology results. The first is when transfer is to an application clearly out of the control of the pathology provider such as the downloading of results to a GP's practice software. In a position statement, the Royal College of Pathology of Australia (RCPA) states that "as electronic systems may be beyond the control of the pathology service, results transmitted electronically should only be guaranteed if they have been 'rendered for display' and are not therefore subject to modification" [26]. In this context 'render for display' infers that the data

is in a form that accurately reflects the results in both content and format as displayed in the pathology's system. If one accepts the RCPA's position the responsibility of the pathology provider ends with the sending of results in a format that cannot be modified readily.

The second situation is when the pathology service is part of a larger health service that requires pathology data to be transferred to an EHR within the control of the health service. Under the National Association of Testing Authorities (NATA) and the RCPA pathology accreditation scheme, the laboratory director is responsible for the accuracy and effective delivery of results to the requesting health provider [25]. Therefore, where pathology results are accessed from an EHR within the same health service as the pathology service, the laboratory director should accept responsibility for the validation of the data transfer and ensuring the EHR pathology data is represented accurately.

### 3.3. Data Transfer Protocols

It is impossible to understand the potential pitfalls in data transfer without understanding some of the basic concepts and terminology of pathology informatics. Australia has adopted the Health Level 7 protocol (HL7) to manage the transfer of data between health IT applications. HL7 replaces the Pathology Information Transfer (PIT) protocol used for Australian pathology messaging since 1993 [27].

The PIT protocol sends results in a fixed format that is analogous to an image of the pathology result being transferred rather than individual data elements. Sending data in the PIT format has been identified as an impediment to the introduction of EHRs [27]. The PIT format does not allow data to be manipulated once it is transferred. For example, it is not possible to present graphical representation of data using the PIT protocol. Distinct from PIT, data sent via HL7 can be in variety of formats such as text, numeric or a mixture of both which can be manipulated within the EHR.

The internationally accepted and accredited standard HL7 [28] defines the data types and structure required for IT systems to communicate with each other. It requires an interface to coordinate expected data fields, format and specific sequence of data elements between the sending application and receiving application [29]. To achieve this, data fields in both applications must be linked or mapped so that the receiving application recognises the data that is

being transferred [30]. It is also possible to send a report with HL7 that cannot be modified, similar to PIT [27].

### 3.4. HL7 Atomic Data

Results sent as distinct items of information with HL7 are termed atomic data [27]. Transferring data in an atomic format can facilitate a variety of functions that can be performed within the EHR such as:

- database searches incorporating result values [31],
- graphical display of data [32],
- presenting data from multiple pathology services in a cumulative report [33] and
- facilitating decision support systems utilising result values [34].

The disadvantage in using HL7 atomic data is that there is no inherent or implied formatting with the transfer. The EHR application is required to reconstruct the individual data elements into an appropriate format to provide a sensible result [27].

### 3.5. The transfer and the display of Pathology Data

The transfer and the subsequent reconstruction of pathology data sent in the atomic form can result in inaccuracies and suboptimal display of pathology results in the EHR. Three examples of faults detected during the development of a HL7 interface linking a laboratory information system and an EHR in our laboratory are briefly described below.

#### 3.5.1. Example 1: Failure in Interface translation

The HL7 protocol uses certain characters such as '^', '|' and '~' to control the flow of data from one application to another [35]. When a pathology result containing one of these characters is transferred as atomic data, the HL7 interface must be able to distinguish the character as a HL7 control character rather than as part of a result. Failure of an interface to correctly identify the control character '^' from a data element is illustrated in Figure 1. The EHR results following the '^' have been truncated and are not displayed. Figure 2 shows the complete report, as it was stored in the laboratory information system.

Result Details					
Test Status: Final results					
Test Type	Value	Units	Ref.Range	Normality	Status
Specimen site	.				F
Epithelial cells	+ Squamous				F
RBC X10	30				F
Specimen type	Midstream urine				F
WBC x10	10				F
Culture	70 x 10				F
Report Finalize	FINAL 08252008				F

Truncated results

**Figure 1:** Cropped screenshot of an EHR display that has truncated results due to an error in the interface software.

Urine micro & culture			
Specimen type :			Midstream urine
Specimen site :			.
WBC x10E6/L (RR <10) :			10
RBC X10E6/L (RR <12) :			30
Epithelial cells :			+ Squamous
Culture :			70 x 10 <sup>6</sup> /L <i>Morganella morganii</i>
Report Finalize :			FINAL 08252008

**Figure 2 :** Cropped screenshot of the same result as in Figure 1 displaying correctly in the laboratory system.

### 3.5.2. Example 2: Failure of accurate display in the EHR

In some situations, comments associated with a numerical result need to be displayed for the correct interpretation of the result. For example in Figure 3, a cumulative

full blood examination (FBE) report is shown with the sample from the 24 February having a film morphology result (Text). The laboratory system displays the FBE and Film Comment result together.

However, Figure 4 illustrates the same report displayed in an EHR sent via a HL7 interface as atomic data. The

EHR display has the numeric result separated from the comment. The transfer of atomic data using the HL7 protocol does not transmit the association between the two results. Further, the film morphology result is displayed

directly following a FBE numeric result from the next day (25 February), increasing the possibility of misinterpreting the results.

Test Name	Results				Ref. Int.	Units
	25Feb2009 0840 R902254045	24Feb2009 0935 R902244061	22Feb2009 2250 R902224098	21Feb2009 1130 R902214066		
<b>GENERAL HAEMATOLOGY</b>						
----FBE-----						
HGB	129	128	146		125-175	g/L
WCC	13.6*	13.2*	12.4*		4-11	x10 <sup>9</sup> /L
PLT	154	137*	168		150-450	x10 <sup>9</sup> /L
RCC	4.34	4.19*	4.73		4.20-6.20	x10 <sup>12</sup> /L
HCT	0.40	0.38	0.43		.38-.54	L/L
MCV	93	92	91		78-98	fL
MCH	29.9	30.6	31.0		27-34	pg
MCHC	323	333	340		310-355	g/L
RDW	14.0	13.9	13.1		<15	%
MPV	8.6	8.8	8.7		6.5-12.0	fL
NEUTROPHILS	12.90*	9.50*	11.70*		2.0-8.0	x10 <sup>9</sup> /L
LYMPHOCYTES	0.40*	0.26*	0.30*		1.0-4.0	x10 <sup>9</sup> /L
MONOCYTES	0.30	0.53	0.30		0.0-1.0	x10 <sup>9</sup> /L
EOSINOPHILS	0.00	0.00	0.00		0.0-0.5	x10 <sup>9</sup> /L
BASOPHILS	0.00	0.00	0.10		0.0-0.2	x10 <sup>9</sup> /L
BAND NEUTROPHILS		2.90*			0-0.85	x10 <sup>9</sup> /L
FILM COMMENT		TEXT				

Film comment displayed by selecting "Text"

**Figure 3:** Cropped screenshot from an in-house web browser where the blood film comment associated with FBE is accessible at the time the FBE numeric results are displayed.

Patient : Diagnostic

Select action ..

Filter: ALL

Test Type	Date	Time
<a href="#">UREA ELECTROLYTES C..</a>	<a href="#">25-Feb-09</a>	<a href="#">08:40</a>
<a href="#">CRP (Sensitive)</a>	<a href="#">25-Feb-09</a>	<a href="#">08:40</a>
<a href="#">FULL BLOOD EXAMINAT..</a>	<a href="#">25-Feb-09</a>	<a href="#">08:40</a>
<a href="#">FILM MORPHOLOGY</a>	<a href="#">24-Feb-09</a>	<a href="#">09:35</a>
<a href="#">UREA ELECTROLYTES C..</a>	<a href="#">24-Feb-09</a>	<a href="#">09:35</a>
<a href="#">CRP (Sensitive)</a>	<a href="#">24-Feb-09</a>	<a href="#">09:35</a>
<a href="#">COMMENT</a>	<a href="#">24-Feb-09</a>	<a href="#">09:35</a>
<a href="#">FULL BLOOD EXAMINAT..</a>	<a href="#">24-Feb-09</a>	<a href="#">09:35</a>
<a href="#">PHENYTOIN</a>	<a href="#">23-Feb-09</a>	<a href="#">14:50</a>

Items 21-40 (of 156)      [Back](#)    [More](#)

Film comment separated from the FBE result

**Figure 4:** Cropped screenshot of an EHR result display sent via HL7 showing the blood film result | separated from the FBE

The preceding information demonstrates the HL7 protocol's inability to control the sequence of how individual tests that make up a pathology result will be displayed [36]. This is further illustrated in Figure 1 where, although all the individual tests that make up the 'urine microscopy and culture' result are displayed, the order in which they appear differs from the laboratory report (Figure 2). The sequence of tests on a report assists in the viewer's interpretation of the information presented. The EHR display lacks the logical flow of related information seen in the laboratory report. The red and white cell counts are separated by the specimen type, which should be presented at the top of the report.

In order to retain the appropriate sequence, the EHR must be configured to link and display transferred tests in their appropriate order. This creates on-going maintenance and validation requirements in the EHR application whenever tests are added or modified in the laboratory system.

### 3.5.3. Example 3: Failure to display reference intervals correctly

Reference intervals for tests can vary when test methodologies change, the patient ages and between different laboratories. Combining results in an EHR from two or more pathology services may create a situation where episodes of the same test have different criteria as to what is normal or abnormal. Hence it is important that the numeric results and the relevant reference intervals are simultaneously visible [26]. Figure 5 illustrates some results displayed in a cumulative format. The display relies on the abbreviations of high '(H)' and low, '(L)' to alert the viewer that the results are above or below reference intervals but does not display the actual reference intervals. This is a practical approach given the space limitations in providing a large amount of information at the one time. The concern with this approach is that on one screen different episodes of the same test with the same numeric result may be displayed as normal, high or low depending on the reference intervals of the particular laboratory. In a graphical representation of the data, the distinction of what is normal or abnormal will not be apparent.

Cumulative Test Summary - UREA ELECTROLYTES CREAT					
Test Type	18-Mar-09 08:05	17-Mar-09 09:30	16-Mar-09 08:25	15-Mar-09 09:30	Units
<input type="checkbox"/> SODIUM	135	134(L)	133(L)	133(L)	mmol/L
<input type="checkbox"/> POTASSIUM	4.1	4.1	4.5	3.8	mmol/L
<input type="checkbox"/> CHLORIDE	97(L)	97(L)	96(L)	95(L)	mmol/L
<input type="checkbox"/> BICARBONATE	26	24	26	25	mmol/L
<input type="checkbox"/> UREA	48.0(H)	47.2(H)	46.0(H)	46.4(H)	mmol/L
<input type="checkbox"/> CREATININE	552(H)	578(H)	550(H)	527(H)	umol/L

[Graph](#)   [Print Preview](#)   [Print](#)   Items 1-4 (of 31)   [More](#)

**Figure 5:** Cropped screenshot of an EHR cumulative result that does not display reference intervals simultaneously with results

It has been recommended that laboratories work towards common reference intervals for tests, where possible, to improve patient safety when results are combined in electronic databases [Jones et al 33].

### 3.6. An alternative to Data Transfer

Transferring data to EHRs is not the only solution to providing real-time access to cross-disciplinary patient results. The Clinical Context Object Workgroup, referred to as CCOW, has produced a HL7 standard protocol designed to enable disparate applications to synchronize in real-time, and at the user-interface level [37].

Using standardised login protocols and what is termed ‘context management’ software, the user can have a single sign on to separate health care applications. Accessing one application within this environment and selecting a patient simultaneously selects the same patient in all other CCOW compliant applications. The context management software then builds a combined view of the patient information [38].

The use of CCOW compliant applications negates the need for data transfer and duplication of pathology data but requires considerable long term planning to implement in a health service [38] and would in a practical sense be limited to a single health service. Also a centralised repository of atomic data in the EHR allows proactive decision support on data from multiple departments and institutions, thus making the decision support systems more accurate [39].

## 4. Discussion

The examples described in this article support the need for processes to check thoroughly the integrity of the data transfer and display before relying on data in EHRs.

Important to this process is the identification of who is responsible for the transfer and subsequent display of pathology results. Australian pathology providers produce reports to an international standard assessed by peer review through the NATA /RCPA accreditation scheme [40]. It is reasonable to assume that the expertise gained through this process makes pathology providers the most suitable to administer the pathology data transfer and display in the EHR. Another important consideration is the involvement of the end-user in the process so that the display within the EHR aligns with the work processes and workflow of the health provider.

Strategies to minimise risk must take into account the reasons why the users of various EHR systems require access to pathology data. These reasons will vary with the type and purpose of the EHR. Strategies include:

- (i) Eliminating the transfer and subsequent reconstruction of the pathology report by linking the EHR to the pathology system with single sign on and context management software. Eliminating the transfer eliminates the errors that can be associated with this process [41]. This process is appropriate when the users of the EHR system only wish to view results and not manipulate the data.
- (ii) Eliminating the need to reconstruct the pathology result by providing results in a fixed format file type [26]. Again, this process is appropriate for the viewing of results with no data manipulation.
- (iii) Transferring data in both fixed and HL7 atomic formats [42]. The fixed format version of the pathology data can then be used to create a display version of the report and the atomic data for data manipulation. However if cumulative displays of data from multiple laboratories or presenting data in graphical form is required, the EHR would still need to use atomic data to create the display of the report. Sending data

in two different formats also relies on the design of the EHR accommodating this functionality.

- (iv) Ensuring that if HL7 atomic data only is required, that there are sufficient resources in terms of manpower, testing protocols and change management procedures available to validate the transfer and display of pathology data contained in the EHR.

Faults can occur in the design of pathology systems, the implementation of the HL7 standard and in the receiving applications display of the data transferred. Detecting these faults can be a time consuming and laborious process that requires collaboration between the pathology provider, the software developer and the health provider. The most productive approach would be to concentrate efforts on interfacing to EHRs that adhere to a common standard record architecture.

## 5. Conclusion

Integrating pathology data with other health information held electronically in EHRs can create complexity in providing a clear and unambiguous pathology result. The challenge for those that control the transfer of pathology data is to ensure true interoperability is achieved with the integrity of data maintained and results presented in the EHR in a context that facilitates accurate interpretation.

## Acknowledgements

We thank Dr Garey Dawson for his assistance in writing this paper.

## References

1. Retzlaff-Roberts D, Chang CF, Rubin RM. Technical efficiency in the use of health care resources: A comparison of oecd countries. *Health Policy*. 2004; 69(1): 55-72.
2. Joumard I, André C, Nicq C, Chatal O. Health status determinants: Lifestyle, environment, health-care resources and efficiency. Economics department working papers no. 627 Organisation for Economic Co-operation and Development. 2008. Available from: [http://www.oalis.org/olis/2008doc.nsf/ENGDATCORPLOOK/NT0000363E/\\$FILE/JT03249407.PDF](http://www.oalis.org/olis/2008doc.nsf/ENGDATCORPLOOK/NT0000363E/$FILE/JT03249407.PDF).
3. Afonso A, St. Aubyn M. Relative efficiency of health provision: A dea approach with non-discretionary inputs. ISEG-UTL Economics Working Paper, No.33 2006 Available from: <http://pascal.iseg.utl.pt/~depeco/wp/wp332006.pdf>.
4. Productivity Commission. Potential benefits of the national reform agenda, report to the council of Australian governments. 2006 Available from: [http://www.pc.gov.au/\\_\\_data/assets/pdf\\_file/0003/61158/nationalreformagenda.pdf](http://www.pc.gov.au/__data/assets/pdf_file/0003/61158/nationalreformagenda.pdf).
5. COAG. Human capital reform: Report by the coag national reform initiative working group. 2006 Available from: [http://www.coag.gov.au/coag\\_meeting\\_outcomes/2006-02-10/docs/human\\_capital\\_reform\\_report\\_COAG\\_100206.pdf](http://www.coag.gov.au/coag_meeting_outcomes/2006-02-10/docs/human_capital_reform_report_COAG_100206.pdf).
6. Hurley E, McRae I, Bigg I, Stackhouse L, Boxhall A, Broadhead P. The Australian health care system: The potential for efficiency gains - a review of the literature. 2009 Available from: [http://www.health.gov.au/internet/nhhrc/publishing.nsf/Content/A5665B8B9EAB34B2CA2575CB00184FB9/\\$File/Potential%20Efficiency%20Gains%20-%20NHHRC%20Background%20Paper.pdf](http://www.health.gov.au/internet/nhhrc/publishing.nsf/Content/A5665B8B9EAB34B2CA2575CB00184FB9/$File/Potential%20Efficiency%20Gains%20-%20NHHRC%20Background%20Paper.pdf).
7. Gonski D. A report by the chair. In national e-health transition authority annual report 2007-08. 2009 Available from: <http://www.nehta.gov.au/nehta-publications>.
8. Friedberg MW, Coltin KL, Safran DG, Dresser M, Zaslavsky AM, Schneider EC. Associations between structural capabilities of primary care practices and performance on selected quality measures. *Ann Intern Med*. 2009; 151(7): 456-63. Jha AK, DesRoches C.M, Shields A.E, Miralles P D, Zheng J, Rosenbaum S, Campbell E.G. Evidence of an emerging digital divide among hospitals that care for the poor. *Health Aff*. 2009; 28(6): 1160-70.
9. Forsman R. The electronic medical record: Implications for the laboratory. *Clin Leadersh Manag Rev*. 2000; 14(6): 292-5.
10. Standards Australia. As iso 18308-2005. Health informatics—requirements for an electronic health record architecture Sydney: Standards Australia International; 2005.
11. Winsten D. Integrated reporting and interpretation of clinical results. *Clin Leadersh Manag Rev*. 2000; 14(6): 272-4.
12. Aller Pathology's contributions to disease surveillance: Sending our data to public health officials and encouraging our clinical colleagues to do so. *Arch Pathol Lab Med*. 2009; 133(6): 926-32.
13. O'Toole MF, Kmetik KS, Bossley H, Cahill JM, Kotsos TP, Schwamberger PA, Bufalino VJ. Electronic health record systems: The vehicle for implementing performance measures. *Am Heart Hosp J*. 2005; 3(2): 88-93.
14. Mount CD, Kelman CW, Smith LR, Douglas RM. An integrated electronic health record and information system for Australia? *Med J Aust*. 2000; 172(1): 25-7.
15. Rudd K, Roxon N. National health and hospitals reform commission. 2008 Available from: [http://www.health.gov.au/internet/ministers/publishing.nsf/Content/7BFE633F257EB5BDCA2573FA001F215E/\\$File/nr024.pdf](http://www.health.gov.au/internet/ministers/publishing.nsf/Content/7BFE633F257EB5BDCA2573FA001F215E/$File/nr024.pdf).
16. NHHRC. A healthier future for all Australians – final report of the national health and hospitals reform commission – June 2009. 2009 Available from: [http://www.nhhrc.org.au/internet/nhhrc/publishing.nsf/Content/1AFDEAF1FB76A1D8CA257600000B5BE2/\\$File/Final\\_Report\\_of\\_the%20nhhrc\\_June\\_2009.pdf](http://www.nhhrc.org.au/internet/nhhrc/publishing.nsf/Content/1AFDEAF1FB76A1D8CA257600000B5BE2/$File/Final_Report_of_the%20nhhrc_June_2009.pdf).
17. COAG. Council of Australian governments' meeting 10 February 2006 communique. 2006 Available from: [http://www.coag.gov.au/coag\\_meeting\\_outcomes/2006-02-10/docs/coag100206.pdf](http://www.coag.gov.au/coag_meeting_outcomes/2006-02-10/docs/coag100206.pdf).
18. DHA. Australian government department of health and ageing: Ehealth: Overview of healthconnect. 2008 Available from: <http://www.health.gov.au/internet/main/publishing.nsf/Content/EHealth+Healthconnect>.

19. DHA. Australian government department of health and ageing: Sharing health records. 2008 Available from: <http://www.health.gov.au/internet/hconnect/publishing.nsf/Content/tour1>.
20. Daurio NR, Fielding M, Cholewka PA. Implementation of an enterprise-wide electronic health record: A nurse-physician partnership. *Stud Health Technol Inform.* 2009; 146: 263-5.
21. Wilson J. Ehealth in cystic fibrosis, in Forum on Clinical Networks and the role of Information Communication Technology. 2008: Melbourne.
22. Karahoca A, Bayraktar E, Tatoglu E, Karahoca D. Information system design for a hospital emergency department: A usability analysis of software prototypes. *J Biomed Inform.* 2009.
23. Terry AL, Thorpe CF, Giles G, Brown JB, Harris SB, Reid GJ, Thind A, Stewart M. Implementing electronic health records: Key factors in primary care. *Can Fam Physician.* 2008; 54(5): 730-6.
24. Standards Australia. As 4633-2004 medical laboratories - particular requirements for quality and competence. Sydney: Standards Australia International; 2004.
25. RCPA. Royal college of pathologists of australasia position statement: Electronic communication of pathology results. 2006 Available from: <http://www.rcpa.edu.au/applications/DocumentLibraryManager2/upload/Electronic%20Communication%20of%20Pathology%20Results.pdf>.
26. Standards Australia. Hb 262—2008. Guidelines for pathology messaging between pathology providers and health service providers. 2nd ed. Sydney: Standards Australia international; 2008.
27. Health Level Seven. Introduction to hl7. 2008 Available from: <http://www.hl7.com.au/FAQ.htm>.
28. Balis UJ. The value of a federated architecture in pathology: Test order entry, in Lab InfoTech Summit. 2008: Las Vegas, Nevada.
29. Oemig F, Blobel B. Semantic interoperability between health communication standards through formal ontologies. *Stud Health Technol Inform.* 2009; 150: 200-4.
30. Mullins IM, Siadaty MS, Lyman J, Scully K, Garrett CT, Miller WG, Muller R, Robson B, Apte C, Weiss S, Rigoutsos I, Platt D, Cohen S, Knaus WA. Data mining and clinical data repositories: Insights from a 667,000 patient data set. *Comput Biol Med.* 2006; 36(12): 1351-77.
31. Dolin RH, Alschuler L, Boyer S, Beebe C, Behlen FM, Biron PV, Shabo Shvo A. HI7 clinical document architecture, release 2. *J Am Med Inform Assoc.* 2006; 13(1): 30-9.
32. Jones G, Barker A, Tate J, Lim CF, Robertson K. The case for common reference intervals. *Clin Biochem Rev.* 2004; 25(2): 99-104.
33. Gardner RM. Computerized clinical decision-support in respiratory care. *Respir Care.* 2004; 49(4): 378-86; discussion 86-8.
34. Beeler G. HI7's role in the development of the electronic patient record in HIC 98: Proceedings. 1998; Health Informatics Society of Australia: Brisbane, Queensland.
35. Standards Australia. As 4700.2-2004. Implementation of health level seven (hl7) version 2.3.1 part 2: Pathology orders and results. Sydney: Standards Australia International; 2004.
36. Seliger R. Overview of hl7's ccow standard. 2001 Available from: <http://www.hl7.org/library/committees/sigvi/CCOW%5Foverview%5F2001%2Edoc>.
37. Berger RG, Baba J. The realities of implementation of clinical context object workgroup (ccow) standards for integration of vendor disparate clinical software in a large medical center. *Int J Med Inform.* 2009; 78(6): 386-90.
38. Wilcox A, Kuperman G, Dorr DA, Hripesak G, Narus SP, Thornton SN, Evans RS. Architectural strategies and issues with health information exchange. *AMIA Annu Symp Proc.* 2006: 814-8.
39. NATA. As 4633 (iso 15189) field application document medical testing. Supplementary requirements for accreditation. July 2009 ed: The National Association of Testing Authorities; 2009.
40. Katehakis DG, Sfakianakis S, Tsiknakis M, Orphanoudakis SC. An infrastructure for integrated electronic health record services: The role of xml (extensible markup language). *J Med Internet Res.* 2001; 3(1): E7.
41. Pantanowitz L, Brodsky V, Aller RD. Laboratory reports in the electronic medical record. *LabMedicine.* 2007; 38(6): 339-40.

## Correspondence

Mr John Hamblin  
 Southern Health Pathology  
 Southern Health, 246 Clayton Rd  
 Clayton VIC 3168  
 Australia  
 Phone: +61 (0)3 9595 4535  
 Fax: +61 (0)3 9494 6223  
[John.hamblin@southernhealth.org.au](mailto:John.hamblin@southernhealth.org.au)