SOME EXPERIENCES IN LABORATORY DATA COLLATION
AT THE HOSPITAL WARD LEVEL

Tom Hartley, B.Sc.Ph.D\textsuperscript{1} and Peter Georgius\textsuperscript{2}, MBBS, B.Med.Sci.

\textsuperscript{1}Senior Scientist, IT Group, Pathology Department
\textsuperscript{2}Clinical Researcher, Neurosurgery and Orthopaedics Departments

Royal Hobart Hospital, Hobart, Tasmania

ABSTRACT:

This paper describes practical solutions to the problem of collating laboratory data on the Hospital Wards in a format that is easier to use than that derived on a case by case basis from the results lookup systems. As a general rule the Laboratory Information Management Systems, LIMS, have been designed for the laboratorians and not for the clinicians. We have exploited the fact that our LIMS can provide data extracts on-demand and that these can then be manipulated by those clinicians who have reasonable skills with MS Excel or MS Works to produce hard copy spreadsheet style reports for use on Ward Rounds. In the process we have identified the 'minimum datasets' that Units such as Neurosurgery, Orthopaedics and General Medical require for ongoing immediate care. It has removed the need to manually update the data collation forms that were a feature on all three Units. In addition because the data extracts were all Unit based the data collation also included those of the Unit's patients that were in outlying Wards. Consequently, the majority of clinical management issues relating to those outlying patients could also be addressed 'from a distance' at the Unit Ward. Although the process has been shown to be amenable to automation and the spreadsheets have been posted onto an Intranet this has not really been a practical advantage given that most PCs on the Wards are remote from the beds.

INTRODUCTION:

The cycle of 'Patient Consultation' leading to a 'Pathology Request' followed by 'Specimen Collection and Analysis' then 'Reporting' and finally 'Clinical Interpretation' is often perceived as a two dimensional process. Certainly this is the case in Private Consulting Room Clinical Practice but in the scenario of a busy General Hospital it has a third dimension. The third dimension exists there because the Junior Clinical Staff are responsible for a 'cohort' of Inpatients that belong to their Clinical Unit. Their challenge is to aportion their time in such a way that they balance the attention given to clinically complex cases with the attention required by the routine clinical cases. It is essential that the latter cases proceed as smoothly as possible so that they can be discharged as soon as possible and new cases from the waiting lists admitted in their place. They can only do this effectively if they have regular overviews of the clinical condition of all their Unit's patients. Since many clinical decisions hinge upon the results of recent tests a regular overview of the Pathology Laboratory Results on all their patients has the potential of being a powerful aid to efficient and effective clinical management of their case load. This paper presents an overview of the IT solutions used in Laboratories to produce these results and illustrates how the database can be presented in spreadsheet format to gain the third dimension perspective.

SCIENTIFIC BACKGROUND:

The laboratorians view of the world is very much a specimen by specimen view. They have no real knowledge of the case history behind the name on the tube and for the most part deal almost entirely with an anonymous specimen number and a precis of the details on the specimen request forms; see Figure 1.

The current generation Laboratory Information Management System, (LIMS), software that they use, however, does give them the opportunity to view cumulative data on the same patient within the window of their specialty; this is particularly true of Biochemistry and Haematology results.
FIGURE 1: A Typical 'Terminal Style' Window Used in the Laboratory to Transcribe Data from the Doctor's Request Form to the LIMS.

FIGURE 2: A Panel of Cumulative Coagulation Results that Show Variations Over Time of the 'Clotability' of the Patient's Blood.

Their principal use of the window, shown in Figure 2, is to assist them in the process of detecting dramatic changes in day to day results of say glucose or coagulation times and taking precautions to ensure that the 'abnormal' result is correct by checking everything from the name and number on the tubes, through to perhaps...
repeating the analysis, as is the case in Figure 3, and checking the most recent quality control results from the instrument in question.

![Table of laboratory results]

**FIGURE 3**: This shows the background screen available to the laboratorian overlaid on the results screen. Because the results for HCO₃, Urea and Creatinine had all deviated outside the panic limits set for these tests, the specimen was reanalyzed as a check of the analytical process.

As laboratorians are the prime driving force behind the evolution of laboratory software it is not surprising that features that focus on 'process' rather than on 'clinical information use and content' tend to be at the forefront of current clinical laboratory software.

On the Hospital Wards a couple of solutions are now more or less routinely deployed for electronic lookup of Pathology Results. The first is to provide access to the native Pathology LIMS with 'cut down' menus more suited to that environment. That solution is usually satisfactory but carries with it the burden of providing training of new staff and the maintenance of computer configurations that are capable of running the LIMS; e.g., Novell Client for the Lab Results, other Network Clients for other Hospital systems. It also means that the data is searched for and presented very much from the laboratorians way of working as has just been discussed. The second and more current trend is to provide WWW Browser portals into the LIMS database; refer to Figure 4 - a commercial product, and to Figure 5 - an 'in house' prototype which runs from this Menu Page that has details of all specimens received from the Casualty Department and that have been fully resulted in the past 15 hours. Double clicking on the item in the Test column takes the user directly to an on screen representation of the associated A5 hard copy report.
FIGURE 4 : A Typical WWW Browser Interface to a Pathology LIMS

CLINICAL BACKGROUND:

The primary role of a clinician is medical management of sick patients and forming a vital part of this role is effective and efficient collection and interpretation of data from clinical IT systems. The majority of clinical IT systems are designed around patient and doctor interaction at the consulting room desk and are not well adapted to the bedside or ward environment. The aim of this project was to experiment with moving away from the philosophy of single vendor single product oriented systems and move towards to information integration from multiple systems using readily available Windows '95 software. This choice would mean that the solutions would become more generally available and hence become more acceptable to all levels of clinicians viz. from junior medical officers to consultants. Consequently, this approach not only has the potential to address the information needs of the ward environment involving multiple clinical cases but also has the flexibility to survive changes in IT networks and changes in the software products used by the Hospital Departments such as Pathology, Pharmacy, Radiology etc. that provide the data needed during the management of patients by doctors. A basic model of this philosophy has been applied and has shown a great improvement in function and efficiency without the need for expensive or complex systems locked into the Hospital's IT infrastructure.
THE STEPS TAKEN TOWARDS THE PROTOTYPE SOLUTION:

- Identified what each clinical discipline really required as their day to day working datasets.
- Procured those data extracts from the laboratory systems in an electronic format that could be easily imported into a spreadsheet program - columns for data, rows for patient IDs.
- Obtained these data extracts at regular intervals using a scripting tool to channel data from the laboratory system into Excel spreadsheets.
- Built simplicity, flexibility and ruggedness into the designs

The datasets required by the various Departments were interesting from the 'pathology' point of view because it highlighted what clinicians really need as a minimum dataset for them to provide ongoing care; provided they had these data they were prepared to delay the looking up of the results of the less essential laboratory tests.

The relevant datasets were:

**Neurosurgery**: Biochemistry Tests = Na, K, Urea, Creat, Glu, Osmo, urine Osmo, Prot, Alb, ALP, ALT,
GGT, Total Bili, Ca, Phos, Mg, Alcohol, Phenytoin, Carbamezapine, CRP

Haematology Tests = Haemoglobin, WCC, Platelets, PTT, PT, INR, ESR

Orthopaedics: Biochemistry Tests = Na, K, Cl, Urea, Creat, Glu, Prot, Alb, ALP, ALT, GGT, Total Bili, Ca, Corrected Ca, Phos, Mg, Chol, Trig, CK, CKMB, Alcohol, Phenytoin, Carbamezapine, Theophylline, Valproate, CRP

Haematology Tests = Haemoglobin, Haematocrit, WCC, Neutrophils, Platelets, PTT, PT, INR, ESR

Medical Units: Biochemistry Tests = Na, K, Cl, Urea, Creat, Glu, Osmo, urine Osmo, Prot, Alb, ALP, ALT, GGT, Total Bili, Neonatal Bili, Ca, Corrected Ca, Phos, Mg, CRP, Chol, Trig, CK, CKMB, Alcohol, Phenytoin, Carbamezapine, Theophylline, Valproate

Haematology Tests = HB, Hcrit, WCC, Neut, Plat, PTT, PT, INR, ESR

The LIMS System was made available to three pilot Clinical Units and they were able to extract the data for their Unit from a 'Data Extractions' menu item. This put a comma separated values, (.CSV), file onto the hard drive of the PC they were using. Being a CSV file they could load that into Microsoft Works or Microsoft Excel on that PC, use the 'auto format' feature of those programs and then print the resulting spreadsheet on their local printer, (see Figure 6.) This gave them the control to collect their results when they wanted them and where they wanted them, provided of course that the PC in question was connected to the relevant Novell fileserver.

The LIMS System was made available to three pilot Clinical Units and they were able to extract the data for their Unit from a 'Data Extractions' menu item. This put a comma separated values, (.CSV), file onto the hard drive of the PC they were using. Being a CSV file they could load that into Microsoft Works or Microsoft Excel on that PC, use the 'auto format' feature of those programs and then print the resulting spreadsheet on their local printer, (see Figure 6.) This gave them the control to collect their results when they wanted them and where they wanted them, provided of course that the PC in question was connected to the relevant Novell fileserver.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>A</td>
<td>G</td>
<td>D</td>
<td>E</td>
<td>B</td>
<td>7/7/98</td>
<td>11:20</td>
<td>139</td>
<td>3,9</td>
<td>5,2</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>H</td>
<td>K</td>
<td>E</td>
<td>B</td>
<td>7/7/98</td>
<td>9:10</td>
<td>139</td>
<td>4,4</td>
<td>4,1</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>D</td>
<td>G</td>
<td>J</td>
<td>A</td>
<td>5/7/98</td>
<td>11:50</td>
<td>143</td>
<td>3,4</td>
<td>4,6</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>G</td>
<td>J</td>
<td>A</td>
<td>5/7/98</td>
<td>9:30</td>
<td>140</td>
<td>3,4</td>
<td>3,6</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>D</td>
<td>G</td>
<td>J</td>
<td>A</td>
<td>7/7/98</td>
<td>10:50</td>
<td>137</td>
<td>4,1</td>
<td>4,3</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>D</td>
<td>G</td>
<td>J</td>
<td>A</td>
<td>6/7/98</td>
<td>14:2</td>
<td>4,1</td>
<td>4,4</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>B</td>
<td>E</td>
<td>K</td>
<td>K</td>
<td>5/7/98</td>
<td>9:45</td>
<td>135</td>
<td>4,4</td>
<td>14,6</td>
<td>122</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>B</td>
<td>E</td>
<td>K</td>
<td>K</td>
<td>5/7/98</td>
<td>17:20</td>
<td>140</td>
<td>3,8</td>
<td>2,2</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>C</td>
<td>R</td>
<td>I</td>
<td>C</td>
<td>6/7/98</td>
<td>9:00</td>
<td>140</td>
<td>4,5</td>
<td>5,9</td>
<td>68</td>
<td>57</td>
<td>37</td>
<td>46</td>
<td>12</td>
<td>20</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>C</td>
<td>R</td>
<td>I</td>
<td>C</td>
<td>6/7/98</td>
<td>139</td>
<td>4,5</td>
<td>5,3</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>C</td>
<td>T</td>
<td>H</td>
<td>P</td>
<td>7/7/98</td>
<td>3:50</td>
<td>130</td>
<td>4,2</td>
<td>5,2</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>C</td>
<td>T</td>
<td>H</td>
<td>P</td>
<td>7/7/98</td>
<td>11:15</td>
<td>133</td>
<td>4,5</td>
<td>5,3</td>
<td>87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>B</td>
<td>E</td>
<td>B</td>
<td>E</td>
<td>5/7/98</td>
<td>138</td>
<td>4,3</td>
<td>22,2</td>
<td>830</td>
<td>5,7</td>
<td>51</td>
<td>24</td>
<td>50</td>
<td>19</td>
<td>19</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>B</td>
<td>E</td>
<td>B</td>
<td>E</td>
<td>5/7/98</td>
<td>145</td>
<td>5,2</td>
<td>21,4</td>
<td>805</td>
<td>54</td>
<td>24</td>
<td>53</td>
<td>95</td>
<td>20</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>B</td>
<td>E</td>
<td>B</td>
<td>E</td>
<td>5/7/98</td>
<td>9:25</td>
<td>142</td>
<td>4,6</td>
<td>21,9</td>
<td>844</td>
<td>24</td>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>B</td>
<td>E</td>
<td>B</td>
<td>E</td>
<td>5/7/98</td>
<td>9:50</td>
<td>144</td>
<td>5,4</td>
<td>21,6</td>
<td>526</td>
<td>55</td>
<td>25</td>
<td>45</td>
<td>90</td>
<td>20</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>T</td>
<td>E</td>
<td>T</td>
<td>E</td>
<td>5/7/98</td>
<td>11:30</td>
<td>138</td>
<td>4,4</td>
<td>1,4</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>S</td>
<td>T</td>
<td>E</td>
<td>T</td>
<td>5/7/98</td>
<td>143</td>
<td>4,9</td>
<td>7,4</td>
<td>107</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 6: A Typical Spreadsheet of Results for a Clinical Unit Generated on the Ward Using Excel Ready for Printing on the Local Printer.

RESULTS:
The system was implemented in two busy Departments - Neurosurgery and Orthopaedics. We found that the collation of data in this way had a significant impact on making better use of the clinicians' time. It removed the need to manually update data collation forms and the Ward Rounds became more effective because the current data were immediately available at the bedside and in hardcopy. In addition because it was Unit based the data collation also included the Unit's patients that were in outlying Wards. Consequently, the majority of clinical management issues relating to those outlying patients could also be addressed 'from a distance' at the Unit Ward Round.

We have also demonstrated that it is possible to automate the data extraction from the LIMS by means of a scripting program called AutoIt, written by Jonathan Bennett - (http://www.hiddensoft.com/AutoIt/). While the LIMS application runs in a Window under Windows ’95, AutoIt can mimic the required keystrokes, including date and time entries, pause while the LIMS completes its tasks, then activate a Visual Basic module that builds the relevant HTML for the web pages including the relevant portions of the Data Extraction files. This approach has not been used on the Wards but is being used within the laboratories where they are able to view a realtime web page of all results produced since midnight. This page is updated every 10 minutes via the AutoIt script. This page is one component of a web based system that tracks workflow and turn around times for every specimen received into the Core Laboratory of the Pathology Department, see Figure 7.

DISCUSSION:

This has demonstrated that with an altered philosophy we should be able to have multiple hospital computer systems work for the clinician, as opposed to the clinician working as a data collection and entry clerk into
multiple systems. The motivation for this trial was purely from the unique pressures within the clinical environment and any financial/clerical benefits are purely a by-product. The role of a clinician is medical management, however the expected quality and volume of administrative tasks has grown to where it is a function in its own right. This has led to a dichotomy between medical and administrative duties.

The clinical environment is unique in the sense there is a high workload dealing with patient’s lives and a massive amount of information, which needs to be at the clinician’s fingertips instantaneously! Furthermore, it is often a hostile working environment as the clinicians frequently fail to achieve comprehensive recall of all clinical and investigative results of all patients. As a result the consequences can range from personal abuse through to formal medico-legal proceedings.

On a busy single specialty ward with approximately 20 patients, the previous system took approximately 4 hours to lookup and collate the necessary data. This inefficient system, resulted in at best a patchy set of results often with transcription errors and the only resource left for the clinician being to either fabricate results or admit ignorance. We have demonstrated that we can reduce 4 hours of data collection to 7 minutes, resulting in complete and well-formatted data with no transcription errors. This was achieved in an easy, timely and cheap method that can cross platforms and technology. The data set can be called at any time for any time period including single set of data to cumulative data stretching over a 4-year period. The format can be easily modified and produced at will. This has freed up the doctor to perform his job as a doctor as opposed to a clerk.

CONCLUSIONS:

We have achieved our objective of demonstrating that data from a proprietary Pathology Laboratory system can be usefully and easily extracted and represented in a format developed dynamically by the clinicians. We have successfully built a prototype solution to the problem of supplying Laboratory Results in an alternative spreadsheet format via a system that clinicians on the wards are in control of and which lends itself to further enhancement. In the process we have learnt which Laboratory Data drive the clinical decision making processes at Ward Rounds and the practical limits to deploying Results Lookup Systems at the Hospital Ward level.