Results of the CSIRO multi-site national trial of telehealth for the management of chronic disease in the home

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Funded by the Australian Government under the National Telehealth Pilots Program

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NBN Telehealth Pilot Program
CSIRO Telehealth Project

Summary

- CSIRO is lead organisation
- Six clinical partners and three industry partners
- Total project size $5.4m ($3.02m from DOHA/DBCDE Pilot Program)
- Six (6) Trial sites in Five (5) states and territories
- Focus on Chronic Disease Management (CDM) in the Community
- Six different models of care represented
- Trial duration 18 months – ends 30th Dec 2014
Additional presentations on the CSIRO NBN Telehealth trial

- Dr. Rajiv Jayasena (today)
  - Organisational change management and models for sustainability
- Dr. Surya Nepal (Wednesday)
  - Data architecture, data models, security and confidentiality
- Dr. Marlien Varnfield (Wednesday)
  - Human factors. Acceptability and useability of telehealth by patients and clinicians
CSIRO NBN Telehealth Trial – 6 Sites

- Townsville
- Penrith
- Nepean Blue Mountains / ARV
- Canberra and ACT
- Ballarat and the Grampians
- Launceston / Northern Tasmania

Number of patients at each site

- 25 Test Patients
- 50 Control Patients

Total

- 150 Test patients
- 300 Control Patients

Trial Design

- Case Matched controls
- Before-After-Control-Impact (BACI)
Key objectives of the CSIRO trial

• Identify and model the impact of introducing telehealth services into existing models for the management of chronic disease in the community.
  - Health and wellbeing outcomes
  - Socio economic outcomes
  - Acceptability and usability of telehealth services
  - Impact on patients, carers and clinicians
  - Effect of workplace culture and capacity for organizational change management

• Develop robust statistical models to automatically risk stratify patients using questionnaires and vital signs data
# Ethics Approvals Received

<table>
<thead>
<tr>
<th>ETHICS COMMITTEE</th>
<th>APPROVAL #, DATE.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Veterans Affairs</td>
<td>Accepted DOHA Ethics Approval</td>
</tr>
<tr>
<td>Nepean Blue Mountains LHD</td>
<td>LNR/13/NEPEAN/79, 1 July 2013.</td>
</tr>
<tr>
<td>Townsville MacKay LHD</td>
<td>HREC/13/QTHS/56, 7 June 2013.</td>
</tr>
<tr>
<td>Canberra Hospital and ACT Health</td>
<td>ETHLR.13.122, 29 May 2013.</td>
</tr>
<tr>
<td>Tasmania North Health Service (Launceston Hospital)</td>
<td>Accepted CSIRO Ethics approval HREC 13/04</td>
</tr>
</tbody>
</table>
Telemedcare Clinical Monitoring Unit
Telehealth Services Provided

• **Vital Signs** (provided as appropriate to patient’s clinical condition)
  - Non Invasive BP (Auscultatory and Oscillometric)
  - Pulse Oximetry
  - Single lead ECG
  - Blood Glucometer
  - Spirometry (FEV$_1$, VC, PEF)
  - Body Temperature
  - Body Weight

• **Communications**
  - Messaging
  - Video Conferencing

• **Questionnaires**
  - Large range of Clinical and Wellness questionnaires to choose from
Patient Selection
ICD-10 Diagnostic Codes for subject selection

At least two unplanned admissions to hospital in the preceding year for one or more of the following chronic conditions;

Chronic Obstructive Pulmonary Disease
  • J41 – J44
  • J41 – J44 J47 and J20
    (only with secondary diagnosis of J41, J42, J43, J44, J47)

Coronary Artery Disease
  • I20 – I25
  • I20 – I25

Hypertensive Diseases
  • I10, I11.9
  • I10 – I15 (I11.0: Hypertensive heart failure will be included in Congestive Heart Failure)

Congestive Heart Failure
  • I11.0, I50, J81
  • I50, J81, I11.0

Diabetes
  • E10 – E14

Asthma
  • J45
Matching control subjects to test subjects

- Perfect matching not possible given the limited number of cases
- The matching variables and associated importance weight, e.g.,

<table>
<thead>
<tr>
<th>Test/Control</th>
<th>Age</th>
<th>Gender</th>
<th>Major Diagnosis</th>
<th>SIEFA Socio-Economic Indexes for Areas</th>
<th>Strength of the match (score of 0 equal perfect match)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>54</td>
<td>M</td>
<td>COPD</td>
<td>1023</td>
<td></td>
</tr>
<tr>
<td>Control 1</td>
<td>56</td>
<td>M</td>
<td>COPD</td>
<td>1015</td>
<td>1.68 #</td>
</tr>
<tr>
<td>Control 2</td>
<td>54</td>
<td>F</td>
<td>HD</td>
<td>1022</td>
<td>2.16 $</td>
</tr>
<tr>
<td>Importance weights</td>
<td>0.2</td>
<td>1</td>
<td>1</td>
<td>0.16</td>
<td></td>
</tr>
</tbody>
</table>

# $|54 - 56| \times 0.2 + 1 \times 0 + 1 \times 0 + |1023 - 1015| \times 0.16 = 1.68$

$|54 - 54| \times 0.2 + 1 \times 1 + 1 \times 1 + |1023 - 1022| \times 0.16 = 2.16$
Data Resources

- PBS Data from DHS
- MBS Data from DHS
- Telemedcare Vital signs data and adherence logs
- Health RoundTable Hospital Data
- Recorded events in Trial portal
- HIE and Business Analytics data
  - Questionnaires and structured interviews
Integration of multiple data sources

DATA INTEGRATION ENGINE

SECURE CLOUD SERVER

AUTHORISED RESEARCHERS
Internet Usage

Overall

ADSL, 19
NBN Fibre, 44
Wireless, 3
NB VDSL, 1

Total monthly data usage (Gb)

Connected patients
Data usage

Data usage
Total number of connected patients

Average traffic (monthly) (GB)

Average traffic (daily) (GB)
Clinician login to patient portal

![Graph showing time spent per login and time spent by clinician per day in minutes from June 2013 to December 2014.](image)
RESULTS
## Final Numbers

Total enrolled
N=287

<table>
<thead>
<tr>
<th></th>
<th>ACT</th>
<th>NSW</th>
<th>QLD</th>
<th>TAS</th>
<th>VIC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
<td>16</td>
<td>16</td>
<td>26</td>
<td>29</td>
<td>26</td>
<td>113</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>23</td>
<td>13</td>
<td>29</td>
<td>60</td>
<td>49</td>
<td>174</td>
</tr>
</tbody>
</table>

### Demographics

<table>
<thead>
<tr>
<th>Demographics</th>
<th><strong>TEST</strong></th>
<th><strong>CONTROL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>71 ±9.2</td>
<td>72±9.5</td>
</tr>
<tr>
<td>% Male</td>
<td>65</td>
<td>56</td>
</tr>
<tr>
<td>BMI (mean± SD)</td>
<td>30.6±8</td>
<td>28.0±7</td>
</tr>
</tbody>
</table>

### Data Analysed

<table>
<thead>
<tr>
<th></th>
<th>Test</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>101</td>
<td>139</td>
</tr>
</tbody>
</table>
Great Variability in PBS and MBS data!
As an example: Number of entries in PBS Data

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TOTAL</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAX</td>
<td>1671</td>
<td>456</td>
<td>297</td>
<td>343</td>
<td>401</td>
<td>325</td>
</tr>
<tr>
<td>MEAN</td>
<td>412</td>
<td>85</td>
<td>72</td>
<td>81</td>
<td>88</td>
<td>87</td>
</tr>
<tr>
<td>SD</td>
<td>257</td>
<td>73</td>
<td>51</td>
<td>52</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>375</td>
<td>72</td>
<td>68</td>
<td>76</td>
<td>82</td>
<td>80</td>
</tr>
<tr>
<td>Q75</td>
<td>535</td>
<td>112</td>
<td>99</td>
<td>109</td>
<td>115</td>
<td>112</td>
</tr>
<tr>
<td>Q25</td>
<td>241</td>
<td>32</td>
<td>37</td>
<td>43</td>
<td>55</td>
<td>53</td>
</tr>
<tr>
<td>IQR=Q75-Q25</td>
<td>294</td>
<td>80</td>
<td>63</td>
<td>66</td>
<td>61</td>
<td>59</td>
</tr>
<tr>
<td>MEDIAN -1.5*IQR</td>
<td>81</td>
<td>-8</td>
<td>6</td>
<td>10</td>
<td>22</td>
<td>21</td>
</tr>
</tbody>
</table>

Because of this unexpected and inexplicable variability and missing data, data from 12 Test patients and 35 potential Control patients were rejected.
Patient Characteristics
.... by disease condition and socio-economic index for areas
## Patient Compliance with questionnaires

<table>
<thead>
<tr>
<th></th>
<th>Number of Scheduled Tasks</th>
<th>Number of Tasks Completed</th>
<th>Compliance Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety and Depression</td>
<td>1069</td>
<td>536</td>
<td>50.1%</td>
</tr>
<tr>
<td>Quality of Life</td>
<td>4379</td>
<td>2254</td>
<td>51.5%</td>
</tr>
<tr>
<td>Medication Adherence</td>
<td>328</td>
<td>98</td>
<td>29.9%</td>
</tr>
<tr>
<td>Living With and Managing Medical Conditions</td>
<td>1092</td>
<td>630</td>
<td>57.7%</td>
</tr>
<tr>
<td>COPD Questionnaire</td>
<td>12269</td>
<td>4337</td>
<td>35.3%</td>
</tr>
<tr>
<td>User Acceptance and Satisfaction</td>
<td>94</td>
<td>32</td>
<td>34.0%</td>
</tr>
<tr>
<td>Dietary Habits and Active Australia</td>
<td>93</td>
<td>34</td>
<td>36.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19324</strong></td>
<td><strong>7921</strong></td>
<td><strong>41.0%</strong></td>
</tr>
</tbody>
</table>
# Patient Compliance with Daily Measurement Schedule

<table>
<thead>
<tr>
<th></th>
<th>Number of Scheduled Tasks</th>
<th>Number of Tasks Completed</th>
<th>Compliance Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>BloodGlucose</td>
<td>12,464</td>
<td>8,739</td>
<td>70.1%</td>
</tr>
<tr>
<td>BloodOximetry</td>
<td>30,834</td>
<td>20,216</td>
<td>65.6%</td>
</tr>
<tr>
<td>BloodPressure</td>
<td>30,679</td>
<td>20,551</td>
<td>67.0%</td>
</tr>
<tr>
<td>BodyTemperature</td>
<td>27,297</td>
<td>17,143</td>
<td>62.8%</td>
</tr>
<tr>
<td>ECG</td>
<td>30,327</td>
<td>19,817</td>
<td>65.3%</td>
</tr>
<tr>
<td>Forced Spirometry</td>
<td>20,692</td>
<td>10,876</td>
<td>52.6%</td>
</tr>
<tr>
<td>Weight</td>
<td>25,122</td>
<td>14,124</td>
<td>56.2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>177,415</strong></td>
<td><strong>111,466</strong></td>
<td><strong>62.8%</strong></td>
</tr>
</tbody>
</table>
Comparing Test Patients and Control Patients over 100 days prior to monitoring commencing

- No significant differences between all parameter except the Number of Visits to GPs

- The non statistically significant differences observed suggest that Test patients may generally be a little more ill than Control Patients!
MORTALITY

• Calculated as % probability of death during the period of intervention
  • For TEST patients \( \frac{2}{3+77} = 3.75\% \)
  • For Control patients \( \frac{5}{5+79} = 5.95\% \)

• Hence telehealth monitoring reduces mortality by 37%
Note a significant greater reduction in Hospital length of stay for test patients than for the control patients. This was significant at the 5% level of significance using a generalised linear mixed effect model assuming that Hospital length of stay in days is a Poisson distribution. **Test patients exhibited a 43.2% fall in the number of hospitalisations, whilst Control patients a 30.6% reduction.**

### Rate of hospitalisation

**NOTE:** These plots were updated from those presented at the HIC2015 conference, which were plotted on the LOG scale.

<table>
<thead>
<tr>
<th>TEST</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of hospitalisation events</strong></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>6.0 (4.6-13)</td>
<td>3.4 (2.6-4.2)</td>
</tr>
</tbody>
</table>

31 Test Patients of 101 had a period of hospitalisation. Period of intervention varied from 30-480 days.
Length of Stay

Note a significant reduction in Hospital length of stay for test patients but not for control patients. This was significant at the 1% level of significance using a generalised linear mixed effect model assuming that Hospital length of stay in days is a Poisson distribution.

Test Patients had a **32.1% greater reduction in Length of Stay (LOS) relative to Control patients**

**NOTE:** These plots were updated from those presented at the HIC 2015 conference, which were plotted on the LOG scale

<table>
<thead>
<tr>
<th>TEST</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length of stay (days) in hospital</strong></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>37.14</td>
<td>18.7</td>
</tr>
<tr>
<td>(18-58)</td>
<td>(8.4-29)</td>
</tr>
</tbody>
</table>

31 Test Patients of 101 had a period of hospitalisation
Period of intervention varied from 30-480 days
Time Series Analysis of PBS Dispensing Costs – for TEST patients

30 day intervals, synchronised to start of intervention
Time Series Analysis of PBS Dispensing Costs – for CONTROL Patients

30 day intervals, synchronised to start of intervention
Time Series Analysis of Total MBS Item Costs – for TEST patients

30 day intervals, synchronised to start of intervention
Time Series Analysis of MBS Item Costs – for CONTROL patients

30 day intervals, synchronised to start of intervention
Model Projection of MBS Item Costs for TEST patients
Model Projection of One Year Cost Savings from telehealth intervention in MBS Item Costs

![Graph showing model projection of one year cost savings from telehealth intervention in MBS Item Costs.](image)
Model Projection of PBS Dispensing Costs for TEST patients
Model Projection of One Year Cost Savings from telehealth intervention in PBS Dispensing Costs
Preliminary Conclusions

..it’s early days yet, but

- The results of the CSIRO NBN trial will make a significant contribution to the development of government policy and funding models.
- The CSIRO NBN Telehealth project has broken new ground in clinical trial methodology and analysis of time series health data.
- The ongoing costs of managing chronically ill patients have been identified and the progression over time of these costs have been modelled.
- We have demonstrated that at home monitoring of vital signs can lead to significant savings over time of PBS dispensing costs and costs associated with MBS items.
- Preliminary data suggests that telehealth monitoring will lead to a significant reduction in unscheduled hospitalisation and Length of Stay.
- At home telehealth monitoring is well accepted by clinicians and patients alike who can readily appreciate the benefits.
- Return on investment on investing in telehealth for the management of chronic disease is likely to be between 2 and 3.
Health economics of Aged Care

The Numbers - Aged Care Cost Per Year:

- Home health monitoring: $1,600 /year ($2,550 in Aust)
- In Home Nursing Visitation: $13,121 /year
- Nursing Home: $77,745 /year

Source – US Veterans Health Administration (VHA)

The Numbers: Health Care Cost Per Day:

- Telecare: $3.46 /day
- Telehealth: $7.14 /day
- Acute Hospital Bed: $967.00 /day

Source - Feros Care (Aust) – Telehealth Care Pilot Program
Estimated Potential Return on Investment
(...hypothetical, but plausible! Based on CSIRO Project experience)

• Minimum estimated Costs / month for telehealth management of chronically ill patient
  • Capital costs averaging $850 amortised over 4 years at 6% pa $20 /month
  • Internet costs (3/4G data costs, 10MB monthly plan) $5 /month
  • Monitoring, hosting and maintenance @ $5/day $150 /month
  • Nurse coordination (0.5 hours/week/patient + overheads) $50 / month

• ANNUAL COST ESTIMATE $2,700 pa ($7.40/day)

• ANNUAL SAVINGS ESTIMATES
  • Savings in PBS dispensing $200 pa
  • Savings in utilisation of clinical services $800 pa
  • Reduced rate of Hospitalisation (1/annum) and reduced LOS $>6000 pa
  • Reduced demand on community nurses
    (Increased case load per nurse, equivalent to saving of 5% EFT) $4000 pa

  TOTAL SAVINGS $11,000 pa

  ESTIMATED ROI = 3.07
ANY QUESTIONS?

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