THE definitive summation of the results of the NBN CSIRO telehealth trial and their policy implications

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Successes and Failures in Telehealth, Darwin, 23/10/2018
Agenda

- Introduction
- The burden of chronic disease
- Clinical evidence for benefits of telehealth
- Telemonitoring technologies and services
- The CSIRO National telehealth trial
- Results of the CSIRO National telehealth trial
- What have learned?
- Conclusions and how to move forward
Why are we still talking about Telehealth?

When we could be talking about;

- Wearable technology
- Big data analytics
- Artificial Intelligence
Because there is now >20 years of evidence that telemonitoring delivers

- Improved healthcare outcomes
- Reduced admissions to hospital
- Reduced length of stay
- Reduced expenditure on medical services
- Reduced mortality
- Best Return on Investment (ROI)

...and yet there has been very little progress made in scaling up and deploying telehealth services nationally!
The CSIRO National Telehealth Trial

- Rate of expenditure on medical services fell by **46.3%**
- Rate of unscheduled admissions to hospital fell by **53.2%**
- Rate of length of stay (LOS) fell by **67.9%**
- Mortality was reduced by **> 40%**
- > **83%** user acceptance and use of telemonitoring technology
- > **89%** of clinicians would recommend telemonitoring services to other patients
- Return on Investment (ROI) was almost **x6**!
The burden of chronic disease
The problem we are addressing:

• An ageing population, doubling of those > 65 and quadrupling of those > 85 in 40 years
• As the population ages the burden of chronic disease increases. Almost 50% of those > 65 have two or more chronic conditions.
• As the population ages the incidence of hospital admissions increase dramatically
• Hospital costs have doubled over the last 10 years and are increasing at > x3 CPI
• Health is now the largest employer in many developed countries – we cannot continue to increase the health workforce!
• Models of care are changing worldwide with a larger focus on self management and team based coordinated care
Burden of Chronic Disease

- Around 80% of Community Doctor consultations relate to chronic disease.
- Patients with a chronic disease or complications use over 60% of hospital bed days.
- Two thirds of patients admitted as medical emergencies have exacerbation of chronic disease or have chronic disease.
- For patients with more than one condition, costs are six times higher than those with only one.
- Some people are highly intensive users of services (10% of inpatients account for 55% of inpatient days) or very intensive users (5% of inpatients account for 40% of bed days).

Improving Chronic Disease Management UK DOH
http://www.dh.gov.uk/assetRoot/04/07/52/13/04075213.pdf
What is \(\textit{or should be!}\) telehealth?

- The delivery of care at a distance, centred around patient needs
- Empowerment of patients with the tools and the knowledge to self manage their long term conditions
- Promotion of better case management through the creation of IT enabled telehealth care teams
- Use of advanced IT and knowledge management to facilitate predictive analytics and evidence based decision support
- Facilitation of an all of population approach to improving healthcare outcomes for those with long term conditions
- Integration of social care, mental health, telecare and telehealth services throughout the primary care sector
Why is telehealth important?

• 70-75% of healthcare budgets is spent on managing chronic disease or its exacerbation
• Increasing worldwide deficits in clinical HR
• Increasing costs of providing hospital services
• Need to reduce unscheduled admissions to ED
• Patients with multiple and complex chronic disease consume a massive proportion of healthcare budgets
• Evidence that assistive technology and self-management are very effective in improving healthcare outcomes and reducing costs
Clinical evidence for benefits of telehealth
## STUDIES MEASURING CHANGE IN EMERGENCY ROOM VISITS WITH TELEMONITORING

<table>
<thead>
<tr>
<th>Authors</th>
<th>Intervention</th>
<th>Disease Groups</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnston et al. (2000)</td>
<td>Video visits</td>
<td>Heart disease, lung disease, diabetes, chronic wounds</td>
<td>Outpatient costs (including ER visits) increased by 12%</td>
</tr>
<tr>
<td>Meyer, Cobb, and Ryan (2002)</td>
<td>Physiological monitoring, video visits, messaging</td>
<td>Heart disease, lung disease, diabetes, chronic wounds</td>
<td>Reduced ER visits by 29% vs. control.</td>
</tr>
<tr>
<td>Noel et al. (2004)</td>
<td>Physiological monitoring, remote wound camera</td>
<td>Heart disease, lung disease, diabetes, chronic wounds</td>
<td>Reduced ER visits by 19% vs. control</td>
</tr>
<tr>
<td>Rees and Bashshur (2007)</td>
<td>Wound camera</td>
<td>Chronic wounds</td>
<td>Reduced ER visits by 59% vs. control</td>
</tr>
<tr>
<td>Strategic Healthcare Programs, LLC (2004)</td>
<td>Physiological monitoring</td>
<td>Heart disease, lung disease, diabetes</td>
<td>Reduced ER visits by 49% for CHF patients, 66% for COPD patients, and 83% for diabetes patients</td>
</tr>
</tbody>
</table>

Vital Signs Via Broadband: Remote Health Monitoring Transmits Savings, Enhances Lives, Robert E. Litan†
# Studies Measuring Change In Hospitalizations and BDOC With Telemonitoring

<table>
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<th>Authors</th>
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<tbody>
<tr>
<td>Cleland et al.</td>
<td>Physiological monitoring, telephone visits</td>
<td>Heart disease</td>
<td>Reduced BDOC by 20% vs. control.</td>
</tr>
<tr>
<td>(2005)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dansky et al.</td>
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</tr>
<tr>
<td>(2001)</td>
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<td>Finkelstein et al.</td>
<td>Physiological monitoring, video visits</td>
<td>Heart disease, lung disease, chronic wounds</td>
<td>Hospital and nursing home admissions reduced by 58% vs. control</td>
</tr>
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<td>(2006)</td>
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</tr>
<tr>
<td>Johnston et al.</td>
<td>Video visits</td>
<td>Heart disease, lung disease, diabetes, chronic wounds</td>
<td>Reduced hospitalization expenses by 44% vs. control</td>
</tr>
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<td>Heart disease, lung disease, diabetes, chronic wounds</td>
<td>Reduced BDOC by 52% vs. control.</td>
</tr>
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<td>Montefiore Care Connect (interview, 2008)</td>
<td>Physiological monitoring, telephone visits, messaging</td>
<td>Heart disease, lung disease, diabetes</td>
<td>Reduced hospitalization and ER costs by 40%</td>
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<td>Chronic wounds</td>
<td>Reduced BDOC by 45% vs. control</td>
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<td>Heart disease, lung disease, diabetes</td>
<td>Reduced hospitalizations by 39% for CHF patients, 51% for COPD patients, and 75% for diabetes patients</td>
</tr>
<tr>
<td>Trappenburg et al. (2008)</td>
<td>Remote messaging</td>
<td>Lung disease</td>
<td>Reduced hospitalization by 41% vs. control</td>
</tr>
</tbody>
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Vital Signs Via Broadband: Remote Health Monitoring Transmits Savings, Enhances Lives, Robert E. Litan†
Studies Measuring Change In Nursing Home Admissions and BDOC With Telemonitoring

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<td>Reduced nursing home BDOC by 68% vs. control.</td>
</tr>
</tbody>
</table>

Vital Signs Via Broadband: Remote Health Monitoring Transmits Savings, Enhances Lives, Robert E. Litan†
Clinical Evidence for the benefits of telehealth

- Telehealth Services for the management of chronic disease in the community are now no longer “Bleeding edge”, but are yet to be deployed in a large scale in Australia, despite their demonstrated success, as summarised below:

  - 15% reduction in A&E Visits
  - 20% reduction in emergency admissions
  - 14% reduction in elective admissions
  - 14% reduction in bed days
  - 8% reduction in tariff costs and
  - 45% reduction in mortality rates

UK Department of Health: Whole System Demonstrator Programme Headline Findings Dec 2011.
The USA Veterans Administration

• The Veterans Health Administration (VHA) model uses a care coordinator who supports and monitors a panel of 100–150 patients, with a focus on empowering patients to take roles in self-management.

• Routine analysis of data obtained for quality and performance purposes from a cohort of 17,025 CCHT patients shows the benefits of a 25% reduction in numbers of bed days of care, 19% reduction in numbers of hospital admissions, and mean satisfaction score rating of 86% after enrolment into the program.

• The cost of CCHT is $1,600 per patient per annum, substantially less than other NIC programs and nursing home care.

• VHA’s experience is that an enterprise-wide home telehealth implementation is an appropriate and cost-effective way of managing chronic care patients in both urban and rural settings.
Addendum:

• The US Department of Veterans Affairs announced that 690,000 US veterans received care in the 2014 fiscal year via telehealth, with 2 million telehealth visits scheduled.

• That means that 12 percent of all veterans enrolled in VA programs received telehealth care of some kind in 2014.

Tele-monitoring technologies and services
The University of NSW
Gen I - Home Telecare System 2001

BP (Ausc + Osc)
ECG (Single Lead)
Spirometry
Pulse Oximetry
Weight
Body Temperature
Questionnaires
Wireless link for falls monitoring

Deployed in Sydney Metropolitan area and at a rural site 400km from Sydney
Demonstrated high user and clinician acceptance and >97% patient compliance over 12 months
First Commercial System
Gen II - TMC Home, July 2006

Deployed at the Austin Hospital in 2006 as part of HARP funded program
Gen III: Home clinical monitoring unit

Deployed in the CSIRO National Telehealth Trial 2013-2014
Today’s alternative for the Home – The Personal Health Monitor

PHM TABLET + 3/4G Internet

BT BASE UNIT (shown without wired Peripherals, NIBP, Pulse Oximeter, BT)

Weight Scale

Glucometer

Easy ECG
Today’s alternative for the Home: The Home Hub and its peripherals!

BT BASE UNIT
(shown without wired Peripherals, NIBP, Pulse Oximeter, BT)

Glucometer

Weight Scale

Easy ECG
The CSIRO National Telehealth Trial
The CSIRO Project Team

- Prof. Branko Celler
- Dr. Marlien Varnfield
- Dr. Surya Nepal
- Dr. Jane Li
- Dr. Ross Sparks
- Dr. Julian Jang-Jaccard
- Mr. Simon McBride
- Dr. Rajiv Jayasena

Project support:
DOHA and NBN Telehealth Pilot Program
CSIRO internal project funding
Partner in-kind contributions
Australian Research Council Grant LP160101202
NBN Telehealth Pilot Program
CSIRO Telehealth Project

• Summary

– CSIRO was lead organisation
– Six clinical partners and three industry partners
– Total project size >$5m ($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 via telemonitoring in the home
– Trial duration 18 months – ended 30th Dec 2014
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
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)

* One site was decommissioned
The hypothesis!

- Empowering the patient
- Improved Outcomes
- Reduced Costs

Improved and more efficient CASE MANAGEMENT

Assisted SELF MANAGEMENT

Better use of available HUMAN RESOURCES
Clinical Triage and Care Coordination
The model of care

Objectives of clinical triage is not to *deliver* care but to *coordinate and orchestrate* the provision of timely and effective care by the patient's normal care giver ie GP or community nurse, to avoid an exacerbation of the patient's chronic condition and unnecessary hospitalisation.
Short video on the CSIRO Telehealth trial

https://www.youtube.com/watch?v=72-xat2gjHg
Data Resources available for the study

- Pharmaceutical Benefits Scheme (PBS) Data from Department of Human Services (DHS)
- Medical Benefits Scheme (MBS) Data from DHS
- 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

- Entry and Exit Questionnaires
- Daily & Weekly Questionnaires
- Telemonitoring Vital Signs Data
- Health RoundTable Hospital Records
- Open Clinica
- TMC Server
- Data Base
- MBS Data
- PBS Data
- HIE and Business Process Data
- Recorded Events in Portal

DATA INTEGRATION ENGINE

SECURE CLOUD SERVER

AUTHORISED RESEARCHERS
Evaluation Framework

- Quality of life (EQ-5D)
- Psychological well-being (e.g., anxiety) (HADS)
- Self-management behavior (HEIG adapted)
- Social isolation (HEIG adapted)
- Medication adherence (Morisky)

**Evaluation**

- Service use
- Hospital utilization
- Primary care utilization
- Post discharge visits
- Community mentor visits
- Prescription drugs
- All cause mortality
- Disease-specific mortality
- Functional measures
- Others
- Cost
- Health utilization measures
- Data quality
- Data integrity etc.

**Participant's experience**

- Use of telehealth attitudes
- Activity monitoring - TMC log data
- Usability
- Anxiety and caregiver strain
- Time spent in providing care and lost productivity
- Workload, new model of care etc.
- Health professionals' experience

**User experience (including qualitative)**

**Carer's experience**

**Factors facilitate or impede the sustainable adoption and integration of telehealth**

- Demographic survey
- Log data
- Other data

**Organizational study (including qualitative)**
## Selection Criteria for Test and Control Patients

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Inclusion</td>
<td>50 years old and over at consent.</td>
</tr>
<tr>
<td>Cognitive capacity</td>
<td>Inclusion</td>
<td>Abbreviated Mental Test (AMT) score &gt; 7.</td>
</tr>
<tr>
<td>Unplanned acute admissions</td>
<td>Inclusion</td>
<td>A rate of unplanned acute admission with the required principal diagnosis code(s) indicated below:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) &gt; 2 in the last 12 months, or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) &gt; 4 in the previous 5 years.</td>
</tr>
<tr>
<td>ICD-10-AM principal diagnosis code(s) for each</td>
<td>Inclusion</td>
<td>Code(s) for each unplanned acute admission indicate a diagnosis for one or more of the following chronic conditions:</td>
</tr>
<tr>
<td>unplanned acute admission</td>
<td></td>
<td>a) Chronic Obstructive Pulmonary Disease (J41 – J44, J47 and J20, with secondary diagnosis of J41-J44, J47),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Coronary Artery Disease (I20 – I25),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Hypertensive Diseases (I10 – I15, I11.9. Note: Hypertensive Heart Failure (I11.0) is included in Congestive Heart Failure),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Congestive Heart Failure (I11.0, I50, J81),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Diabetes (E10-E14),</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) Asthma (J45).</td>
</tr>
</tbody>
</table>
# 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>

Data Analysed

<table>
<thead>
<tr>
<th></th>
<th>Test</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>100</strong></td>
<td>137</td>
<td></td>
</tr>
</tbody>
</table>

<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>
Why you can't use simple Before and After statistics when data is time varying!
Time series analysis of data

- In this method we used 30 day intervals for MBS and PBS analysis and 100 day intervals for number of admissions and length of stay.
- All data were time aligned so that the time interval “0” represented the day when telemonitoring commenced, and 0 to -35 is the period of 36 x 30 days BEFORE the intervention and 1 to 12 represents the 12 x 30 days AFTER the intervention.
- The disadvantage of this method is that the effects of seasonal variations cannot be assessed and indeed are minimised because of averaging effects. This method however emphasises that the intervention is the first order effect that we are seeking to analyse.
Results of the CSIRO National Telehealth Trial
Baseline comparison between test patients and control patients over 100 days prior to intervention and last 100 days prior to end of intervention. Bracketed terms are 95% CI.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Patients</th>
<th>Test Patients</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure in last 100 days prior to start of intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N&lt;sub&gt;Test&lt;/sub&gt; = 100, N&lt;sub&gt;Control&lt;/sub&gt; = 137)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost of medications prescribed</td>
<td>$1,077 (867 - 1,288)</td>
<td>$959 (814 - 1,088)</td>
<td>0.3</td>
</tr>
<tr>
<td>Total expenditure on medical and pharmaceutical items</td>
<td>$2,020 (1,633 - 2,406)</td>
<td>$2,030 (1,697 - 2,338)</td>
<td>0.17</td>
</tr>
</tbody>
</table>

| Expenditure in last 100 days prior to end of intervention               |                  |               |         |
| (N<sub>Test</sub> = 100, N<sub>Control</sub> = 137)                    |                  |               |         |
| Total cost of medications prescribed                                    | $860 (615 - 1,149) | $506 (318 - 770) | < 0.01  |
| Total expenditure on medical and pharmaceutical items                    | $1,942 (1,366 - 2,637) | $1,038 (656 - 1,570) | < 0.01  |

Savings in MBS and PBS expenditure over one year $3,298
...... a 46.5% reduction!
Model based time course for MBS expenditure for Test and Control subjects

Both ANCOVA and regression are based on a covariate, which is a continuous predictor variable. ANCOVA stands for Analysis of Covariance. It is a combination of one-way ANOVA (Analysis of Variance) and linear regression.
Estimate of impact of telemonitoring on MBS expenditure

Projected Savings
$720 (28%)
Savings in MBS expenditure over one year of telemonitoring

<table>
<thead>
<tr>
<th>PATIENT COHORT</th>
<th>Rate of MBS Expenditure at start of Intervention</th>
<th>Predicted Rate of MBS Expenditure at Year +1 (Without Intervention)</th>
<th>Estimated Rate of MBS Expenditure at Year +1 (With Intervention)</th>
<th>% Reduction in rate of MBS expenditure over one year</th>
<th>Predicted Annual Cost of MBS items after Intervention</th>
<th>Actual Annual Cost of MBS items after Intervention</th>
<th>Savings in MBS Expenses over one year</th>
<th>% Savings in MBS expenses over one year</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients (N=100)</td>
<td>$2,405</td>
<td>$2,803</td>
<td>$1,504</td>
<td>46.3</td>
<td>$2,602</td>
<td>$1,991</td>
<td>$611</td>
<td>23.5</td>
</tr>
<tr>
<td>Male patients only (N=67)</td>
<td>$2,267</td>
<td>$2,623</td>
<td>$1,401</td>
<td>46.6</td>
<td>$2,444</td>
<td>$1,914</td>
<td>$529</td>
<td>21.7</td>
</tr>
<tr>
<td>Female patients only (N=33)</td>
<td>$2,381</td>
<td>$2,611</td>
<td>$1,477</td>
<td>43.5</td>
<td>$2,495</td>
<td>$2,001</td>
<td>$495</td>
<td>19.8</td>
</tr>
<tr>
<td>Patients with Cardiac disease as their primary diagnosis (N=50)</td>
<td>$2,491</td>
<td>$2,951</td>
<td>$1,562</td>
<td>47.1</td>
<td>$2,719</td>
<td>$1,915</td>
<td>$804</td>
<td>29.6</td>
</tr>
<tr>
<td>Patients with Respiratory disease as their primary diagnosis (N=30)</td>
<td>$2,165</td>
<td>$2,454</td>
<td>$1,296</td>
<td>47.2</td>
<td>$2,308</td>
<td>$1,899</td>
<td>$409</td>
<td>17.7</td>
</tr>
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Impact of telemonitoring on Number of Hospital Admissions

<table>
<thead>
<tr>
<th>Rate of Admissions at start of Intervention (N/annum)</th>
<th>Predicted Rate at Year +1 (N/annum) after intervention</th>
<th>Estimated Rate at Year +1 (N/annum) after intervention</th>
<th>% Change in Rate</th>
<th>Predicted Number Admissions in Year after Intervention (N/annum)</th>
<th>Actual Number Admissions in Year after Intervention (N/annum)</th>
<th>Reduction in Number Admissions over one year (N/annum)</th>
<th>% Change in Number Admissions over one year</th>
</tr>
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<tbody>
<tr>
<td>2.55</td>
<td>3.09</td>
<td>1.45</td>
<td>53.2%</td>
<td>2.82</td>
<td>2.15</td>
<td>0.67</td>
<td>23.8%</td>
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Impact of telemonitoring on Hospital Length of Stay (LOS)

<table>
<thead>
<tr>
<th>Rate of LOS at start of Intervention (days)</th>
<th>Predicted Rate of LOS without intervention Year +1 (days)</th>
<th>Estimated Rate of LOS with Intervention Year +1 (days)</th>
<th>% Change in Rate of LOS</th>
<th>Predicted LOS over one year without Intervention (days)</th>
<th>Estimated LOS in year after Intervention (days)</th>
<th>Estimated reduction in LOS over one year (days)</th>
<th>% Change in LOS over one year after intervention</th>
</tr>
</thead>
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<tr>
<td>19.8</td>
<td>24.6</td>
<td>7.9</td>
<td>67.9%</td>
<td>22.2</td>
<td>14.7</td>
<td>7.5</td>
<td>33.8%</td>
</tr>
</tbody>
</table>
Impact of telemonitoring on Mortality

<table>
<thead>
<tr>
<th>Age Distribution</th>
<th>50-60</th>
<th>60-70</th>
<th>70-80</th>
<th>80-90</th>
<th>90-100</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths in BDM Master</td>
<td>180</td>
<td>310</td>
<td>441</td>
<td>414</td>
<td>84</td>
<td>1429</td>
</tr>
<tr>
<td>Age Specific Death Rate</td>
<td>9.4%</td>
<td>14.8%</td>
<td>13.6%</td>
<td>22.0%</td>
<td>44.0%</td>
<td>17.6%*</td>
</tr>
<tr>
<td>Weights</td>
<td>0.126</td>
<td>0.217</td>
<td>0.309</td>
<td>0.290</td>
<td>0.059</td>
<td>1.0</td>
</tr>
<tr>
<td>Test Patient by Age</td>
<td>41</td>
<td>31</td>
<td>14</td>
<td>13</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Age Specific Deaths</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Expected Deaths</td>
<td>3.85</td>
<td>4.59</td>
<td>1.9</td>
<td>2.86</td>
<td>0.44</td>
<td>13.64</td>
</tr>
<tr>
<td>Deaths Saved</td>
<td>2.85</td>
<td>2.59</td>
<td>-2.1</td>
<td>1.86</td>
<td>0.44</td>
<td>5.64</td>
</tr>
</tbody>
</table>

Using age adjusted death rates from the Master Register of eligible patients, 13.64 deaths were expected but only eight were recorded. This represents a saving of 5.64 lives, a reduction of **41.3%**. This is in good agreement with the reduction of 48.0% and 44.5% calculated relative to matched controls.
## Patient adherence to measurement schedules

<table>
<thead>
<tr>
<th>Vital signs</th>
<th>Number of Scheduled Items</th>
<th>Number of Items Completed</th>
<th>% Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure</td>
<td>31,117</td>
<td>21,890</td>
<td>70.35%</td>
</tr>
<tr>
<td>ECG</td>
<td>33,719</td>
<td>22,405</td>
<td>63.70%</td>
</tr>
<tr>
<td>Pulse Oximetry</td>
<td>31,102</td>
<td>21,363</td>
<td>68.69%</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>12,579</td>
<td>8,501</td>
<td>67.58%</td>
</tr>
<tr>
<td>Spirometry</td>
<td>20,498</td>
<td>11,493</td>
<td>56.07%</td>
</tr>
<tr>
<td>Body Temperature</td>
<td>29,792</td>
<td>19,158</td>
<td>64.31%</td>
</tr>
<tr>
<td>Body Weight</td>
<td>27,777</td>
<td>16,051</td>
<td>57.79%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>186,584</strong></td>
<td><strong>120,861</strong></td>
<td><strong>64.78%</strong></td>
</tr>
</tbody>
</table>
Patient adherence over time
Seasonal variation and effect of time synchronisation

\[ S_p(i) = \sum_{j=1}^{3} \sum_{k=1}^{N_j} P_j (\text{Start of monitoring for } k\text{th Patient in Actual Calendar} + i - 1) \]
Summary of Impact of Telemonitoring

- **Rate** of expenditure on medical services fell by **46.3%**
  - Savings over the first year was **23.5%**
- **Rate** of unscheduled admissions to hospital fell by **53.2%**
  - Reduced number of admissions over one year **23.8%**
- **Rate** of length of stay fell by **67.9%**
  - Reduced length of stay over first year **33.8%** (7.5 days)
- **Mortality** was reduced by **> 40%**
- **> 83%** user acceptance and use of telemonitoring technology
- **> 89%** of clinicians would recommend telemonitoring services to other patients
Estimated Potential Return on Investment

- **Minimum estimated Costs / month for telehealth management of chronically ill patient**
  - Capital costs averaging $1324 amortised over 4 years at 7% pa $35 /month
  - Internet costs (3/4G data costs, 10MB monthly plan) $5 /month
  - Monitoring, hosting and maintenance @ $70/month $70 /month
  - Nurse coordination (100 patients / clinical care coordinator, $4 /day / patient) $120 / month

  **TOTAL** $230/month

- **ANNUAL COST ESTIMATE** $2,760 pa ($7.40/day)

- **ANNUAL SAVINGS ESTIMATES**
  - Savings in MBS and PBS Costs (from CSIRO trial) $1000 pa
  - Reduced LOS, averaging 7.5 bed days @ $2,051 / day $15,383 pa
  - Reduced demand on community nurses
    (Reduction of one visit / week @ $60 /visit) $2880 pa

  **TOTAL SAVINGS** $19,263 pa

**ESTIMATED ROI = 5.98**
Journal Papers


• Argha A, Savkin A, Liaw ST, Celler BG. Effect of Seasonal Variation on Clinical Outcome in Patients with Chronic Conditions: Analysis of the Commonwealth Scientific and Industrial Research Organization (CSIRO) National Telehealth Trial. JMIR medical informatics. 2018 Jan;6(1).

• Celler B, Varnfield M, Nepal S, Sparks R, Li J, Jayasena R. Impact of At-Home Telemonitoring on Health Services Expenditure and Hospital Admissions in Patients With Chronic Conditions: Before and After Control Intervention Analysis. JMIR Medical Informatics. 2017 Jul;5(3)

• Celler B, Varnfield M, Jayasena R. What Have We Learned from the CSIRO National NBN Telehealth Trial?. Studies in health technology and informatics. 2018;246:1-17.


• Sparks R., Branko Celler, Chris Okugami, Rajiv Jayasena and Marlien Varnfield, J Telehealth Monitoring of Patients in the Community. Journal of Intelligent Systems. ISSN (Online) 2191-026X, ISSN (Print) 0334-1860, DOI: 10.1515/jisys-2014-0123, January 2015

What have we learned?
Conclusions.
What have we learned?

• The longitudinal health record from the home is a very powerful diagnostic tool – something ED physicians learned a long time ago! ie modified early warning scoring (MEWS)/EWS track and trigger system (TTS) is based on the recording of physiological signals in ED

• The telehealth enabled model of care is cost efficient and allows one care coordinator to manage ~75-100 chronically ill patients

• Video conferencing is a nice-to-have but really not necessary – it was barely used in the CSIRO trial

• Whilst the project demonstrated that approximately 50% of predicted admissions were avoided, the other 50% potentially were avoidable as well! We need more intelligent and robust methods for risk stratification!

• Notwithstanding the limitations encountered, the return on investment was approximately 6!

• Appropriate workplace culture and capacity for organisational case management is essential! GP involvement was disappointing.
What have we learned?

Our results are better than those obtained in a number of other studies, mainly in Europe, why?

“normal care” in Australia is very light touch and mainly based on GP care, which is reactive and episodic. Normal care in Europe often involves more community based and hospital based outreach – akin to Victorian HARP program.

Existing low touch, GP based “normal care” + at home vital signs telemonitoring and care coordination could be more cost effective than intensive post discharge hospital based care.

GP involvement however will need to be much more pro-active and in partnership with telehealth care coordination for the best results to be achieved.
Why has Australia been so slow in large scale adoption of telehealth?

• There are many reasons, beyond the obvious!
• Medicare only understands funding the provider – patient model. Hence the limited funding for telehealth video consultations
• There is no funding model or developed business case for at home telemonitoring
• The industry sector is weak and does not inspire confidence
  – Products are lacking in innovation and are not standards based
  – Inter-operability is a major issue
  – Insufficient consideration of clinical governance requirements
  – Almost impossible to engage with clinical thought leaders and health service providers
  – Lack of resources to implement state of the art systems including
    • Predictive analytics and artificial Intelligence tools
    • Advanced web services and cyber security
    • Advanced non-invasive bioinstrumentation
    • Quality systems and smart algorithms to maximise reliability of at-home telemonitoring
How to move forward?
ADHA – Strategic priorities

Strategic priorities

1. Health information that is available whenever and wherever it is needed
2. Health information that can be exchanged securely
3. High-quality data with a commonly understood meaning that can be used with confidence
4. Better availability and access to prescriptions and medicines information
5. Digitally-enabled models of care that improve accessibility, quality, safety and efficiency
6. A workforce confidently using digital health technologies to deliver health and care
7. A thriving digital health industry delivering world-class innovation
A trial of home monitoring via telehealth for patients with chronic diseases in an aged care setting was conducted by the CSIRO over a 20-month period. Concluding in December 2014, the results provided a series of insights showing numerous benefits, including a 46% reduction in Medicare Benefits Schedule (MBS) expenditure and a 25% reduction in Pharmaceutical Benefits Scheme (PBS) expenditure.

The trial also showed a 53% reduction in the rate of admissions to hospital. Among those patients who were admitted, there was also a 75% reduction in the rate of length of stay, with a greater than 40% reduction in mortality.

Users and clinicians alike were strongly supported the system, with over 83% user acceptance and use of telemonitoring technology, and over 89% of clinicians saying that they would recommend telemonitoring services to other patients.134
A Unique Opportunity!

- **ARC – Industry Transformation Research Hub**
  - A $2.5m pa centre of excellence in Telehealth
  - Platform technologies and services for the digital transformation of the Australian health care sector – *Clinician Lead and Industry Driven*
  - $1m Industry + $1m ARC + $0.5m Universities (pa)
  - Major Clinical User Group Established (Hospitals + LHDs)
  - Universities include UNSW, WSU, Flinders, CDU (Menzies Foundation)
  - Application due 12\textsuperscript{th} December, 2018
Opportunities

• Medical Research Futures Fund (MRFF) EOI
  – Frontiers in Health & Medical Research Program
  – 2016-2018 Priorities – Disruptive Technologies
  – Stage 1, if successful, $1m for one year
  – Stage 2, will support best applicants from Stage 1 with 5 years of funding ($10-20m pa)

• Both opportunities will be explored simultaneously with existing partners
Case Study: Exacerbation event, COPD patient. Hospitalisation NOT avoided! Why?

PATIENT OCID: 38
Journal Papers


• Argha A, Savkin A, Liaw ST, Celler BG. Effect of Seasonal Variation on Clinical Outcome in Patients with Chronic Conditions: Analysis of the Commonwealth Scientific and Industrial Research Organization (CSIRO) National Telehealth Trial. JMIR medical informatics. 2018 Jan;6(1).

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Thank you!

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