Results of the Australian CSIRO National Multi-site Trial of At-home Telemonitoring for the Management of Chronic Disease

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Abstract—**A clinical trial of telehealth services was carried out along the Eastern seaboard of Australia from Townsville in the North to Launceston in Tasmania over a period of 18 months from mid-2013 to end-2014. Patients were selected based on their history of hospitalization for their chronic conditions. A Test group of 114 patients was supplied with at home telemonitoring equipment and 173 patients were enrolled as a matched control group who were subjected to normal care. The impact of telemonitoring over one year following the start of telemonitoring, was analyzed using linear regression and analysis of covariance (ANCOVA). Mortality was reduced by >40%, the rate of hospitalization was reduced by 53% and length of stay was reduced by 7.5 days. The rate of expenditure on medical services was reduced by 46.3% and that for Pharmaceutical expenditure by 25.5%. There were significant differences in results for patients with Heart Failure, those with Lung Disease and those with Diabetes. The effective introduction of telemonitoring was dependent on local factors such as workplace culture and capacity for organizational change management.**

Keywords- telehealth; home telehealth; home telemonitoring; chronic disease management; clinical trial protocol; BACI design; case matched control design.

I. INTRODUCTION

In industrialized nations, approximately 70-78% of healthcare budgets are spent on the management of chronic disease or its exacerbation. As the population ages the burden of chronic disease will increase and place healthcare budgets under increasing strain. Telehealth services have been demonstrated as an effective innovation in international contexts, but there are low levels of evidence from Australian studies.

This study analyzed whether the introduction of at-home telemonitoring services for the management of chronic disease in the community reduces patient use of the health system and improves mortality, healthcare outcomes and patient quality of life. We also explored the issues and challenges in deploying telemonitoring services in the community.

This trial was designed to create a robust evidence base for these key success factors and to demonstrate an effective and scalable model for Internet-enabled telehealth services in Australia. Armed with the insights provided by this evidence base, policy makers may have much of the data they require

to implement funding models and create a sustainable Telehealth services sector in Australia.

II. AIMS

The project bbjectives were to demonstrate and document how telehealth services can be successfully deployed across Australia, by piloting services in five different settings across five states, with a range of health service providers, including Local Health Districts, Medicare Locals and not for profit community organisations. This was carried out by deploying and demonstrating the operation of Telehealth monitoring in a multi-site multi-state case matched control trial (Before-After-Control-Impact (BACI) design) of chronically ill patients living in their own homes in the community. This has never previously been attempted in Australia. Specific aims included;

- Provide evidence that at home telemonitoring has the potential to reduce unscheduled admissions to hospital compared to the control group.
- Provide evidence for an impact on hospital admissions, mortality, clinical events and symptoms and improvements in functional measures and patients' and carers' experiences with care.
- Evaluate health economic benefits
- Evaluate impact on clinical work force availability and deployment
- Evaluate impact of human factors (acceptability, usability by patients, carers, nurses, General Practitioners (GPs) and administrators)
- Evaluate impact of workplace culture and capacity for organizational change management.
- Derive clinical and health economic evidence on how Telehealth services can be scaled up nationally to provide an alternative cost effective health service for the management of chronic disease in the community.

III. METHODS

The clinical trial design has been previously reported in the literature [1] and will only briefly be summarized here.

The trial was carried out at five different sites representing two different models for the management of chronic disease in the community, one Hospital based and the other Community based. This allowed the analysis of site specific differences in workplace culture, organizational change management and staff and management capabilities,

that contribute to differences in measured health, social and economic outcomes.

The trial design required 25 test patients and 50 case matched control patients at six sites in five states and Territories. Test patients were supplied with state of the art Telehealth technology in the home for the monitoring of vital signs, delivery of clinical questionnaires and messaging between patients and carers. Test and Control patients were closely matched using a range of clinical, demographic and socio-economic criteria. Before and after data was available from national data bases on medical expenses (MBS data) and pharmaceutical expenses (PBS Data), as well as hospitals admissions and length of stay (LOS) from National Hospital RoundTable data.

A preliminary graphical analysis of both PBS and MBS data, using the MATLAB function *normplot* as well as the Chi-square goodness of fit test indicated that the data were not normal. Both lognormal and sqrt transformations were found to be effective in normalizing the data. The sqrt transformation was chosen as a little better, and applied to data before linear regression analysis was carried out.

MBS data were summed over 30-day intervals back approximately three years (36x30-day intervals) from the start of intervention and forward by almost one year (12x30-day intervals). When a Test patient had two controls, the data for both controls were averaged.

Ignoring missing points, data were then averaged and the 95% confidence limits calculated across all rows for each time interval. Before and after data were generally varying over time, and were analyzed using analysis of covariance (ANCOVA) a general linear model, which blends ANOVA and linear regression.

IV. RESULTS

Two sites in the Nepean Blue Mountains Area were ultimately merged into a single site for logistical reasons. Following dropouts, withdrawal of consent and patients rejected because of poor or missing data, 100 Test patients and 114 Control patients were analyzed in detail. Out of these, 67 were males and 33 were females.

The average age of patients was 71.9±9.4 years. There was no significant difference in age between males and females or Test and Control patients. Test patients were monitored for an average of 276 days with 75% monitored for more than 6 months.

TABLE 1: LINEAR REGRESSION AND ANCOVA ANALYSIS OF SQRT(MBS) DATA

	BEFORE	AFTER		BEFORE	AFTER
	Slope	Slope	Sig	Intercept	Intercept
CONTROL	0.05098	-0.03953	0.1	12.58	12.98
	(0.0293, 0.0727)	(-0.1305, 0.0515)		(12.13, 13.02)	(12.29, 13.66)
TEST	0.0919	-0.2729	<0.001**	14.06	14.44
	(0.0625, 0.1213)	(-0.4236, -0.1222)		(13.47, 14.66)	(13.33, 15.55)
P	0.0268*	0.009**			
DIFF (Control - Test)	-0.9446	3.916	0.1025	-55.38	-30.91
	(-2.073, 0.1839)	(-3.251, 11.08)		(-78.71, -32.05)	(-83.66, 21.84)

In the period of 100 days, prior to the onset of telemonitoring, there were only minor differences in the number of GP visits (P=0.04) and no significant differences in number of visits to specialists, number and cost of medications prescribed or number and cost of laboratory tests carried out.

ANCOVA analysis was carried out on Test and Control patient data and control-test differences. A matrix of results with slopes, intercepts and P values is shown in Table 1 for all Test patients. Graphical data of sqrt(MBS Costs) against time is shown in Figure 1.
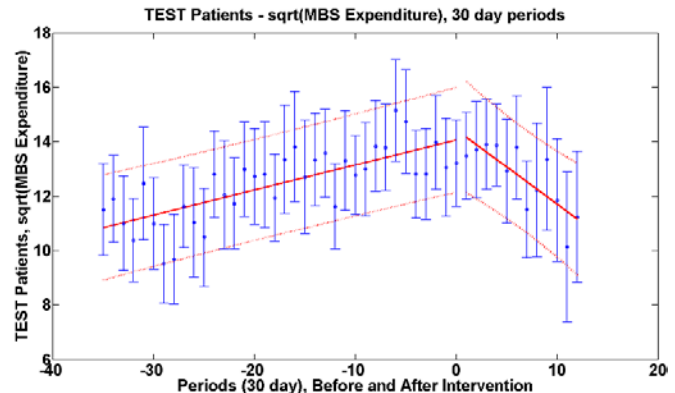

Figure 1. sqrt(MBS Costs) plotted for Test patients before and after intervention with 95% Prediction Intervals shown as red dotted lines

Similar analysis was carried out for PBS data as well as for different patient cohorts and different disease conditions. MBS data showed a 46.3% reduction in the rate of expenditure after one year and a 23.5% saving of $611. PBS savings were more modest with rates of expenditure falling by 25.5% and savings of 11.5% or $354 over one year.

Detailed hospital data was available for 53 Test patients and 64 Control patients. A similar ANCOVA analysis carried out on data averaged over 100 day intervals, revealed a 53.2% reduction in the rate of admission and a saving of approximately 23.8% or 0.67 admissions over the year following the intervention. Rates of LOS were reduced by almost 68% resulting in a 33.8% saving over the year of 7.5 days. Mortality for Test patients over the trial period was reduced by >40% relative to their Controls.

V. CONCLUSION

Results of the CSIRO National Telehealth Trial have been briefly summarized. Telemonitoring of patients with a range of chronic conditions has been shown to reduce expenditure on medical services and pharmaceutical items as well as significantly reduce the rate of hospitalization and length of stay. Mortality was also significantly reduced. Patients found the telemonitoring equipment easy to use and compliance rates >50% were achieved for daily measurement of vital signs. There were significant differences observed between different patient cohorts and different chronic conditions.

REFERENCES

[1] B. G. Celler et al. "Design of a multi-site multi-state clinical trial of home monitoring of chronic disease in the community in Australia." BMC Public Health, 2014, 14(1), pp.1270-1285.