ABSTRACT
Cardiovascular disease is the leading cause of death and one of the greatest burdens to economies worldwide. Cardiac rehabilitation can effectively address risk factors prevalent to cardiovascular disease, as well as reduce morbidity and mortality. In spite of documented benefits, poor rates of referral, uptake and utilization of cardiac rehabilitation programs continue. The Care Assessment Platform (CAP) is an innovative home care model which provides an alternative delivery approach to rehabilitation for cardiac patients, utilising a mobile phone platform. This paper reports results on use and user acceptance of mobile phone applications utilised in the CAP model and evaluated in a randomized controlled trial. The implementation of mobile applications in the CAP model showed high usage and acceptance by patients (>85%). Mobile applications, such as a health diary and step counter, show promise in supporting self monitoring and management of lifestyle related health risk factors in the management of other chronic diseases.

KEY WORDS
Cardiac rehabilitation, information & communication technology, health diary, self monitoring, self management, chronic diseases.

1. Introduction
Cardiovascular disease (CVD) remains the biggest cause of deaths worldwide. Over the past two decades, CVD has increased at an astonishingly fast rate in developing countries [1]. Secondary prevention measures, such as cardiac rehabilitation (CR), have been effective in reducing the risk factors leading to recurrence of cardiac events and hence reducing morbidity and mortality [2]. Cardiac rehabilitation programs offer a coordinated sum of interventions required to ensure the best physical, psychological and social conditions so that people with heart disease may return to an active and satisfying life and to prevent the recurrence of cardiac events [3-5]. In spite of reported benefits, traditional models of CR delivered through a hospital- or centre-based program have disappointingly poor rates of referral, uptake and utilisation. It is estimated that only 10 to 30% of eligible patients complete CR [6-8].

The poor utilization of the centre-based CR programs have been hampered by their limited capacity to address the barriers reported such as lack of access, transportation issues, return to work, cost, time issues, lack of motivation and the perception that CR is inconvenient [9]. Hence, there is need for an alternative approach to the delivery of CR. Previous attempts of an alternative CR delivery have been in patients’ homes but remained limited to only the exercise component of the CR program due to the lack of communication between the carer and patient.

Lately, the advances in information and communication technologies (ICT) have been harnessed to support home care CR models. Studies using the telephone or internet support and telemonitoring to support home-based CR delivery have demonstrated effective risk factor reduction and also cost effectiveness compared to centre-based CR programs [10-13]. A Science Advisory publication from the American Heart Association, 2012, which explored future directions to increase participation in CR, recommends “ innovative strategies to bring rehabilitation to more patients” that comprises “telemedicine, internet based, home based, and community programs” “…as alternative models for outpatient CR” [14].

Recently, an innovative Care Assessment Platform (CAP) CR model was developed by the Australian E-Health Research Centre and Queensland Health, using the advances in ICT to deliver an alternative and comprehensive home based program [15]. CAP utilizes a smart mobile phone platform, with built-in accelerometer, a health diary application and the internet in offering all the core components of CR. CAP delivers CR in a flexible program which is focused on individual patient needs and risk factor reduction strategies. Each patient is also allocated a dedicated mentor, who accesses the patient’s health data via internet, for feedback and goal setting sessions through weekly telephone or video conferencing. The CAP CR model has been trialed amongst patients in the Metro North Health Service District, Queensland Health and uptake and completion rates of the CR program
in the intervention group were significantly better than that of the traditional hospital care group.

This paper will report on the results on the uptake of the mobile phone applications, from a recently undertaken randomised controlled trial (RCT) [16], to better understand how the technologies utilised in the CAP model were perceived by cardiac patients. The results reported will be on usage and user acceptance of the health diary and step counter applications on the phone.

2. Methods

Patients in the intervention group of the CAP RCT received education and exercise guidance via multimedia content provided on the mobile phone and a dedicated mentor used an internet portal to view patients’ progress prior to structured weekly telephonic consultations. Fig. 1 shows a brief outline of the components of the CAP model. In the control group, patients attended traditional outpatient centre-based CR.

![Figure 1. The Care Assessment Platform home-care cardiac rehabilitation model](image)

2.1 WellnessDiary and StepCounter Applications

The WellnessDiary (WD) (Fig. 2) is a health diary mobile phone application component of the CAP CR model, for regular data collection and personal self-monitoring of cardiovascular related health factors. To evaluate the progress and performance indicators of patient’s uptake and adherence to CAP CR delivery, patients are required to use the WD application to record their physical activity patterns and health parameters on a daily basis. It also provides feedback to the patients, enabling them to evaluate and monitor their status and progress against the goals they set with their mentor.

Simple graphs, such as line and bar charts that display the status with respect to personal goals, form the basis for the feedback (Fig. 3). Physical activity is recorded by a built-in StepCounter (SC) application (Fig. 4) and data from the SC is automatically transferred to the WD as exercise and steps entries.
According to the CAP RCT protocol, patients were advised to manually make daily entries in the WD: weight, blood pressure, sleep time and quality, exercise (additional to automatically transferred steps from SC), alcohol, smoking and stress. They were advised to make three daily entries for eating to account for the three meals a day.

2.2 Data collection

In order to determine usage of the WD application, we carried out analysis of data synchronized on a daily basis by patients from their mobile phone WD to a CAP data server. Data were extracted from the server and evaluated. Usage activities of the WD application were measured as number and types of daily entries over six week periods, starting for each patient at the date of baseline assessment. The baseline assessments, for determining risk factors and setting goals addressing modifiable lifestyle behaviours, were conducted by trained clinical professionals at a community based CR centre.

User acceptance of the mobile applications was measured using an Evaluation Questionnaire which was administered during follow-up assessment after the six-week intervention program (which was also attended at the community based CR centre).
The questionnaire included questions regarding all the components of the CAP CR program, but only responses to items relating to the WD and SC applications on the mobile phone, are included in this report.

Patient responses were based on a 5 point Likert scale (fully agree (1), somewhat agree (2), neither agree nor disagree (3), somewhat disagree (4) and completely disagree (5)). The two categories (1) and (2) were combined as ‘agree’ with the item in the questionnaire and reported as a percentage.

These items included:

1. The WellnessDiary/StepCounter motivated me in meeting the goals of the rehabilitation programme.
2. The WellnessDiary/StepCounter was easy to use.
3. The WellnessDiary/StepCounter was useful to me.
4. Long-term follow up of health parameters with the Wellness Diary/StepCounter was important for me.
5. I have learned to better understand my health with the Wellness Diary/StepCounter.
6. I would recommend Wellness Diary/StepCounter for other users like myself.

In addition, to investigate the validity of self observed readings entered on the WD, we correlated data extracted from the server with measurements made by clinicians (for weight entries only). For the correlation study, self reported weight entries were only used for patients who made an entry on the WD on the same day as being measured by the clinician during the baseline assessment, and again on the date of the follow-up six week assessment (±1 day).

3. Results

Table 1 presents information for the CAP trial intervention patients included in usage and acceptability analysis.

| Patient information | Patients randomised to CAP intervention n=60 | Gender (Male/female) | Age (mean±SD) | 55.5±9.6 | Included in usage analysis n=48 | Completed Evaluation Questionnaire n=38 | Included in correlation evaluation n=27 |

Seven patients withdrew from the study before they were scheduled for baseline assessment and five withdrew before completing at least 80% of rehabilitation. The reasons for withdrawal are presented in Table 2.

<table>
<thead>
<tr>
<th>Reason for withdrawal</th>
<th>n</th>
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<tbody>
<tr>
<td>Logistical reason (lack of time)</td>
<td>1</td>
</tr>
<tr>
<td>Change in circumstances</td>
<td>7</td>
</tr>
<tr>
<td>Not specified</td>
<td>2</td>
</tr>
<tr>
<td>No longer interested/not motivated</td>
<td>1</td>
</tr>
<tr>
<td>Felt no longer needed CR – improved health</td>
<td>1</td>
</tr>
</tbody>
</table>

Patients consistently made on average > 5 manual entries daily over the six week intervention period.

Adherence to daily entries of health measures, common to all patients, over the six week CR program was very high (>90% for weight, blood pressure and sleeping entries). Manual exercise entries reported were gardening, gym, swimming and cycling sessions but also include walking entries.

Results from the six week Patient Evaluation Questionnaire, regarding the acceptability of the WD and SC on the mobile phone, are shown in Fig 5.
Results show that >85% of patients found the WD and SC motivational in reaching CR goals, easy to use, useful, educational and would recommend the applications to others.

Table 3 shows the results for the correlation evaluation and indicates significant correlation between self-observed and clinician measured data.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Measured</th>
<th>WD</th>
<th>Correlation</th>
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<tbody>
<tr>
<td>Baseline (kg±SD)</td>
<td>85.9 (26.7)</td>
<td>84.9 (26.6)</td>
<td>0.999**</td>
</tr>
<tr>
<td>Follow-up (kg±SD)</td>
<td>84.4 (26.2)</td>
<td>83.6 (26.1)</td>
<td>0.999**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

4. Discussion

Use of mobile phone technologies have become a common daily lifestyle tool among millions of people, worldwide. Harnessing these technologies, for improving the health of all individuals irrespective of locality, is strategic to gain better adherence for adopting health programs. Our study evaluated the usage and acceptance of a health diary and step counter applications on a mobile phone, as a component of a comprehensive home-based CR program.

The implementation of mobile applications in the CAP model has shown high usage and acceptability to patients. Our results confirm preliminary data which we reported previously [17]. Patients made on average >5 manual entries per day. These results are in correspondence with two 12-week user studies by Mattila and co-workers [18] who reported 5.32 entries per day in a weight management study (8 obligatory parameters) and 5.48 entries per day in a general wellness management study using a similar WD application. Most commonly used variables in our study were weight, blood pressure and sleeping, variables general to all patients.

Participants in the study found the WD and SC useful, easy to use, motivational, educational and they were well prepared to recommend the application to other people in similar circumstances. Although manual entries of self observations are simple to perform, a small percentage of patients thought that the manual entries required effort. Automatic transmission of measurements may facilitate data entry and with the emergence of wireless physiological monitoring devices, data transmission from external measurement devices will become more feasible.

Automatic transmission could also minimize user errors which could impact on accuracy of information.

Correlation between self observed measurements and clinician measured data was significant, albeit the self observed weight values were slightly lower. This could be explained by the time of measurement as the patients were recommended to take their own weight measurements early in the morning at home. Most people at home weigh first thing in the morning, before eating or drinking, and after going to the bathroom, without clothes.

Our study findings suggest that applications such as the SC and WD are promising in supporting self monitoring and management of lifestyle related health risk factors for individuals recovering after a cardiac event. The CAP home care service model demonstrated increased uptake and completion rate of CR programs and a high level of usage and acceptance. This model, therefore, has the potential to provide an effective approach to preventive care and self management of other chronic diseases. Diabetes is a good example of a chronic disease that requires ongoing management and expanding the WD to include manual or wireless entry of blood glucose levels for individuals living with diabetes could enable more effective glycaemic control. COPD is another example of a long term disease which requires ongoing management of risk factors similar to CVD, such as smoking cessation, physical exercise and psychosocial interventions. By expanding the CAP care model to include breathing, spirometer and sputum entry parameters, COPD patients could be supported in home-monitoring in order to maintain stable state symptoms and thereby delaying the process of disease progression.

Regrettably, worldwide, the prevalence of many health risks factors is expected to increase in the future: overweight and obesity rates, for example, are predicted to continue rising with significant consequences [19]. Many of these risk factors are associated with several different diseases and prevention and management of these factors can therefore have substantial benefits. The CAP care model provides for clinician involvement and support over distance through mobile phone applications and internet connection and it offers the capabilities of enabling long term self monitoring, goal setting, performance measurement and risk reduction strategies for chronic disease management.

The positive outcomes from the CAP have inspired initiatives to roll out the CR program to a wider population in Queensland and also to develop a Mobile Chronic Disease rehabilitation platform.

5. Conclusion

An innovative home-care model using smart phones and the internet was developed and integrated to address the core components of CR services offering potential benefits
to patients recovering after a cardiac event. The different mobile phone applications utilized in the model have demonstrated high usage and user acceptance. Similar methods and components of monitoring are also required in management of many other chronic diseases and therefore CAP has the potential to be applied in risk reduction strategies for diseases such as diabetes and COPD in an effective and acceptable way.

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References