

The clinical and economic impact of a multicomponent digital therapeutic mobile app: a retrospective analysis

Part 2: Economic impact

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1. INTRODUCTION

Medication adherence represents a global burden to patients, society and healthcare systems (1). The negative consequences derived from patients not adhering to their medications are related to a diminution in the clinical benefits of the medication therapy and poor health outcomes (2). The latter may be linked to an increase in the use of healthcare services such as hospitalisations and medical costs (2, 3) representing a significant economic burden for the healthcare system.

Although non-adherence has been associated to a higher use of healthcare resources, research on the economic impact of non-adherence is limited, mainly due to the heterogeneity of the available data reporting non-adherence related costs and the variability in the methods used to calculate these costs (4). In Australia, it is estimated that between 2 to 3% of hospital admissions are associated with an inadequate use of medicines, with 20-30% of admissions being in the older population (≥ 65 years), costing the Australian health care system \$1.2 billion annually (5). However, the cost associated to non-adherence is thought to be underestimated (6), as the economic analysis usually accounts for other factors that affect the proper use of medications such as patients not receiving the medications on time (4).

A widely cited systematic review aiming at determining the economic impact of medication non-adherence across multiple disease groups reported costs of non-adherence ranging from \$USD949 to \$USD44,190 per patient per year (4). Specifically, the costs ranged between \$USD5,000 and \$USD10,000 for Cardiovascular diseases, between \$USD3,252 and \$USD19,363 in Mental Health diseases, between \$USD804 and \$USD36,259 for Respiratory diseases, between \$USD3408 and \$USD28126 in Musculoskeletal conditions and between \$USD3,000 and \$USD10,000 for Diabetes (4).

Consequently, medication adherence management interventions are needed to improve the efficiency of the health care system. Different interventions have been developed and evaluated across different settings (7). However, there is still conflicting evidence on the most effective medication adherence interventions (7). Wiecek et al. found that multicomponent interventions were successful at improving medication adherence during long-term follow-up periods (≥ 10 months) (8). Those interventions including technical components (e.g. reminders), educational components (e.g. provision of disease and/or medication information) and attitudinal components (e.g. interventions

aiming to modify behavioural intentions were found to be the most effective at maintaining adherence overtime (8).

In the last decade there has been an increase in the use of mHealth technologies to deliver health-related interventions, such as those related to the management and adherence to medications (9). The Global Observatory for eHealth (GOe) has defined mHealth as medical and public health practice supported by mobile devices including complex functionalities and applications (10). Until 2018, more than 300,000 mHealth apps had been developed, with nearly 25% being focused on the management of chronic conditions and medications (11). A literature review identified a range of benefits in using mobile apps to manage medication adherence (12). Another literature review on medication adherence apps found that the most common features found in these apps included the use of technical, educational and gamification (e.g. any method providing video game-like elements) components (13). In this sense, previous research has identified that gamification is linked to an increase in intrinsic motivation to engage in an activity (14), which could positively impact on medication non-adherence.

As the prevalence of chronic conditions continue to raise, and consequently the use of medications, interventions targeting medication adherence are necessary (15). On top on their positive clinical impact, medication adherence management interventions can result in a reduction of avoidable healthcare costs. Cutler et al. analysed the economic impact of a community pharmacist-led intervention, estimating cost-savings of AUD\$1.9 billion per year from the healthcare system perspective (16). However, a similar analysis has not been conducted for interventions delivered through mobile apps. As the number of smartphone users increases, with 3.6 billion of smartphone users in 2020 (17), the use of mobile apps is growing. Therefore, it is pivotal to analyse the impact of the interventions delivered through these mHealth apps.

The Perx app is an mHealth app that includes educational, technical and gamification components. It has previously been proven to be an effective intervention to maintain medication adherence in patients with chronic conditions during different follow-up periods (18). This app gathers real-world data (RWD), referred as data collected from sources others than clinical settings (19), which can be useful to understand the behaviour of medication adherence in uncontrolled settings and therefore, assist in the development of innovative interventions. Although its clinical impact has been evaluated, the economic impact of this mHealth app is yet to be estimated.

To the best of our knowledge, this is the first study analysing the economic impact of a medication adherence management mHealth app from the health care system perspective.

1.1 Objectives

To estimate the economic impact of the Perx app on medication adherence by analysing PBS prescription medication usage in relation to 12-month user medication adherence rates and literature reported non-adherence costs.

2. METHODS

This report includes the retrospective analysis of real-world data collected from the Perx app. Users data included medication, clinical conditions and clinical variables data and was de-identified.

This study has been approved by the University of Technology Sydney Human Research Ethics Committee (HREC) (Application number: ETH21-5730).

2.1 Intervention

A medication adherence management intervention was provided through the digital Perx app. The Perx app supports individuals manage their chronic conditions and develop better health habits (i.e. medication adherence). A Perx program participant can download the app to their mobile phone or mobile device from a digital platform (i.e. Apple App Store or Google Play). Medication information (name, strength, dose and frequency), treatment schedules and physical health tasks can be recorded in the app. Clinical health measurements and doctor appointments can also be recorded and scheduled. Medication doses taken and mobile direct observation of therapy (MDOT) photo verification are recorded by the users. When it is time for a medication dose, games are offered to the individual to promote medication taking behaviour, receiving either a randomised reward or and/or “points” when a medication dose is taken on time. Points can also be earned by completing other daily tasks (e.g. exercise, appointments) or engaging with educational content (e.g. condition-specific education or tips for healthy living). Reaching a certain amount of gold points will cause the individual to “level-up”, unlock new potential rewards and improve their position on the leader board. Completion of all health tasks during the course of a day will provide participants with an in-app Heart badge and another gamified opportunity to earn a reward (e.g. gift card or charity donation). When Hearts are earned continuously over time they build into a Streak (representing how many days in a row a participant has achieved 100% adherence).

The Perx app involves technical components such as dose reminders (prompted from the patient’s scheduled doses for each medication) and visual feedback on medication adherence behaviour. It also includes self-serve educational content and resources (i.e. informative messages about the disease and the medications) and reward vouchers when accomplishing daily tasks.

2.2 Medication Adherence

Medication adherence was calculated as the number of medication doses taken (medication tasks completed in the app) over the total scheduled doses. The result was reported as a percentage. Time periods of 30 days were selected to conduct the analysis. A 12-month timeframe was adopted for this analysis.

2.3 Costs calculations

Costs associated to medication non-adherence for Respiratory, Musculoskeletal and Rheumatology, Mental Health, Cardiology and Endocrine clinical conditions were extracted from the literature (4) and converted to Australian dollars (2021 values) with the Cochrane Economics Methods Group – Evidence for Policy and Practice Information and Coordinating – Centre Cost Converter tool (20). The Medication Adherence Cost Estimate (MACE) framework (21), hospital cost data (22) and the PBS (Pharmaceutical Benefits Scheme) expenditure data (23) were accounted to estimate the national expenditure attributed to non-adherence. An estimation of the cost saving and projected cost saving potential of the Perx app was also undertaken. A time horizon of 12 months was adopted.

3. RESULTS

A total of 289 users of the Perx app were included in the 12-month analysis. Users were distributed across five different clinical condition categories: Respiratory (n=58), Musculoskeletal and Rheumatology (n=43), Mental Health (n=79), Endocrine (n=45), Cardiology (n=64). The majority of patients were female (64.63%). Baseline characteristics are described on Table 1.

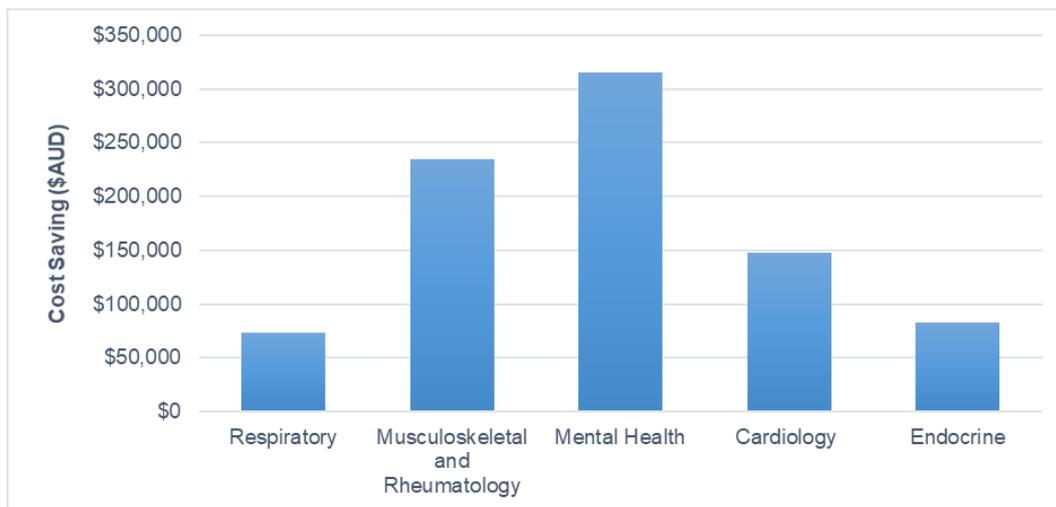
Table 1. Baseline demographic characteristics

Variable	12 months timeframe (n=246)
Age, years (SD)	49.71 (15.78)
Genre (%)	
- Female	64.63%
- Male	29.27%
- NULL	4.07%
- Undisclosed	2.03%
Location (%)	
- Australia	99.19%
- NULL	0.81%

Medication Adherence: Overall median adherence rates were reported across clinical condition groups. For the Respiratory group, rates were 98.1% (IQR 88.8%-100%). Overall rates for the Musculoskeletal and Rheumatology conditions were 99.8% (IQR 96.4%-100%) and 98.9% (IQR 91.2%-100%) for Mental Health. For Cardiology conditions, overall was 100% (IQR 95.4%-100%) and for Endocrine conditions, overall rate was 100% (IQR 95.7%-100%).

Cost Estimation: The National estimate cost of non-adherence extrapolated from non-adherence rates found in literature was AUD\$4,077,470,478 for respiratory conditions, AUD\$10,258,894,254 for Musculoskeletal and Rheumatology, AUD\$6,409,426,608 for Mental Health, AUD\$3,842,043,064 for Cardiology and AUD\$4,469,171,101 for Endocrine conditions.

The total cost saving of the Perx app after 12 months was AUD\$73,455 for respiratory conditions, AUD\$234,954 for Musculoskeletal and Rheumatology conditions, AUD\$315,258 for Mental Health conditions, AUD\$147,328 for Cardiology conditions and AUD\$82,530 for Endocrine conditions (Figure 1).

Figure 1. Cost Saving or the Perx app across clinical condition groups

When analysing the national projected cost saving potential, the highest cost was attributed to the Musculoskeletal and Rheumatology conditions, with a value of AUD\$10,222,255,345, followed by Mental Health conditions (AUD\$6,231,566,637), Endocrine conditions (AUD\$4,469,171,101), Respiratory (AUD\$3,925,116,615) and Cardiology (AUD\$3,842,043,064). The cost analysis is described on Table 2.

Derivation of cost process	Reported Findings				
Australian adult population (2020) ⁽²⁴⁾	20,036,045				
	Respiratory ⁽²⁵⁾	Musculoskeletal and Rheumatology ⁽²⁶⁾	Mental Health ⁽²⁵⁾	Cardiology ⁽²⁷⁾	Endocrine ⁽²⁶⁾
Prevalence rates of conditions (%)	31%	16.7%	20%	19.6%	21.3%
Prevalence rates of conditions (number of patients)	6,211,173	3,346,019	4,007,209	3,927,064	4,267,677
Average adherence rate (literature)	49.15% ⁽²⁹⁾	44% ⁽³⁰⁾	60.36% ⁽³¹⁾	57.5% ⁽³²⁾	42.9% ^(30, 33)
National estimate non-adherence (\$AUD)	\$4,077,470,478	\$10,258,894,254	\$6,409,426,608	\$3,842,043,064	\$4,469,171,101
Perx user numbers	58	43	79	64	45
Perx adherence rate	98.1%	99.8%	98.9%	100%	100%
Perx cost saving (\$AUD)	\$73,455	\$234,954	\$315,258	\$147,328	\$82,530
Perx user per patient saving potential (\$AUD) ^(4, 28)	\$1,291	\$5,475	\$4,035	\$2,302	\$1,834
Perx Cost Saving Potential (\$AUD)	\$3,925,116,615	\$10,222,255,345	\$6,231,566,637	\$3,842,043,064	\$4,469,171,101

Table 2. Derivation of Cost process. Reported as annual cost.

4. DISCUSSION

This study reports novel evidence on the estimated economic impact of an innovative intervention to manage medication adherence. Based on the costs of non-adherence and average adherence rates extrapolated from literature it was possible to estimate the potential cost savings of the Perx app.

Non-adherence has been associated with an increase in clinical negative outcomes (2). However, there is limited evidence on the costs associated with non-adherence (4). The national costs of non-adherence associated to specific diseases such as respiratory, musculoskeletal and rheumatology, mental health, cardiology and endocrine conditions have been found to range between AUD\$3 billion and AUD\$10 billion (4, 28), significantly impacting the healthcare system. The cost analysis of the Perx app resulted on potential savings, derived from higher rates of medication adherence.

When estimating the potential cost savings of the Perx app, the highest cost savings were observed in the Mental Health group, with an estimated saving potential of \$AUD4,035 per patient and overall value of AUD\$315,258 followed by the Musculoskeletal and Rheumatology group, with cost savings of \$AUD5,475 per patient and \$AUD234,954. This positive result may be associated to the components of the app targeting patient behaviour change. A network meta-analysis of interventions to improve medication adherence across different diseases found that interventions with educational and attitudinal (i.e. those aiming to modify patient's attitudes related to their medications or disease) in mental health disease and attitudinal interventions in Musculoskeletal diseases were the most effective (34). For the Cardiology conditions group, the cost savings of the Perx app was estimated at \$AUD2,302 per patient and \$AUD147,328 per year. This result aligns with previous research, where higher adherence levels were associated with lower healthcare costs (35). Regarding the Respiratory and Endocrine conditions, the analysis resulted in estimated cost savings of \$AUD1,291 per patient (\$AUD73,455 overall) and \$AUD1,834 per patient (\$AUD82,530 overall) respectively. Considering the high prevalence of these conditions in Australia (31% for Respiratory conditions and 21.3% for Endocrine conditions) (25, 26), it is evident the broader implementation of the Perx app could be an ideal strategy to contribute to the sustainability of the health care system.

The cost savings estimated across all the clinical condition groups may be linked to the multi component nature of the Perx app. Previous evidence has found that multi

component interventions are effective at improving medication adherence (8). Additionally, the Perx app includes gamification features, which may have the potential to improve medication adherence by increasing intrinsic motivation (14) commonly associated to non-adherence behaviours.

Although the clinical impact of different medication adherence interventions has previously been evaluated, the evidence on the economic impact of medication adherence interventions is limited. The Perx app resulted in estimated savings of nearly AUD\$1 million with the users included in the analysis (n=289) . This is supported by a larger scale retrospective analysis of dispensing data (n=20,335) that modelled estimated national savings from a community pharmacist-led adherence intervention to reduce the costs of non-adherence by AUD\$1.9 billion annually and improve adherence rates by approximately 10% (16). The main difference between the studies may be due to the different number of patients included analysed. It may be inferred that a greater sample size could result in greater cost savings.

When extrapolating the costs across the national prevalence of the diseases, the cost saving potential of the Perx app ranged between AUD\$3-10 billion per year per condition. Given these findings, the implementation of this app in a broader population may result in greater cost savings for the healthcare system. Possible partnerships with health insurers or other health companies could enhance the reach of the Perx app. Moreover, as the number of smartphones and, therefore, mobile apps increases (17), there is a potential opportunity to provide access to more patients with different clinical conditions. Policy makers should consider the integration of mHealth apps as modern strategies to target medication non-adherence.

There are some limitations to this analysis. A baseline of medication adherence before using the app could not be established due to the nature of the study and the data. Additionally, the cost analysis has been based on a conceptual model. Nonetheless, it has accounted actual prevalence of clinical conditions and national population. Despite the limitations, these results highlight the potential of the Perx app at saving non-adherence costs.

To our knowledge this is the first analysis of the economic impact of a multicomponent mHealth app targeting medication adherence. Future research should involve the cost analysis across different number of medications and number of clinical conditions.

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