

## **Title page**

# **Dietary patterns, nutrition knowledge, lifestyle, and health-related quality of life: Associations with anti-hypertension medication adherence in a sample of Australian adults**

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## **Abstract**

**Introduction:** Poor anti-hypertension medication (AHT) adherence can increase disease costs and adverse outcomes. Hypertensive individuals who have a better nutrition knowledge may lead a healthier lifestyle, have a better health-related quality of life (HRQoL) and greater confidence to change behaviour. On this basis, they may have better treatment adherence.

**Aim:** This study aimed to explore the association between the above-mentioned variables and AHT adherence in a group of Australian adults with high blood pressure (BP) in a cross-sectional clinical and community-based study. **Methods:** Adults with high BP (n=270) completed a questionnaire including: food frequency questionnaire (FFQ), nutrition knowledge, HRQoL, self-efficacy of diet and exercise, lifestyle and AHT adherence sections. Bivariate analysis and hierarchical logistic regression were used to explore the data. **Results:** Three dietary patterns were identified from the FFQ, using factor and cluster analyses (Western, Snack & Alcohol, and Balanced). We observed that following a Western dietary pattern, having lower exercise self-efficacy and shorter sleep duration were more dominant in the poor AHT adherence individuals compared to their counterparts. A positive association was observed between self-efficacy and sleep duration with AHT adherence. A Western dietary pattern was prevalent in high BP participants which slightly reduced the likelihood of good adherence. **Conclusion:** A healthier dietary pattern, better exercise self-efficacy and adequate sleep (more than six hours a night) may increase the likelihood of AHT adherence in individuals with high BP. Interventions focusing on improving these variables are required to confirm the findings of this study.

Keywords: medication adherence, hypertension, dietary pattern, lifestyle

## Introduction

Nearly one-third of Australian adults aged 18 years and older have high BP, or hypertension (HTN) [1]. It is a condition with a high disease-associated burden and carries enormous economic and social costs [2]. Controlling HTN is crucial to reduce the risk of diseases, such as coronary heart disease and stroke [3]. Although the primary approach to control high BP involves diet and lifestyle modification, most individuals require AHT to assist with BP control [4, 3]. However, adherence to both lifestyle modification and medication appears to be poor, resulting in a relatively high rate of uncontrolled HTN [5, 6]. In Australia, more than two-thirds of individuals with high BP have not controlled their condition [1], causing HTN to be one of the biggest challenges facing the health care system [7].

Medication efficacy is largely related to an individual's adherence to the treatment regimen, and the continuation of medication as prescribed [8]. A number of factors are associated with poor medication adherence in hypertensive individuals. Medication is often taken by individuals in response to the symptoms they experience [9]. Since physical symptoms of HTN are not usually experienced or perceived, individuals with HTN may not feel the need to take medication as prescribed [9]. In addition, poor health-related knowledge, poor general health, the fear of side effects, poor socioeconomic status, patients' beliefs and forgetfulness are positively associated with medication non-adherence behaviour [10, 9]. **Exacerbating this issue, individuals who fail to adhere to lifestyle (e.g. diet and physical activity) modifications necessary for HTN therapy, often have poor AHT medication adherence [11].**

Improving adherence to AHT in hypertensive individuals is pivotal for successful treatment outcomes, and to reduce the disease complications [12]. Based on the Individual and Family Self-Management Theory (IFSMT) behavioural change results from an individual's ability to self-manage their condition [13]. In this model, self-efficacy is a core aspect of self-

management [14]. Those with more confidence to follow necessary behavioural changes are more successful in self-managing their condition.

Knowledge can also play an important role in improving confidence [15] and adherence to treatment regimens [16]. Individuals with better knowledge of diet and its relationship with HTN may be more confident in following healthier dietary patterns [17-19]. In addition, based on the *outcome* dimension of IFSMT, healthy diet and lifestyle modifications may encourage and motivate healthy dietary and lifestyle choices, which can further improve behavioural change self-efficacy, and adherence to a treatment regimen [19-21]. Lastly, based on the *context* dimension of IFSMT, the physical and psychological wellbeing of hypertensive individuals can influence their behavioural change self-efficacy and determine their adherence to a treatment regimen. Health-related quality of life (HRQoL) is defined as complete physical, mental and social wellbeing [22]. Individuals who have better nutrition knowledge and follow a healthier lifestyle may have a better HRQoL [20, 21] and better medication adherence [23]. Therefore, the framework of this study has been designed based on the IFSMT theory and is presented in Figure 1.

Accordingly, this study hypothesises that nutrition knowledge, dietary patterns, lifestyle, HRQoL and behavioural change self-efficacy are associated with AHT adherence in a sample of Australian adults with high BP. Given the importance of AHT adherence in HTN treatment and control, there is a need to identify dietary and lifestyle determinants of adherence in hypertensive Australian individuals.

## **Methods**

### *Design and data collection*

This study's design and data collection process is explained elsewhere [24]. Briefly a cross-sectional study design was employed with data collected from clinics (the Medical Assessment Unit of the Gold Coast University Hospital) and community units (the Gold Coast City Council Active and Healthy Classes; and Griffith University) between August and December 2014. The residents of the City of Gold Coast, Australia were also invited to participate, and were included in the Community unit of sampling. Individuals were included in the present study if they were: a) adults  $\geq 18$  years of age; and b) diagnosed with high BP. High BP was defined as systolic BP  $\geq 140$  mmHg and/or diastolic BP  $\geq 90$  mmHg. Those medically diagnosed with high BP were also considered hypertensive. Blood pressure measurements technic used in this study is explained elsewhere [24]. Those unable to consent to the study, or individuals with severe mental or neurological impairment, or with secondary HTN (due to other causes such as kidney or endocrine problems) were excluded from the study. Participants completed a consent form prior to the study and a medical screening in the first instance to determine eligibility. Ethics approvals were obtained from the Gold Coast University Hospital, and Griffith University prior to conducting the study (HREC Reference Number: HREC/14/QGC/115).

Data was collected using a questionnaire. The food frequency questionnaire (FFQ) used in the study was a modified version of the one developed by the Blue Mountains Eye Study [25]. The modified FFQ had a total of 39 questions on the major and commonly consumed foods as well as questions on the added salt, oil, and sugar during cooking or serving of foods. The questionnaire had an acceptable level of internal consistency with Cronbach's alpha of 0.66. The modified FFQ is validated against 3-day food records, with a good Bland-

Altman relative agreement and described in details elsewhere [26]. Dietary patterns were derived using factor analysis with Varimax rotation, and the analysis is described in details elsewhere [24]. Three patterns were derived. The Western pattern was loaded with Western-style foods, alcohol and processed meat. The Snack & Alcohol pattern was loaded with snacks (such as chips, crisps, cakes) and alcohol, and the Balanced pattern was a moderate combination of all food groups. The FoodWork version 7 dietary analysis software (Xyris Software, High Gate Hill, Qld, Australia) was used to analyse energy and nutrients intake. Western, and Snack & Alcohol patterns were higher in energy, SFA, and sodium compared to the Balanced pattern [24].

A modified and shortened version of the nutrition knowledge questionnaire developed by Hendrie et al. [27] was also included in the survey. This contained 26 questions regarding dietary recommendations, source of food and nutrients, everyday food choices, and the diet-disease relationship [24]. To evaluate the HRQoL, the Short Form 12 (SF-12 V2) was used [28]. The SF-12 had an acceptable internal consistency with  $\alpha=0.66$ . A short questionnaire on lifestyle variables (physical activity, smoking, and drinking habits) was also included in the survey. To assess individuals confidence to carry out diet and exercise modification, a short version of the self-efficacy questionnaire developed by Sallis et al. [29] was used. The self-efficacy of diet (with 8 questions) and exercise (with 4 questions) questionnaires had good internal consistency with  $\alpha=0.76$  and  $\alpha=0.89$ , respectively. Self-reported anthropometric measures of weight and height, as well as socio-demographic questions, were included in the survey.

Adherence to AHT was assessed with four questions using a modified version of the Morisky Scale [30]. It had 4 items on medication, compliance and reasons for medication non-compliance with a moderate internal consistency ( $\alpha=0.50$ ). The internal consistency value did not change heavily by omitting any individual question in the scale [31]. Answers were

scored on a 3-point scale. Scores of 0-2 were considered 'poor adherence', and a score of 3 was coded as 'good adherence'.

### *Statistical analysis*

The process of data cleaning and management is explained elsewhere [24]. Chi-square and independent t-tests (or Mann-Whitney U tests for non-parametric data) were used for bivariate analysis of differences between good and poor adherence groups. To explore the association between nutrition knowledge, dietary pattern, lifestyle and HRQoL with AHT adherence, a hierarchical regression analysis was used [32]. Based on the conceptual framework (Figure 1) and IFSMT theory, the association of nutrition knowledge and the AHT adherence was investigated in model 1. Dietary patterns and lifestyle variables were added to nutrition knowledge and their association with AHT adherence was examined in model 2. The HRQoL was added in model 3. Model 4 had the self-efficacy variable in addition to nutrition knowledge, dietary pattern, lifestyle and HRQoL and their associations with AHT were explored. Sociodemographic variables with significant bivariate differences between good and poor AHT adherence were controlled in all models. The differences in sampling units were also controlled in all regression models. Nutrition knowledge, dietary patterns and HRQoL were entered into the model, even if their differences did not reach a statistically significant level.

The sample size required to test the association between nutrition knowledge, dietary patterns, lifestyle and HRQoL with AHT adherence was estimated considering the odds of good AHT adherence can increase by 5 times with a good knowledge of disease and risk factors (the proportion of good adherence in good knowledge group = 0.60) [33]. To be more conservative, an odds ratio of 2.5 was considered. Using GPower software version 3.0

(Heinrich Heine Universität, Dusseldorf, Germany) with 80% power and  $\alpha = 0.05$  a sample size of 70 participants was considered an adequate sample to examine the association.

Including an additional 20% for non-completed or missing survey responses, a sample size of 84 participants was considered adequate to allow examination of associations for this study.

## Results

A total of 270 individuals with high BP completed the survey. Of these, 30 participants were not taking AHT to control their HTN. Additionally, 16 participants did not answer all four questions regarding AHT adherence. Therefore, 224 participants were included in the regression analysis. Almost half (47%) of the participants had poor AHT adherence. The characteristics of included individuals are presented in Table 1. A significant difference between poor and good AHT adherence participants existed for age, gender, income and employment. The good AHT adherence group were more likely to be older, female and retired or have an annual income of < \$20k compared to the poor AHT adherence group. The single most common reason for AHT non-adherence was forgetfulness (40%), followed by the fear of side effects (16%) and financial reasons (13%) (data not presented in table).

Table 2 presents data on the number of AHT types and common AHT medications taken by participants, their comorbidities and the sampling units. A significant difference was only observed in the sampling units, with more than half of the participants with good AHT adherence being from the Clinical unit. The majority of participants with poor AHT adherence were from the Community unit of sampling.

No significant difference between nutrition knowledge, HRQoL, physical activity status, the self-efficacy of diet, smoking and drinking were observed between good and poor AHT adherence groups (Table 3). The difference in dietary patterns showed a slightly higher intake of a Western pattern in the poor compared to good adherence group. In the activity and sleeping variable, individuals with good adherence had slightly higher than 7 hours of sleep daily compared to 6 hours in the poor adherence group. The good adherence group also had a significantly higher exercise self-efficacy compared to the poor adherence group. 22% of the

good adherence group reported never having stress compared to 8% in the poor adherence group. There were no significant differences in other variables (Table 3).

Nutrition knowledge, dietary pattern, lifestyle, self-efficacy and HRQoL were compared between sampling units (Supplemental Table 1). The Clinical unit of sampling had significantly lower nutrition knowledge, total physical and total mental HRQoL scores, and lower diet and exercise self-efficacy. Participants in the Clinical sample unit were also more sedentary compared to other sampling units.

Table 4 reports the associations between nutrition knowledge, dietary patterns and lifestyle on AHT adherence, while controlling for confounding variables. Based on the Hosmer-Lemeshow test, all models (except model 1) had a good model fit. Nutrition knowledge alone was not associated with AHT adherence when controlling for confounding variables. In this model, being male reduced the likelihood of good AHT adherence compared to being female. When dietary patterns and sleep duration were added to the model, the odds of having good AHT increased by 1.04 times, with an increase in sleep duration. Adding HRQoL in model 3 did not change the association. In model 4, exercise self-efficacy was added to the model. Both sleep duration and exercise self-efficacy was associated with a higher likelihood of good AHT adherence when controlling for confounding variables. Although a lower likelihood of good adherence was observed following a Western dietary pattern, the association did not reach a statistically significant level. Age, gender, employment, income or sampling units did not show any moderating influence on the final model (Table 4). The stress variable was not included in the regression analysis due to its significant bivariate correlation (0.37,  $p < 0.01$ ) with the HRQoL total mental domain.

## Discussion

The results of this study indicate that the majority of participants with HTN take AHT to control their condition. However, only about half (53%) of these individuals had good AHT adherence. Findings from this study are lower than the 67% adherence to AHT reported by the Second Australian National Blood Pressure study [6]. Poor adherence to AHT can increase the odds of coronary disease and chronic heart failure by 1.07 and 1.42 times, respectively [34], and increase the cost of health care associated with managing HTN [34, 35]. According to the results of this study, forgetfulness is the single most common reason for non-adherence among participants, followed by the fear of side effects of medication and the financial cost. Non-adherence to medication can be classified as intentional non-adherence or unintentional non-adherence [10]. The fear of side effects of the medication and patients' attempts to avoid these side effects have been categorised as intentional non-adherence [8, 10]. Unintentional non-adherence is usually due to forgetfulness, impaired and poor cognition or poor education and knowledge [10, 8].

The results of this study also show that poor adherence is more common in individuals aged < 65 years compared to those at or over this age group. Previous reports indicate that medication non-adherence can be associated with younger age [8], however, no significant association was observed between age groups and AHT adherence in the present study.

Although similar findings are reported in the literature [16, 36], it seems likely that adherence to medication increases with age, as individuals become more concerned about their health [37]. Individuals with good AHT adherence were more likely to be females. Similar findings have been reported previously [36]. A possible explanation is that females are more likely to have regular contacts with health professionals regarding their condition as they are often

more concerned about their health, which may increase their adherence to medication and treatment [38].

Based on the IFSMT theory [13] and the conceptual model of this study, we hypothesised that better nutrition knowledge, a healthier dietary pattern and lifestyle, a better HRQoL and more confidence in behavioural change are associated with better AHT adherence. However, this study failed to observe any association between nutrition knowledge alone and AHT adherence, suggesting that nutrition knowledge is not a critical determinant of AHT adherence. Similarly, dietary patterns and HRQoL were not associated with AHT adherence. However, better exercise self-efficacy and adequate sleep (around 7 hours) were positively associated with the likelihood of AHT adherence.

Although evidence is lacking on the association between nutrition knowledge and AHT adherence, a good knowledge of HTN and its risk factors may increase the likelihood of medication adherence [33]. Based on the Knowledge-Attitude-Behaviour (KAB) approach [39], it is generally understood that individuals with a better nutrition knowledge usually follow a healthier diet and lifestyle and are more concerned about their health. According to the KAB approach, it is also more likely for individuals who have a healthier diet and lifestyle to adopt healthier behaviour and adhere better to the therapeutic regimens necessary to manage their condition [40].

In contrast, those following poor dietary habits (frequent consumers of take-away foods and a Western-style diets) have a poorer perception and knowledge of health [18] and may not adhere to their required treatment [41]. The results of our study align with this to some extent. The poor AHT adherence group in this study were more likely to follow Western and Snack & Alcohol dietary patterns. Regression analysis also showed a trend for a slightly lower likelihood of having good adherence if Western and Snack & Alcohol dietary patterns were

consumed compared to a Balanced dietary pattern. In the context of treatment adherence, poor adherence to medication and lifestyle changes (including diet and physical activity) often go hand in hand. This is likely to be a result of factors such as poor health knowledge, low self-efficacy to change and forgetfulness [11]. A patient's knowledge about the disease, treatment and consequences of non-adherence to treatment can enhance active participation in treatment and self-efficacy to implement the necessary lifestyle changes [11, 42]. Those who actively follow necessary dietary and lifestyle changes may also improve medication adherence.

Physical activity duration was not significantly different between poor and good AHT adherence groups. However, individuals with good adherence had more hours sleep per night (average of 7 hours) compared to those from the poor adherence group (6 hours). Although the focus of this variable was on the quantity of sleep rather than quality, medication adherence can decrease with a reduction in sleep quality [43]. Perhaps inadequate and poor quality sleep can influence cognitive function [43], and the ability to pay attention and make good decisions [44]. Impaired cognitive function may increase forgetfulness and unintentional medication non-adherence. The higher exercise self-efficacy observed in the good AHT adherence group suggests greater confidence in following behavioural change and problem-solving recommendations among these participants [45]. Based on the conceptual framework of this study and IFSMT theory [13], individuals with a higher self-efficacy are more likely to follow the behavioural changes necessary to manage their condition, and may have better medication adherence [46, 47].

To the best of our knowledge, the current study is one of few studies addressing lifestyle determinants of medication adherence in Australian adults with high BP. Overall, following a healthier dietary pattern, getting sufficient sleep duration (7 hours a day) and a better self-efficacy were observed in those with good adherence to AHT. These findings suggest that

promoting dietary changes, involvement in exercise and adequate sleep in individuals with hypertension may be beneficial to reduce AHT non-adherence. Future interventions and longitudinal studies are necessary to confirm these findings.

However, there were several limitations in this study. Firstly, the population chosen for this study may not be representative of the entire Australian population, as participants were purposively sampled in one region of Australia. To increase the generalisation of the results, data were collected at different Clinical and Community units, and their confounding influence was controlled for in the regression analysis. Secondly, the main data collection tool used in this study was a self-reported survey, which may have measurement bias [48]. Although the internal consistency of the selected questionnaires was generally acceptable to high, the modified Morisky Scale used for AHT adherence had a low to moderate internal consistency. While this is a widely used and valid scale, similar limitations have been reported previously [49]. Overall, self-administered questionnaires cannot be considered as the 'gold standard' measure in quantitative studies. Thirdly, the length of medication consumption can influence adherence rates. However, an accurate recall of AHT medication duration, especially in the older population of the study, was limited. Also, this study had limited access to the recorded medical history, especially from individuals in the Community sampling unit. Therefore, acquiring information on the length of AHT medication was not possible, and this information was not included in the present study. In addition, the sleep quality, which may have a similar effect to sleep duration, was not measured in this study. Finally, the conclusions made in this study are based on a short observational study and do not reflect the cause-effect relationship between AHT adherence and mediating variables. Future investigation involving large cohorts and interventions is required to confirm these associations and the influence of lifestyle factors on AHT adherence.

## **Conclusion**

Poor adherence to AHT is more common among those following a Western dietary pattern, sleeping 6 hours or less a day and having lower exercise self-efficacy. In contrast, adequate sleep (7 or more hours a day), and better exercise self-efficacy can increase the likelihood of good AHT adherence. Hypertensive individuals may benefit from interventions and **approaches** that promote adequate sleep and behavioural change self-efficacy to improve AHT adherence.

### **Compliance with Ethical Standards**

Funding: Authors declare that there is no source of funding for this study.

Conflict of Interest: Authors declare that there is no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Griffith University and the Gold Coast Human Research Ethics Committee) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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**Figure caption:**

The conceptual framework of the association between dietary pattern, nutrition knowledge, lifestyle and HRQoL with medication adherence.

