Citation:
Hobbs, M and Duncan, MJ and Collins, P and McKenna, J and Schoeppe, S and Rebar, AL and Alley, S and Short, C and Vandelanotte, C (2019) Clusters of health behaviours in Queensland adults are associated with different socio-demographic characteristics. J Public Health (Oxf), 41 (2). pp. 268-277. ISSN 1741-3850 DOI: https://doi.org/10.1093/pubmed/fdy043

Link to Leeds Beckett Repository record:
https://eprints.leedsbeckett.ac.uk/id/eprint/4948/

Document Version:
Article (Accepted Version)

The aim of the Leeds Beckett Repository is to provide open access to our research, as required by funder policies and permitted by publishers and copyright law.

The Leeds Beckett repository holds a wide range of publications, each of which has been checked for copyright and the relevant embargo period has been applied by the Research Services team.

We operate on a standard take-down policy. If you are the author or publisher of an output and you would like it removed from the repository, please contact us and we will investigate on a case-by-case basis.

Each thesis in the repository has been cleared where necessary by the author for third party copyright. If you would like a thesis to be removed from the repository or believe there is an issue with copyright, please contact us on openaccess@leedsbeckett.ac.uk and we will investigate on a case-by-case basis.

Clusters of health behaviours in Queensland adults are associated with different socio-demographic characteristics

Hobbs, M[1]., Duncan, M, J[2]., Collins, P[1]., McKenna, J[1]., Schoeppe, S[3]., Rebar, A, L[3]., Alley, S[3]., Short, C[4]., and Vandelanotte, C[3].

[1] Centre for Active Lifestyles, Carnegie Faculty, Research Institute of Sport, Physical Activity and Leisure, Leeds Beckett University, Leeds, UK.

[2] School of Medicine & Public Health; Priority Research Centre for Physical Activity and Nutrition, Faculty of Health and Medicine, The University of Newcastle.

[3] Physical Activity Research Group, School of Human Health and Social Science, Central Queensland University, Rockhampton, Queensland Australia.

[4] University of Adelaide, Adelaide, South Australia, Australia

Abstract

Background: The co-occurrence of unhealthy lifestyles, calls for interventions that target multiple health behaviours. This study investigates the clustering of health behaviours and examines demographic differences between each cluster.

Methods: 934 adults from Queensland, Australia completed a cross-sectional survey assessing multiple health behaviours. A two-step hierarchical cluster analysis using multiple iterations identified the optimal number of clusters and the subset of distinguishing health behaviour variables. Univariate analyses of variance and chi-squared tests assessed difference in health behaviours by socio-demographic factors and clusters.

Results: Three clusters were identified: the 'lower risk' cluster (n=436) reported the healthiest profile and met all public health guidelines. The 'elevated risk' cluster (n=105) reported a range of unhealthy behaviours such as excessive alcohol consumption, sitting time, fast-food consumption, smoking, inactivity and a lack of fruit and vegetables. The 'moderate risk behaviour' cluster (n=393) demonstrated some unhealthy behaviours with low physical activity levels and poor dietary outcomes. The 'elevated risk' cluster were significantly younger and more socio-economically disadvantaged than both the 'lower and moderate risk' clusters.

Discussion: Younger people who live in more deprived areas were largely within the 'elevated risk' cluster and represent an important population for MHBC interventions given their wide range of unhealthy behaviours.

Keywords: Public Health, Clustering, Health Behaviours, Multiple Health Behaviour Change.

Introduction

Modifiable health behaviours such as physical inactivity, excessive sedentary behaviour, alcohol, smoking and a poor diet contribute to morbidity and mortality (Lim et al., 2012). These health behaviours are the primary causes of non-communicable diseases, which account for almost 70% of deaths globally and 91% of total deaths in Australia (World Health Organisation, 2014). However, these health behaviours do not occur in isolation (Prochaska and Prochaska, 2011). Therefore modifying one health behaviour in isolation (Busch et al., 2013) may not be an adequate health behaviour change strategy.

Studies in the UK (Poortinga, 2007, Buck and Frosini, 2012) and Australia (Feng and Astell-Burt, 2013) have demonstrated that unhealthy behaviours co-exist. A study of English adults demonstrated that one in four individuals had three or more health risk behaviours simultaneously (Poortinga, 2007). Similar findings were reported in Australian and Dutch studies that reported clustering at both ends of the risk factor spectrum (all risk factors and no risk factors) as well as clustering of smoking with other lifestyle risk behaviours (Schuit et al., 2002). This clustering of unhealthy behaviours may have important implications for health promotion, particularly if health behaviours share underlying psychological characteristics and can be changed using the same behaviour change techniques (e.g., self-monitoring) (Băban and Crăciun, 2007). To maximise change in behaviours in multiple behaviour change interventions it is necessary to target multiple behaviours with specific behaviour change techniques (Pronk et al., 2004).

Interventions focusing on multiple health behaviours have demonstrated improved health outcomes compared with single behaviour interventions (Goldstein et al., 2004). However, reaching people through health behaviour change interventions remains challenging. It may be therefore more cost-effective to change multiple behaviours simultaneously once individuals have been reached (Prochaska and Prochaska, 2011, Prochaska et al., 2008).

This is important as more cost-effective health behaviour interventions are needed due to increasing pressures on health services (Australian Government Department of Health and Ageing, 2006). Furthermore, when two behaviours are closely related to one another, intervening on only one behaviour is not likely to generate lasting effects (Busch et al., 2013).

Few studies have explored whether specific clusters of risk factors are more or less prevalent in population subgroups. This is important to better target the right multiple health behaviour change interventions to specific population subgroups. Previous research has demonstrated how a 'one-size-fits-all' approach to health behaviour change is generally ineffective (Ball et al., 2006). A cluster analysis will help to identify individuals who express similar health behaviours, therefore identifying potential target populations for health promotion efforts. With these considerations in mind, this study aims to investigate the prevalence of individual health behaviours by socio-demographic factors such as age, gender and socio-economic factors. Secondly, it aims to examine the clustering of these health behaviours. Thirdly, it aims to examine any between cluster differences in socio-demographic factors.

Methods

Study Population

Data were collected as part of the Queensland Social Survey (QSS) via computer-assisted telephone interviews. The QSS is an omnibus survey of households in the state of Queensland, Australia administered by the Population Research Laboratory at Central Queensland University. For sampling purposes the state of Queensland was delineated into two areas for telephone interviewing; first, South-East Queensland and second, the remainder of Queensland. A two-stage selection process was then employed; first, selection of households and second, selection of respondent gender within each household. A sample of 1293 Australian adults were reached by randomly selecting households in the state of

Queensland (Australia) and then quota sampling by gender. Overall, there was variation from the Queensland population from which they were drawn with an over-sampling in the 55 and above age categories, and under sampling in the under 35 age categories. The QSS included socio-demographic and health behaviour-related questions (Department of Health and Ageing, 2013). The overall response rate of the QSS was 41.2% (n = 1,293). Ethical approval was obtained through the Central Queensland University research ethics committee and all participants provided informed consent. Data collection took place between June and July 2013.

Health behaviours

Physical activity

Physical activity (PA) data were captured using the Active Australia Survey. The Active Australia Survey is a brief PA questionnaire (Australian Institute of Health and Welfare (AIHW), 2003) demonstrating acceptable validity compared with Actigraph accelerometry (r = 0.46–0.50) (Helmerhorst et al., 2012). Questions include items on duration and frequency of walking and moderate and vigorous-intensity physical activity in the previous week. All activities had to be performed continuously for at least 10 minutes at a time. Total duration of physical activity (TPA) was calculated using this formula: total walking minutes + moderate activity minutes + (vigorous activity minutes * 2). In line with current public health guidance (Australian Bureau of Statistics, 2013), to meet the physical activity guideline, 150 minutes of activity a week over 5 days were needed. A binary outcome was created with ≥150.00 minutes of total activity in 5 or more session classed as meeting the guidelines.

Sitting time

Sitting time was calculated as the average daily time spent sitting in the past week, as reported on the Workforce Sitting Questionnaire (Chau et al., 2011). On this 10-item measure, participants were asked how much time they spent sitting on non-work and work days while working, commuting, using a computer, watching TV, and during other leisure-time activities. This measure has demonstrated acceptable reliability ($r=0.58$, $p<0.05$) and validity ($r=0.48$, $p<0.01$) (Chau et al., 2012). As there is no concrete guideline (Department of Health, 2014); a recent meta-analysis (Chau et al., 2013) was used as a guide to dichotomise sitting time. Accordingly, a binary outcome was defined with sitting time of > 7 hours per day classed as excessive sitting time, given its association with increased risk in all-cause mortality.

<u>Fruit and vegetable consumption</u>

Fruit and vegetable consumption was assessed by two items used previously in research (Smith et al., 2009b): 'How many serves of vegetables do you eat on a usual day?' and 'How many serves of fruit do you eat on a usual day?' In line with recent research (Australian Bureau of Statistics, 2015, Oyebode et al., 2014) a binary outcome was created based on whether or not participants were meeting the public health guidance recommendation of ≥5 servings of vegetables and ≥2 fruit (Department of Health and Ageing, 2013).

<u>Fast-food consumption</u>

Fast-food consumption was assessed using one item: "In the last 7 days, how many times did you eat something from a fast-food restaurant like McDonald's, Hungry Jacks, KFC, etc? This also includes other fast-food and takeaway such as fish and chips, Chinese food and pizza." There was little literature to guide a binary outcome for fast-food, therefore a threshold of ≥1 fast-food meal per week equated to not meeting public health guidelines (Australian Government Department of Health, 2015). The Australian recommendation is to limit fast food as much as possible, so logically none in the last week is ideal (Australian Government Department of Health, 2015). Fast-food consumption was used as a proxy for unhealthy food behaviour as it has been associated with weight gain (Paquet et al., 2010, Thornton et al., 2009, Thornton et al., 2016) and deleterious health outcomes (Pereira et al., 2005, An, 2016).

Smoking

Smoking status was assessed using one item: 'Are you presently a smoker?' (yes/no). In line with current public health recommendations smoking is not recommended (Zwar et al., 2005).

Alcohol consumption

Participants were asked: "During the past 30 days did you consume at least one drink of any alcoholic beverage", and if yes, "how many drinks did you have on average each day". An estimate of alcohol consumption was created by multiplying the number of drinks per day in the last month and the average number of drinks per day divided by 30 to give an estimate of drinks per day. Based on established public health guidelines a binary outcome was created based on the guideline of ≥2 drinks per day (Australian Government National Health and Medical Research Council, 2014).

Socio-demographic factors

Socio-demographic factors measured included age group (18-34, 35-44, 45-54, 55-64, 65+), gender (male, female), level of education (pre-school, primary or high school and college or university), BMI (underweight, healthy weight, overweight and obese) (calculated from self-report height (cm) and weight (kg)) and postcode. Post codes were linked to the socio-economic index for areas (SEIFA) developed by the Australian Bureau of Statistics (Australian Bureau of Statistics, 2016). As part of this The Index of Relative Disadvantage which ranks community areas in Australia according to relative socio-economic disadvantage using census data on education, employment, occupation, housing and English proficiency was used (Australian Bureau of Statistics, 2016). The Index of Relative Disadvantage was then split into four equal quartiles specific to this population (Q1 0-964; Q2 965-1020; Q3 1021-1058; Q4 1059-1129) with a lower score meaning greater disadvantage.

Statistical Analysis

Only individuals with complete data for all health behaviour and demographic variables were included in the final sample (n=934) resulting in the exclusion of 359 individuals. A sensitivity analysis showed no differences by socio-demographic factors and health behaviours in excluded data (Additional File 1). Prior to cluster analysis, engagement in the health behaviours were presented as simple proportions of those who meet the public health guidelines.

To identify clusters of multiple health behaviours a two-step cluster approach was used which ensures that the size of the distance matrix is determined by the number of pre-clusters rather than individual cases (Bitman and Gelbard, 2007). Firstly, based on the distance criterion, cases were either assigned to an existing pre-cluster or assigned a new pre-cluster. Pre-clusters were then clustered in the second step using the standard hierarchical clustering algorithm, which assessed multiple cluster solutions and automatically determined the optimal number of clusters. The researchers made no assumptions regarding cluster membership or number, as this was determined in the hierarchical two-step clustering approach (Bitman and Gelbard, 2007).

The cluster analysis was conducted multiple times with multiple iterations undertaken to establish both the optimum number of clusters and the format of health behaviour variables to be included. This process initially included conducting the analysis with continuous behavioural variables and smoker or not, before multiple versions were conducted alternating an additional categorical variable. For example, the inclusion of fast-food as both continuous (servings per week) and categorical (meeting guidelines or not) was explored.

The final combination of variables included within the cluster was determined using the Schwarz Bayesian Criterion (Bitman and Gelbard, 2007). Based on this analysis, the following variables were included in the final cluster analysis: physical activity, sedentary behaviour, fruit and vegetable intake, fast-food intake, smoking and alcohol consumption. The silhouette measure used to validate the cluster indicated 0.5, which demonstrates a good level of both cohesion and separation, and provided a stronger solution than comparative 2-cluster and 4-cluster alternative solutions. To examine differences between clusters on socio-demographic factors Pearson chi squared was used with independent variables as categorical predictors. For all tests, significance levels were set at $p < 0.05$. Analyses were undertaken in SPSS v22 (IBM Corporation).

3.0 Results

Demographic characteristics

In the sample of 934 individuals, 495 (53.0%) were male and 439 (47.0%) were female (Table 1). The mean age of participants was 53.79 years (±14.92). Using the index of relative disadvantage, and defining deprivation as living in the top 25% deprived areas (IRD <964), 238 (25.5%) adults were categorised as living in the most deprived areas (Table 1). Most individuals were either college or university educated (64.5% n=602) and 35.0% (n=327) and 23.1% (n=215) were classified as overweight and obese, respectively.

INSERT TABLE 1 HERE

Behaviours

<u>Physical activity</u>

In total, participants reported an average of 317.72 (SD ±322.78) minutes of physical activity per week with 48.9% (n=457/934) categorised as not meeting the physical activity guidelines (Table 1). The percentage of participants meeting physical activity guidelines was not associated with gender (p>0.05), deprivation (p>0.05) or age (p>0.05).

Sitting time

A mean value of 413.37 (±193.59) minutes/day of sitting time was reported (≈7 hours/day) with 45.5% (n=425) of people categorised as sitting >7 hours/day. Sitting time was associated with gender (χ^2 [1] = 14.46, *p*<.001), with more males than females exceeding the guideline to sit >7 hours per day (50.5% vs. 39.9%) (*Cramer's V* = 0.124). Sitting time was not associated with deprivation (p>0.05). However, sitting time was lower in those with increasing age (χ^2 [5] = 25.77 *p*<0.001, *Cramer's V* = 0.17). Fewer people reported sitting for >7 hours/day as age increased (18-34 years, 55.8%, >65 years 34.5%).

Fruit and vegetable

A daily mean value of 1.95 (±1.27) fruit servings and 2.96 (±1.59) vegetable servings was reported; 86.1% (n=804) of participants were categorised as not meeting the recommended guidelines that combine >2 fruit and >5 vegetables. More females (63.1% vs. 45.1%) than males met the guidelines (χ^2 [1] = 30.46, *p*<0.001, *Cramer's V* = 0.18). There was no association between fruit and vegetable consumption and deprivation (p>0.05) or age (p>0.05).

Fast-food

Participants reported consuming an average of 1.61 (±0.79) servings of fast-food in the previous week (44.9% exceeded ≥1 fast-food meal per week). There was a significant association between fast-food consumption and gender (χ^2 [4] = 16.57, *p*<0.01): more males (48.5%) than females (40.8%) consumed ≥1 fast food meal per week. Deprivation was not associated with fast-food intake (p>0.05), whereas age was associated with intake (χ^2 [20] = 120.12, *p*<0.001). The percentage of individuals consuming at least one weekly serving of fast-food was significantly higher for those with a lower age.

Smoking

In total, 10.8% (n=101) of individuals smoked. There was no association between smoking (yes/no) and gender (p>0.05). However, there was an association of deprivation and smoking; residents of the most disadvantaged quartile (Q1) reported higher levels of smoking (38.6% vs. 13.9%) than those in the least disadvantaged quartile (Q4 ; χ^2 [3] = 7.44, *p<0.01, Cramer's V* = 0.12). Smoking was also associated with age (χ^2 [3] = 15.17, *p<0.01, Cramer's V* = 0.13); A higher proportion of younger participants smoked compared to older participants.

Alcohol

Participants reported a mean value of 0.83 (±1.75) alcoholic drinks per day. On average, 14.0% of participants exceeded the guideline of ≥2 drinks per day. Alcohol consumption differed by gender (χ^2 [1] = 31.47, *p<0.001*): 20.0% of males and 7.3% of females exceeding alcohol guidelines. There was no association between alcohol and deprivation (p>0.05) or age (p>0.05).

Clustering of health behaviours

Descriptive characteristics of the cluster profiles can be seen in Table 2. Three clusters were identified; the '*lower risk behaviour*' cluster included 46.7% (n=436) participants, 42.1% (n=393) of participants were in the *'moderate risk behaviour'* cluster and 11.2% (n=105) were in '*elevated risk behaviour*' cluster. All *'lower risk behaviour'* cluster members were non-smokers (100%) and sufficiently active (100%); they also consumed the most fruit and vegetables (5.34 servings/day) and had the lowest levels of sitting time (400 mins/day). This differs considerably from the *'moderate risk behaviour'* cluster which included insufficiently active adults (100%), non-smokers (100%) and poorer dietary behaviours (4.56 servings of fruit and vegetables per day). Most individuals in the '*elevated risk behaviours'* cluster smoked (96.2%), were insufficiently active (61%), were sedentary for the highest amount of time (437 minutes/day) and consumed the least fruit and vegetables per day (4.43 servings), the most fast-food meals per week (1.68 meals) and the most alcohol per day on average (1.83 drinks/day).

There was a statistically significant difference between clusters for smoking behaviours (F(2,931) = 10,432, p<0.001). A Bonferroni post hoc test showed no difference between '*low risk behaviours'* and '*moderate risk behaviours'* (p>0.05). However, '*low risk behaviours'* were significantly different to *'elevated risk behaviours'* (p<0.001). *'Moderate risk behaviours'* were significantly different to '*elevated risk behaviours'*. Physical activity levels were significantly between all three clusters (F(2,931) = 3881.93, p<0.001). Another one-way ANOVA (F(2,931) = 20.51, p<0.001) demonstrated drinks per day in '*low risk behaviours'* were significantly lower than in the *'elevated risk behaviours'*, and *'elevated risk behaviours'* were significantly higher than *'moderate risk behaviours'*. (p<0.05). Despite this, there was no difference between *'low risk behaviours'* and *'moderate risk behaviours'* (p>0.05). Fruit and vegetable intake also differed significantly between clusters (F(2,931) = 14.38, p<0.001). Although post-hoc tests revealed no different between '*elevated risk behaviours'* and '*moderate risk behaviours'* in fruit and vegetable intake (p<0.05), there were statistically significant differences between *'low risk behaviours'* and *'elevated risk behaviours'* (p<0.001). Moreover, there were also statistically significant differences between *'low risk behaviours'* and *'moderate risk behaviours'* in fruit and vegetable intake (p<0.001). In contrast there were no statistically significant differences for sitting time (F(2,931) = 2.32, p=0.10) or fast-food consumption (F(2,931) = 1.97, p=0.14) between clusters.

INSERT TABLE 2 HERE

Table 3 shows demographic differences between the three clusters. There was no significant gender differences for cluster membership; however, there was a significant effect for cluster membership by age ((χ^2 [8] = 17.95, *p=0.02, Cramer's V* = 0.10). The *'elevated risk behaviour'* cluster included significantly younger adults than the *'moderate risk behaviour'* cluster and '*lower risk behaviour'* cluster. Deprivation also differed as a function of cluster membership ((χ^2 [6] = 16.46, *p=0.01, Cramer's V* = 0.10). The *'elevated risk behaviour'* cluster was significantly more disadvantaged than the '*moderate risk'* and *'lower risk* *behaviour'* cluster. In contrast, there was no significant difference between clusters on education level (p>0.05).

INSERT TABLE 3 HERE

Discussion

Main findings of this study

There is a growing body of literature examining clusters of health behaviours. However, few present findings on a wide range of health behaviours by age, gender and area-level deprivation. Three clusters were identified within this study as '*lower risk',* '*elevated risk' and 'moderate risk'* behaviour clusters. The '*elevated risk'* cluster were younger and more socio-economically disadvantaged. As such, this study is among the first to suggest different clusters of individuals may require different types of multiple health behaviour change (MHBC) interventions.

What is already known on this topic

This study supports previous evidence that shows how health behaviours are socio-demographically related (Buck and Frosini, 2012). Younger and more disadvantaged individuals were more likely to smoke. Although smoking rates continue to decline (Australian Institute of Health and Welfare, 2014), Australian data highlights that individuals living in the low socio-economic (SES) areas are three times more likely to smoke (daily) than people within the highest SES areas (19.9% vs. 6.7%) (The Department of Health, 2015). Similar to previous research, 48.9% of adults were categorised as insufficiently active (Duncan et al., 2012). However, in contrast to previous research (Department of Health, 2014, Feng and Astell-Burt, 2013) physical activity was independent of age, gender and deprivation. Also similar to other population based data, males reported consuming more alcohol, fast-food and less fruit and vegetables (Smith et al., 2009a, White, 2013). Finally, females and older participants were more likely to sit less than 7 hours per day. This is in contrast to a plethora of previous research which suggests as people age they become more sedentary (Hallal et al., 2012). Evidence of an association between deprivation and sitting time remains equivocal (O'Donoghue et al., 2016). We suggest dissimilarities may occur due to the differences in arbitrary cut-offs used to define higher or lower levels of sitting time. Findings within this study show that sitting time was independent of level of disadvantage. This study also highlights how these behaviours converge by demonstrating three unique and distinct clusters of health behaviours.

What this study adds

In public health terms, the behaviour of those in the *'elevated risk'* cluster, who did not meet most public health guidelines, is concerning. It is worth noting that while the *'elevated risk'* cluster were significantly younger than the other clusters, the *'elevated risk'* cluster was balanced towards younger middle-aged people, rather than older middle-aged people. Consistent with previous research (Poortinga, 2007, Schuit et al., 2002) our findings show that excessive alcohol consumption, smoking, poor diet and to a lesser extent inactivity were found to cluster together within the *'elevated risk'* cluster. A recent review (Noble et al., 2015) concluded that males and those with greater social disadvantage showed riskier patterns of health behaviours. However, several of the included studies were poor quality. In contrast, findings in this study showed no differences by gender, potentially as a result of the wider range of behaviours considered (MacArthur et al., 2012). Considering the greater risk posed by each of these behaviours and the likely exacerbated risk associated with engaging in multiple risky behaviours this population subgroup is an obvious target for preventive health initiatives. The high levels of inactivity and poor diet demonstrated within the *'moderate risk'* cluster are also a public health concern.

Although both *'moderate'* and *'elevated risk'* clusters are unhealthy and at risk, there are important differences in health behaviours between them. For instance, compared to the '*moderate risk'* cluster the '*elevated risk'* cluster consumes more alcohol (1.83 drinks vs. 0.65 drinks/day per day), cigarettes (100% vs 3.8% were non-smokers) with differences in physical activity too. In a recent study, deaths for all-cause mortality were advanced by 4.0 years for physically inactive adults. However, the rate advancement period for all-cause mortality was 7.9 years among current smokers (Borrell, 2014). Those in the '*moderate risk'* cluster may represent very different attitudes and intentions towards health behaviours (Prochaska et al., 2008, Prochaska and Prochaska, 2011). However, such between cluster differences are important and should not be ignored, as these two unhealthy clusters will require different behaviour change interventions. They represent an important opportunity to tailor public health interventions. Interventions have been successful in changing two, three or even four or more health behaviours simultaneously, suggesting that MHBC is possible (Hyman et al., 2007).

Due to both the wider range and greater extent of unhealthy behaviours, and perhaps more serious consequences in terms of all-cause mortality (Borrell, 2014), individuals within the '*elevated risk'* cluster may require a much more intense behaviour change intervention compared to those who are within the *'moderate risk'* cluster. In addition to this, given that a dose-response relationship exists between health behaviours and health outcomes – where there is the greatest benefit of improving health behaviours of individuals who are the most unhealthy (Lee and Skerrett, 2001) – the overall health of the population may be improved most by focusing on those within the *'elevated risk'* cluster. In contrast to this, a significant proportion of the *'moderate risk'* cluster may only require small changes to health behaviours to meet public health guidelines, which is also a viable option for intervention.

Limitations of this study

A cross-sectional design remains strong for observational purposes however it does encounter causality limitations. Subjective measures were used throughout the research design and are subject to measurement error due to recall limitations and social desirability bias (Atkin et al., 2012). Furthermore, alcohol data could have been standardised around units per day rather than drinks per day. Moreover, while fast-food consumption has been associated with deleterious health outcomes and weight gain it is also plausible that other foods not captures within this study may be adverse for weight gain and health. Valid and reliable self-report measures were used where available (Helmerhorst et al., 2012, Chau et al., 2012). Although not always possible, future research should use objective measures of health behaviours. Furthermore, there are currently no accepted thresholds for excessive sedentary behaviour or fast-food; therefore classifications are arbitrary and may vary considerably between studies (Owen et al., 2011). Results may also not be generalisable beyond the study sample and area as the study is restricted to one geographical area, the sample was divided into clusters based on a data driven approach and adults aged over 50 were oversampled. Future research should consider stronger research designs to build on existing, tentative support for the implementation of MHBC into public health policy. Further research is needed to assess interactions between multiple health behaviours and any mediation or relationships between different behaviours and chronic disease.

Conclusion

This study has progressed our understanding of the clustering of the most prevalent health behaviours in adults and is amongst the first to identify clusters of health behaviours within population subgroups. Younger people who lived in the more deprived areas were largely within the '*elevated risk'* cluster representing an important target group for MHBC interventions given their wide range of unhealthy behaviours. The *'moderate risk'* cluster still exhibited a range of unhealthy behaviours but may benefit from a less intensive MHBC intervention that focuses on smaller changes in health behaviours. This study supports previous calls for a more comprehensive approach to behaviour change. Future interventions and policies should acknowledge a range of behaviours when designing MHBC interventions, particularly for those who are younger and reside within deprived neighbourhoods.

6.0 References

AN, R. 2016. Fast-food and full-service restaurant consumption and daily energy and nutrient intakes in US adults. *Eur J Clin Nutr,* 70**,** 97-103.

ATKIN, A. J., GORELY, T., CLEMES, S. A., YATES, T., EDWARDSON, C., BRAGE, S., SALMON, J., MARSHALL, S. J. & BIDDLE, S. J. 2012. Methods of Measurement in epidemiology: Sedentary Behaviour. *International Journal Of Epidemiology,* 41**,** 1460-1471.

AUSTRALIAN BUREAU OF STATISTICS 2013. *Australian Health Survey: Physical Activity 2011-12,* Canberra, ABS.

AUSTRALIAN BUREAU OF STATISTICS. 2015. *National Health Survey: First Results, 2014-15.* [Online]. Canberra: Australian Bureau of Statistics. Available: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.001~2014-15~Main%20Features~Exercise~29 [Accessed 20th May 2016].

AUSTRALIAN BUREAU OF STATISTICS. 2016. *2033.0.55.001 - Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2011* [Online]. Canberra: Australian Bureau of Statistics,. Available: http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001 [Accessed 5th July 2016].

AUSTRALIAN GOVERNMENT DEPARTMENT OF HEALTH 2015. *Australian Dietary Guidelines 1 - 5,* Canberra, Australian Government Department of Health,.

AUSTRALIAN GOVERNMENT DEPARTMENT OF HEALTH AND AGEING 2006. *National chronic disease strategy,* Canberra, DoHA.

AUSTRALIAN GOVERNMENT NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL 2014. *Alcohol guidelines: reducing the health risks.,* Canberra, Australian Government National Health and Medical Research Council.

AUSTRALIAN INSTITUTE OF HEALTH AND WELFARE 2014. *National Drug Strategy Household Survey 2013,* Canberra, Australian Institute of Health and Welfare.

AUSTRALIAN INSTITUTE OF HEALTH AND WELFARE (AIHW) 2003. *The Active Australia Survey: a guide and manual for implementation, analysis and reporting,* Canberra, AIHW.

BĂBAN, A. & CRĂCIUN, C. 2007. Changing health-risk behaviors: A review of theory and evidence-based interventions in health psychology. *Journal of Cognitive and Behavioral Psychotherapies,* 7**,** 45-66.

BALL, K., TIMPERIO, A. & CRAWFORD, D. 2006. Understanding environmental influences on nutrition and physical activity behaviours: where should we look and what should we count? *International Journal of Behavioural Nutrition and Physical Activity,* 3**,** 33-40.
BITMAN, R. & GELBARD, R. 2007. Decision-making method using a visual approach for cluster analysis problems; indicative classification algorithms and grouping scope. *Expert System,* 24**,** 171-187.
BORRELL, L. N. 2014. The effects of smoking and physical inactivity on advancing mortality in U.S. adults. *Ann Epidemiol,* 24**,** 484-7.
BUCK, D. & FROSINI, F. 2012. *Clustering of unhealthy behaviours over time - implications for policy and practice,* London, The Kings Fund.
BUSCH, V., VAN STEL, H., SCHRIJVERS, A. & RJ DE LEEUW, J. 2013. Clustering of health-related behaviors, health outcomes and demographics in Dutch adolescents: a cross-sectional study. *BMC Public Health,* 13.
CHAU, J., GRUNSEIT, A., CHEY, T., STAMATAKIS, E., BROWN, W., MATTHEWS, C., BAUMAN, A. & VAN DER PLOEG, H. 2013. Daily sitting time and all cause-mortality: a meta-analysis. *Plos One,* e80000.
CHAU, J., VAN DER PLOEG, H., DUNN, S., KURKO, J. & BAUMAN, A. 2011. A tool for measuring workers' sitting time by domain: the Workforce Sitting Questionnaire. *British Journal Of Sports Medicine,* 45**,** 1216-1222.
CHAU, J. Y., VAN DER PLOEG, H. P., DUNN, S., KURKO, J. & BAUMAN, A. E. 2012. Validity of the occupational sitting and physical activity questionnaire. *Med Sci Sports Exerc,* 44**,** 118-25.
DEPARTMENT OF HEALTH 2014. *Australia's physical activity and sedentary behaviour guidelines: evidence summary,* Canberra, Department of Health.
DEPARTMENT OF HEALTH AND AGEING 2013. *Eat for health: Australian dietary guidelines* Canberra, Department of Health and Ageing.
DUNCAN, M., VANDELANOTTE, C., CAPERCHIONE, C., HANLEY, C. & MUMMERY, K. 2012. Temporal trends in and relationships between screen time, physical activity, overweight and obesity. *BMC Public Health,* 12.
FENG, X. & ASTELL-BURT, T. 2013. Neighborhood Socioeconomic Circumstances and the Co-Occurrence of Unhealthy Lifestyles: Evidence from 206,457 Australians in the 45 and Up Study. *Plos One,* 8**,** e72643.
GOLDSTEIN, M., WHITLOCK, E. & DEPUE, J. 2004. Multiple behavioural risk factor interventions in primary care. Summary of research evidence. . *American Journal of Preventative Medicine,* 27**,** 61-79.
HALLAL, P., ANDERSEN, L., BULL, F., GUTHOLD, R., HASKELL, W. & EKELUND, U. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet,* 380**,** 247-257.
HELMERHORST, H. J. F., BRAGE, S., WARREN, J., BESSON, H. & EKELUND, U. 2012. A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. *Int J Behav Nutr Phys Act,* 9**,** 103-103.
HYMAN, D., PAVLIK, V., TAYLOR, W., GOODRICK, G. & MOYE, L. 2007. Simultaneous vs sequential counseling for multiple behavior change. *Archives of Internal Medicine,* 167**,** 1152-1158.
LEE, I. M. & SKERRETT, P. J. 2001. Physical activity and all-cause mortality: what is the dose-response relation? *Med Sci Sports Exerc,* 33**,** S459-71; discussion S493-4.
LIM, S. S., VOS, T., FLAXMAN, A. D., DANAEI, G., SHIBUYA, K., ADAIR-ROHANI, H., ALMAZROA, M. A., AMANN, M., ANDERSON, H. R., ANDREWS, K. G.,

ARYEE, M., ATKINSON, C., BACCHUS, L. J., BAHALIM, A. N., BALAKRISHNAN, K., BALMES, J., BARKER-COLLO, S., BAXTER, A., BELL, M. L., BLORE, J. D., BLYTH, F., BONNER, C., BORGES, G., BOURNE, R., BOUSSINESQ, M., BRAUER, M., BROOKS, P., BRUCE, N. G., BRUNEKREEF, B., BRYAN-HANCOCK, C., BUCELLO, C., BUCHBINDER, R., BULL, F., BURNETT, R. T., BYERS, T. E., CALABRIA, B., CARAPETIS, J., CARNAHAN, E., CHAFE, Z., CHARLSON, F., CHEN, H., CHEN, J. S., CHENG, A. T.-A., CHILD, J. C., COHEN, A., COLSON, K. E., COWIE, B. C., DARBY, S., DARLING, S., DAVIS, A., DEGENHARDT, L., DENTENER, F., DES JARLAIS, D. C., DEVRIES, K., DHERANI, M., DING, E. L., DORSEY, E. R., DRISCOLL, T., EDMOND, K., ALI, S. E., ENGELL, R. E., ERWIN, P. J., FAHIMI, S., FALDER, G., FARZADFAR, F., FERRARI, A., FINUCANE, M. M., FLAXMAN, S., FOWKES, F. G. R., FREEDMAN, G., FREEMAN, M. K., GAKIDOU, E., GHOSH, S., GIOVANNUCCI, E., GMEL, G., GRAHAM, K., GRAINGER, R., GRANT, B., GUNNELL, D., GUTIERREZ, H. R., HALL, W., HOEK, H. W., HOGAN, A., HOSGOOD III, H. D., HOY, D., HU, H., HUBBELL, B. J., HUTCHINGS, S. J., IBEANUSI, S. E., JACKLYN, G. L., JASRASARIA, R., JONAS, J. B., KAN, H., KANIS, J. A., KASSEBAUM, N., KAWAKAMI, N., KHANG, Y.-H., KHATIBZADEH, S., KHOO, J.-P., KOK, C., et al. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet,* 380**,** 2224-2260.

MACARTHUR, G. J., SMITH, M. C., MELOTTI, R., HERON, J., MACLEOD, J., HICKMAN, M., KIPPING, R. R., CAMPBELL, R. & LEWIS, G. 2012. Patterns of alcohol use and multiple risk behaviour by gender during early and late adolescence: the ALSPAC cohort. *Journal of Public Health (Oxford, England),* 34**,** i20-i30.

NOBLE, N., PAUL, C., TURON, H. & OLDMEADOW, C. 2015. Which modifiable health risk behaviours are related? A systematic review of the clustering of Smoking, Nutrition, Alcohol and Physical activity ('SNAP') health risk factors. *Prev Med,* 81**,** 16-41.

O'DONOGHUE, G., PERCHOUX, C., MENSAH, K., LAKERVELD, J., VAN DER PLOEG, H., BERNAARDS, C., CHASTIN, S. F. M., SIMON, C., O'GORMAN, D. & NAZARE, J.-A. 2016. A systematic review of correlates of sedentary behaviour in adults aged 18–65 years: a socio-ecological approach. *BMC Public Health,* 16**,** 1-25.

OWEN, N., SUGIYAMA, T., EAKIN, E., GARDINER, P., TREMBLAY, M. & SALLIS, J. 2011. Adults' sedentary behavior determinants and interventions. *American Journal of Preventative Medicine,* 41**,** 189-196.

OYEBODE, O., GORDON-DSEAGU, V., WALKER, A. & MINDELL, J. S. 2014. Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *Journal of Epidemiology and Community health*.

PAQUET, C., DANIEL, M., KNAUPER, B., GAUVIN, L., KESTENS, Y. & DUBE, L. 2010. Interactive effects of reward sensitivity and residential fast-food restaurant exposure on fast-food consumption. *Am J Clin Nutr,* 91**,** 771-6.

PEREIRA, M. A., KARTASHOV, A. I., EBBELING, C. B., VAN HORN, L., SLATTERY, M. L., JACOBS JR, D. R. & LUDWIG, D. S. 2005. Fast-food

habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *The Lancet,* 365**,** 36-42.
POORTINGA, W. 2007. The prevalence and clustering of four major lifestyle risk factors in an English adult population. *Prev Med,* 44**,** 124-128.
PROCHASKA, J. J. & PROCHASKA, J. O. 2011. A Review of Multiple Health Behavior Change Interventions for Primary Prevention. *American journal of lifestyle medicine,* 5**,** 10.1177/1559827610391883.
PROCHASKA, J. J., SPRING, B. & NIGG, C. R. 2008. Multiple Health Behavior Change Research: An Introduction and Overview. *Prev Med,* 46**,** 181-188.
PRONK, N. P., ANDERSON, L. H., CRAIN, A. L., MARTINSON, B. C., O'CONNOR, P. J., SHERWOOD, N. E. & WHITEBIRD, R. R. 2004. Meeting recommendations for multiple healthy lifestyle factors: Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *Am J Prev Med,* 27**,** 25-33.
SCHUIT, A. J., VAN LOON, A. J. M., TIJHUIS, M. & OCKÉ, M. C. 2002. Clustering of Lifestyle Risk Factors in a General Adult Population. *Prev Med,* 35**,** 219-224.
SMITH, J. A., WHITE, A. K., RICHARDSON, N., ROBERTSON, S. & WARD, M. 2009a. The men's health policy contexts in Australia, the UK and Ireland: advancement or abandonment? *Critical Public Health,* 19**,** 427-440.
SMITH, K. J., MCNAUGHTON, S. A., GALL, S. L., BLIZZARD, L., DWYER, T. & VENN, A. J. 2009b. Takeaway food consumption and its associations with diet quality and abdominal obesity: a cross-sectional study of young adults. *International Journal of Behavioral Nutrition and Physical Activity,* 6**,** 1-13.
THE DEPARTMENT OF HEALTH. 2015. *Tobacco key facts and figures* [Online]. Canberra: The Department of Health. Available: http://www.health.gov.au/ [Accessed 1st March 2016].
THORNTON, L. E., BENTLEY, R. J. & KAVANAGH, A. M. 2009. Fast food purchasing and access to fast food restaurants: a multilevel analysis of VicLANES. *International Journal of Behavioral Nutrition and Physical Activity,* 6**,** 28.
THORNTON, L. E., LAMB, K. E. & BALL, K. 2016. Fast food restaurant locations according to socioeconomic disadvantage, urban–regional locality, and schools within Victoria, Australia. *SSM - Population Health,* 2**,** 1-9.
WHITE, A. 2013. Raising awareness of men's risk of premature death. *Nursing Standard,* 27**,** 35-41.
WORLD HEALTH ORGANISATION 2014. *Noncommunicable Diseases (NCD) Country Profiles – Australia,* Geneva, WHO.
ZWAR, N., RICHMOND, R., BORLAND, R., STILLMAN, S., CUNNINGHAM, M. & LITT, J. 2005. Smoking cessation guidelines for Australian general practice. *Aust Fam Physician,* 34**,** 461-6.

Table 1: Demographic characteristics of participant's and the percentage (% (n)) that meet public health guidelines

Demographic characteristic	Total sample	Non-smoker	Alcohol	Physically Active	<7 hours sitting time	Fruit and vegetable	Fast-food
Overall	100.0 (934)	89.2 (833)	86.0 (803)	51.1 (477)	54.5 (509)	13.9 (130)	55.1 (515)
Gender							
Male	53.0 (495)	88.3 (437)	80.0 (396)	49.5 (245)	58.6 (290)	45.1 (223)	51.5 (255)
Female	47.0 (439)	90.2 (396)	92.7 (407)	60.1 (264)	73.3 (322)	63.1 (277)	59.2 (260)
Age							
18-34	9.2 (86)	14.0 (12)	86.0 (74)	57.0 (49)	58.1 (50)	44.2 (38)	37.2 (32)
35-44	18.4 (172)	14.5 (25)	91.9 (158)	50.6 (87)	64.5 (111)	49.4 (85)	41.3 (71)
45-54	22.7 (212)	14.6 (31)	85.8 (182)	45.3 (96)	62.3 (132)	50.9 (108)	46.7 (99)
55-64	24.2 (226)	8.8 (20)	83.2 (188)	52.2 (118)	61.9 (140)	54.4 (123)	61.9 (140)
65+	25.5 (238)	5.5 (13)	84.5 (201)	53.4 (127)	75.2 (179)	61.3 (146)	72.7 (173)
SEIFA IRD Quintiles							
1 < 964 (Lowest IRD)	25.5 (238)	83.6 (199)	85.7 (204)	48.3 (115)	68.5 (163)	53.8 (128)	55.9 (133)
2 965 – 1020	24.8 (232)	90.9 (211)	87.5 (203)	49.1 (114)	71.1 (165)	49.6 (115)	49.1 (114)

3 1021- 1058	26.4 (247)	89.1 (220)	84.6 (209)	56.7 (140)	62.3 (154)	53.4 (132)	60.3 (149)
4 > 1059 (Highest IRD)	23.2 (217)	93.5 (203)	86.2 (187)	49.8 (108)	59.9 (130)	57.6 (125)	54.8 (119)
Education							
Pre, Primary or High School	35.5 (332)	87.3 (290)	84.0 (279)	47.9 (159)	70.8 (235)	57.2 (190)	57.2 (190)
College/University	64.5 (602)	90.2 (543)	87.0 (524)	52.8 (318)	62.6 (377)	51.5 (310)	54.0 (325)
Weight Status (BMI)							
Underweight (<18.5)	1.7 (16)	75.0 (12)	100.0 (16)	43.8 (7)	87.5 (14)	62.5 (10)	68.8 (11)
Healthy weight (18.5-24.99)	34.5 (332)	87.0 (280)	88.5 (285)	54.0 (174)	69.6 (224)	55.9 (180)	59.3 (191)
Overweight (25.00-29.99)	35.0 (327)	92.7 (303)	84.4 (276)	54.4 (178)	61.8 (202)	53.5 (175)	54.4 (327)
Obese (≥30.00)	23.0 (215)	87.9 (189)	84.7 (182)	40.5 (87)	59.5 (128)	47.0 (101)	48.4 (104)

Note: SEFIA= Socio-Economic Indexes for Areas; IRD = Index of relative disadvantage; IRD lower score = greater disadvantage

Table 2: Health behaviours by cluster membership

	Cluster 1 'Lower risk behaviour' (46.7%, n=436)	**Cluster 2** 'Moderate risk behaviour' (42.1%, n=393)	**Cluster 3** 'Elevated risk behaviour' (11.2%, n=105)	***Overall Sample*** (n=934)
Smoker (% do not smoke)	100	100	3.8	89.2
Physical Activity (% active)	100	0	61	51.1
Alcohol (drinks/day)	0.75	0.65	1.83	0.83
Fruit and Vegetable (servings/day)	5.34	4.56	4.43	4.91
Sitting time (minutes/day)	400	422	437	413
Fast-food (meals/week)	1.56	1.65	1.68	1.61

Table 3: Between group differences in cluster demographics (% of participants (n))

	Cluster 1 Lower risk behaviours	**Cluster 2** Moderate risk behaviours	**Cluster 3** Elevated risk behaviours
Total	46.7 (436)	42.1 (393)	11.2 (105)
Gender			
Male	55.3 (241)	49.4 (194)	57.1 (60)
Female	44.7 (195)	50.6 (199)	42.9 (45)
Age years* (Mean, (SD))	53.89 (±15.56)	54.81 (±14.38)	49.52 (±13.53)
18-34	10.5 (46)	6.1 (28)	11.4 (12)
35-44	17.7 (77)	17.6 (69)	24.8 (26)
45-54	19.5 (85)	24.4 (96)	29.5 (31)
55-64	25.0 (109)	24.2 (95)	21.0 (22)
65+	27.3 (119)	26.7 (105)	13.3 (14)
IRD* (Mean, (SD))	1013.33, (±62.80)	1014.48 (±60.60)	991.40 (±66.51)
Quartile 1	23.4 (102)	24.4 (96)	38.1 (40)
Quartile 2	23.9 (104)	27.0 (106)	21.0 (22)
Quartile 3	29.4 (128)	23.2 (91)	26.7 (28)
Quartile 4	23.4 (102)	25.4 (100)	14.3 (15)
Education			
Pre, Primary or High school	32.6 (142)	37.4 (9)	41.0 (43)
College/University	67.4 (294)	62.6 (246)	59.0 (62)

BMI (Mean, (SD))	26.73 (±5.25)	27.88 (±5.83)	26.71 (±5.68)
Weight Status			
Underweight	1.6 (7)	1.0 (5)	3.8 (4)
Healthy weight	35.6 (155)	31.6 (124)	41.0 (43)
Overweight	38.8 (169)	33.8 (133)	23.8 (25)
Obese	17.6 (77)	28.2 (110)	26.7 (28)

Note: * significantly differences by cluster membership $p<0.05$.
Figures are reported as % (n) unless stated as mean, SD.