Changes in Health Behaviours in Adults At-Risk of Chronic Disease: Primary Outcomes From The *My Health for Life* Program

Charlotte Seib

Griffith University

Stephanie Moriarty

Griffith University

Nicole McDonald

Griffith University

Debra Anderson

University of Technology Sydney

Joy Parkinson (✉ j.parkinson@griffith.edu.au)

Griffith University

Research Article

Keywords: Modifiable health behaviours, healthy lifestyle index, chronic disease, intervention, dietary intake, body mass index, waist circumference, smoking, physical activity.

Posted Date: September 23rd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-895190/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background

Chronic disease is the leading cause of premature death globally, and many of these deaths are preventable by modifying some key behavioural and metabolic risk factors. This secondary data analysis examines changes in health behaviours among men and women at risk of diabetes or cardiovascular disease (CVD) who participated in a 6-month lifestyle intervention called the *My health for life* program.

Methods

My health for life is a government-funded multi-component program designed to reduce chronic disease risk factors amongst at-risk adults. The intervention comprises six sessions over a 6-month period, delivered by a trained facilitator or telephone health coach. The analysis presented in this paper stems from 9,372 participants who participated in the program between July 2017 and December 2019. Primary outcomes included fruit and vegetable intake, consumption of sugar-sweetened drinks and take-away, alcohol and tobacco smoking, physical activity, body mass index (BMI), and waist circumference (WC). Variables were summed to form a single Healthy Lifestyle Index (HLI) ranging from 0 to 18, with higher scores denoting healthier behaviours. Longitudinal associations between lifestyle indices, assessed using Gaussian Generalized Estimating Equations (GEE) models with an identity link and robust standard errors.

Results

Improvements in HLI scores were noted between baseline (Md = 10.0; IQR = 8.3, 11.7] and 26-weeks (Md = 11.7; IQR = 10.0, 13.2] which corresponded with increases in fruit and vegetable consumption and decreases in takeaway frequency, and weight indices ($p < .01$ for all) but not risky alcohol intake. Modelling showed higher average HLI among those aged 45 or older ($\beta = 0.97$, 95% CI = 0.81, 1.13, $p < .01$) with vocational educational qualifications (certificate/diploma: $\beta = 0.47$, 95% CI = 0.19, 0.76, $p < .01$; bachelor/post-graduate degree $\beta = 1.05$, 95% CI = 0.76, 1.34, $p < .01$) while being male, Aboriginal or Torres Strait Islander background, or not currently working conferred lower average HLI scores ($p < .01$ for all).

Conclusions

While participants showed improvements in many healthy lifestyle indices including BMI, waist circumference, physical activity, and dietary indicators, changes in alcohol consumption were less amenable to the program. There is a need for additional research to understand the multi-level barriers and facilitators of behaviour change in this context to tailor the intervention for more-difficult-to-treat groups.

Background

Chronic disease poses the greatest threat to global health accounting for almost three-quarters of all deaths annually [1]. Currently, chronic diseases like cardiovascular disease, cancer, diabetes, and chronic respiratory diseases account for around 33 million deaths each year [2]. The prevalence in Australia is similar with more than three-quarters of all deaths in 2018 attributable to one of several major chronic conditions (cardiovascular disease, cancer, chronic obstructive pulmonary disease, diabetes, asthma, chronic kidney disease, and mental illness) and a further 47% of Australian adults are living with at least one chronic condition [3]. The ramifications of chronic disease burden to individuals, their families, and the wider community is significant, collectively costing the Australian economy between \$840 million and \$185 billion annually [3–5].

The development of chronic disease is underpinned by varying risk factors, including both non-modifiable (e.g., age, gender, ethnicity) and modifiable factors (unhealthy lifestyle behaviours) [1–4, 6] with behavioural and metabolic risk factors accounting for 45.8% of global disease burden in 2015 (30.3% behavioural and 15.5% metabolic) [7]. During the same period, an estimated 38% of total burden of disease experienced by Australians was attributable to tobacco use, overweight and obesity, dietary risks, hypertension, and hyperglycaemia [4]. Clearly, unhealthy lifestyle behaviours pose a significant public health issue in high-, medium-, and low- income countries alike, and without intervention are likely that fatal and non-fatal disease burden will continue to rise.

To reduce the risk of chronic disease and their health sequelae, interventions targeting smoking cessation, reduction of harmful alcohol use, healthy eating and increased physical activity are needed [8–10]. However, despite the significant health and economic burden posed by unhealthy lifestyle behaviours, and the significant investment in management and prevention programs, health promotion activities to date have demonstrated limited success [2, 11–13]. A possible explanation is that many existing health promotion interventions fail to account for complex concurrent risk factors [14] such as overweight and obesity [12], sleep insufficiency [15] and the impact of social determinants including low income, education level and obesogenic environments [13]. For example, a recent study of 304,779 adolescents from 89 countries showed clustering between physical inactivity and inadequate fruit and vegetable intake and the co-occurrence of cigarette smoking, alcohol drinking, physical inactivity, and poor dietary indicators (though this effect was stronger in females than males) [16].

Unhealthy lifestyle behaviours are linked with physical and psychological symptoms including pain, fatigue and depressive symptoms [17]. Among people participating in community lifestyle programs, positive clinical and behavioural outcomes are often associated with corresponding improvements in general health [18, 19]. Building on the success of multiple health behaviour approaches to disease prevention in other Australian locales (see for example <https://www.lifeprogram.org.au/>), the Queensland Government invested in a large public health program, *My health for life*, aiming to reduce the risk of cardiovascular disease and diabetes in priority groups through supporting individuals to make changes to their health behaviours. As the program targeting the reduction of multiple modifiable chronic disease

risk factors in individuals at high risk of future chronic disease, to create a healthy lifestyle index (HLI) the combination of dietary, alcohol and tobacco smoking, physical activity, and weight indices form a composite score. This paper examined changes in the primary outcome (health behaviour measured using the HLI) in participants of the *My health for life* program.

Methods

The *My health for life* program is a novel, multi-component program that aimed to reduce chronic disease risk factors among adults at risk of diabetes or CVD. The state funded program was developed by an alliance of health organisations including Diabetes Queensland Stroke Foundation, Heart Foundation, Queensland Primary Health Networks, Ethnic Communities Council of Queensland and Queensland Aboriginal and Islander Health Council (collectively referred to as the Healthier Queensland Alliance). Details about the program can be found at <https://www.myhealthforlife.com.au/>.

Program participants were identified using adapted risk assessment tools (stemming from Australian Diabetes Risk assessment (AUSDRISK) [20] or Absolute Cardiovascular Disease Risk assessment (CVD Check) [21]) offered by qualified health professionals in primary health care settings, community events or workplaces, or by self-referral (AUSDRISK) via an online risk-assessment platform hosted by Diabetes Queensland. The program was offered to 'high risk' adults aged 45 years and over (or 18 years for Aboriginal and/or Torres Strait Islander peoples) offered either the face-to-face group-based program (GBP) or one-on-one telephone health coaching (THC) programs.

The intervention comprised of six sessions over a 6-month period at fortnightly intervals (sessions 1–5) with session 6 (related to maintenance) occurring at around 26 weeks that were delivered by a trained facilitator or telephone health coach. The intervention, underpinned by the Health Action Process Approach (HAPA), aimed to develop knowledge, skills and strategies to adopt positive lifestyle behaviours, while educating participants on different risk factors, including healthy eating, physical activity, alcohol and tobacco use [22]. The Program was culturally adapted for Aboriginal and Torres Strait Islander peoples and culturally and linguistically diverse populations, described elsewhere (Ref all relevant papers).

Data from 9,372 participants of the *My health for life* program collected between July 2017 and December 2019 who contributed weight, diet, physical activity, and alcohol and smoking were analysed in this study. Ethical approval was granted from the Darling Downs Health Human Research Ethics Committee (HREA/2021/QTDD/72406) and Griffith University (GU Ref No: 2021/143) before accessing de-identified, secondary data.

Measurements

Data were collected at three timepoints, session 1 (0–6 weeks after enrolment), 12-weeks (session 5), and 24-weeks (session 6) via either a self-administered survey (GBP participants) or interviewer-administered (THC participants) survey schedule. Primary outcome variables included fruit and vegetable intake,

consumption of sugar-sweetened drinks and take-away, alcohol and tobacco smoking, physical activity, body mass index (BMI), and waist circumference (WC).

Weight

Excess weight was measured using two indicators: body mass index (BMI) and waist circumference (WC). For this paper, BMI were grouped according to adult weight guidelines [23] with a BMI < 25 kg/m² representing normal weight, 25-29.9 kg/m² representing overweight, 30-39.9 kg/m² representing obesity and ≥ 40 kg/m² representing extreme obesity. Sex-specific waist circumference was grouped according to increased risk (94-101cm in men and 80-87cm in women) and greater increased risk (> 102cm in men and > 88cm in women). Both measures were included in this analysis to adequately capture adiposity. BMI is an adequate measure of adiposity for clinical purposes [24] whereas among overweight/class-I obese (i.e., BMI 25–34.9 kg/m²) individuals, waist circumference is preferred as it provides additional information about increased disease risk [25].

Diet

Four items from the General Population Health Survey [26] comprised the dietary indicator. They included daily serves of fruit and vegetables (none/less than 1 serve/1–5 serves/6 or more serves), sugar-sweetened drinks (daily/several times per week/about once a week/about once a fortnight/about once a month/less often than once per month/never) and takeaway consumption (everyday/weekly/monthly/rarely/never) which were grouped according to Australian Dietary Guidelines [27]. Healthy diet was defined as two or more serves of fruit, five or more serves of vegetables, infrequent sugar sweetened drinks (either weekly or less than weekly) and take-away (either weekly or less than weekly) consumption.

Physical activity

The physical activity indicator was measured using a single item obtained from the Active Australia Survey [28]. The variable was collapsed into a trichotomous variable indicating whether individuals were sedentary, insufficiently active, and sufficiently active for health.

Alcohol and cigarette smoking

Alcohol and tobacco smoking were measured using 3-items from the Australian Health Survey [29]. Cigarette smoking was measured using one variable that was grouped as current smoker, former smoker or never smoked. Alcohol was measured using 2 items; quantity (number of standard drinks consumed in a single session, range < 1 – >20) and frequency (daily/weekly/monthly/rarely/never). Alcohol use was grouped according to the *2009 National Health and Medical Research Council* [30] with healthy alcohol intake measured as ≤ 4 drinks per session and consuming alcohol less than weekly (and not daily).

Healthy Lifestyle Index

The healthy lifestyle index was derived from current Australian guidelines for good health. Initially, factors were combined into common lifestyle factors for diet, alcohol and tobacco smoking, physical activity and weight before an overall score was computed. Diet was defined using 5 indicators including the minimum daily serves of fruit (0 = < 2 serves, 1 = $\geq$ 2 serves) and vegetables (0 = < 5 serves, 1 = $\geq$ 5 serves), intake of sugar-sweetened drinks (0 = > weekly, 1 = weekly, 2 = < weekly) and take-away consumption (0 = daily, 1 = weekly, 2 = < weekly) [27]. The dietary index was computed as the sum of all five indicators (range 0–6) with higher scores representing greater compliance with dietary guidelines. For the physical activity component, a single indicator was used. The variable, derived from the Active Australia Survey, was collapsed to form a single trichotomous variable indicating being sedentary (no points), insufficiently active (1 point), and sufficiently active for health (2 points) [28]. The alcohol and tobacco index, based on the health guidelines for drinking alcohol [30], comprised 3 indicators outlining alcohol frequency (0 = daily, 1 = less than daily), alcohol quantity (2 = none, 1 = 1–4 drinks per session, 3 = $\geq$ 5 drinks per session), and smoking status (0 = current smoker, 1 = former smoker, 2 = never smoked). The final index was computed by summing the 3 indicators with higher scores denoting less alcohol and smoking (range 0–5). Finally, the weight index was computed using body mass index (0 = $\geq$ 40.0 kg/m², 1 = 30.0–39.9 kg/m², 2 = 25.0–29.9 kg/m², 3 = < 25.0 kg/m²) and waist circumference (0 = $\geq$ 102cm $\square$ and $\geq$ 88cm $\square$, 1 = 94-101cm $\square$ and 80-87cm $\square$, 2 = < 94cm $\square$ and < 80cm $\square$). Higher scores represented a lower BMI and smaller waist circumference (range 0–5). The scoring for each indicator is further detailed in Supplementary Table 1.

To create the HLI, the dietary, physical activity, alcohol and smoking, and weight indexes were summed. The final score ranged from 0 to 18, with a score of 18 being characterized by consuming a healthy diet ($\geq$ 2 serves of fruit and 5 serves of vegetables and infrequent consumption of sugar-sweetened drinks and take-away food), avoidance of alcohol and cigarette smoking, high physical activity (least 150 minutes of activity over one week), and a normal BMI (< 25 kg/m²) and waist circumference < 94cm in men and < 80cm in women.

Preliminary analysis of the HLI composite score revealed that it was not calculated for 30% of cases (n = 2805) and this was due to missing weight indicator data. Further examination showed that more than one-quarter of either BMI (n = 2,381) and waist circumference (n = 2,433) data were missing at session 1. These participants were more likely to have a university degree ($\chi^2(4) = 42.67, p < .01$), employed outside the home ($\chi^2(4) = 83.74, p < .01$), and have enrolled in the telephone health coaching modality ($\chi^2(1) = 3907.66, p < .01$). While several other variables reached statistical significance, the proportional differences between groups were small and were therefore determined to be clinically non-significant [31]. The characteristics of those that provided information about adiposity, and those who did not, are further detailed in Supplementary Table 1.

Covariates: Adjustment was made for socio-demographic characteristics (i.e., gender, socio-economic status, ethnicity, education, First Nations People (i.e., Aboriginal and/or Torres Strait Islander background), Culturally or Linguistically Diverse (CALD) background, and employment [15]), relative socio-economic advantage and disadvantage (derived from the Australian Bureau of Statistics Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) that compares the relative economic and

social conditions of people and households within a specific geographic area [16]), and study variables (modality: THC vs. GBP; number of sessions attended, range 1–6).

Data analysis

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 23 [32] and STATA 13 [33]. Descriptive data are expressed as counts and percentages, mean, and standard deviation (SD), and bivariate statistics were performed using chi-square (χ^2) tests and ANOVA with statistical significance set at $\alpha = .01$ and clinical significant achieved with percentage differences greater than 10% [31].

Before undertaking multivariate analysis, the patterns of missing data were examined. For the primary outcomes, the amount of missing data at Session 1 varied from < 1% on dietary and alcohol indicators (smoking, 1.9%; physical activity, 7.1%) to more around 35% on weight indicators (see Supplementary Tables 2 and 3 for additional detail). Analysis of the missing patterns showed Session 1 missingness was strongly correlated with program modality (85% occurred in THC participants) and several participant socio-demographic characteristics (see Supplementary Table 2), and so data were not plausibly missing completely at random. To further evaluate the assumption of longitudinal random missingness, multiple logistic regression was used to calculate the area under the receiver operating characteristic curve to predict missingness [34, 35] (see Supplementary Fig. 1).

Based on the assumption that data were missing at random [36, 37], multiple imputation by monotone conditional univariate equations were performed using the 'regress' command in Stata [38]. All analysis and auxiliary variables were included in the imputation model to improve the prediction of missing values [36] with fifty imputed datasets generated [19]. To assess the robustness of the multiply imputed data parameter estimates, data for the observed sample were presented alongside the imputed data at each timepoint (Sessions 1, 5 and 6).

Longitudinal associations between lifestyle indices were assessed using Gaussian Generalized Estimating Equations (GEE) models with an identity link and robust standard errors [39–41]. To determine the best working correlation matrix, the Quasilikelihood under the Independence model Criterion (QIC) was computed with the an exchangeable correlation structure best fitting the data [42, 43]. Separate models were fitted for HLI estimates for time only (Model 1), for time and program characteristics (study modality and number of sessions attended; Model 2), and for time, program characteristics and personal background (employment status, gender, age bracket, educational attainment, First Nations People, and IRSAD quintile; Model 3). Finally, to assess the contribution of individual dietary, physical activity, alcohol and smoking, and weight indices, lasagne (or lasagna) plot was generated [44, 45] using the predicted probabilities from nominal logistic models that were fitted for each health behaviour separately while adjusting for study modality, number of sessions attended, time, employment status, gender, age bracket, educational attainment, First Nations People, and IRSAD quintile.

Results

This paper presents primary outcome data from 9,372 Queensland adults who participated in the *My health for life* program from July 2017 to December 2019. Tables 1 and 2 presents baseline study modality, and socio-demographic characteristics by healthy lifestyle indices grouped into quintiles (Quintile 1 represents unhealthy lifestyle behaviours; Quintile 5 represents greatest number of healthy lifestyle behaviours).

Bivariate comparisons of the healthy lifestyle index showed that healthy lifestyle was associated with age (45 years or older; $\chi^2(4) = 285.15, p < .01$), gender (female; $\chi^2(4) = 22.34, p < .01$), retirement ($\chi^2(16) = 328.41, p < .01$), higher educational attainment ($\chi^2(16) = 79.10, p < .01$), and greater relative advantage (IRSAD Quintiles 4 and 5; $\chi^2(16) = 124.93, p < .01$). Socio-demographic characteristics by HLI quintile are outlined in Table 1.

Table 1
Baseline characteristics by healthy lifestyle index (HLI) quintiles ^a

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Mode						
THC	74 (8.1)	126 (8.8)	78 (8.3)	80 (8.9)	143 (8.0)	501 (8.4)
GBP	841 (91.9)	1,302 (91.2)	858 (91.7)	819 (91.1)	1,645 (92.0)	5,465 (91.6)
Employment status						
Employed	519 (60.0)	719 (52.9)	426 (47.1)	414 (48.1)	747 (43.6)	2,825 (49.6)*
Home duties	53 (6.1)	86 (6.3)	52 (5.8)	37 (4.3)	72 (4.2)	300 (5.3)
Retired	105 (12.1)	333 (24.5)	307 (34.0)	320 (37.2)	728 (42.5)	1,793 (31.5)
Not working	111 (12.8)	117 (8.6)	64 (7.1)	43 (5.0)	78 (4.6)	413 (7.2)
Other	77 (8.9)	105 (7.7)	55 (6.1)	46 (5.3)	87 (5.1)	370 (6.5)
Gender						
Female	656 (71.7)	1,067 (74.7)	739 (79.0)	715 (79.5)	1,380 (77.2)	4,557 (76.4)*
Male	259 (28.3)	361 (25.3)	197 (21.0)	184 (20.5)	408 (22.8)	1,409 (23.6)
Age bracket						
<45 years	265 (29.0)	215 (15.1)	97 (10.4)	69 (7.7)	135 (7.6)	781 (13.1)*
45 or older	649 (71.0)	1,211 (84.9)	838 (89.6)	830 (92.3)	1,651 (92.4)	5,179 (86.9)
First Nations People						

THC, Telephone health coaching; GBP, Group-based program; CALD, Culturally or Linguistically Diverse; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

^a Highest quintile represents greatest number of healthy lifestyle indices while the lowest represents most unhealthy lifestyle behaviours

* $p < .01$

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Total
No	825 (90.2)	1,373 (96.1)	898 (95.9)	879 (97.8)	1,753 (98.0)	5,728 (96.0)*
Yes	90 (9.8)	55 (3.9)	38 (4.1)	20 (2.2)	35 (2.0)	238 (4.0)
Educational attainment						
Primary education	28 (3.1)	43 (3.1)	38 (4.1)	28 (3.1)	51 (2.9)	188 (3.2)*
Secondary education	321 (35.6)	462 (32.9)	302 (32.9)	281 (31.6)	522 (29.8)	1,888 (32.2)
Certificate/diploma	381 (42.3)	534 (38.0)	324 (35.3)	322 (36.2)	584 (33.3)	2,145 (36.6)
Bachelor/postgraduate	157 (17.4)	336 (23.9)	241 (26.2)	239 (26.9)	562 (32.1)	1,535 (26.2)
Other	14 (1.6)	31 (2.2)	14 (1.5)	19 (2.1)	34 (1.9)	112 (1.9)
CALD						
No	899 (98.3)	1,383 (96.8)	910 (97.2)	876 (97.4)	1,688 (94.4)	5,756 (96.5)
Yes	16 (1.7)	45 (3.2)	26 (2.8)	23 (2.6)	100 (5.6)	210 (3.5)
IRSAD quintile						
Quintile 1	136 (14.9)	190 (13.3)	113 (12.1)	92 (10.2)	154 (8.6)	685 (11.5)*
Quintile 2	220 (24.1)	261 (18.3)	148 (15.8)	133 (14.8)	229 (12.8)	991 (16.6)
Quintile 3	200 (21.9)	321 (22.5)	230 (24.6)	201 (22.4)	417 (23.3)	1,369 (23.0)
Quintile 4	184 (20.1)	310 (21.7)	188 (20.1)	211 (23.5)	441 (24.7)	1,334 (22.4)
Quintile 5	174 (19.0)	346 (24.2)	255 (27.3)	262 (29.1)	546 (30.6)	1,583 (26.6)
THC, Telephone health coaching; GBP, Group-based program; CALD, Culturally or Linguistically Diverse; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.						
^a Highest quintile represents greatest number of healthy lifestyle indices while the lowest represents most unhealthy lifestyle behaviours						
* $p < .01$						

Overall, three-quarters of participants were female, most were aged 45 years or older (> 80%), around two-thirds reported a secondary school or certificate/diploma level education, and half were employed outside the home. Some modest but statistically significant differences were noted with attrition highest in men ($\chi^2(4) = 16.41, p < .01$) aged 45 years or less ($\chi^2(2) = 67.36, p < .01$) with primary or secondary school education ($\chi^2(8) = 16.93, p = .03$).

Table 2
Percentage of healthy behaviours among complete cases at Sessions 1, 5 and 6

	Session 1	Session 5	Session 6
	n (%)	n (%)	n (%)
Diet index			
Daily fruit intake ^a			
<2 serves	5,032 (53.7)	1,716 (29.2)	1,097 (26.5)*
2 or more serves	4,340 (46.3)	4,168 (70.8)	3,047 (73.5)
Daily veg. intake ^a			
<5 serves	8,447 (90.1)	4,522 (76.8)	3,081 (74.3)*
5 or more serves	925 (9.9)	1,363 (23.2)	1,064 (25.7)
Sugar-sweetened drinks			
More than weekly	1,531 (16.3)	559 (9.1)	410 (8.2)*
Once a week	1,071 (11.4)	715 (11.6)	497 (9.9)
Less than weekly	6,770 (72.2)	4,869 (79.3)	4,103 (81.9)
Takeaway			
More than weekly	29 (0.3)	14 (0.2)	6 (0.1)*
Once a week	3,289 (35.1)	1,416 (23.0)	993 (19.8)
Less than weekly	6,054 (64.6)	4,726 (76.8)	4,014 (80.1)
Physical activity index			
Physical activity ^b			
Sedentary	1,803 (19.2)	383 (6.5)	549 (10.9)*
Insufficient for health	4,370 (46.6)	2,104 (35.5)	1,802 (35.8)

^a Current dietary guidelines recommend a minimum of 2 fruit per day and 5 serves of vegetables [27]

^b Physical activity was defined according to the Australian Physical Activity Guidelines [28] denoting the accumulation of at least 150 minutes of activity over one week

^c Waist circumference (WC) ≥ 94 cm in men and WC ≥ 80 cm in women denoted increased risk and WC ≥ 102 cm in men and WC ≥ 88 cm in women denoted greater increased risk

* $p < .01$

	Session 1	Session 5	Session 6
Sufficient for health	3,199 (34.1)	3,433 (58.0)	2,687 (53.3)
Alcohol and smoking index			
Alcohol quantity			
5 or more	3,574 (38.1)	2,371 (38.5)	1,913 (38.2)*
1–4 drinks	1,584 (16.9)	943 (15.3)	650 (13.0)
None	4,214 (45.0)	2,840 (46.1)	2,450 (48.9)
Alcohol frequency			
Daily	203 (2.2)	58 (0.9)	45 (0.9)*
Weekly or less	9,169 (97.8)	6,096 (99.1)	4,967 (99.1)
Smoking status			
Current	752 (8.0)	348 (3.9)	301 (3.3)*
Former	2,248 (24.0)	2,334 (25.9)	2,350 (26.1)
Never	6,372 (68.0)	6,339 (70.3)	6,362 (70.6)
Weight index			
Body mass index			
≥ 40 kg/m ²	1,011 (16.0)	710 (14.6)	426 (13.0)*
30–39.9 kg/m ²	3,134 (49.5)	2,409 (49.4)	1,515 (46.4)
25–29.9 kg/m ²	1,621 (25.6)	1,318 (27.0)	942 (28.8)
< 25 kg/m ²	569 (9.0)	436 (8.9)	384 (11.8)
Waist circumference ^c			
Greater increased risk	5,154 (84.8)	3,892 (83.3)	2,357 (78.4)*
Increased risk	612 (10.1)	535 (11.4)	417 (13.9)

^a Current dietary guidelines recommend a minimum of 2 fruit per day and 5 serves of vegetables [27]

^b Physical activity was defined according to the Australian Physical Activity Guidelines [28] denoting the accumulation of at least 150 minutes of activity over one week

^c Waist circumference (WC) ≥ 94 cm in men and WC ≥ 80 cm in women denoted increased risk and WC ≥ 102 cm in men and WC ≥ 88 cm in women denoted greater increased risk

* $p < .01$

	Session 1	Session 5	Session 6
Normal	314 (5.2)	248 (5.3)	234 (7.8)
^a Current dietary guidelines recommend a minimum of 2 fruit per day and 5 serves of vegetables [27]			
^b Physical activity was defined according to the Australian Physical Activity Guidelines [28] denoting the accumulation of at least 150 minutes of activity over one week			
^c Waist circumference (WC) ≥ 94 cm in men and WC ≥ 80 cm in women denoted increased risk and WC ≥ 102 cm in men and WC ≥ 88 cm in women denoted greater increased risk			
* $p < .01$			

Table 2 presents the descriptive health behaviours for complete cases at Sessions 1, 5 and 6. The proportion of participants consuming recommended daily serves of fruit (Session 1, 46.3%; Session 5, 70.8%; Session 6, 73.5%, $p < .01$) and vegetables increased over time (Session 1, 9.9%; Session 5, 23.2%; Session 6, 25.7%, $p < .01$) while the frequency takeaways also decreased. Similarly, the proportion of participants who were sufficiently active for health according to the Australian Physical Activity Guidelines [28] increased from 34.1% at Session 1 to 53.3% at Session 6. Risky alcohol intake (i.e., daily drinking or having more than 4 standard drinks on any one day [29]) was largely unchanged over the program period though current cigarette smoking decreased from 8.0% at Session 1 to 3.3% at Session 6 ($p < .01$ but percentage differences $< 10\%$ [31]). Finally, there were small incremental decreases in BMI and WC with increased tendency towards healthy body mass (Session 1, 9.0%; Session 6, 11.8%, $p < .01$) and normal WC (Session 1, 5.2%; Session 6, 7.8%, $p < .01$).

However, while there were general trends towards healthy lifestyle behaviours over the program period, significant attrition might have influenced prevalence and therefore data were imputed. To assess the robustness of imputation, the original and imputed healthy lifestyle indices summary statistics are provided. Table 3 shows the point estimates for the HLI (range 0–18) which did not change at each time point with the average HLI at Session 1 being 10.9 (SD = 2.5), 11.2 (SD = 2.4) at Session 5 and 11.6 (SD = 2.4) at Session 6.

Table 3

Summary statistics for the original and imputed healthy lifestyle indices (with and without weight)

	Session 1		Session 5		Session 6	
	Original	Imputed	Original	Imputed	Original	Imputed
Healthy lifestyle index ^a						
n	5,858	202,808	3,928	126,828	2,568	132,618
M(SD)	10.1 (2.5)	10.0 (2.5)	11.2 (2.4)	11.2 (2.4)	11.4 (2.4)	11.6 (2.4)
Median [IQR]	10.0 [8.0, 12.0]	10.0 [8.3, 11.7]	11.0 [10.0, 13.0]	11.3 [9.6, 12.9]	11.0 [10.0, 13.0]	11.7 [10.0, 13.2]
Minimum	1	-1	3	1	3	-1
Maximum	18	22	18	21	18	22
^a Healthy lifestyle index computed as the sum of dietary, physical activity, alcohol and smoking and weight indices						

The results of Gaussian Generalized Estimating Equations which incrementally adjusted for program characteristics (Model 2) and personal background (Model 3) are shown in Table 4. Over the program period, the average HLI increased by around 1-point at Session 5 (Model 1: $\beta = 0.93$, 95% CI = 0.87, 1.00, $p < .01$; Model 2: $\beta = 0.93$, 95% CI = 0.87, 1.00, $p < .01$; Model 3: $\beta = 0.94$, 95% CI = 0.87, 1.01, $p < .01$) and this was sustained at Session 6 (Model 1: $\beta = 1.29$, 95% CI = 1.10, 1.29, $p < .01$; Model 2: $\beta = 1.19$, 95% CI = 1.10, 1.28, $p < .01$; Model 3 $\beta = 1.18$, 95% CI = 1.09, 1.28, $p < .01$).

Model 2 examined the additive effect of program characteristics. In Models 2 and 3, adjustment suggested that neither study modality (THC vs. GBP), nor number of sessions attended, significantly influenced HLI scores ($p > .01$). Model 3 also adjusted for background socio-demographic factors. Findings showed being retired ($\beta = 0.73$, 95% CI = 0.61, 0.85, $p < .01$), aged 45 or older ($\beta = 0.97$, 95% CI = 0.81, 1.13, $p < .01$), and having a certificate or diploma ($\beta = 0.47$, 95% CI = 0.19, 0.76, $p < .01$) or bachelor's degree or higher ($\beta = 1.05$, 95% CI = 0.76, 1.34, $p < .01$) conferred a higher average HLI while being male, Aboriginal or Torres Strait Islander background, or not currently working conferred lower average HLI scores ($p < .01$ for all).

Table 4

Longitudinal modelling of a HLI using Gaussian Generalized Estimating Equations with an Exchangeable structure

	Model 1 ^a	Model 2 ^b	Model 3 ^c
	β (95% CI)	β (95% CI)	β (95% CI)
Constant	10.23 (10.16, 10.30)*	9.88 (9.43, 10.32)*	8.17 (7.64, 8.70)*
Sessions			
Session 1	-	-	-
Session 5	0.93 (0.87, 1.00)*	0.93 (0.87, 1.00)*	0.94 (0.87, 1.01)*
Session 6	1.20 (1.10, 1.29)*	1.19 (1.10, 1.28)*	1.18 (1.09, 1.28)*
Mode			
THC		-	-
GBP		-0.07 (-0.19, 0.06)	-0.14 (-0.27, -0.02)
No. sessions (range 1–6)		0.09 (0.00, 0.18)	0.06 (-0.03, 0.15)
Employment status			
Employed			-
Home duties			-0.12 (-0.36, 0.12)
Retired			0.73 (0.61, 0.85)*
Not working			-0.54 (-0.75, -0.33)*
Other			-0.29 (-0.50, -0.08)*
Gender			
Female			-
Male			-0.23 (-0.35, -0.11)*

THC, Telephone health coaching; GBP, Group-based program; CALD, Culturally or Linguistically Diverse; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

^a Model 1, unadjusted relationship between HLI and time (sessions 5 and 6)

^b Model 2, adjusted for program characteristics (delivery mode and no. sessions attended)

^c Model 3, adjusted for program characteristics and personal background (employment status, gender, age bracket, educational attainment, First Nations People, and IRSAD quintile)

* $p < .01$

	Model 1 ^a	Model 2 ^b	Model 3 ^c
Age bracket			
<45 years			-
45 or older			0.97 (0.81, 1.13)*
Educational attainment			
Primary education			-
Secondary education			0.26 (-0.02, 0.55)
Certificate/diploma			0.47 (0.19, 0.76)*
Bachelor/postgraduate			1.05 (0.76, 1.34)*
Other			0.59 (0.13, 1.05)
First Nations People			
No			-
Yes			-0.55 (-0.84, -0.27)*
IRSAD quintile			
Quintile 1			-
Quintile 2			-0.02 (-0.19, 0.16)
Quintile 3			0.37 (0.20, 0.54)*
Quintile 4			0.53 (0.35, 0.71)*
Quintile 5			0.68 (0.51, 0.85)*
THC, Telephone health coaching; GBP, Group-based program; CALD, Culturally or Linguistically Diverse; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.			
^a Model 1, unadjusted relationship between HLI and time (sessions 5 and 6)			
^b Model 2, adjusted for program characteristics (delivery mode and no. sessions attended)			
^c Model 3, adjusted for program characteristics and personal background (employment status, gender, age bracket, educational attainment, First Nations People, and IRSAD quintile)			
* $p < .01$			

To assess the changes of each health behaviour individually, the predicted probabilities for each health behaviour were estimated using nominal logistic models, with results showing consistent trends towards healthier lifestyle behaviours over the program period. Overall, obesity decreased from 65% at Session 1 to 57% at Session 6, while the proportion of people in the normal weight range increased from 9–13%.

Similar trends were noted for waist circumference, though to a lesser extent. Dietary indices also showed a shift towards recommended dietary guidelines with 25% meeting the guidelines for daily vegetable intake, 70% meeting the guidelines for daily fruit intake, and ~ 82% consuming take-away and sugar sweetened drinks less than weekly.

At baseline, 19% of participants reported being sedentary and 46% were insufficiently active for health. Over the program period, the proportion of people meeting physical activity guidelines increased, though at Session 6, only 53% reported being sufficiently active for health. Finally, few participants consumed alcohol daily (< 1%) though around one-third (37%) of participants consumed an average of 5 or more alcoholic drinks in one session and this was largely unchanged over the program period. Percentage changes using predicted probabilities in individual health behaviours from Session 1 to Session 6 are illustrated in Fig. 1.

Discussion

This paper explores changes in primary health outcomes of participants from the *My health for life* program, which aimed to reduce the risk factors of chronic diseases among at-risk populations. When compared with the lifestyle indicators of Queenslanders more generally, *My health for life* participants reported higher baseline average single occasion risky drinking, and lower compliance with recommended daily fruit consumption or physical activity levels that were sufficient for health [46]. Notably however, over the *My health for life* program period, the proportion of participants meeting recommended health behaviour guidelines (e.g., diet, smoking cessation, physical activity), in some instances, was greater than is reported by Queensland adults [46].

During the intervention, the proportion of participants in the extremely obese and obese categories decreased from Session 1 to Session 6, while those in the normal weight range increased from 9–13%. Recent studies have shown that even modest reductions in BMI (~ 1 kg/m²) in 'at-risk' populations, is associated with a significant reduction in disease burden [47, 48]. Thus, the downward trend in both BMI and waist circumference in *My health for life* program participants has the potential to have a significant impact on the burden of chronic disease.

Dietary indicators improved overtime, with many participants increasingly likely to meeting recommended fruit and vegetable intake at Session 5. In Queensland, it is estimated that around 2.1 million (53%) adults were meeting recommendations for fruit consumption and only 320,000 (8.0%) adults meet recommendations for vegetable consumption [46]. The favourable results demonstrated by this multiple health behaviour approach are consistent with existing research showing that optimal behaviour change occurs when addressing concurrent risk factors rather than targeting unhealthy lifestyle behaviours individually [49]. Significant changes in other dietary indicators were noted over time. While greater than daily take-away consumption was low in this sample, weekly take-away meals were reported by around one-third of participants at baseline. Over the program period however, frequency of take-away intake was significantly reduced which, if maintained might alter mortality risk. For example, a recent study showed

highest fast-food intake (i.e., Quintile 5) conferred a ~ 16% increased risk of all-cause mortality compared lowest quartile of intake [50].

General improvements in physical activity were observed between Session 1 and 5 though only around half of participants were sufficiently active for health at program completion. While results are similar to previous findings in Queensland (59% of adults aged 18–75 years completed the recommended minimum of 150 minutes of moderate intensity physical activity over at least five sessions in the previous week) [46]. While there is a growing body of research showing the effectiveness of lifestyle interventions on increasing physical activity, the efficacy in some populations is less (e.g., among the elderly, minorities, economically-disadvantaged, and individuals with concurrent disease) [51]. Additional exploration of the environmental factors that can be manipulated to increase physical activity as well as the use of technologies to enhance positive health behaviours might provide additional benefit to individuals for whom behaviour change is sub-optimal [51].

Strengths and limitations

This paper has several limitations that need to be acknowledged. First, the program comprised a pragmatic quasi-experimental trial-based methodology. The absence of a control group, which would be extremely challenging to establish given the size and intent of the program, could affect the ability to make causal inferences about the impact of the intervention of health indicators. Because participants were enrolled in a lifestyle modification program, it is plausible they were highly motivated to improve their health regardless of the intervention. Second, akin with many longitudinal studies, missing data were present in around 61% of participants at Session 5 and 74% of participants at Session 6 and this might have impacted the magnitude of outcomes and the representativeness of the sample [52]. To account for missing data, patterns of missingness per assessed and as data were plausibly missing at random, multiple imputation were performed. Finally, in many instances data were collected by self-report, and despite efforts to minimise (through memory aids, multiple data-checkpoints and training of facilitators [53]), might have increasing the risk of information bias [54].

Despite this, the intervention was associated with improvements in healthy lifestyle indicators, which contributes new information to this research area. While participants showed significant improvements in many healthy lifestyle indices including BMI, waist circumference, dietary indicators, and moderate improvements in physical activity, changes in alcohol consumption were less amenable to the program. Additional research is needed to help understand the multi-level barriers and facilitators of behaviour change in this context to further tailor the intervention for more-difficult-to-treat groups.

List Of Abbreviations

CVD, cardiovascular disease ; BMI, body mass index; WC, waist circumference; GEE, Generalized Estimating Equations; HLI, Healthy Lifestyle Index; IQR, interquartile range; AUSDRISK, Australian Diabetes Risk assessment; CVD, Check Absolute Cardiovascular Disease Risk assessment; GBP, group-

based program; THC, telephone health coaching programs; HAPA, Health Action Process Approach; CALD, Culturally or Linguistically Diverse; IRSAD, Index of Relative Socio-Economic Advantage and Disadvantage; QIC, Quasilikelihood under the Independence model Criterion.

Declarations

Ethics approval and consent to participate

Ethical approval was granted from Darling Downs Health Human Research Ethics Committee (HREA/2021/QTDD/72406) and Griffith University (GU Ref No: 2021/143).

Informed consent to participate was obtained from all subjects.

All methods used in this study were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Health and Wellbeing Queensland have provided informed consent for publication of their identifying information and that of the *My health for life* program.

Availability of data and materials

The data that support the findings of this study are available from Health and Wellbeing Queensland but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Health and Wellbeing Queensland.

Funding

My health for life is funded by the Queensland Government through Health and Wellbeing Queensland.

Author contributions

JP, DA, CS, SM and NM are members of the evaluation project team having made substantial contributions to the evaluation design and implementation. JP and CS wrote the main manuscript, CS conducted the analysis and synthesis of findings and prepared tables and figures. SM prepared the data for analysis. All authors read and approved the final manuscript.

Acknowledgements

We would like to acknowledge the *My health for life* participants, *My health for life* program facilitators and service providers and the *My health for life* project team. We would like to acknowledge the review of the manuscript on behalf of the program by Dr Anna Lewis.

Conflict of interests

The authors declare that they have no conflict of interests.

References

1. **Noncommunicable diseases** [<https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases>]
2. WHO: **Global status report on noncommunicable diseases 2014**. In. Geneva: WHO; 2014.
3. AIHW: **Australia's health 2020**. In. Canberra: Australian Institute of Health and Welfare; 2020.
4. AIHW: **Australian Burden of Disease Study: Impact and causes of illness and death in Australia 2015**. In. Canberra: Australian Institute of Health and Welfare; 2019.
5. Crosland P, Ananthapavan J, Davison J, Lambert M, Carter R: **The economic cost of preventable disease in Australia: a systematic review of estimates and methods**. *Australian and New Zealand Journal of Public Health* 2019, **43**(5):484–495.
6. Beaglehole R, Yach D: **Globalisation and the prevention and control of non-communicable disease: the neglected chronic diseases of adults**. *Lancet* 2003, **362**(9387):903–908.
7. Forouzanfar MH, Afshin A, Alexander LT, Anderson HR, Bhutta ZA, Biryukov S, Brauer M, Burnett R, Cercy K, Charlson FJ *et al*: **Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015**. *The Lancet* 2016, **388**(10053):1659–1724.
8. Alliance N: **Non-Communicable Diseases: A Priority for Women's Health and Development**. In. Brussels: NCD Alliance; 2011.
9. Beaglehole R, Bonita R, Horton R, Ezzati M, Bhala N, Amuyunzu-Nyamongo M, Mwatsama M, Reddy KS: **Measuring progress on NCDs: one goal and five targets**. *The Lancet* 2012, **380**(9850):1283–1285.
10. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, Baugh V, Bekedam H, Billo N, Casswell S: **Priority actions for the non-communicable disease crisis**. *The Lancet* 2011, **377**(9775):1438–1447.
11. Brennan L, Murphy KD, de la Piedad Garcia X, Ellis ME, Metzendorf M-I, McKenzie JE: **Psychological interventions for adults who are overweight or obese**. *Cochrane Database Syst Rev* 2016(3).
12. Roberto CA, Swinburn B, Hawkes C, Huang TTK, Costa SA, Ashe M, Zwicker L, Cawley JH, Brownell KD: **Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking**. *Lancet* 2015, **385**(9985):2400–2409.
13. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML, Gortmaker SL: **The global obesity pandemic: shaped by global drivers and local environments**. *Lancet* 2011, **378**(9793):804–814.
14. Östlin P, Eckermann E, Mishra US, Nkowane M, Wallstam E: **Gender and health promotion: A multisectoral policy approach**. *Health Promot Int* 2006, **21**(suppl_1):25–35.

15. Patel SR, Malhotra A, White DP, Gottlieb DJ, Hu FB: **Association between reduced sleep and weight gain in women.** *American journal of epidemiology* 2006, **164**(10):947–954.
16. Uddin R, Lee E-Y, Khan SR, Tremblay MS, Khan A: **Clustering of lifestyle risk factors for non-communicable diseases in 304,779 adolescents from 89 countries: A global perspective.** *Preventive Medicine* 2020, **131**:105955.
17. Peeters G, Burton NW, Brown WJ: **Associations between sitting time and a range of symptoms in mid-age women.** *Preventive Medicine* 2013, **56**(2):135–141.
18. Eaglehouse YL, Schafer GL, Arena VC, Kramer MK, Miller RG, Kriska AM: **Impact of a community-based lifestyle intervention program on health-related quality of life.** *Quality of Life Research* 2016, **25**(8):1903–1912.
19. Xu F, Cohen SA, Lofgren IE, Greene GW, Delmonico MJ, Greaney ML: **Relationship between Diet Quality, Physical Activity and Health-Related Quality of Life in Older Adults: Findings from 2007–2014 National Health and Nutrition Examination Survey.** *The journal of nutrition, health & aging* 2018, **22**(9):1072–1079.
20. Government A: **Background to the Australian Type 2 Diabetes Risk Assessment Tool (AUSDRISK).** In. Canberra: Department of Health, Australian Government 2010.
21. Alliance NVDP: **Guidelines for the management of absolute cardiovascular disease risk.** In. Victoria: National Stroke Foundation; 2012.
22. Schwarzer R: **Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors.** *Applied Psychology: An International Review* 2008, **57**(1):1–29.
23. World OH: **Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. WHO Technical Report Series 894.** In: *WHO*. Geneva; 2000.
24. Mooney SJ, Baecker A, Rundle AG: **Comparison of anthropometric and body composition measures as predictors of components of the metabolic syndrome in a clinical setting.** *Obes Res Clin Pract* 2013, **7**(1):e55-e66.
25. National Heart L, and Blood Institute in cooperation with the National Institute of Diabetes and Digestive and Kidney Diseases: **The Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report.** In. New York: NIH; 1998.
26. Department of Health AG: **2014 General Population Self Reported Health Survey.** In. Brisbane: Queensland Government; 2014.
27. NHMRC: **Australian Dietary Guidelines.** In. Canberra: National Health and Medical Research Council; 2013.
28. AIHW: **The Active Australia Survey: a guide and manual for implementation, analysis and reporting.** In. Cancerra: AIHW; 2003.
29. AIHW: **2016 National Drug Strategy Household Survey In., vol. Drug statistics series no. 25.** Canberra: AIHW; 2016.

30. NHMRC: **Australian Guidelines to Reduce Health Risks from Drinking Alcohol**. In. Canberra: NHMRC; 2009.
31. Kazdin AE: **The meanings and measurement of clinical significance**. *Journal of Consulting and Clinical Psychology* 1999, **67**(3):332–339.
32. Statistics IS: **Statistical Package for the Social Sciences (Version 19.0)**. In. Chicago: SPSS Inc; 2010.
33. StataCorp: **Stata Statistical Software: Release 11**. In. College Station, Texas: StataCorp LP; 2009.
34. Donders ART, Van Der Heijden GJ, Stijnen T, Moons KG: **A gentle introduction to imputation of missing values**. *Journal of clinical epidemiology* 2006, **59**(10):1087–1091.
35. Fan J, Upadhye S, Worster A: **Understanding receiver operating characteristic (ROC) curves**. *CJEM* 2006, **8**:19–20.
36. Sterne JAC, White IR, Carlin JB, Spratt M, Royston P, Kenward MG, Wood AM, Carpenter JR: **Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls**. *BMJ* 2009, **338**:b2393.
37. Cramer A, von Wyl A, Koemeda M, Schulthess P, Tschuschke V: **Sensitivity analysis in multiple imputation in effectiveness studies of psychotherapy**. *Frontiers in Psychology* 2015, **6**(1042).
38. Rubin D: **Multiple imputation for non-response in surveys**. New York: John Wiley & Sons; 1987.
39. Hubbard AE, Ahern J, Fleischer NL, Van der Laan M, Satariano SA, Jewell N, Bruckner T, Satariano WA: **To GEE or not to GEE: comparing population average and mixed models for estimating the associations between neighborhood risk factors and health**. *Epidemiology* 2010:467–474.
40. Laird NM, Ware JH: **Random-effects models for longitudinal data**. *Biometrics* 1982:963–974.
41. Liang K-Y, Zeger SL: **Longitudinal data analysis using generalized linear models**. *Biometrika* 1986, **73**(1):13–22.
42. Cui J: **QIC program and model selection in GEE analyses**. *The Stata Journal* 2007, **7**(2):209–220.
43. Zeger SL, Liang K-Y: **Longitudinal Data Analysis for Discrete and Continuous Outcomes**. *Biometrics* 1986, **42**(1):121–130.
44. Jones M, Hockey R, Mishra GD, Dobson A: **Visualising and modelling changes in categorical variables in longitudinal studies**. *BMC Med Res Methodol* 2014, **14**(1):32.
45. Swihart BJ, Caffo B, James BD, Strand M, Schwartz BS, Punjabi NM: **Lasagna plots: a saucy alternative to spaghetti plots**. *Epidemiology (Cambridge, Mass)* 2010, **21**(5):621–625.
46. Health Q: **The health of Queenslanders 2020. Report of the Chief Health Officer Queensland**. In. Brisbane: Queensland Government; 2020.
47. AIHW: **Impact of overweight and obesity as a risk factor for chronic conditions**. In. Canberra: AIHW; 2017.
48. Kearns K, Dee A, Fitzgerald AP, Doherty E, Perry IJ: **Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level**. *BMC Public Health* 2014, **14**(1):143.

49. Salam RA, Padhani ZA, Das JK, Shaikh AY, Hoodbhoy Z, Jeelani SM, Lassi ZS, Bhutta ZA: **Effects of Lifestyle Modification Interventions to Prevent and Manage Child and Adolescent Obesity: A Systematic Review and Meta-Analysis.** *Nutrients* 2020, **12**(8):2208.
50. Barrington WE, White E: **Mortality outcomes associated with intake of fast-food items and sugar-sweetened drinks among older adults in the Vitamins and Lifestyle (VITAL) study.** *Public Health Nutrition* 2016, **19**(18):3319–3326.
51. Dunn AL, Andersen RE, Jakicic JM: **Lifestyle physical activity interventions: History, short- and long-term effects, and recommendations.** *American Journal of Preventive Medicine* 1998, **15**(4):398–412.
52. Madley-Dowd P, Hughes R, Tilling K, Heron J: **The proportion of missing data should not be used to guide decisions on multiple imputation.** *Journal of Clinical Epidemiology* 2019, **110**:63–73.
53. Althubaiti A: **Information bias in health research: definition, pitfalls, and adjustment methods.** *J Multidiscip Healthc* 2016, **9**:211–217.
54. Preston SH, Fishman E, Stokes A: **Effects of categorization and self-report bias on estimates of the association between obesity and mortality.** *Annals of Epidemiology* 2015, **25**(12):907–911.e902.

Figures

Figure 1

Lasagne plot for the predicted probabilities for individual health behaviours at Sessions 1, 5 and 6 Notes:

(a) BMI, Body mass index (highest ranked health indicator = normal <25.0 kg/m²; lowest ranked health indicator = obese ≥30 kg/m²); (b) Waist, (highest = higher increased risk <94cm & < 80cm; lowest =

102cm and ≥ 88 cm) ; (c) Vegetables and fruit (highest = ≥ 5 serves veg and ≥ 2 serves fruit, lowest = < 5 serves veg and < 2 serves fruit); Take-away (highest = $<$ weekly; lowest = daily); (d) Sugar-sweetened drinks (highest = $<$ weekly; lowest = $>$ weekly); (e) Physical activity (highest = sufficiently active for health; lowest = sedentary); (f) Alcohol quantity (highest = none; highest = ≥ 5 drinks per session); Alcohol frequency, (highest = daily; lowest = less than daily); (g) Smoking (highest = never smoked; lowest = current smoker); (h) The predicted probabilities from nominal logistic models were fitted separately for each health behaviour. Adjustment was made for study modality, no. sessions, time, employment status, gender, age bracket, educational attainment, First Nations People, and IRSAD quintile.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTables.docx](#)