PEC Innovation 3 (2023) 100224

Contents lists available at ScienceDirect

PEC Innovation

journal homepage: www.elsevier.com/locate/pecinn

Validation of the Consumer Health Activation Index (CHAI) in general population samples of older Australians

Ingrid Flight [a], Nathan J. Harrison [a,b,c], Erin L. Symonds [a,d], Graeme Young [a], Carlene Wilson [a,e,f,*]

[a] Cancer Research, Flinders Health and Medical Research Institute, College of Medicine and Public Health, Flinders University, Bedford Park, South Australia, Australia
[b] National Centre for Education and Training on Addiction, Flinders Health and Medical Research Institute, College of Medicine and Public Health, Flinders University, Bedford Park, South Australia, Australia
[c] Health Policy Centre, South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia
[d] Department of Gastroenterology and Hepatology, Flinders Medical Centre, Bedford Park, South Australia, Australia
[e] Olivia Newton-John Cancer Wellness and Research Centre, Austin Health, Heidelberg, Victoria, Australia
[f] Centre for Epidemiology and Biostatistics, Melbourne School of Population and Global Health, The University of Melbourne, Parkville, Victoria, Australia

ARTICLE INFO

Keywords:
Health activation
Health literacy
Validation study
Consumer participation
Health promotion
Australia

ABSTRACT

Objective: To validate the 10-item Consumer Health Activation Index (CHAI), developed in the United States, as an activation measure for interventions targeted at the Australian older general population.
Methods: The study was a cross sectional design. Exploratory factor analysis (EFA) was conducted on survey data from a community sample of participants ($n = 250$), aged 55–75 years. Confirmatory factor analysis (CFA) was used to evaluate dimensionality among a second sample of participants randomly sampled from the electoral roll ($n = 571$), aged 50–75 years. Associations between the CHAI and self-reported health behaviours were examined.
Results: EFA revealed a 7-item, two-factor structure ('Health self-management' and 'Patient-provider engagement'). CFA indicated optimum model fit was obtained with this structure. Subscale reliability and validity were confirmed, with significant correlation to age, functional health literacy and health screening.
Conclusion: In contrast to the original structure, optimum model fit was obtained with a two-factor solution and retention of seven items. The subscales have utility as a measure of health activation for tailoring of information in this group.
Innovation: A freely-available, unidimensional health activation measure has demonstrated an underlying two-scale structure that will enable tailored approaches toward the enhancement and maintenance of self- and externally-managed health behaviours in an Australian population.

1. Introduction

Consumer-centred care is integral to health care policy in countries such as the United States [1], the United Kingdom [2] and Australia [3,4]. This approach advocates for sharing of health management between the health consumer and the health provider. A core aspect of this approach, empowerment, remains ill-defined [5,6] but emphasises an individual's role in their own health care. 'Activation' is regarded as complementary to the empowerment domain and describes a person's ability and motivation to manage their health [7].

Activation has been shown to have a stronger association with health outcomes than known socio-demographic variables [8,9]. Higher activation is associated with greater likelihood of screening uptake, participation in check-ups and immunisations, adoption of healthy diet and exercise, and achievement of good outcomes on clinical health indicators. The latter is assumed to reflect increased engagement in positive health behaviours and supports effective health management [10,11]. Knowledge of differences in activation level and subsequent optimisation through intervention should serve to support good health over time. Activation assessment is used throughout the UK National Health Service [12] and increasingly in Australia [13,14].

A widely used health activation measure, the Patient Activation Measure (PAM), was developed in the United States by Hibbard and colleagues [15]. It has strong psychometric properties and

* Corresponding author at: Centre for Epidemiology and Biostatistics, Melbourne School of Population and Global Health, The University of Melbourne, Parkville, Victoria, Australia.
E-mail address: carlene.wilson1@unimelb.edu.au (C. Wilson).

https://doi.org/10.1016/j.pecinn.2023.100224
Received 21 May 2023; Received in revised form 12 September 2023; Accepted 30 September 2023
Available online 1 October 2023

unidimensional structure. Research utilising the PAM has largely focused on populations with a chronic disease [14,16-18] or in the primary care environment e.g., [19,20]. Fewer studies have explored the importance of health activation in the general population e.g., [21,22,23].

The Consumer Health Activation Index (CHAI), developed by Wolf and colleagues in the United States [24], is a publicly available, brief measure of health activation. The unidimensional, 10-item scale was shown to have good internal consistency and moderate test-retest reliability. It has been used in research relating to a variety of health behaviours and contexts, including treatment adherence [25-27], COVID preparedness [28], COVID vaccine trust [29], and satisfaction with telehealth [30]. Elsewhere, a smaller number of CHAI items have been used to extract a patient activation score e.g., [31,32].

The CHAI has recently been utilised in an Australian general population context with a focus on COVID-19 attitudes and behaviours [30,33]. Given that the items represent the domains of beliefs, knowledge, locus of control, self-efficacy and actions [24, supplementary Appendix A], all of which are intimately associated with determinants of health behaviour generally [34], we were interested in whether the CHAI had utility as a unidimensional measure of health activation in the older Australian general population with no known chronic disease, specifically its ability to quantify the likelihood of engagement in primary and secondary health-promoting behaviours. For example, knowledge of level of activation could inform the design of targeted public health interventions to influence behaviours like physical activity, diet, and participation in population-based cancer screening. We conducted a validation study of the CHAI in this context using two separate samples of older Australians recruited from the general population. Specifically, over three phases we investigated unidimensionality and any underlying structure using exploratory factor analysis (EFA), evaluated structural invariance using confirmatory factor analysis (CFA), and evaluated the concurrent validity (CV) of the CHAI. We hypothesised that we would find positive relationships between the CHAI and other health-promoting variables, including health checks (e.g., screening compliance), physical activity and diet, and functional literacy. One population sample provided data for the EFA and CV, and the second sample the CFA. Methods and results are presented below.

2. Methods

The study was a cross-sectional design as is the case with validation studies [35]. Data were collected via surveys. Ethics approval was obtained from the Social and Behavioural Research Ethics Committee of Flinders University (7223) to cover the EFA and CV phases. The CFA phase was part of a larger study approved by the Southern Adelaide Clinical Human Research Ethics Committee (483.14) and registered on the Australian New Zealand Clinical Trials Registry (ACTRN12615000972527).

2.1. Phase 1: EFA

2.1.1. Participants and data collection

A professionally-accredited, commercial social research company recruited participants. Potentially eligible people registered on their database were approached via email and invited to complete an online researcher-designed survey. They were recruited in a 1:1 gender ratio and as specified, recruitment ceased once a total of $n = 250$ eligible participants were reached. The company collected responses and provided the researchers with de-identified data, indicated by ID only. Disease status was unknown at recruitment. Data collection occurred between August and September 2016. Participants confirmed they had met the inclusion criteria (aged between 55 and 75 years; resident of the Adelaide, South Australia metropolitan area) and indicated informed consent by proceeding. The opportunity to win one of five AU $50 gift vouchers was offered to participants.

2.1.2. Measures

The survey contained the CHAI [24], consisting of 10 items measured on a six-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). Items and descriptive statistics are shown in Table 1. Also included were demographic items and measures of functional health literacy, self-rated general health, chronic conditions, self-initiated health checks, physical activity, fruit and vegetable consumption. These measures are described in para 2.3.2. Other measures collected for a separate study are not reported here.

2.1.3. Statistical analyses

Analyses were performed using IBM SPSS Statistics 27 (IBM Corp., Armonk, NY). Summed CHAI scores were transformed to a 0–100 scale [36], consistent with Wolf et al. [24] and with the PAM [15]. Apart from providing equivalence with the PAM, 0–100 scores (where 0 = the lowest possible activation and 100 = the highest possible activation) enable more comprehensible cut-offs when measuring extent of activation and change over time. For example the PAM places individuals at one of 4 levels of activation based upon their transformed score [9,15] and the CHAI developers propose a 3-level activation cut-off [24]. Exploratory factor analysis of the 10 items of the CHAI used maximum likelihood estimation and oblique oblimin rotation. Correlations were conducted to assess the relationship of each item with the overall scale, and internal consistency was assessed using Cronbach's alpha and mean inter-item correlation, which is recommended for short scales (<10 items), and has an optimal range of .2 to .4 [37]. There were no missing data.

2.2. Phase 2: CFA

2.2.1. Participants and data collection

Data were collected as part of a population-based, randomised trial to increase uptake of colorectal cancer screening [38,39]. Baseline survey data collected between May and October 2016 are reported. Recruitment was via post, after addresses were randomly extracted from the South Australian Electoral Roll. Participants were aged 50–74 years at invitation, consistent with eligibility for Australia's National Bowel

Table 1
Original CHAI items and response distribution ($n = 250$)

Statement	Item Response *M(SD)*	Skew[a]
1. It is very important that I treat my health as my top priority	5.26 (0.85)	-1.71
2. I always know what steps to take when I have a health problem	4.73 (0.93)	-.74
3. I always know how to make myself feel better	4.35 (1.01)	-.61
4. I always know where to look for information before making decisions about my health	4.57 (1.02)	-.68
5. I can always take care of myself	4.30 (1.03)	-.83
6. It is very easy for me to understand my doctor's instructions	4.95 (0.88)	-.75
7. It is very easy for me to make changes to my daily life to improve my health	4.14 (1.23)	-.62
8. It is very easy for me to follow my doctor's instructions	4.75 (0.96)	-.81
9. I always attend all of my doctor appointments	5.32 (0.83)	-1.56
10. I always make the health changes I should even if I do not feel well	4.30 (1.05)	-.65

Note. Potential range 1–6 for all CHAI items.
[a] Standard error for each item = 0.15.

Cancer Screening Program.[1] No financial incentive was offered, and informed consent was indicated by survey completion.

2.2.2. Measures

We report only on CHAI data collected in the survey, in addition to demographic items (country of birth; gender and age; marital, employment, and health insurance status; educational level) when describing CFA results.

2.2.3. Statistical analyses

We used maximum likelihood estimation methods in Amos Graphics 27 (IBM Corp., Armonk, NY), to compare the original 10-item structure of the CHAI measure against the 7-item structure derived from the EFA.

2.3. Phase 3: CV—relationship to health-promoting behaviour

2.3.1. Participants and data collection

Participants and procedures are identical to Phase 1; functional health literacy, medical, lifestyle and health monitoring measures were obtained after completing the CHAI items in the online questionnaire. Relationships between these variables and the 2 factors confirmed by CFA were undertaken to test validity of the structure.

2.3.2. Measures

2.3.2.1. Functional health literacy. Functional health literacy is defined as "…the ability to read, understand and act upon information" [40]. For functional health literacy items suitable for self-report, we adapted 3 questions previously used by Hibbard and colleagues [11]. These assessed frequency of: asking a doctor or pharmacist about medication side effects when taking a new prescription medication; reading about side effects when taking a new prescription medication; and reading food labels for content. The question stem was "I always…" Responses were based on a 6-point Likert scale ranging from 1 = *strongly disagree* to 6 = *strongly agree*. Each item represented a distinct behaviour and was considered as a separate variable in the analyses.

2.3.2.2. Health checks. The frequency of completing health checks was measured on a 4-item Likert scale ranging from 1 = *never* to 4 = *always*, with a not applicable option. These checks were subjectively grouped as 'self-managed health checks' (monitor weight, inspect skin for moles, dental check-ups, score range 3–12); 'doctor-managed health checks' (health checks through doctor, skin cancer checks through doctor, score range 2–8) and 'population health checks' (screening for breast and cervical cancer among women only with score range 2–8, and colorectal cancer screening, score range 1–4). Reliability analyses of the self-managed and doctor-managed health check item groupings indicated acceptable mean inter-item correlation (.2 and .3 respectively), as did the breast and cervical cancer grouping (.5)

2.3.2.3. Medical factors. Participants indicated current and lifetime chronic disease status (i.e., diagnosis of cancer, heart, lung disease, diabetes, high blood pressure, high cholesterol, arthritis). They also rated their general health as excellent, very good, good, or fair to poor. Body mass index (BMI) was calculated from self-reported height and weight data.

2.3.2.4. Lifestyle behaviours. Participants reported their smoking status (non-smoker/former smoker; current smoker) and combined daily consumption of fruit and vegetable serves during the preceding week. Physical activity was measured using the short version of the International Physical Activity Questionnaire (IPAQ) [41] and expressed as MET-minutes of total activity per week, in accordance with the IPAQ scoring manual. A MET describes the intensity of an activity and is a ratio of working metabolic rate relative to resting metabolic rate where 1 MET = resting rate [42]. Details of private health insurance status and knowledge of health funds were also collected.

2.3.3. Statistical analyses

The relationship between variables and the two subscales was examined using Spearman's Rank Order correlation for ordinal variables, independent samples *t*-test and one-way between-groups ANOVA with post hoc tests, as appropriate. Probability values were corrected for multiple comparisons with the Benjamini-Hochberg method [43] as indicated on relevant tables. 'Not applicable' responses to frequency of health check items were treated as missing data because they were few. Physical activity data, as measured on the IPAQ, were screened and outlier scores exceeding 960 min daily (6720/week; $n = 22$; 9%) were excluded.

3. Results

3.1. Phase 1: exploratory factor analysis

By design the gender split was equal. Ages ranged from 55 to 75 years, approximately equally distributed over five-year age bands, with a mean age of 64.4 years (standard deviation (SD) =5.4). The majority were born in Australia (72.4%), not currently employed (60.4%) and were married or in a de facto relationship (76.8%).

The distribution of responses to the 10 CHAI items is shown in Table 1. Scores were non-normally distributed, with skewness ranging from −.61 to −1.71 (standard error (*SE*) = 0.15 for each item). Individual items exhibited no floor effects but 6/10 items had potential ceiling effects given that >15% of respondents indicated the highest score [44]. For the 10-item scale as a whole, no respondents indicated the minimum potential scale score, and only three (1.20%) participants achieved the maximum potential scale score. The mean total CHAI score was 46.66 (SD = 6.45, range 26–60); the mean transformed total CHAI score was 73.33 (SD = 12.89, range 32–100).

Internal consistency for the scale was good (Cronbach's α = .85), as was the mean item correlation (.36). Notwithstanding good reliability of the scale, results of Bartlett's Test of Sphericity (χ^2 (45) =897.81, $p <$ .001) and Kaiser-Meyer-Olkin test (KMO = .84) indicated that the data were appropriate for exploratory factor analysis to determine any more parsimonious underlying structure.

The eigenvalue (EV) plot supported a two-factor solution and accounted for 56% of variance overall (EV factor 1 = 4.31, accounting for 43.14% of variance; EV factor 2 = 1.29, accounting for 12.87% of variance). Items were removed sequentially, taking into account factor loadings of .5 or greater as adequate indicators [45]: item 10 was cross loaded with both factor loadings <.5; item 1 loaded on factor 2 < .5 and had an extracted communality of <.20; and item 7 was cross loaded with both factors <.5. Although item 9 had very low extracted communality at this stage compared to the other items (.28, see Table 2), we prioritised the inclusion of ≥3 items per factor [46]. Removal of item 9 would have necessitated a 2-item second factor that would have explained less cumulative variance and weakened the scale [45]. The chosen 7 item, 2-factor solution (factor 1: items 2, 3, 4, 5; factor 2: items 6, 8, 9) combined explained 63.7% of variance (EV factor 1 = 3.25, accounting for 46.4% of variance; EV factor 2 = 1.21, accounting for 17.3% of variance). These factors were moderately correlated (.51). Properties of the solution are shown in Table 2.

The internal consistency of all seven retained items was good (Cronbach's α = .81); and acceptable for the subscales (Factor 1 α = .79; Factor 2 α = .72). The mean inter-item correlation values for Factors 1 and 2 were .49 and .46 respectively, also indicating an acceptable

[1] Australia's National Bowel Screening Program provides all Australian the potential to access a free Faecal Immunochemical Test in the mail every two years from their 50th to 74th birthday.

Table 2
Properties of CHAI items retained in Exploratory Factor Analysis with Maximum Likelihood Extraction and Direct Oblimin Rotation (Study 1; $n = 250$)

Item number	Pattern matrix of factor loadings		Communalities (extraction)	Corrected item-total correlation[a]	Cronbach's α if item deleted[b]
	Factor 1: Health Self-management	Factor 2: Patient-provider Engagement			
2	**.58**	.13	.42	.58	.76
3	**.92**	-.18	.71	.66	.71
4	**.56**	.21	.47	.60	.74
5	**.66**	.06	.47	.57	.76
6	-.00	**.77**	.59	.59	.58
8	.14	**.68**	.58	.59	.57
9	-.03	**.54**	.28	.45	.73
Initial eigenvalues	3.25	1.21			
Extraction sums of squared loadings	2.76	0.75			
Rotation sums of squared loadings	2.44	2.07			

Note. Primary factor loadings are presented in bold type.
[a] Calculated relative to subscale (items with primary loadings on factor only).
[b] Factor 1 Cronbach's α = 0.79; Factor 2 Cronbach's α = 0.72.

relationship between the items within a factor. We labelled factor 1 'Health Self-management', reflecting more autonomous aspects of consumer-centred care such as looking for information and taking care of oneself. Factor 2 represented items related to elements of shared care with a doctor (i.e., understanding and following instructions, and attending appointments). Notwithstanding mention of "doctor" in the items, we considered the statements to represent engagement with healthcare professionals in general; thus we termed the factor 'Patient-provider Engagement'. We conducted a confirmatory factor analysis (CFA) on this model using a second sample of participants.

3.2. Phase 2: confirmatory factor analysis

Participants ($n = 571$, females = 54.5%) were aged 50–75 years at survey completion (mean 64.32, SD = 6.89). Sample characteristics were comparable to the Phase 1 EFA cohort; most were born in Australia (70.7%), not in the workforce (60.8%), married or in a de facto relationship (74.2%), had private health insurance coverage (85.0%), and 45.9% had primary or secondary school as their highest level of completed education. Complete responses for all 10 CHAI items were obtained from $n = 566/571$ (99.1%) respondents; the missing responses ($n = 6$) were considered missing at random (MAR) and imputed using maximum likelihood estimation.

In an initial model utilising the original 10 CHAI items and a latent 'activation' construct (i.e., one-factor solution), standardised loadings ranged between .48 (item 9) and .73 (item 2). In this model, the overall fit was suboptimal: $\chi 2\ (35) = 486.19$, $p < .001$, CFI = .79, TLI = .66, RMSEA = .15. The two-factor model, which retained seven items of the CHAI derived from the EFA (items 2, 3, 4, 5 and 6, 8, 9), is shown in Fig. 1. It achieved an acceptable fit to the data on each of the test statistics: $\chi 2\ (13) = 64.87$, $p < .001$, CFI = .96, TLI = .92, RMSEA = 0.08. In this model, all standardised estimates loading on the two factors exceeded .5 (ranging from .53 for item 9 to .82 for item 3) to confirm acceptable construct validity [47]. Internal consistency was very good for the first factor, Health Self-management (α = .82), and good for the second factor, Patient-provider Engagement (α = .73). Therefore, to explore the relationship between CHAI and health-promoting behaviours, we used the two-factor model to investigate concurrent validity.

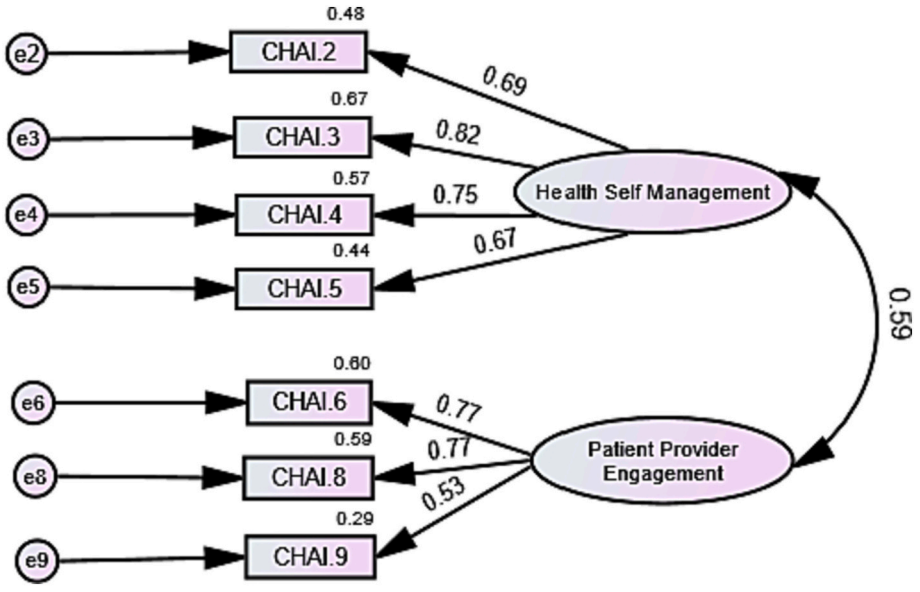

Fig. 1. Path diagram of final model in confirmatory factor analysis ($n = 571$). Squared multiple correlations are presented above observed variables (CHAI items 2, 3, 4, 5, 6, 8, and 9), and loading estimates above paths to latent constructs (Factors 1 and 2). Error terms are indicated for each observed variable (e.g., e2). All values presented are standardised.

3.3. Phase 3: concurrent validity

The Phase 1 EFA cohort provided data for an investigation of concurrent validity. Demographic details are provided in para 3.1. Current morbidities ranged from 0 to 4 ($M = 1.2$, SD = 1.1); the most prevalent current morbidity was arthritis ($n = 102$, 40.8%) followed by high blood pressure ($n = 76$, 30.4%). High cholesterol was reported by 46 (18.4%); and diabetes by 30 (12.0%); 13 (5.2%) participants reported each of heart disease and lung disease, and 12 (4.8%) cancer. Nearly one third of respondents ($n = 82$, 32.8%) did not report any current morbidity. Half the respondents rated their health as excellent or very good ($n = 126$, 50.4%) and only a minority of respondents viewed their health status as being fair to poor ($n = 21$, 8.4%).

Results for categorical variable analyses are shown in Table 3. Mean scores for each subscale did not differ significantly by gender, marital, employment or smoking status. Mean Health Self-management differed between groups varying on self-rated general health ($p = .002$); poorer health and little or no knowledge of health insurance was associated with lower Health Self-management ($p = .005$).

Mean scores for the Patient-provider Engagement subscale differed significantly by health insurance ($p = .006$) and educational status ($p < .001$). Those without private health insurance were significantly less likely to report engaging with their doctor than those with insurance status. Those who had completed Year 12 were significantly less likely to engage with their doctor compared to university graduates ($p = .008$). Those who had completed some high school had significantly lower scores than university graduates ($p = .005$) and post-graduates ($p = .018$).

The results of correlation analyses for both subscales are shown in Table 4. Neither subscale correlated significantly with BMI, fruit and vegetable consumption, physical activity, current morbidities, or history of morbidities. The Health Self-management subscale was positively and moderately associated with all 3 health literacy items and self-managed health checks but only weakly with doctor-managed health checks ($p \leq .001$).

Older age was significantly associated with higher scores on the Patient-provider Engagement subscale, albeit with a small correlation ($r_s = .19$). The Patient-provider Engagement subscale had small but significant correlations with each functional health literacy item ($p < .001$). It was also positively and moderately associated with completion of self-monitored and doctor-monitored health checks and weakly associated with colorectal cancer screening. There was no relationship with women's participation in breast and cervical cancer screening ($r_s = .10$, $p = .26$). Secondary analysis to examine a potential gender difference in colorectal screening uptake revealed no difference (males M = 3.19, SD = 0.983); females (M = 3.33, SD = 0.964), t(245) = −1.194).

Table 3
CHAI subscales scores and demographic variables ($n = 250$).

Variable	*n* (%)	Health Self-management score[a] *M* (*SD*)	*p*	Patient-provider Engagement score[a] *M* (*SD*)	*p*
Gender					
Male	125 (50.0)	69.24 (14.92)	.62	78.99 (14.19)	.21
Female	125 (50.0)	70.24 (16.47)		81.28 (14.36)	
Marital status					
Married/de facto	192 (76.8)	70.73 (15.40)	.07	80.0 (14.14)	.79
No current partner	58 (23.2)	66.47 (16.33)		80.57 (14.90)	
Employment status					
Employed	99 (39.6)	71.01 (15.0)	.30	79.06 (14.60)	.34
Not employed	151 (60.4)	68.91 (16.12)		80.84 (14.10)	
Highest level of education					
Some high school	12 (4.8)	65.42 (12.52)	.06	69.44 (12.86)	**<.001**
Year 12	65 (26.0)	70.54 (17.12)		76.51 (16.71)	
Some college/ 2-year course	74 (29.6)	66.01 (15.24)		79.37 (13.30)	
University graduate	67 (26.8)	73.43 (14.36)		84.58 (11.02)	
Postgraduate	32 (12.8)	70.63 (16.10)		83.96 (14.15)	
Smoking status					
Non/former smoker	231 (92.4)	70.26 (15.43)	.07	80.55 (14.50)	.11
Current smoker	19 (7.6)	63.42 (17.88)		75.09 (10.62)	
Self-rated general health					
Excellent/very good	126 (50.4)	71.90 (15.10)	**.002**	81.75 (13.42)	.06
Good	103 (41.2)	69.22 (14.85)		79.42 (14.85)	
Fair/poor	21 (8.4)	59.29 (19.25)		73.97 (15.33)	
Private health insurance					
Hospital coverage	195 (78.0)	70.72 (15.29)	.06	81.44 (13.80)	**.006**
No hospital coverage	55 (22.0)	66.27 (16.73)		75.52 (15.18)	
Knowledge of health funds					
Know a fair amount/know a lot	52 (20.8)	75.87 (13.01)	**.005**	84.36 (12.31)	.02
Know a little	133 (53.2)	68.57 (15.98)		80.15 (13.94)	
Know nothing	65 (26.0)	67.23 (16.01)		76.72 (15.73)	

With 16 comparisons, significance was set at p ≤ .009 [43]
[a] Transformed scores 0–100.

4. Discussion and conclusion

4.1. Discussion

This study evaluated dimensionality of the CHAI in two Australian older population samples and explored relationships with related health-promoting variables. We found preliminary evidence of a 7-item, two-factor health activation structure (Health Self-management and Patient-provider Engagement) and associations with health outcomes. Our finding accords with Park and Jung's [48] evaluation of the CHAI; they also found a two-factor solution, albeit with the inclusion of all 10 items and in a cohort of young adults. It is of note that the three items (6, 8, 9) comprising one factor reported by these researchers were the same as we found, i.e., all mentioning "my doctor", which the researchers regarded as relating to interactions with one's regular physician (we widened this description to encapsulate any health provider). Nevertheless, the small number of items in this factor appear to measure slightly different constructs; the cognitive ability to understand instructions and motivation to attend appointments. Further work should focus on increasing the precision of this scale by developing additional items that represent the underlying mechanisms. The current items in both factors fall broadly and logically in line with the theorised domains attributed to each item by Wolf and colleagues [24 Supplementary Appendix A]; the Health Self-management factor represents *knowledge* (items 2, 3, 4) and *locus of control* (item 5). The Patient-provider Engagement factor represents *self-efficacy* (items 6 and 8) and *action* (item 9).

Scale relationship to demographic factors followed a logical pattern

Table 4
Relationship between CHAI subscales and demographic, health literacy and population monitoring variables.

	N	Score M (SD)	Health Self-management		Patient-provider Engagement	
			r_s	*p*	r_s	*p*
Demographics (M/SD)						
Age	250 (M = 64.4, SD = 5.4)		.18	.004	.19	**.003**
BMI	250 (M = 28.7, SD = 6.0)		-.05	.46	-.03	.61
Current morbidities	250 (M = 1.17, SD = 1.06)		.001	.92	.04	.54
Morbidity history	250 (M = 1.87, SD = 1.40)		.05	.45	.03	.61
F&V serves/day	250 (M = 5.6, SD = 3.62)		-.02	.79	.002	.97
Physical activity (MET-mins/week)	226 (M = 2180.97, SD = 1722.67)		.05	.46	.04	.54
Functional health literacy						
Always *ask* about medication side effects ^	250	4.17 (1.34)	.39	**<.001**	.28	**<.001**
Always *read* about medication side effects ^	250	4.33 (1.32)	.29	**<.001**	.25	**<.001**
Always read food labels for content ^	250	4.04 (1.36)	.31	**<.001**	.23	**<.001**
Population health monitoring						
Breast, cervical cancer screening (F only) ^^	123	6.65 (1.77)	.10	.29	.10	.26
Colorectal cancer screening ^^^	247	3.26 (0.97)	.12	.06	.19	**.003**
Self-managed health checks						
Monitor weight; inspect skin for moles; dental checkups #	243	10.14 (1.52)	.31	**<.001**	.30	**<.001**
Doctor-managed health checks						
Health checks; skin cancer checks ^^	245	6.6 (1.38)	.26	**<.001**	.29	**<.001**

With 26 comparisons, significance was set at $p \leq .003$ [43].
Actual $n < 250$, reflecting responses treated as missing data for analyses.
r_s Spearman's rho.
^ Potential range 1–6
^^ Potential range 2–8
^^^ Potential range 1–4
# Potential range 3–12

whereby better self-reported health was associated with higher Health Self-management scores. Higher Patient-provider Engagement scores were associated with a higher level of education. Nevertheless, these socio-demographic factors may be more closely linked to health literacy; Greene and colleagues in the US found that health literacy had a stronger relationship to Medicare decision making (i.e., ability to use comparative information to make health plan choices) than did patient activation [49]. Health literacy and patient activation separately play a major role in health self-management [16] and have been found to be weakly correlated e.g., [8,50] or not at all [51] and this observation is partly borne out in our results; Patient-provider Engagement was weakly but significantly correlated with all three functional health literacy items. Future research could address a self-reported literacy scale measure to more adequately test the relationship with Health Self-management and Patient-provider Engagement.

We anticipated that higher Health Self-management scale scores would be significantly and positively associated with higher fruit and vegetable consumption, greater physical activity and non-smoking, but this was not the case. This outcome may reflect a low sensitivity of the CHAI items to these behaviours and indicate further refinement of variables impacting on these behaviours.

We found a significant relationship between uptake of colorectal cancer screening and the Patient-provider Engagement subscale. Those with higher engagement with their health provider might be more likely to discuss and act upon preventive screening recommendations. Secondary analysis to investigate possible gender influence found no difference in mean scores, despite the fact that male participation in colorectal cancer screening has been consistently lower than women [52-55]. It may be that males who have higher engagement with health providers are more likely to act upon colorectal cancer screening recommendations or that there are other factors pertaining to males' reluctance to participate in CRC screening programs. Despite the significant relationship between females and CRC screening for this subscale, there was no significant association with breast or cervical cancer screening for the Health Self-management or Patient-provider Engagement subscales.

The limitations of this study include that articulated by Wolf and colleagues [24]; validation against the PAM was not possible given its proprietary status and subsequent constraints on test use and availability. Our study was cross-sectional and limited to self-reported outcomes within the initial sample, limiting the ability to test associations with behaviour across time. The survey was conducted in an older Australian population and results may be moderated by the differing health system of the USA in which the PAM and the CHAI were developed, and also in the UK, where the PAM is in widespread use within the National Health System [9,12,56]. In the USA, notwithstanding the Affordable Care Act, a mixed model of private and public access exists. The Australian system of medicine is somewhat more socialised [57] and could be described as falling between the US system and the full and free access to health services typical in the UK National Health System—the requirements of the different systems are likely to impact the extent to which the population takes an active role in personal health management.

4.2. Innovation

Research suggests the impact of health activation on health-promoting behaviours is greater than a range of sociodemographic variables. Consequently, measuring activation is critical to the development of communication strategies designed to meet and enhance health-seeking behaviour. This research is innovative in that we have taken a freely-available, theoretically-based, unidimensional health activation measure developed in the United States and demonstrated an underlying parsimonious, two-scale structure in an Australian older population. These scales can enable approaches to optimise activation in this group. Further development can broaden their applicability to encompass other populations (e.g., differing age groups and cross-culturally in Australia and overseas) to enhance people-centred healthcare systems, potentially using innovative e-health strategies. Researchers could also address the relationship of these scales to other motivational approaches, e.g. Self Determination Theory [58,59].

4.3. Conclusion

Our results show that the CHAI developed in the USA, when validated in a general population of Australian men and women 50–74 years in the context of public health promotion, was most appropriately described by a two-factor solution with the retention of 7 items. Although Health self-management and Patient-provider Engagement showed no association with fruit and vegetable consumption, physical activity, or smoking, they were both significantly related to self- and doctor-managed health checks adherence and to functional health literacy. However, the moderate associations with health status and behavioural variables hypothesised as being associated with consumer activation suggest that activation is not measured adequately by the current two factor model. Wolf et al. [24] suggested a CHAI item bank to cover specific health self-care roles such as type 2 diabetes and engagement in lifestyle behaviours, and this approach may improve content validity. Alternatively, activation as an outcome variable is not adequately explicated or that other variables, over and above locus of control, self-efficacy, knowledge, and motivation to act, impact activation. Further research is required to expand the behavioural mediators and moderators of aspects of health activation and individual differences in participation in health-impacting behaviours.

Funding

Exploratory Factor Analysis data collection was funded by a Flinders University Establishment Grant. This work was supported by the Cancer Council South Australia's Beat Cancer Project on behalf of its donors and the State Government of South Australia through the Department of Health together with the support of the Flinders Medical Centre Foundation, its donors, and partners.

Confirmatory Factor Analysis data were collected as part of a study funded by a NHMRC project grant (APP1101837).

CRediT authorship contribution statement

Ingrid Flight: Conceptualization, Methodology, Investigation, Writing – original draft, Project administration, Funding acquisition, Formal analysis. **Nathan J. Harrison:** Data curation, Formal analysis, Writing – original draft. **Erin L. Symonds:** Investigation, Funding acquisition, Data curation, Writing – review & editing. **Graeme Young:** Writing – review & editing. **Carlene Wilson:** Writing – review & editing, Supervision.

Declaration of Competing Interest

None.

Data availability

Due to the nature of this research, participants did not agree for their data to be shared publicly, so supporting data is not openly available. The metadata for datasets that support the findings of this study are available in Flinders University's Repository of Open Access Data Sets:

https://doi.org/10.25451/flinders.17819714.v1 (Exploratory Factor Analysis and concurrent validity).

and https://doi.org/10.25451/flinders.17824715.v1 (Confirmatory Factor Analysis),

with contact details for the corresponding author if other researchers wish to discuss accessing the data.

We confirm all patient/personal identifiers have been removed or disguised so the patient/person(s) described are not identifiable and cannot be identified through the details of the research.

Acknowledgements

We thank Professor Michael S. Wolf and his team at Northwestern University, Chicago, USA for making the CHAI measure available to us ahead of its publication. We also thank Dr. Rosie Meng, Dr. David Smith and Dr. Pawel Skuza for their statistical advice and Camilla Trenerry for data management assistance. We are grateful to the many participants who took the time to provide survey responses.

References

[1] Stack E, Kier K. Key aspects and health care benefits of patient-centred medical homes part 1 of 3. Consult Pharm 2014;29:196–9. https://doi.org/10.4140/TCP.n.2014.196.
[2] NHS England. Equity and Excellence: Liberating the NHS. UK Department of Health; 2010. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/213823/dh_117794.pdf [Accessed 18 April 2023].
[3] Trevena L, Shepherd H, Bonner C, Jansen J, Cust A, Leask J, et al. Shared decision making in Australia in 2017. Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen (ZEFQ). German J Eviden Quali Health Care 2017;123–124:17–20.
[4] Australian Commission on Safety and Quality in Healthcare. Patient-centred care: Improving quality and safety through partnerships with patients and consumers, Sydney: ACSQHC; 2011.
[5] McAllister M, Dunn G, Payne K, Davies L, Todd C. Patient empowerment: the need to consider it as a measurable patient-reported outcome for chronic conditions. BMC Health Serv Res 2012;12:157. https://doi.org/10.1186/1472-6963-12-157.
[6] Barr P, Scholl I, Bravo P, Faber M, Elwyn G, McAllister M. Assessment of patient empowerment - a systematic review of measures. PloS One 2015;10:e0126553. doi:10.1186/.
[7] Pekonen A, Eloranta S, Stolt M, Virolainen P, Leino-Kilpi H. Measuring patient empowerment - a systematic review. Patient Educ Couns 2020;103:777–87. https://doi.org/10.1016/j.pec.2019.10.019.
[8] Smith SG, Curtis LM, Wardle J, von Wagner C, Wolf MS. Skill set or mind set? Associations between health literacy, patient activation and health. PloS One 2013;8:e74373. https://doi.org/10.1371/journal.pone.0074373.
[9] Hibbard J, Gilburt H. Supporting people to manage their health: an introduction to patient navigation. The King's Fund; 2014. https://www.kingsfund.org.uk/sites/default/files/field/field_publication_file/supporting-people-manage-health-patient-activation-may14.pdf [Accessed 17 April 2023].
[10] Greene J, Hibbard J. Why does patient activation matter? An examination of the relationships between patient activation and health-related outcomes. J Gen Intern Med 2012;27:520–6. https://doi.org/10.1007/s11606-011-1931-2.
[11] Hibbard JH, Mahoney ER, Stock R, Tusler M. Do increases in patient activation result in improved self-management behaviors? Health Serv Res 2007;42:1443–63. https://doi.org/10.1111/j.1475-6773.2006.00669.x.
[12] NHS England. Patient activation: at the heart of self-care support. UK Department of Health; 2016. https://www.england.nhs.uk/wp-content/uploads/2016/04/pa-prog-faqs.pdf [Accessed 18 April 2023].
[13] Janamian T, Greco M, Cosgriff D, Baker L, Dawda P. Activating people to partner in health and self-care: use of the patient activation measure. Med J Aust 2022;216:S5–8. https://doi.org/10.5694/mja2.51535.
[14] Consumers Health Forum of Australia. Patient activation in Australians with chronic illness - survey results. https://chf.org.au/sites/default/files/20191030_rpt_patient_activation_survey_report_final.pdf; 2019 [Accessed 17 April 2023].
[15] Hibbard JH, Stockard J, Mahoney ER, Tusler M. Development of the patient activation measure (PAM): conceptualizing and measuring activation in patients and consumers. Health Serv Res 2004;39:1005–26. https://doi.org/10.1111/j.1475-6773.2004.00269.x.
[16] Hosseinzadeh H, Downie S, Shnaigat M. Effectiveness of health literacy- and patient activation-targeted interventions on chronic disease self-management outcomes in outpatient settings: a systematic review. Aust J Prim Health 2022;28:83–96. https://doi.org/10.1071/PY21176.
[17] Sacks RM, Greene J, Hibbard J, Overton V, Parrotta CD. Does patient activation predict the course of type 2 diabetes? A longitudinal study. Patient Educ Couns 2017;100:1268–75. https://doi.org/10.1016/j.pec.2017.01.014.
[18] Mazanec S, Sattar A, CP D, Daly B. Activation for health management in colorectal cancer survivors and their family caregivers. West J Nurs Res 2016;38:325–44. https://doi.org/10.1177/0193945915604055.
[19] Donald M, Ware RS, Ozolins IZ, Begum N, Crowther R, Bain C. The role of patient activation in frequent attendance at primary care: a population-based study of people with chronic disease. Patient Educ Couns 2011;83:217–21. https://doi.org/10.1016/j.pec.2010.05.031.
[20] Alvarez C, Greene J, Hibbard J, Overton V. The role of primary care providers in patient activation and engagement in self-management: a cross-sectional analysis. BMC Health Serv Res 2016;16. https://doi.org/10.1186/s12913-016-1328-3.
[21] Fowles JB, Terry P, Xi M, Hibbard J, Bloom CT, Harvey L. Measuring self-management of patients' and employees' health: further validation of the patient activation measure (PAM) based on its relation to employee characteristics. Patient Educ Couns 2009;77:116–22. https://doi.org/10.1016/j.pec.2009.02.018.
[22] Harvey L, Fowles JB, Xi M, Terry P. When activation changes, what else changes? The relationship between change in patient activation measure (PAM) and

employees' health status and health behaviors. Patient Educ Couns 2012;88:338–43. https://doi.org/10.1016/j.pec.2012.02.005.
[23] Terry PE, Fowles JB, Xi M, Harvey L. The ACTIVATE study: results from a group-randomized controlled trial comparing a traditional worksite health promotion program with an activated consumer program. Am J Health Promot 2011;26:e64–73. https://doi.org/10.4278/ajhp.091029-QUAN-348.
[24] Wolf MS, Smith SG, Pandit AU, Condon DM, Curtis LM, Griffith J, et al. Development and validation of the consumer health activation index. Med Decis Making 2018;38:334–43. https://doi.org/10.1177/0272989X17753392.
[25] Morawski K, Ghazinouri R, Krumme A, McDonough J, Durfee E, Oley L, et al. Rationale and design of the medication adherence improvement support app for engagement-blood pressure (MedISAFE-BP) trial. Am Heart J 2017;186:40–7. https://doi.org/10.1016/j.ahj.2016.11.007.
[26] Bailey SC, Wismer GA, Parker RM, Walton SM, Wood AJJ, Wallia A, et al. Development and rationale for a multifactorial, randomized controlled trial to test strategies to promote adherence to complex drug regimens among older adults. Contemp Clin Trials 2017;62:21–6. https://doi.org/10.1016/j.cct.2017.08.013.
[27] Mehawej J, Tran K-VT, Filippaios A, Paul T, Abu H, Ding E, et al. Self-reported efficacy in patient-physician interaction in relation to anxiety, patient activation, and health-related quality of life among stroke survivors. Ann Med 2023;55:526–32. https://doi.org/10.1080/07853890.2022.2159516.
[28] Bailey SC, Serper M, Opsasnick L, Persell S, O'Conor R, Curtis LM, et al. Changes in COVID-19 knowledge, beliefs, behaviors, and preparedness among high-risk adults from the onset to the acceleration phase of the US outbreak. J Gen Intern Med 2020;35:3285–92. https://doi.org/10.1007/s11606-020-05980-2.
[29] Arvanitis M, Opsasnick L, O'Conor R, Curtis LM, Vuyyuru C, Benavente J, et al. Factors associated with COVID-19 vaccine trust and hesitancy among adults with chronic conditions. Prev Med Rep 2021;101484:1–6. https://doi.org/10.1016/j.pmedr.2021.101484.
[30] Isautier J, Copp T, Ayre J, Cvejic E, Meyeroweiz-Katz G, Batcup C, et al. People's experiences and satisfaction with telehealth during the COVID-19 pandemic in Australia: cross-sectional survey study. J Med Internet Res 2020;22:e24531. https://doi.org/10.2196/24531.
[31] Zulman D, Maciejewski M, Grubber J, Weidenbacher H, Blalock D, Zullig L, et al. Patient-reported social and behavioral determinants of health and estimated risk of hospitalization in high-risk veterans affairs patients. JAMA Netw Open 2020;3:e2021457. https://doi.org/10.1001/jamanetworkopen.2020.21457.
[32] Martin P, Kim J, Jasper A, Baek Y, Russell D. The development of a brief measure of health personality. J Health Psychol 2021;26:2768–80. https://doi.org/10.1177/1359105320931179.
[33] McCaffery K, Dodd R, Cvejic E, Ayre J, Batcup C, Isautier J, et al. Health literacy and disparities in COVID-19 - related knowledge, attitudes, beliefs and behaviours in Australia. Public Health Res Pract 2020;30. https://doi.org/10.17061/phrp30342012. e30342012.
[34] Glanz K, Rimer B, Viswanath K. Health behavior: Theory, research, and practice. 5th ed. San Francisco: Jossey-Bass; 2015.
[35] Campbell MJ. Study design and choosing a statistical test. In: Campbell MJ, editor. Statistics at square one. Oxford, UK: John Wiley & Sons Ltd; 2021. p. 215–26.
[36] Cohen P, Cohen J, Aiken L, West S. The problem of units and the circumstance for POMP. Multivar Behav Res 1999;34:315–46. https://doi.org/10.1207/S15327906MBR3403_2.
[37] Briggs S, Cheek J. The role of factor analysis in the development and evaluation of personality scales. J Pers 1986;54:106–48. https://doi.org/10.1111/j.1467-6494.1986.tb00391.x.
[38] Symonds EL, Hughes D, Flight I, Woodman R, Chen G, Ratcliffe J, et al. A randomized controlled trial testing provision of fecal and blood test options on participation for colorectal cancer screening. Cancer Prev Res (Phila) 2019;12:631–40. https://doi.org/10.1158/1940-6207.CAPR-19-0089.
[39] Young GP, Chen G, Wilson CJ, McGrane E, Hughes-Barton D, Flight I, et al. "rescue" of nonparticipants in colorectal cancer screening: a randomized controlled trial of three non-invasive test options. Cancer Prev Res (Phila) 2021;14:803–10. https://doi.org/10.1158/1940-6207.CAPR-21-0080.
[40] Andrus R, Toth M. Health literacy: a review. Pharmacotherapy 2012;22:282–302. https://doi.org/10.1592/phco.22.5.282.33191.
[41] Craig C, Marshall A, Sjostrom M, Bauman A, Booth M, Ainsworth B, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35:1381–95. https://doi.org/10.1249/01.MSS.0000078924.61453.FB.
[42] Ainsworth B, Haskell W, Herrmann S, Meckes N, Bassett DJ, Tudor-Locke C, et al. 2011 compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 2011;43:1575–81. https://doi.org/10.1249/MSS.0b013e31821ece12.
[43] Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Series B Stat Methodology 1995;57:289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x.
[44] Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, et al. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol 2007;60:34–42. https://doi.org/10.1016/j.jclinepi.2006.03.012.
[45] Costello A, Osborne J. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. Pract Assess Res Eval 2005;10. https://doi.org/10.7275/jyj1-4868. Article 7.
[46] Tabachnick B, Fidell L. Using multivariate statistics. 5th ed. Boston, MA: Allyn & Bacon; 2007.
[47] Hair J, Black W, Babin B, Anderson R, Black W. Multivariate data analysis. 7th ed. Pearson: Harlow, Essex; 2014.
[48] Park M, Jung H. Measuring health activation among foreign students in South Korea: initial evaluation of the feasibility, dimensionality, and reliability of the Consumer Health Activation Index (CHAI). Int J Adv Cult Technol 2020;8:192–7. https://doi.org/10.17703/IJACT.2020.8.3.192.
[49] Greene J, Hibbard JH, Tusler M. How much do health literacy and patient activation contribute to older adults' ability to manage their health? AARP Public Policy Institute; 2005. http://resource.nlm.nih.gov/101259851 [Accessed 18 April 2023].
[50] Hibbard J. Patient activation and health literacy: What's the difference? How do each contribute to health outcomes. Stud Health Technol Inform 2017;240:251–62.
[51] Couture EM, Chouinard M-C, Fortin M, Hudon C. The relationship between health literacy and patient activation among frequent users of healthcare services: a cross-sectional study. BMC Fam Pract 2018;19:38. https://doi.org/10.1186/s12875-018-0724-7.
[52] Australian Institute of Health and Welfare. National Bowel Cancer Screening Program: monitoring report 2020. AIHW; 2020. https://www.aihw.gov.au/reports/cancer-screening/national-bowel-cancer-screening-monitoring-2020/summary [Accessed 18 April 2023].
[53] Australian Institute of Health and Welfare. National Bowel Cancer Screening Program: monitoring report 2021. AIHW; 2021. https://www.aihw.gov.au/reports/cancer-screening/nbcsp-monitoring-report-2021/summary [Accessed 18 April 2023].
[54] Australian Institute of Health and Welfare. National Bowel Cancer Screening Program: monitoring report 2022. AIHW; 2022. https://www.aihw.gov.au/reports/cancer-screening/nbcsp-monitoring-2022/summary [Accessed 18 April 2023].
[55] Zajac I, Duncan A, Flight I, Wittert G, Cole S, Young GP, et al. Theory-based modifications of an advanced notification letter improves screening for bowel cancer in men: a randomised controlled trial. Soc Sci Med 2016;165:1–9. https://doi.org/10.1016/j.socscimed.2016.06.036.
[56] Ellins J, Coulter A. How engaged are people in their healthcare? Findings of a national telephone patient survey. Picker Institute; 2005. https://www.health.org.uk/publications/how-engaged-are-people-in-their-healthcare [Accessed 17 April 2023].
[57] Willis E, Reynolds L, Rudge T. Understanding the Australian health care system. 3rd edition ed. Sydney: Elsevier; 2020.
[58] Deci E, Ryan R. The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. Psychol Inq 2000;11:227–68. https://doi.org/10.1207/S15327965PLI1104_01.
[59] Ryan R, Patrick H, Deci E, Williams J. Facilitating health behaviour change and its maintenance: interventions based on self-determination theory. European Health Psychol 2008;10:2–5.