Accepted Manuscript

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PII: S0091-7435(19)30048-9
DOI: https://doi.org/10.1016/j.ypmed.2019.02.009
Reference: YPMED 5618

To appear in: *Preventive Medicine*

Received date: 7 September 2018
Revised date: 21 December 2018
Accepted date: 8 February 2019

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Word count:

Abstract = 247, main text = 3,475.

Print requirements:

Black-and-white.

Abstract

Evidence suggests that health-related behaviours (HRBs) cluster in mid-adulthood and are associated with social circumstances (i.e. economic circumstances, cultural norms, employment relations) at the same age. However, little is known about the level of stability in HRB cluster membership during mid-adulthood and how social circumstances in early mid-adulthood may influence movement between HRB clusters during mid-life.

Data were taken from a British cohort born in 1958 (N=12,784), to examine the stability of membership of three HRB clusters: 'Risky', 'Moderate Smokers' and 'Mainstream' (the latter pattern consisting of more beneficial HRBs such as not smoking, moderate alcohol consumption, being physically active), between ages 33 and 42. The relationship between social circumstances at age 33 and movement between HRB clusters during mid-adulthood was also examined.

HRB cluster membership was relatively stable during mid-adulthood, over 60% of the participants remained in the same cluster at both ages. However, there was considerable probability of movement from the 'Risky' and 'Moderate Smokers' clusters at age 33 to the 'Mainstream' cluster at age 42. Members of the 'Risky' cluster had a lower probability of transitioning to the 'Mainstream' cluster (men=17%, women=9%, $p<0.001$) in comparison to the 'Moderate Smokers' cluster (men=26%, women=27%, $p<0.001$). Social circumstances at age 33 did not influence change in HRB cluster membership between ages 33 and 42 ($p>0.05$).

Movement from the 'Risky' and 'Moderate Smokers' cluster to the 'Mainstream' cluster during mid-adulthood highlights improvements for most HRBs. Person-centred interventions are required to prevent persistent negative HRBs amongst 'Risky' cluster members.

Highlights

Health-related behaviour (HRB) cluster membership is relatively stable in mid-life.

Movement that does occur tends to be towards the 'Mainstream' non-smoking cluster.

Social circumstances in early mid-life are unlikely to influence this movement.

'Risky' cluster members are less likely to move than 'Moderate Smoker' cluster members.

Person-centred interventions are required to encourage 'Risky' cluster movement.

Introduction

Research evidence shows that health related behaviours (HRBs) are relatively stable during mid-life (1,2) and that more disadvantaged social circumstances are associated with negative HRBs (e.g. smoking, heavy alcohol consumption, a diet high in sugar and fat and low in fruit and vegetables, and physical inactivity) (3,4).

However, amongst those whose HRB patterns change during mid-adulthood, this tends to be in a positive direction. For example, increased fruit and vegetable intake (1,2,5–7), reduced numbers of smoked cigarettes or cessation from smoking (2,5,6,8), and reductions in alcohol consumption (1,2,6,9–11). At the same time, it has been reported that levels of physical activity may decline during mid-adulthood (2,5,12–14). Whilst insightful, these studies focus on individual HRBs. To date, little is known about the stability of HRB clustering during mid-adulthood.

Studying change in HRB cluster membership during mid-life is an important area of enquiry. Persistent negative lifestyles consisting of multiple negative HRBs during mid-life have been found to be associated with earlier mortality (15), whilst positive change in HRBs during mid-adulthood appears to reduce the risk of premature death (15), improve physical functioning (16) and protect against disability in later life (5). Moreover, understanding how HRB cluster membership changes over time can inform the development of more effective interventions that target multiple negative HRBs (17,18).

Our previous work found three clusters of four HRBs (smoking, alcohol, diet and physical activity), subsequently labelled ‘Mainstream’, ‘Moderate smokers’ and ‘Risky’, in a British cohort of middle-aged adults (19). We also identified that social circumstances (i.e. economic circumstances, cultural norms, employment relations) in early mid-life were associated with membership to these three clusters at the same age (20). Our findings add support to previous evidence of HRB clustering which is socially patterned (21,22). Furthermore, previous studies suggest that social circumstances may predict change in multiple HRBs simultaneously (23,24). It is therefore possible that social circumstances in early mid-adulthood may be associated with a change in a HRB cluster membership during mid-life.

This work focuses on understanding the extent to which HRB clustering is stable between ages 33 and 42 in a British cohort born in 1958 and the influence of social circumstances at age 33 on HRB cluster membership stability thereafter.

Methods

Sample

Data were taken from the National Child Development Study (NCDS), targeting 17,514 individuals from across England, Scotland and Wales who were born in the same week in 1958, when participants were age 33 (data collected in 1991) (25) and age 42 (data collected in 2000) (26). The analytical sample included participants who had information on at least one of four HRBs (smoking, alcohol, diet, physical activity) at either age 33 or 42 (excluding 50 cases) and information on at least one socio-economic position (SEP) indicator at age 33 (excluding 163 cases). This yielded a final analytical sample of 12,784 (Men=6,396; Women=6,388).

The data were collected in line with ethical approval procedures at both time points and anonymised prior to the deposit at the UK data archive (27), which exempted our work from requiring ethical approval.

Measures

HRB cluster indicators age 33

This study focused on four HRBs: smoking, alcohol, diet and physical activity. Smoking was identified through the self-report of the numbers of cigarettes smoked per day. Based upon the UK government guidelines (28), active at the time of the data collection for alcohol use, three categories of alcohol use status (‘never/infrequent’, ‘within limits’, ‘above limits’) were derived using the self-report of alcohol consumption in units during the previous week. Participants’ self-report on their frequency of leisure-time physical activity was used to derive four categories of physical activity (‘≤ 3 times a month’, ‘once a week’, ‘2–3 days a week’, ‘4–7 days a week’). Diet was indicated by the total sum of confirmatory factor scores obtained from data on the frequency of consuming three food groups: (1) fruit and vegetables; (2) chips and fried food; and (3) sweets, chocolate, biscuits and cakes. Further details on the derivation of these variables are described in Error! Reference source not found..

HRB cluster indicators age 42

Similar to the age 33 indicators, four HRBs at age 42 were included in the model. Although the wording for some questions was slightly different between data collection at age 33 and age 42, the harmonisation process was straightforward and enabled us to capture the consistent characteristics of each HRB (see Error! Reference source not found. for the harmonisation process).

Social circumstances at age 33

A multi-faceted measure of socio-economic position (SEP) was used to capture social circumstances at age 33. We applied the conceptual model from our previous work (20), that HRBs are influenced through material, cultural and occupational pathways, indicated by economic circumstances, cultural norms and employment relations.

Economic aspects of SEP at age 33 were captured through receiving benefits associated with disadvantage, living in social housing, owning a car, overcrowding and household equivalised income (29). Cultural norms were captured by cohort participants' highest qualification achieved by age 33 and their Cambridge scale (30). Employment relations were indicated by the National Statistics Socio-economic Classification (NS-SEC) (31), and employee's benefits such as pension, medical scheme, and company shares. Descriptive statistics for the SEP indicator variables at age 33 are presented in Error! Reference source not found..

Statistical analysis

Confirmatory Factor Analysis (CFA)

All indicators of SEP were captured as a whole through CFA, using Mplus Version 7 (32). Missing data for the SEP indicator variables was handled using the weighted least squares with robust standard errors estimator function (33), assuming that missing values can be explained by pairs of variables in the model.

In the CFA model, most indicators contributed at least moderately to their respective latent SEP construct (>0.32) (34). Indicators with weaker loadings (<0.32) were retained if they were significant for at least one gender group (p<0.05) (34). Adequate model fit was determined by a Comparative Fit Index (CFI) of >0.9 (35) and the Root Mean Square Error of Approximation (RMSEA) of <0.05 (36). See Error! Reference source not found. for the estimates from the CFA model.

Latent Transition Analysis (LTA)

LTA is a longitudinal extension of Latent Profile Analysis (LPA) (37), which was applied to examine HRB cluster membership transitions between ages 33 and 42, using Mplus Version 7 (32). LTA models were run separately for men and women.

The LTA model consists of three types of parameters (37). The first is the probability of being in a particular class (in this case, HRB cluster) at each time point. The second is the probability of a participant's response to the observed variables given their class (or HRB cluster) membership at each time point. These second parameters assesses the degree of error in each observed indicator in capturing the latent variable. The third is the probability of transitioning to a class (or HRB cluster) at the second time point (i.e. age 42), given class (or HRB cluster) membership at the first time point (i.e. age 33).

Scholars recommend imposing measurement invariance in LTA models when it can be reasonably assumed (37). Based on our prior knowledge of 3 clusters existing at age 33, labelled 'Risky' (consisting of the riskiest HRBs including heavy smoking, excessive alcohol consumption and physical inactivity), 'Moderate Smokers' (whose members smoked fewer cigarettes, drank fewer alcohol units and had higher levels of physical activity than the 'Risky' cluster) and 'Mainstream' (representing the most prevalent HRB patterns) (19), we presupposed that the same three clusters would be present at age 42 (i.e. measurement invariance).

Imposing measurement invariance in LTA models can ensure reasonable identification of the LTA model and interpretation of class membership transitions (37). However, sensitivity analysis was undertaken to validate our assumption of measurement invariance over time. This analysis found that at age 33 and 42 the nature of the 'Moderate Smokers' and 'Mainstream' clusters were very similar. However, the nature of the 'Risky' cluster differed slightly at each age and therefore a partial measurement invariance model was selected. This model takes into account differences in the nature of this smallest cluster over time for some HRBs i.e. fried food amongst men and leisure-time physical activity amongst women (see Error! Reference source not found.).

We investigated how HRBs differed for those that moved HRB clusters between ages 33 and 42 compared to those who did not move, using t-tests and chi-squared tests in Stata version 14 (38).

To test for an association between mid-adulthood SEP and transitions in HRB cluster membership, LTA models incorporating mid-adulthood SEP as a covariate were run, using Mplus Version 7 (32). These models are a type of Structural Equation Model (SEM) (39). The analysis was operationalised by comparing two models. The first model (hereafter named 'model 1') is described in Figure 1. The second model (hereafter name 'model 2') is described in Figure 2.

If moderation were present (i.e. the effect of SEP at age 33 predicts transitions in HRB cluster membership over time) we would expect to see the effect of SEP at age 33 on HRB cluster membership at age 42 stratified by HRB cluster membership at age 33 (see model 1, Figure 1) to be different to the effect of SEP at age 33 on HRB cluster membership at age 42 adjusting for HRB cluster membership at age 33 (see model 2, Figure 2).

Figure 1: Model 1 testing the effect of Socio-Economic Position (SEP) at age 33 on transitions in HRB cluster membership between ages 33 and 42.

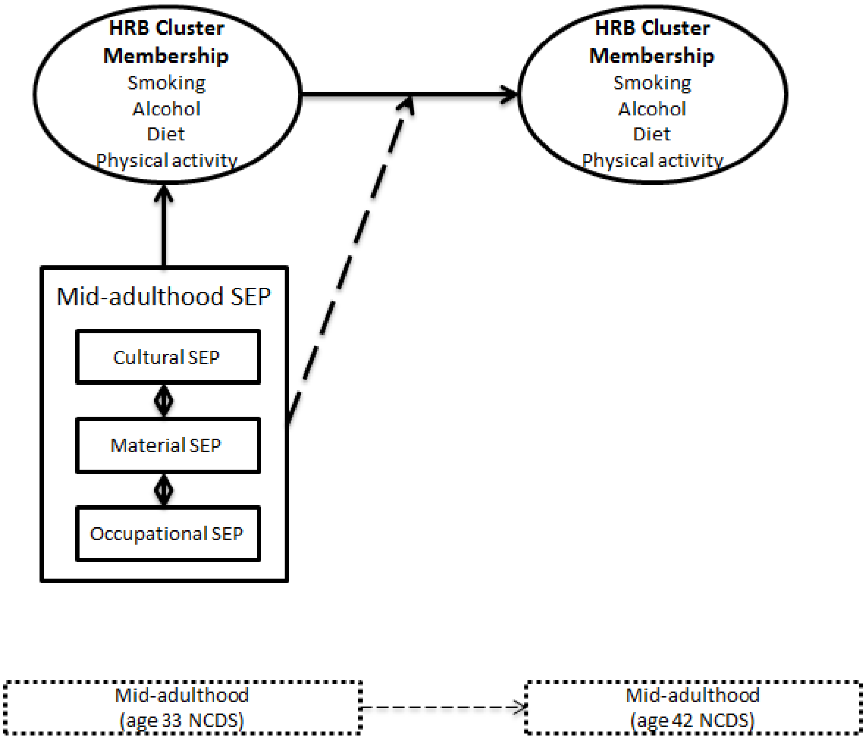
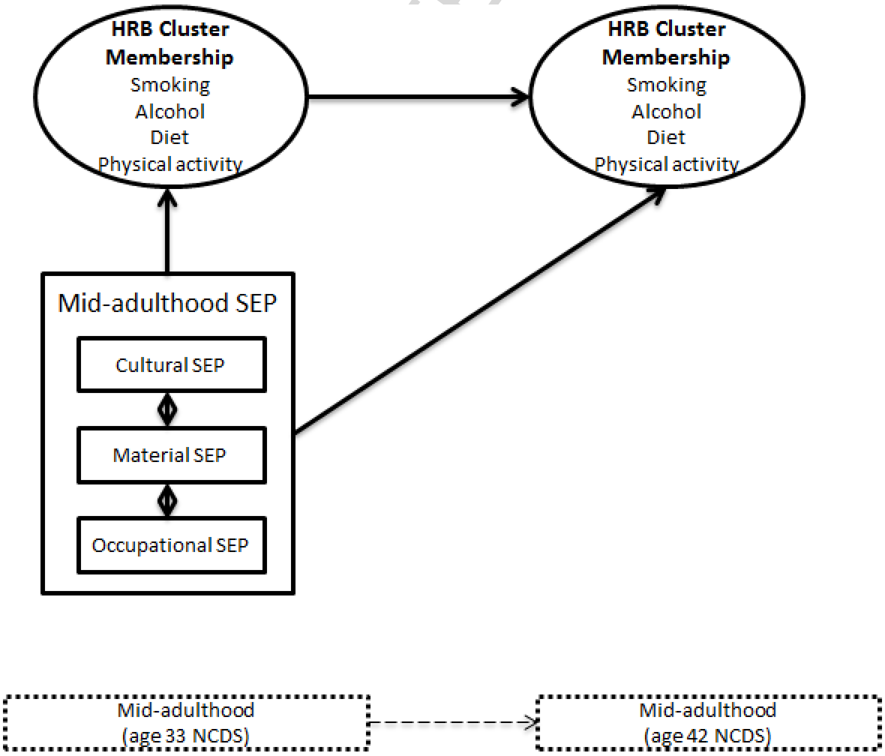


Figure 2: Model 2 testing the effect of Socio-Economic Position (SEP) at age 33 on HRB cluster membership at age 42 adjusting for HRB cluster membership at age 33.



The Full Information Maximum Likelihood (FIML) function in Mplus Version 7 (32) was employed to manage missing data (10.6%). This approach utilises all available information in the data under a missing at random (MAR) assumption (40).

Results

Descriptive analysis

Table 1 shows the descriptive statistics for the HRB variables at ages 33 and 42. For both men and women, smoking and diet behaviours tended to be more health promoting (e.g. not smoking, frequent consumption of fruit and vegetables) at age 42 compared to age 33 ($p<0.001$). In contrast, levels of physical activity and alcohol consumption tended to be more health damaging (e.g. infrequent physical activity and drinking above recommended limits) at age 42 in comparison to age 33 ($p<0.001$).

The distribution of the missing data is similar across the HRB variables suggesting that missing data are not related to item non-response. Therefore, item non-response is unlikely to invalidate the MAR assumption (i.e. that data in one variable can be explained by other variables in the model).

Table 1: Descriptive statistics for HRB indicator variables at age 33 and age 42. Data: The National Child Development Study (NCDS) at age 33 (1991) and 42 (2000).

HRB cluster indicator variables†	Total age 33 N=12,784 (100%)	Men age 33 N=6,396 (100%)	Women age 33 N=6,388 (100%)	Total age 42 N=12,784 (100%)	Men age 42 N=6,396 (100%)	Women age 42 N=6,388 (100%)
	Mean (sd)	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**
Number of cigarettes smoked per day [a]	17.35 (8.9)	18.51 (9.52)	16.22 (8.20)	17.45 (8.52)	18.75 (9.02)	16.21 (7.82)
Frequency of fruit and vegetable consumption [b]	4.97 (2.1)	4.40 (2.01)	5.51 (2.00)	5.48 (2.24)	4.67 (2.14)	5.97 (2.22)
Frequency of fried food consumption [b]	3.14 (1.6)	3.58 (1.57)	2.73 (1.46)	2.54 (1.08)	2.79 (1.10)	2.30 (0.96)
Frequency of sweet food consumption [b]	4.59 (2.3)	4.53 (2.28)	4.65 (2.34)	4.37 (2.29)	4.40 (2.27)	4.35 (2.30)
Proportion smoking cigarettes daily	11,330 (100%)	5,560 (100%)	5,770 (100%)	10,717 (100%)	5,266 (100%)	5,451 (100%)
0	7,761 (68.5%)	3,797 (68.3%)	3,964 (68.7%)	7,830 (73.1%)	3,855 (73.2%)	3,975 (72.9%)
1–10	1,031 (9.1%)	458 (8.2%)	573 (9.9%)	790 (7.4%)	333 (6.3%)	457 (8.4%)
11–20	1,896 (16.7%)	912 (16.4%)	984 (17.1%)	1,582 (14.8%)	740 (14.1%)	842 (15.5%)
21+	642 (5.7%)	393 (7.1%)	249 (4.3%)	515 (4.8%)	338 (6.4%)	177 (3.3%)
Frequency of leisure-time physical activity	11,311 (100%)	5,561 (100%)	5,750 (100%)	11,208 (100%)	5,527 (100%)	5,681 (100%)
≤3 times a month	3,548 (31.4%)	1,773 (31.9%)	1,775 (30.9%)	3,877 (34.6%)	1,895 (34.3%)	1,982 (34.9%)
Once a week	2,480 (21.9%)	1,166 (21.0%)	1,314 (22.9%)	2,022 (18.0%)	1,080 (19.5%)	942 (16.6%)
2–3 days a week	2,402 (21.2%)	1,292 (23.2%)	1,110 (19.3%)	2,377 (21.2%)	1,193 (21.6%)	1,184 (20.8%)
4–7 days a week	2,881 (25.5%)	1,330 (23.9%)	1,551 (27.0%)	2,932 (26.2%)	1,359 (24.6%)	1,573 (27.7%)
Alcohol units consumed in the previous week [c]	11,367 (100%)	5,583 (100%)	5,784 (100%)	11,194 (100%)	5,518 (100%)	5,676 (100%)
No units	2,424 (21.3%)	754 (13.5%)	1,670 (28.9%)	2,065 (18.5%)	712 (12.9%)	1,353 (23.8%)
Within limits (≤14 units women, ≤21 units men)	6,920 (60.9%)	3,280 (58.8%)	3,640 (62.9%)	6,062 (54.2%)	2,746 (49.8%)	3,316 (58.4%)
Above limits (≥15 units women, ≥22 units men)	2,023 (17.8%)	1,549 (27.7%)	474 (8.2%)	3,067 (27.4%)	2,060 (37.3%)	1,007 (17.7%)
Missing data	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Smoking						
Item missing	104 (0.8%)	57 (0.9%)	47 (0.7%)	523 (4.1%)	280 (4.4%)	177 (2.8%)
No data at age 33	1,350 (10.6%)	779 (12.2%)	571 (8.9%)	N/A	N/A	N/A
No data at age 42	N/A	N/A	N/A	1,544 (12.1%)	850 (13.3%)	694 (10.9%)
Diet						
Fruit and vegetable consumption item missing	68 (0.5%)	36 (0.6%)	32 (0.5%)	32 (0.3%)	19 (0.3%)	13 (0.2%)
Fried food consumption item missing	79 (0.6%)	40 (0.6%)	39 (0.6%)	41 (0.3%)	29 (0.5%)	12 (0.2%)
Sweet food consumption item missing	80 (0.6%)	38 (0.6%)	42 (0.7%)	31 (0.2%)	19 (0.3%)	12 (0.2%)
No data at age 33	1,350 (10.6%)	779 (12.2%)	571 (9.0%)	N/A	N/A	N/A
No data at age 42	N/A	N/A	N/A	1,544 (12.08%)	850 (13.3%)	694 (10.9%)
Frequency of leisure-time physical activity						
Item missing	123 (1.0%)	56 (0.9%)	67 (1.1%)	32 (0.3%)	19 (0.3%)	13 (0.2%)
No data at age 33	1,350 (10.6%)	779 (12.2%)	571 (8.9%)	N/A	N/A	N/A
No data at age 42	N/A	N/A	N/A	1,544 (12.08%)	850 (13.3%)	694 (10.9%)
Alcohol units consumed in the previous week						
Item missing	67 (0.5%)	34 (0.5%)	33 (0.5%)	46 (0.4%)	28 (0.4%)	18 (0.3%)
No data at age 33	1,350 (10.6%)	779 (12.2%)	571 (8.9%)	N/A	N/A	N/A
No data at age 42	N/A	N/A	N/A	1,544 (12.1%)	850 (13.3%)	694 (10.9%)

† Proportions excluding missing data. N/A = not applicable.

a. Range 1–80 age 33. Range 1–70 age 42.

b. A Higher score indicates a higher consumption frequency. Range 0–10. Diet score equivalent (rounded to zero decimal places): 'never' [0] 'occasionally /less than 1 day a week' [1–2] '1–2 days a week' [3–4] '3–6 days a week' [5–6] once a day' [7–8] 'more than once a day' [9–10].

c. 'No units' category includes never drinkers and non-frequent drinkers who report 0 units in the previous week. Frequent drinkers who report 0 units in the previous week have been placed in category 'within limits'.

Transitions in HRB cluster membership during mid-life

The probabilities for transitions in HRB cluster membership between ages 33 and 42, shown in Table 2, indicate that HRBs are relatively stable during mid-adulthood. For men and women, there was a high probability (lowest: 67% for men, 70% for women, p<0.001) of remaining in the same cluster at the two time points.

At the same time, there was significant movement to a different HRB cluster at age 42. For most participants who did move, this tended to be in a positive direction, with HRB cluster membership at age 42 consisting of more positive HRBs than the one left behind.

For example, characteristics of the 'Mainstream' cluster at age 42 were non-smoking, more frequent consumption of fruit and vegetables, less frequent consumption of fried food and more frequent leisure-time physical activity in comparison to the 'Risky' and 'Moderate Smokers' clusters (p<0.001). There was more than a 25% probability (men=27%, women=26%, p<0.001) of transitioning from the 'Moderate Smokers' to the 'Mainstream' cluster between ages 33 and 42 and more than a 9% probability (men=17%, women=9%, p<0.001) of transitioning from the 'Risky' to the 'Mainstream' cluster.

Table 2: The 3 cluster LTA model transition probabilities from age 33 to age 42. Data: The National Child Development Study (NCDS) at age 33 (1991) and 42 (2000).

HRB cluster membership	'Risky' age 42		'Moderate Smokers' age 42		'Mainstream' age 42	
	Men	Women	Men	Women	Men	Women
'Risky' age 33	**0.67 (0.08)**	**0.70 (0.04)**	0.16 (0.08)	0.21 (0.04)	0.17 (0.02)	0.09 (0.02)
'Moderate Smokers' age 33	0[a]	0[a]	**0.73 (0.16)**	**0.74 (0.03)**	0.27 (0.03)	0.26 (0.02)
'Mainstream' age 33	0[a]	0.002 (<0.01)	0.04 (<0.01)	0.04 (<0.01)	**0.96 (<0.01)**	**0.96 (<0.01)**

Note: Transitions probabilities in bold correspond to staying in the same HRB cluster. Standard errors are in brackets. Measurement invariance assumed over time (i.e. item means and response probabilities restricted to be equal across time). Transition probabilities sum to 1.0 (with rounding error) across rows. Superscript a = transitions not estimated in model but instead fixed at 0 (to prevent a negative probability being estimated in Mplus Version 7).

Differences in HRBs between those who moved and those who did not move HRB clusters

Error! Reference source not found. shows how the single behaviours at the two time points differ for participants who moved to a different HRB cluster between ages 33 and 42 in comparison to those who remained in the same HRB cluster over time.

This analysis suggests that differences at age 33 in relation to particular HRBs, may to some extent, predict movement from one cluster to another at age 42. For example, cigarettes smoked per day at age 33 was significantly lower amongst those who moved from the 'Moderate Smokers' to the 'Mainstream' cluster compared to those who remained in the 'Moderate Smokers' cluster (men=14.6 vs 16.5 ; women 12.1 vs 14.0, p≤0.05). Moreover, there was a difference between the two groups in the proportion consuming alcohol consumption above recommended limits (men=29.2% vs 31.6%, women=8.1% vs 9.9%, p≤0.05). This suggests that smoking and alcohol consumption differentiate individuals at age 33 in the 'Moderate Smokers' cluster whose HRB cluster membership changes in a positive direction from those whose HRBs remain the same (see Error! Reference source not found.).

The influence of social circumstances at age 33 on transitions in HRB cluster membership

Comparisons of the coefficients from models 1 and 2 (see Table 3), exploring whether SEP at age 33 had a moderating effect on transitions in HRB cluster membership, suggested no significant difference for the effect of SEP at age 33 on HRB cluster membership at age 42. For example, comparing 'Moderate Smokers' and 'Mainstream' cluster membership (see 'Moderate Smokers' age 42 column), shows confidence intervals that overlap (men model 1 'Moderate Smokers' coefficient=0.40 (0.16, 0.63), men model 1 'Mainstream' coefficient=0.52 (0.31, 0.72), men model 2 coefficient=0.43 (95% CI=0.27, 0.58); women model 1 'Moderate Smokers' coefficient=0.47 (0.25, 0.69), women model 1 'Mainstream' coefficient=0.43 (0.19, 0.67), women model 2 coefficient=0.46 (95% CI=0.31, 0.62)). Estimates from models using FIML were very similar to those using complete cases (results not shown).

These results imply that SEP at age 33 does not influence transitions in HRB cluster membership between age 33 and 42.

Table 3: Regression coefficients for the effect of SEP at age 33 on HRB cluster membership at age 42 from models 1 and 2. Data: The National Child Development Study (NCDS) at age 33 (1991) and 42 (2000).

	'Risky' age 42	**'Moderate Smokers' age 42**	**'Mainstream' age 42**
Men	**Logit coefficient (95% CI)**	**Logit coefficient (95% CI)**	**Logit coefficient (95% CI)**
Model 1 ('Risky' age 33)	0.38 (-0.14, 0.91)	-0.48 (-1.46, 0.49)	Reference
Model 1 ('Moderate Smokers' age 33)	2.63[a]	0.40 (0.16, 0.63)*	Reference
Model 1 ('Mainstream' age 33)	3.63[a]	0.52 (0.31, 0.72)*	Reference
Model 2	0.44 (-0.07, 0.96)	0.43 (0.27, 0.58)*	Reference
Women			
Model 1 ('Risky' age 33)	0.05 (-0.61, 0.71)	0.28 (-0.52, 1.09)	Reference
Model 1 ('Moderate Smokers' age 33)	5.40[a]	0.47 (0.25, 0.69)*	Reference
Model 1 ('Mainstream' age 33)	1.76 (0.69, 2.83)	0.43 (0.19, 0.67)*	Reference
Model 2	0.20 (-0.42, 0.83)	0.46 (0.31, 0.62)*	Reference

Note: Partial measurement invariance over time for fried food consumption in the 'Risky' cluster for men. Partial measurement invariance over time for physical activity in the 'Risky' cluster for women. SEP=socio-economic position at age 33, CI=95% confidence interval, *p≤0.01.
Superscript a = 95% CI not estimated in model, p value fixed at 0.999 in Mplus Version 7.

Discussion

Using prospectively collected data from a cohort of participants born in 1958, we found HRB cluster membership was relatively stable during mid-adulthood with a large proportion of participants (>67%, p<0.001) remaining in the same cluster at ages 33 and 42. At the same time this stability was not universal, there was significant movement from the 'Risky' and 'Moderate Smokers' cluster to the 'Mainstream' cluster. Members of the 'Risky' cluster had a lower probability of transitioning to the 'Mainstream' cluster (17% men, 9% women, p<0.001) in comparison to the 'Moderate Smokers' cluster (27% men, 26% women p<0.001), whose other HRBs were more aligned with the 'Mainstream' cluster.

It should be noted that a transition in HRB cluster membership between ages 33 and 42 does not imply that an individual changed all four HRBs. Instead, movement to a cluster characterised by more positive HRBs than the one left behind suggests general improvements in HRB patterns over time.

The significant probability of transitioning from either the 'Moderate Smokers' or 'Risky' cluster to the 'Mainstream' cluster, highlights improvements for a number of HRBs, most notably smoking, and is consistent with other research suggesting that, on average, individuals tend to improve their HRBs during mid-adulthood (1,2,5–7,9). Moreover, these improvements reflect HRB trends observed in the UK population over the last 20 years, such as decreases in smoking prevalence (41), increases in fruit and vegetable consumption and reductions in fat intake (42). These results are also consistent with general increases in leisure-time physical activity observed across developed countries since the 1990s (43,44).

In this study we found a lack of evidence of an effect of social circumstances, captured through participant SEP at age 33, on transitions in HRB cluster membership between ages 33 and 42. However, our previous work found SEP (incorporating economic circumstances, social norms and employment relations) at age 33 to be associated with HRB cluster membership at the same age (20). It may therefore be the case that social circumstances shape lifestyles in early mid-adulthood yet other factors unrelated to SEP dictate their persistence thereafter. For example, increased demands placed upon individuals in mid-adulthood, such as caring responsibilities and employment (45), are likely to lead to a lack of time and energy. These are both considered barriers to effective HRB change (3), reducing motivation and capacity to alter HRB patterns (46), thus contributing to the stability of HRB patterns for a large proportion of mid-age adults.

However, there is compelling evidence that SEP influences change in multiple HRBs over time (23,24). It may therefore be possible that SEP does play some role in HRB change during mid-life but, given the relatively small number of participants who do change their

HRBs, there is a lack of statistical power to detect an effect in our study. Consequently, the existence of an effect between social circumstances in early mid-life and change in HRB cluster membership during the subsequent nine years cannot be completely ruled out.

Strengths and limitations

The application of LTA to identify the progression of HRBs over time strengthens this work. LTA is considered a powerful tool and superior to other methods such as index scoring (47) and generalised estimation equations (48). Using LTA to examine HRB clustering over time allowed for a person centred approach which considered the underlying relationship between multiple HRBs, in order to better understand the stability of lifestyles during mid-adulthood.

There was a discrepancy between the descriptive results and the LTA in relation to alcohol consumption. The descriptive statistics showed an increase in alcohol consumption between age 33 and 42, which contradicts the results from the LTA models, suggesting lower levels of alcohol consumption amongst those who moved HRB cluster compared to those who remained in the same HRB cluster over time. This discrepancy may be due to the lack of consideration in the descriptive results to the ways in which HRBs interrelate. For example, the descriptive result for alcohol consumption does not consider the relationship which has been found to exist between smoking, alcohol and dietary preferences (49–51).

However, only information at two-time points could be incorporated into the LTA models. Ideally, information pertaining to all four HRBs from more than two-time points during mid-life would have been included, allowing for a more detailed description of the transitions that may have occurred during this nine-year period (i.e. ages 33 to 42). Using repeated HRB measures at other time points may also elucidate ‘natural fluctuations’ in HRB cluster patterns across the lifecourse, highlighting optimal points for multiple HRB interventions which could maximise their efficacy (2). Moreover, the inclusion of information on all four HRBs at multiple time points could have improved statistical power (37), thus increasing the ability to detect a possible effect of SEP at age 33 on HRB cluster transitions over time.

We acknowledge that the age of the data (1991 and 2000) is a limitation of the study and that later-born cohorts of mid-age adults have been exposed from an earlier age to interventions that may have influenced their HRBs in mid-adulthood (i.e. smoke-free legislation implemented in 2007 (52)) within a different social context. However, similarities in HRB cluster patterns in this cohort when compared to other studies using more recent data (53,54) indicate that these HRB clusters remain relevant. For example, both of these studies and our results have identified a cluster (which we labelled ‘Risky’) characterised by heavy smoking and alcohol consumption and lower intakes of fruit and vegetables and levels of physical activity and a cluster (which we labelled 'Moderate Smokers') characterised by not smoking, moderate alcohol consumption, higher intakes of fruit and vegetables and higher levels of physical activity. Moreover, literature reviews of HRB clustering research, incorporating studies from different contexts, demonstrate a strong and persistent relationship between disadvantaged SEP and membership of HRB clusters characterised by multiple negative HRBs (21,22).

Information for all four HRBs was self-reported by participants and therefore could be subject to bias in regard to their measurement (55–57).

Results from the 'partial' LTA models should be interpreted with consideration to the measurement variability identified in relation to particular behaviours in the 'Risky' cluster (see Error! Reference source not found.). This implies that change between ages 33 and 42 for fried food consumption amongst men and physical activity amongst women is over and above what can be captured by the HRB cluster transitions estimated in the model. Thus changes for some HRBs extend beyond the underlying relationship between these four HRBs.

Policy implications

The finding that HRBs are relatively stable during mid-life suggests prolonged patterns of negative HRBs for participants in the 'Moderate Smokers' and 'Risky' cluster. The higher number of cigarettes smoked per day and the lower probability of movement amongst 'Risky' cluster members suggests that members of this cluster may be experiencing higher levels of nicotine addiction which is interrelated with other aspects of their lifestyle, i.e. diet, physical activity and alcohol consumption.

Moreover, our previous work found that, at age 33, members of the 'Risky' cluster were more socially disadvantaged than members of the 'Moderate Smokers' and 'Mainstream' clusters (20). Given their more disadvantaged social circumstances, participants in the 'Risky' cluster may be less able to respond to traditional downstream interventions (e.g. smoking cessation) which do not resonate with their everyday experience of HRBs or their social circumstances. In comparison, members of the 'Moderate Smokers' cluster, who are more socially advantaged, are already making positive changes to their HRBs.

Consequently, members of the 'Risky' cluster may benefit from targeted lifestyle person-centred interventions, administered via consultation with a trained clinician, which take into account how their social circumstances could undermine their ability to change negative HRBs and start to unpick how these HRBs interrelate (17). On the basis of these consultations, the clinician and the individual can together develop a realistic person-centred care plan which resonates with the individual's everyday experience of HRBs. By contrast, members of the 'Moderate Smokers' cluster may not need such specialist support; instead, they will have a greater capacity to make positive lifestyle changes and be motivated at the individual level by a brief intervention with a clinician or through their growing awareness of the impact of negative HRBs on their health (e.g. increased breathlessness when walking upstairs).

Population level policies, such as taxation and legislation, can be useful to complement these person-centred interventions in order to address the social structure that shapes lifestyles in adulthood (20) and avoid placing undue emphasis on individual responsibility and agency and perpetuating social differentials in HRBs (58).

Conclusion

Using data from a British cohort of participants born in 1958, we found HRB cluster membership was relatively stable between ages 33 and 42. However, there was a significant probability of movement to a cluster characterised by more positive HRBs than the one left behind. This movement highlights improvements for a number of HRBs, most notably smoking. At the same time, members of the cluster characterised by the most negative HRBs and more disadvantaged social circumstances at age 33 were less likely to move.

The findings provide insights into how HRBs interrelate over time and suggest person-centred interventions that take into consideration an individual's current social circumstances are required to prevent prolonged membership of clusters characterised by multiple negative HRBs.

Conflict of interest

The authors declare there is no conflict of interest.

Acknowledgements

The authors would like to acknowledge the Economic and Social Research Council for funding this research (grant ES/J500185/1; ES/J019119/1). The authors would also like to acknowledge members of the International Centre for Lifecourse Studies (ICLS), University College London and Dr Bray and colleagues from the Methodology Center, Penn State University for their suggestions and feedback on the analytical approach.

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