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Stability of clustering of lifestyle risk factors in the Dutch adult population and the association with mental health

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Background: Lifestyle factors often co-occur in clusters. This study examines whether clusters of lifestyle risk factors, such as smoking, alcohol use, physical inactivity, poor diet, sexual risk behaviour, cannabis and other drug use, change over time in a representative sample of Dutch adults. Additionally, the association between mental health and self-reported depression of lifestyle clusters was examined. **Methods:** Each year cross-sectional data of approximately 7500 individuals of 18 years and older from the annual Dutch Health Survey of 2014–2019 were used. Clusters were determined by a two-step cluster analysis. Furthermore, regression analyses determined the association between clusters of lifestyle risk factors and mental health. **Results:** Results show six clusters composed of one, multiple or no lifestyle risk factors. The clusters remained relatively stable over time: in some clusters, the number of people slightly changed between 2014 and 2019. More specifically, clusters that increased in size were the cluster with *no lifestyle risk factors* and the cluster with *multiple lifestyle risk factors*. Furthermore, results show that clusters with none to a few lifestyle risk factors were associated with better mental health and a lower prevalence of self-reported depression compared with clusters with multiple lifestyle risk factors. **Conclusions:** The clustering of lifestyle risk factors remained stable over time. People with multiple lifestyle risk factors had poorer mental health than those without risk factors. These findings may emphasize the need for intervention strategies targeting this subgroup with multiple lifestyle risk factors.

Introduction

The prevalence of chronic diseases is rapidly increasing worldwide.[1] Along with physical diseases, the prevalence of mental disorders has also been rising. National Dutch data showed that one in four adults from 18 to 64 years old has faced depression in their lives, making depression a leading cause of disability and a major contributor to the public health burden in the Netherlands.[2]

Risk factors in lifestyle behaviours, such as smoking, physical inactivity and poor diet, are some of the leading behavioural risk factors for cardiovascular deaths.[3] Likewise, excessive alcohol consumption, excessive drug use and engaging in risky sexual behaviour carry a high risk for people's health.[4] Besides this, lifestyle behaviours are often associated with mental health. Previous research illustrates that individual risk factors, such as smoking, excessive drinking and drug use, often co-occur with poor mental health.[5,6] Also, healthier behaviours, such as physical activity and a healthy diet, often seem to correlate with better mental health.[7,8]

However, lifestyle factors do not stand alone but often co-occur in clusters, indicating that a pattern of lifestyle behaviours is more prevalent in a cluster than expected based on existing prevalence rates of individual lifestyle factors. Studying the relationship between these clusters of lifestyle factors and health is relevant due to the increased risk of morbidity, mortality and synergistic effects of these behaviours[9] and for preventive actions. Previous studies showed clusters of lifestyle factors between physical inactivity and low fruit and vegetable intake.[10] Furthermore, smoking and alcohol use[11] frequently cluster in combination with physical inactivity[12] and low fruit and vegetable intake.[10]

To our knowledge, little is known about the stability of lifestyle clusters during adulthood. Previous research on adolescence[13,14] and mid-adulthood[15] showed that clusters are relatively stable, in size and composition. Also, the link between lifestyle behaviours and mental health has been found in previous research, where healthier behaviours have been associated with healthier clusters that contain individuals with more positive mental health, and vice versa.[16–19] However, these studies only focused on a small set of lifestyle behaviours.

Increased insights into the clustering of unhealthy lifestyle factors and their association with mental health might contribute to the development of more effective prevention programs. Therefore, the present study examines whether clusters of lifestyle factors, such as smoking, alcohol use, physical activity, diet, sexual risk behaviour and cannabis and other drug use, change over time in five cross-sectional samples of Dutch adults between 2014 and 2019. Additionally, the association of these lifestyle clusters with mental

health and self-reported depression is studied. It is expected that clusters remain relatively stable over the years, as seen in adolescent studies. Furthermore, it is expected that mental health will be worse in the unhealthier clusters and better in the healthier clusters.

Methods

Study population and data collection

Data were collected by the nationwide, annual Health Survey/Lifestyle Monitor that started in 2014. This is a survey on health, medical contacts, lifestyle and preventive behaviour in the Netherlands. Annually a random sample of the Dutch population (0 years and older) were selected from the Personal Records Database (Dutch abbreviation: BRP). Data were collected throughout the whole year by a 'mixed mode' design, which is a combination of Computer Assisted Web Interviewing (CAWI, online respondents) and Computer Assisted Personal Interviewing (CAPI, face-to-face interviewing for non-respondents). CAPI respondents were given the possibility to answer more personal questions regarding alcohol use, sexual behaviour, and drug use by Computer Assisted Self Interviewing (CASI).

Each year, approximately 15 000–18 000 people of 0 years and older were invited to participate. In 2018 an incentive was introduced, i.e. the chance of winning an iPad when participating. Each year, about 54–62% of the invitees responded, resulting in 9000–10 000 respondents annually. For the present study, data from the Health Surveys 2014–19 were used and only respondents of 18 years and older were included (±7500 per year).

Sample characteristics can be found in table 1. Participants were excluded when they had missing values on one of the lifestyle factors. Attrition analyses comparing the included participants with the excluded participants in 2014 showed that respondents who were excluded were more likely to be older [odds ratio (OR) = 1.02, 95% confidence interval (CI) = 1.02–1.03), more likely to be female (OR = 1.23, 95% CI = 1.07–1.42), less likely to follow a higher education (OR = 0.63, 95% CI = 0.58–0.70), less likely to be married (OR = 1.00, 95% CI = 0.94–1.06), less likely to have a paid job (OR = 1.00, 95% CI = 1.00–1.01) and more likely to have a (non-)Western background (OR = 1.39, 95% CI = 1.24–1.56).

Measurements

Sociodemographic characteristics

Several sociodemographic variables were collected for all participants (see table 1).

Lifestyle risk factors

For all lifestyle risk factors dichotomous (yes/no) variables were constructed. Here the definition for each lifestyle risk factor will be described.

Daily smoking was measured with the question 'Do you smoke daily?'.

Excessive alcohol consumption was defined as ≥21 glasses per week for males and ≥14 glasses per week for females.[20] This was based on how many alcoholic beverages they consumed per week on average, distinguishing between weekdays and weekends. The participants were asked about an average week in the past couple of weeks.

Physical inactivity was defined as not adhering to at least one of the two physical activity guidelines. The Dutch Physical Activity (PA) guidelines include that (1) one must at least spend 150 min/week on at least moderately intensive activities, such as walking or cycling, spread out over several days and (2) one must do bone and muscle strengthening exercises at least twice a week. PA was measured using the Short Questionnaire to Assess Health (SQUASH).[21]

Cannabis use was defined as the use of cannabis in the last year.[22]

Other drug use was defined as the use of other drugs in the last year.[23,24] Participants were asked if and when they last used one of the following drugs: amphetamine, XTC, LSD, magic mushrooms, cocaine, heroin, GHB, methadone, 4-fluor amphetamine, nitrous oxide and other drugs (cannabis was excluded). In 2014, participants ≥65 years were not asked about their drug use. To be able to compare 2014 with the other years, the value of 0 was imputed for these respondents (not having used drugs in the past year). This can be justified by the fact that the prevalence rate of drug use for this age group was very low in 2015–19, i.e. 0.5%.

Sexual risk behaviour was defined as sexual intercourse or anal sex in the last 12 months without protection (condom) with a partner with whom the person is not in a steady relationship.[25]

Unhealthy diet was defined as adhering to neither one of the Dutch dietary recommendations. These recommendations were

Table 1 Sample characteristic (percentages) and descriptive statistics per year

Variable	2014 (*N* = 7304)	2015 (*N* = 7238)	2016 (*N* = 7099)	2017 (*N* = 7635)	2018 (*N* = 8028)	2019 (*N* = 7821)
Socio-demographic characteristics						
Average age of participants, mean (SD)	50.0 (17.8)	50.0 (17.8)	50.3 (17.9)	51.2 (18.1)	50.5 (17.2)	50.9 (18.1)
Sex						
Females	51.6	51.1	52.0	51.2	50.9	51.1
Males	48.4	48.9	48.0	48.8	49.1	48.9
Education						
Low—primary school, VMBO, first three years of HAVO/VWO and mbo-1	29.9	29.9	29.7	28.0	26.0	27.0
Intermediate—last 3 years of HAVO/VWO, mbo-2, mbo-3 and mbo-1	41.9	42.0	40.5	41.8	40.9	40.0
High—HBO and WO	28.2	28.1	29.8	30.3	33.1	33.0
Lifestyle factors (% with 95% CI)[a]						
Daily smokers	19.7 (18.8–20.6)	19.6 (18.6–20.4)	18.6 (17.7–19.5)	17.2 (16.4–18.0)	16.0 (15.2–16.8)	15.9 (15.1–16.7)
Excessive alcohol consumption	9.9 (9.3–10.6)	9.5 (8.9–10.2)	8.8 (8.2–9.5)	9.2 (8.6–9.9)	8.2 (7.6–8.8)	8.5 (7.9–9.1)
Cannabis use	–	6.7 (6.2–7.3)	6.6 (6.0–7.2)	7.2 (6.6–7.7)	7.5 (6.9–8.1)	7.2 (6.6–7.8)
Other drugs	–	4.1 (3.6–4.5)	4.1 (3.7–4.6)	4.3 (3.9–4.8)	4.1 (3.7–4.5)	4.6 (4.2–5.1)
Not physically active	18.0 (17.1–18.9)	17.8 (16.9–18.7)	18.3 (17.4–19.2)	16.2 (15.3–17.0)	15.6 (14.8–16.4)	14.5 (13.7–15.3)
Unhealthy diet	50.0 (48.9–51.2)	47.4 (46.3–48.5)	54.5 (53.4–55.6)	52.3 (51.2–53.4)	53.8 (52.7–54.9)	52.7 (51.6–53.8)
Sexual risk behaviour	2.2 (1.8–2.5)	2.5 (2.1–2.9)	2.6 (2.2–3.0)	2.9 (2.5–3.3)	2.6 (2.2–2.9)	3.2 (2.7–3.6)

Note: Values are percentage unless stated otherwise.

a: Weighted data (Boonstra, 2019) to compare lifestyle factors between the years 2014–19. Average scores of MHI-5 and self-reported depression can be found in Supplementary appendix D (table S13).

eating 250 g of vegetables and 200 g of fruit every day and one must consume fish at least twice a week, of which once fatty fish.[26]

Outcome measures. Mental health was measured with the Mental Health Inventory (MHI-5). The MHI-5 is a short questionnaire consisting of five questions to determine one's mental health via a score ranging from 1 to 100.[27] In this research, this scale was used as a continuous variable with a higher score indicating better mental health.

Self-reported depression was measured by a self-reported diagnosis of depression. Participants were asked if they: 'Could indicate whether you suffered from the following chronic diseases in the past 12 months: Depression?'. This created a dichotomous no/yes variable.

Statistical analysis

The data were analysed with the program SPSS version 24.

Descriptive analyses were conducted to analyse the distribution of the seven lifestyle risk factors included in the cluster analysis: daily smoking, excessive alcohol consumption, cannabis use, other drug use, physical activity, diet and sexual risk behaviour.

Firstly, the data on lifestyle risk factors collected in 2014 (reference year) were analysed with a two-step cluster analysis. This analysis could be used since all the variables were binary and the sample size was very large.[12,17] The reference year was used to compare with 2015–19. Based on several fit measures, the two-step cluster analysis determined the number of clusters with the best fit. The average silhouette coefficient was used to indicate the goodness of fit of the model; it determines how well the cases in the same cluster match each other and how each cluster differentiates from the other clusters.[28] Furthermore, Akaike's Information Criterion (AIC) was used to determine the correct number of clusters and the model fit.[29] The lifestyle risk factors were attributed to the clusters when the prevalence of this behaviour was higher in this cluster compared to the overall sample.

The stability of the clusters over the years was assessed based on two criteria: (i) size and (ii) composition. Firstly, to determine whether the *size* of the clusters of 2015–19 differed from the clusters of the reference year (2014), the 'scoring wizard' in SPSS was used. This wizard can predict to which cluster a respondent would belong according to the rules of the cluster model of the reference year. In other words, it determined the predicted values for respondents of the data in each dataset of the years 2015–19 based on the clusters of 2014 to examine the changes in the size of the clusters over the years. Secondly, to determine the *stability* of the composition of the clusters, for each year the two-step cluster analysis was again performed resulting in a separate cluster model. The true cluster memberships (to which cluster a participant belongs) were compared with the predicted values based on the clusters of the reference year to examine the comparability of the clusters.

The association of the clusters with mental health was examined by the evaluation field function in the two-step cluster analysis. This function shows the association between the total MHI-5 score, self-reported depression and the separate clusters per year. Both MHI-5 and self-reported depression are used since they measure different aspects of mental health ($r = 0.47$, $P \leq 0.01$). Following, linear and logistic regressions were executed to further examine the relationship between the total MHI-5 score and the self-reported depression, and the separate clusters controlled for multiple sociodemographic factors, using cluster 1 (healthy lifestyle) as the reference category. Age was not included because it did not correlate with mental health ($P > 0.05$). The differences in sociodemographic variables per cluster were determined with a chi-square test for every separate sociodemographic factor.

Results

Descriptive statistics

Over the years 2014–19, the percentage of daily smokers in the sample decreased from 19.7% to 15.9% (table 1). Additionally, excessive alcohol consumption decreased from 9.9% to 8.5%. Moreover, cannabis use and other drugs were stable from 6.7% to 7.2% and 4.1% to 4.6%. The number of people who do not adhere to any of the physical activity guidelines decreased from 18.0% to 14.5%. The number of people who did not adhere to any of the nutritional guidelines decreased from 50.0% to 52.7%. Finally, 3.2% of the respondents engaged in sexual risk behaviour in 2019 compared with 2.2% in 2014.

Clustering of lifestyle risk factors

The cluster analysis showed that the lifestyle risk factors clustered together in six different groups. The average fit silhouette measure of cohesion and separation for this analysis was 0.75, which indicates that the six clusters have good quality, and the respondents were well-matched to their cluster. Additionally, the model also shows that six clusters are the most optimal number, since the ratio of distance measures peaks at six (2.191) and the decrease in the AIC flattens after six clusters (0.127) (see also Supplementary appendix A, table S5).

Clusters of the reference year (2014)

In 2014, six different clusters were found (see table 2).

Cluster 1. No risk factors/healthy lifestyle: In this cluster, none of the respondents ($N = 2.033$, 32.7%) reported any risk factors.

Cluster 2. Poor diet: In this cluster, all respondents ($N = 1.701$, 27.4%) reported one risk factor: poor diet. None of these respondents met any of the nutritional guidelines.

Cluster 3. Daily smokers, poor diet and physical inactivity: In this cluster, the respondents ($N = 803$, 12.9%) were identified based on three risk factors. All of them smoked daily. Almost two-thirds of the respondent in this cluster (61.0%) adhered to none of the nutritional guidelines. Over a quarter (27.5%) did not adhere to any of the physical activity guidelines.

Cluster 4. Physical inactivity and poor diet: In this cluster, the respondents ($N = 652$, 10.5%) were identified based on two risk factors. None of them adhered to any of the physical activity guidelines and more than half of them (54.6%) adhered to none of the nutritional guidelines.

Cluster 5. Excessive alcohol consumption and daily smokers: In this cluster, the respondents ($N = 538$, 8.7%) were identified by two main risk factors. All of them excessively consumed alcohol and about one-third smoked daily (29.6%).

Cluster 6. Multiple risk factors/unhealthy lifestyle (daily smokers, excessive alcohol consumption, cannabis use, other drug use, sexual risk behaviour and poor diet): In this cluster, the respondents ($N = 492$, 7.9%) were identified based on multiple risk factors. More than two-thirds of them used cannabis in the last year (70.1%), more than one-third of them used other drugs (37.6%) and about a quarter excessively consumed alcohol (22.8%). About two-fifths of them also smoked daily (41.9%) and about two-thirds did not adhere to any of the nutritional guidelines (56.9%). Moreover, almost a quarter engaged in sexual risk behaviour (23.8%).

Comparability in the composition of clusters over the years (2014–19)

The cluster sizes over the different years can be seen in table 3. Cluster 2 (unhealthy diet) remained stable over the years. Cluster 1 (healthy lifestyle/no risk factors) and cluster 6 (unhealthy/multiple risk factors) increased in size. Clusters 3–5, all clusters with several risk factors, decreased in size.

Table 2 Clustering of risk factors in the reference year (2014): percentage of people within the cluster engaging in lifestyle risk factors

Variables	Explanation of variables	Cluster 1 (32.7)	Cluster 2 (27.4)	Cluster 3 (12.9)	Cluster 4 (10.5)	Cluster 5 (8.7)	Cluster 6 (7.9)	Total (100.0)
		No risk factors/ healthy	Poor diet	Daily smoking, physical inactivity and poor diet	Physical inactivity and poor diet	Daily smoking and excessive alcohol use	Multiple risk factors/ unhealthy	
Smoking	Daily smokers	0.0	0.0	100.0	0.0	29.6	41.9	19.7
Alcohol	Excessive alcohol consumption	0.0	0.0	0.0	0.0	100.0	22.8	9.9
Physical activity	Meet none of PA guidelines	0.0	0.0	27.5	100.0	16.5	12.2	18.0
Cannabis use	Cannabis use in the past year	0.0	0.0	0.0	0.0	0.0	70.1	6.0
Drug use	Drug use in the past year	0.0	0.0	0.0	0.0	0.0	37.6	3.2
Sexual health	Sexual risk behaviour	0.0	0.0	0.0	0.0	0.0	23.8	2.2
Diet	Meet none of nutritional guidelines	0.0	100.0	61.0	54.6	48.7	56.9	50.0

Table 3 The sizes of the clusters over the years (2014–19)

	Cluster 1 (no risk factors/healthy)	Cluster 2 (unhealthy diet)	Cluster 3 (daily smoking, physical inactivity and unhealthy diet)	Cluster 4 (physical inactivity and unhealthy diet)	Cluster 5 (daily smoking and excessive alcohol use)	Cluster 6 (unhealthy)
2014	2.033 (32.7%)	1.701 (27.4%)	803 (12.9%)	652 (10.5%)	538 (8.7%)	492 (7.9%)
2015	2.052 (33.9%)	1.586 (26.2%)	762 (12.6%)	606 (10.0%)	490 (8.1%)	552 (9.1%)
2016	1.780 (30.1%)	1.804 (30.5%)	724 (12.2%)	599 (10.1%)	447 (7.6%)	560 (9.5%)
2017	1.990 (31.8%)	1.879 (30.1%)	712 (11.4%)	572 (9.2%)	485 (7.8%)	613 (9.8%)
2018	2.156 (32.1%)	2.125 (31.6%)	669 (9.9%)	632 (9.4%)	481 (7.2%)	661 (9.8%)
2019	2.090 (32.5%)	2.097 (32.6%)	628 (9.8%)	498 (7.7%)	443 (6.9%)	680 (10.6%)

Note: Values are numbers and (%); percentage is percentage of people belonging to that cluster in the specific year.

The composition of the clusters of the different years (2014–19) is comparable to each other (Supplementary appendix B, table S6). More specifically, all years except for 2018 fit perfectly in the true cluster models of each year. Only 2018 was slightly different (±0.2%).

Sociodemographic characteristics of the six clusters

All clusters were significantly different from each other based on sociodemographic variables ($P \leq 0.05$). Healthier clusters consisted of individuals who were more likely to be female, more likely to be higher educated and more likely to be married compared with the unhealthier clusters. Moreover, the healthiest cluster had a higher percentage of native Dutch people and a higher average age compared with the unhealthiest cluster. For the exact numbers of all the years, see Supplementary appendix C.

Association with mental health and self-reported depression

In all years the average MHI-5 score is lowest in cluster 6 (unhealthy lifestyle) and highest (healthy lifestyle) in cluster 1 (figure 1). Moreover, the MHI-5 score is relatively stable in the clusters over time. In addition, the percentage of people with self-reported depression is highest in cluster 6 and lowest in clusters 1 and 2 for all years. Similar to the average MHI-5 score, the percentage of people with self-reported depression in each cluster is relatively stable over time. For detailed numbers, see Supplementary appendix D.

Multiple linear regression analyses using the data of 2014 showed that clusters 3, 4 and 6 had a significantly lower MHI-5 score compared with the healthy cluster (cluster 1) (Supplementary appendix E). For depression, clusters 3, 4 and 6 showed higher percentages of self-reported depression compared with the healthy cluster (cluster 1).

Results of the multivariate model also showed that clusters 2, 3, 4 and 6 were associated with lower MHI-5 scores. Furthermore, from socio-demographic variables, only sex, societal position, origin, and marital status were associated with the MHI-5 score. For self-reported depression, clusters 3 and 6 were associated with higher depression according to the multivariate model as well. From the sociodemographic variables, only societal position, living environment and educational level were not associated with depression.

Discussion

The present study examined the stability of clusters of lifestyle risk factors (smoking, alcohol use, physical activity, cannabis and drug use, diet and sexual behaviour) over time (2014–19) in the Dutch population. Additionally, the association between these clusters and mental health was examined. Results showed that lifestyle factors clustered in six different groups: a no-risk factor cluster (healthy), an unhealthy diet cluster, three clusters with different lifestyle risk factors and a multiple risk factor (unhealthy) cluster. These clusters are in line with clusters found in previous studies.[12,17]

Furthermore, the results showed that the composition of the lifestyle factors within the clusters did not change over time, which is similar to earlier research where clusters were also stable during other life stages.[13–15] However, the sizes of the existing clusters did change slightly over time, in particular, the cluster with multiple risk factors increased over the last years. An explanation for this could be that there might have been behavioural changes in the population resulting in the growth and the decrease of some clusters. Additionally, the increasing prevalence of mental health problems over time possibly leads to changes in lifestyle behaviours.

Furthermore, results showed that the healthier clusters are associated with better mental health, whereas the unhealthy cluster is associated with worse mental health. This is in line with previous studies.[17,18] However, cluster 5 (daily smoking and excessive alcohol use) has relatively positive mental health compared with the other clusters. An explanation for this could be that there are a very high percentage of native Dutch and married people in this cluster, which are both indicators for better mental health.

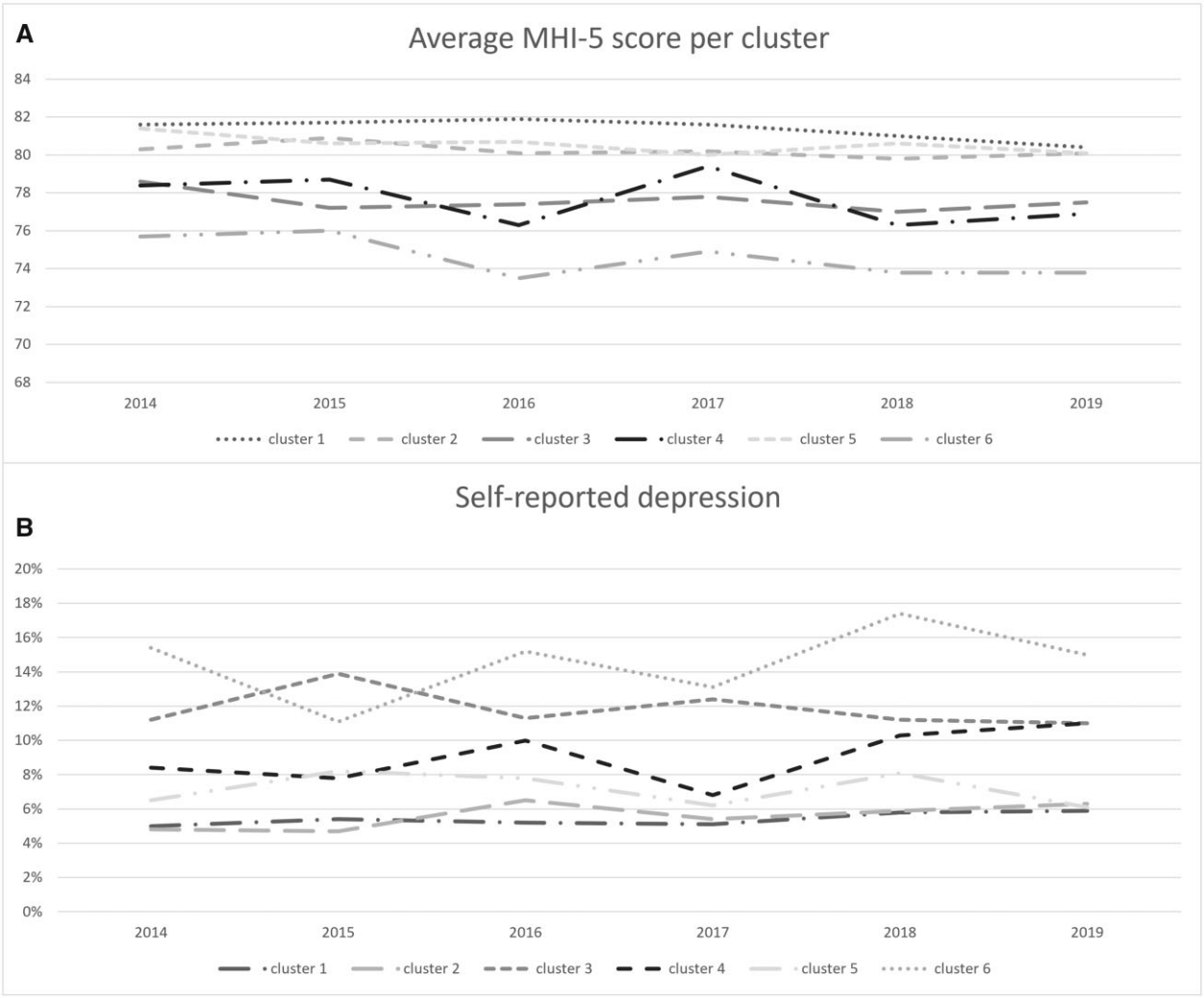

Figure 1 (A) The average Mental Health Inventory-5 score per cluster over 2014–19. (B) The percentage of people self-reported with depression per cluster over 2014–19. Note. Cluster 1 = healthy, cluster 2 = unhealthy diet, cluster 3 = daily smoking, physical inactivity and unhealthy diet, cluster 4 = physical inactivity and unhealthy diet, cluster 5 = daily smoking and excessive alcohol use and cluster 6 = unhealthy

Most sociodemographic factors differed between the clusters, similar to the study of Birch et al.[12] In line with existing literature, cluster 1 consisted of mostly females and higher educated individuals, as they tend to live a healthier lifestyle with regard to smoking and alcohol consumption.[30,31] Moreover, cluster 6 consisted of mostly young individuals, which corresponds to the increased drug use and high urbanization in this cluster.

There are several notable strengths of this study, such as the large sample size in all 6 years and the representative sample of the Dutch population. Furthermore, the present study included many different lifestyle factors, which provides a better and more complete outline of the behaviour of the respondents. Moreover, this study also comprised an extensive examination of the sociodemographic factors. Study limitations include the exclusion of around 1000 respondents annually (13% of the sample) due to missing lifestyle data, potentially affecting representativeness. Excluded participants showed higher vulnerability to unhealthy behaviours, possibly reducing the size of unhealthy clusters. Secondly, because the variables in the cluster analysis were used as binary variables, it was unable to distinguish between the quantity of usage. This could have led to more extreme clusters (e.g. smoking one cigarette a day or a whole pack of cigarettes a day were both labelled as the same risk factor for smoking). However, this was chosen to look at risk behaviour and is comparable with other previous cluster studies.[12,17] Thirdly, the variable *Unhealthy diet* is limited, as there is no measurement on meat intake in the Health Survey 2014–19. Meat intake is an important risk factor for cardiovascular diseases[32] and is therefore also added as measurement to the Health Survey 2023. Lastly, although multiple years are included in the analysis, the design of the study is cross-sectional. To get more insight if clusters change within a person over time and to be able to draw any causal conclusions, a longitudinal design is recommended.

The results of the present study give insight into the lifestyle behaviours of the Dutch population and provide additional, lifestyle-related knowledge for policymakers. Moreover, it provides some suggestions for the usefulness of targeting multiple lifestyle behaviours in one intervention instead of only focusing on one lifestyle behaviour at a time, since the interaction between several lifestyle behaviours remained stable over time. These multiple-component interventions are increasingly being recognized as an efficient and effective way to improve lifestyle behaviours, as reviewed by Meader et al.[33] They could not only be advantageous for the improvement of mental health problems but also for other chronic diseases that are associated with lifestyle.[3,34] Intervention strategies targeting clusters with increasing sizes or room for improvement are recommended. Moreover, preventive interventions for mental health problems could also focus on smoking, drug use and sexual risk behaviour, which is already seen in some existing programs.[35]

Further research should explore additional lifestyle factors like sleep[36] and expand the nutritional variable to include fast food, meat intake and sugary drinks.[32,37,38] Further investigation is also needed to evaluate the effect of the implemented health policies by the Dutch government on these findings. This will provide a better understanding of intervention effectiveness, identify shortcomings and inform future policymaking. Additionally, investigating the association between clusters and healthcare utilization is recommended. Lastly, it is recommended to conduct a similar study with a longitudinal design[39] to gain more insight into the dynamics of the clusters over time.

In conclusion, this study shows that lifestyle clusters in the Dutch population remain stable over time. Besides, it shows that lifestyle factors are associated with mental health. This knowledge can be used for improvement and better targeting of interventions to prevent chronic diseases and mental health problems.

Ethical approval

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Author contributions

Hannah Dorsman: Formal analysis, Writing—original draft preparation; Ellen de Hollander: Conceptualization, Supervision, Writing-reviewing; Wanda Wendel-Vos: Writing—reviewing; Caroline van Rossum: Writing—reviewing; Kemler: Writing—reviewing; Christianne Hupkens: Writing—reviewing; Karen Hosper: Writing—reviewing; Derek de Beurs: Writing—reviewing; Marieke Hiemstra: Conceptualization, Validation, Supervision, Writing—reviewing and editing.

Data availability

The datasets analysed during the current study are available in the DANS repository, Gezondheidsenquête 2014–19:

- Gezondheidsenquête 2014—EASY (knaw.nl)
- Gezondheidsenquête 2015—GECON 2015—EASY (knaw.nl)
- Gezondheidsenquête 2016—GECON 2016—EASY (knaw.nl)
- Gezondheidsenquête 2017—GECON 2017—EASY (knaw.nl)
- Gezondheidsenquête 2018—GECON 2018—EASY (knaw.nl)
- Gezondheidsenquête 2019—GECON 2019—EASY (knaw.nl)

Key points

- In a representative Dutch sample lifestyle risk factors cluster in six groups.
- Clusters of lifestyle risk factors remain stable over time (2014–19).
- Clusters with multiple lifestyle risk factors are associated with poorer mental health.

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