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Original article

Healthy ageing in a multi-ethnic population: A descriptive cross-sectional analysis from the HELIUS study

Marilyne Menassa [a,b,c,*], Oscar H. Franco [a,c], Henrike Galenkamp [d], Eric P. Moll van Charante [d], Bert-Jan H. van den Born [d], Esther M.C. Vriend [d], Pedro Marques Vidal [e], Karien Stronks [d]

[a] Institute of Social and Preventive Medicine, University of Bern, Mittelstrasse, 43 3012 Bern, Switzerland
[b] Graduate School for Health Sciences, University of Bern, Mittelstrasse, 43 3012 Bern, Switzerland
[c] Department of Global Public Health & Bioethics, Julius Center for Health Science and Primary Care, UMC Utrecht, Utrecht University, P.O. Box 85500, 3508 GA Utrecht, the Netherlands
[d] Department of Public and Occupational Health, Amsterdam University Medical Centers, University of Amsterdam, Meibergdreef 9, 1105 AZ Amsterdam, the Netherlands
[e] Department of Medicine, Internal Medicine, Lausanne University Hospital, University of Lausanne, Rue du Bugnon 46, CH-1011 Lausanne, Switzerland

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ABSTRACT

Objective: We investigated ethnic health disparities in the Healthy Life in an Urban Setting multi-ethnic cohort using the multidimensional Healthy Ageing Score.
Study design: We conducted a cross-sectional analysis of the study baseline data (2011–2015) collected through questionnaires/physical examinations for 17,091 participants (54.8 % women, mean (SD) age = 44.5 (12.8) years) from South-Asian Surinamese (14.8 %), African Surinamese (20.5 %), Dutch (24.3 %), Moroccan (15.5 %), Turkish (14.9 %), and Ghanaian (10.1 %) origins, living in Amsterdam, the Netherlands.
Main outcome measures: We computed the Healthy Ageing Score developed in the Rotterdam Study, which has seven biopsychosocial domains: chronic diseases, mental health, cognitive function, physical function, pain, social support, and quality of life. That score was used to discern between healthy, moderate, and poor ageing. We explored differences in healthy ageing by ethnicity, sex, and age group using multinomial logistic regression.
Results: The Healthy Ageing Score [overall: poor (69.0 %), moderate (24.8 %), and healthy (6.2 %)] differed between ethnicities and was poorer in women and after midlife (cut-off 45 years) across ethnicities (all $p < 0.001$). In the fully adjusted models in men and women, poor ageing (vs. healthy ageing) was highest in the South-Asian Surinamese [adjusted odds ratios (95 % confidence intervals)] [2.96 (2.24–3.90) and 6.88 (3.29–14.40), respectively] and Turkish [2.80 (2.11–3.73) and 7.10 (3.31–15.24), respectively] vs. Dutch, in the oldest [5.89 (3.62–9.60) and 13.17 (1.77–98.01), respectively] vs. youngest, and in the divorced [1.48 (1.10–2.01) and 2.83 (1.39–5.77), respectively] vs. married. Poor ageing was inversely associated with educational and occupational levels, mainly in men.
Conclusions: Compared with those of Dutch ethnic origin, ethnic minorities displayed less healthy ageing, which was more pronounced in women, before and after midlife, and was associated with sociodemographic factors.

1. Introduction

The world's population is growing at an unprecedented rate and living longer. By 2050, the world population will reach 9.7 billion, 16 % will be ≥65 years old, and an average longevity will increase to 77.2 years [1]. These demographic changes create socioeconomic and health challenges. As people age, their risk of diseases increases leading to poor health outcomes and burdening healthcare systems [2]. Furthermore, existing social and health systems are not devised to accommodate this demographic transition, which will necessitate adapted pension plans and long-term social and health care for the ageing population. These

* Corresponding author at: Department of Global Public Health & Bioethics, Julius Center for Health Science and Primary Care, UMC Utrecht, Utrecht University, P. O. Box 85500, 3508 GA Utrecht, the Netherlands.
E-mail addresses: m.menassa@umcutrecht.nl (M. Menassa), O.H.Franco@umcutrecht.nl (O.H. Franco), h.galenkamp@amsterdamumc.nl (H. Galenkamp), e.p.mollvancharante@amsterdamumc.nl (E.P. Moll van Charante), b.j.vandenborn@amsterdamumc.nl (B.-J.H. van den Born), e.m.vriend@amsterdamumc.nl (E.M.C. Vriend), Pedro-Manuel.Marques-Vidal@chuv.ch (P.M. Vidal), k.stronks@amsterdamumc.nl (K. Stronks).

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Abbreviations

aORs	Adjusted Odds Ratios
COPD	Chronic Obstructive Pulmonary Disorder
HAS	Healthy Ageing Score
HELIUS	Healthy Life in an Urban Setting
SF-12	12-Item Short Form Health Survey
PHQ-9	Patient Health Questionnaire
SD	Standard Deviation
SSQT	Social Support Questionnaire for Transactions
SSQS	Social Support Questionnaire for Satisfaction

projections have steered attention to the importance of healthy ageing [3].

Ethnic differences have been documented in ageing and comorbidities relating to mental health, cardiovascular/respiratory diseases, and mortality, disadvantaging migrants compared to host populations in Europe [4,5]. Studies have also shown that health disparities vary by sex and socioeconomic status with ageing [6–10]. However, most healthy ageing research has explored ethnic differences in populations aged ≥50 years [9–13]. In the Netherlands, such studies have mainly included participants of Dutch origin, and less so of ethnic minorities that currently constitute 14 % of the population [14–18]. The Healthy Life in an Urban Setting (HELIUS) is a multi-ethnic cohort that has reported ethnic differences in the prevalence of age-related diseases, focusing on physical or mental health outcomes [19–22]. The prevalence of comorbidities at an earlier age has been documented, but a multidimensional approach from an ageing perspective has not been adopted before [23–25].

Healthy ageing has been conceptualized and operationalized multidimensionally [26]. The Healthy Ageing Score (HAS) is one such example that emerged from the Rotterdam Study and is validated in the Dutch population [27]. It includes seven biopsychosocial domains: chronic diseases, mental health, social support, physical function, quality of life, pain, and cognition. In this study, we aimed to describe healthy ageing using the HAS in HELIUS. We explored whether there are differences in healthy ageing between ethnicities, by sex, and age group. We also investigated whether these differences were associated with a specific score domain, a younger age group, ethnicity, and/or sociodemographic factors.

2. Methods

2.1. Sample

We used HELIUS baseline data (2011–2015) described by Snijder et al. 2017 [22]. HELIUS is a multi-ethnic prospective cohort study conducted in Amsterdam. It investigates the unequal burden of mental health, cardiovascular, and infectious diseases in six ethnicities. Briefly, the sample included Amsterdam residents of Dutch, Surinamese (South-Asian and African), Turkish, Moroccan, and Ghanaian (18–70 years) origins. Participants were randomly sampled from the municipality registry after stratification by ethnicity. Respondents were invited for a physical examination and received the digital/paper version of the questionnaire to fill at home. Those who were willing to participate but needed more information were assisted by an ethnic- and sex-matched trained interviewer speaking their preferred language. Questionnaires were available in English and Turkish for Ghanaian and Turkish participants, respectively. A total of 24,782 participants were included. 22,162 completed the baseline questionnaire and physical examination after providing written informed consent. The study was ethically approved by the Institutional Review Board (Amsterdam University Medical Center) and conducted in accordance with the Declaration of Helsinki.

2.2. The Healthy Ageing Score

The Healthy Ageing Score was developed in the Rotterdam Study based on seven biopsychosocial domains: chronic diseases, mental health, cognitive function, physical function, pain, social support, and quality of life [27]. HELIUS includes measures for these domains. A full description of the tools, coding, and scoring is available in *Supplement 1*. Briefly, chronic diseases included eight self-reported diseases: coronary heart disease (myocardial infarction/revascularization), stroke, heart failure, cancer, asthma/chronic obstructive pulmonary disease (COPD), diabetes, intermittent claudication, and chronic kidney disease, with the latter three also clinically diagnosed during the physical examination. Mental health and social well-being were based on the Patient Health Questionnaire (PHQ-9) and the social support transaction/satisfaction questionnaires (SSQT/SSQS) respectively [28,29]. The 12-Item Short Form Health Survey (SF-12) questionnaire was used for physical function based on the physical component score, for quality of life based on the physical and mental component scores, and for pain based on the pain question [21,28,30]. For cognitive function, we used handgrip strength as a proxy because baseline cognition variable was not available. Handgrip strength constituted our best available indicator for this domain. For instance, cross-sectional and longitudinal analyses of >40,000 participants from the UK Biobank showed that higher grip strength is associated with better cognitive performance and increased grey matter volume, and has been proposed as a complementary measure for cognition [31]. For physical function, quality of life, and cognition no clear clinical cut-offs or scoring systems exist, so we used tertiles (lowest tertile for lowest performance) similar to previous studies [32]. All seven domains were summed up to obtain a HAS (0–14), categorized into: healthy (13–14), moderate (11−12), or poor (0−10) ageing. We created categorical variables for each domain and applied the same approach in coding and scoring as in the Rotterdam Study: high (healthiest categories, score 2), moderate (less healthy categories, score 1), and low (least healthy categories, score 0) (Supplement 1).

2.3. Ethnicity and covariates

Ethnic origin was based on the participants' and their parents' country of birth obtained from the registry as follows: Dutch (they and their parents born in the Netherlands), first generation migrants (born outside the Netherlands with one or both parents born outside the Netherlands), and second generation migrants (born inside the Netherlands with both parents born outside the Netherlands) [22]. Surinamese were asked if they were South-Asian, African, or other subethnicity because it could not be determined from the register. Age and sex *[We refer to biological sex as men and women instead of males and females to align with HELIUS publications. Gender as a social construct was not collected in HELIUS.]* were derived from the registry and menstruation (yes/no) was based on the question "Have you menstruated over the past year?", with post menopause defined as cessation of menstruation for 12 consecutive months. Marital status and educational/occupational levels were self-reported. Participants were categorized into five age brackets: 18–35 years, 36–45 years, 46–55 years, 56–65 years, and > 65 years and into two broader age groups for stratification: pre midlife (≤45 years) and post midlife (>45 years). The latter cut-off is based on the sample mean age and the literature, as the definition of midlife varies with time, life expectancy, and context, and is related to social roles rather than chronological age [33]. We aimed to explore whether in ethnic minorities less healthy ageing scores were observed in young adulthood. Categorizations were as follows: marital status [married/registered partnership, cohabiting, unmarried (never married), divorced/separated, widowed], educational level (no education/elementary education, lower vocational/lower secondary education, intermediate

vocational/ intermediate or higher secondary education, higher vocational/university), and occupational level (elementary, lower, medium, higher, or scientific).

2.4. Statistical analyses

Baseline participants characteristics were described using mean and standard deviation (SD) for continuous and count (percentages) for categorical variables. The HAS distribution and its domains were checked for normality and equality of variances. To explore differences in HAS between ethnic groups, men and women, and age groups (≤45 years and > 45 years), we used first the Kruskal Wallis test. Similarly, differences in HAS categories (poor, moderate, healthy) were tested first using Pearson's Chi-squared and Fischer's Exact tests. To explore the role of covariates in ethnic differences in the HAS categories (healthy ageing as reference), we performed several multinomial logistic regressions. We first stratified by sex with HAS as the dependent variable (healthy ageing as reference) and ethnicity (Dutch as reference) as the independent variable in the unadjusted model (model 1 not shown). We then tested for covariate (age, marital status, occupational, and educational levels) multicollinearity using spearman's correlation coefficient ($\rho < 0.7$) to include in the adjusted models. For model 2, we adjusted for marital status and age category as main sociodemographic factors. For model 3, we further adjusted for occupational and educational levels as additional factors, proxies of socioeconomic status. Using a similar approach as models 1, 2, and 3, we performed further regression analyses stratified by sex and age category (≤45 years and > 45 years). To explore the role of covariates in ethnic differences by HAS domain, we performed multinomial logistic regressions following the same approach for models 1, 2, and 3 with each biopsychosocial domain as the dependent variable (healthy categories as reference) in each regression. The results were reported as odds ratios (adjusted) (aORs) with 95%CIs. Analyses were conducted using Stata version 16 and 18 (Stata Corp., College Station, TX, USA) with significance level 0.05.

2.5. Exploratory and sensitivity analyses

Similar to the main analyses, we conducted further regression analyses by ethnicity and sex to explore the associations between the covariates and the HAS within each ethnic group. We also tested whether menstruation status and HAS were significantly correlated in women (overall and pre/post midlife) using Spearman's correlation ($\rho > 0.3$). We performed sensitivity analyses on models 1 and 2 including the participants who were excluded because of missing values for occupational and educational levels. To test the robustness of the handgrip strength proxy, all analyses were repeated without the cognition domain using a HAS (rescaled by removing 2 points).

3. Results

3.1. Sociodemographic characteristics

We included n = 17,091 (77 %) participants with complete information on exposure, covariates, and outcome. We excluded participants who did not belong to the six ethnic groups (unknown Surinamese/Javanese as these were small groups n = 528), or with missing values for marital status (n = 128), educational level (n = 207), occupational level (n = 3436), or HAS (n = 1440) (Fig. 1). Most missing values were for occupational level in women who worked less often and did not report occupation. Half of excluded participants were in the elementary educational/lower occupational levels. The characteristics of included and excluded participants were mostly comparable except for the educational and occupational levels in the Turkish and Moroccans (Supplement 2). Included participants consisted of Dutch (24.3 %), South-Asian Surinamese (14.8 %), African Surinamese (20.5 %), Ghanaian (10.1 %), Turkish (14.9 %), and Moroccan (15.5 %), with 54.8 % women (of whom 32.0 % postmenopausal). The mean age was 44.5 years (SD 12.8). Most were married/in registered partnerships (38.8 %), had a higher vocational/university education (30.2 %) or intermediate vocational/secondary education (29.8 %), and a low (29.6 %) or medium (26.6 %) occupational level. Table 1 shows a full description of these characteristics.

3.2. Ethnic and sex differences in healthy ageing

Most participants had poor (69 %), followed by moderate (24.8 %),

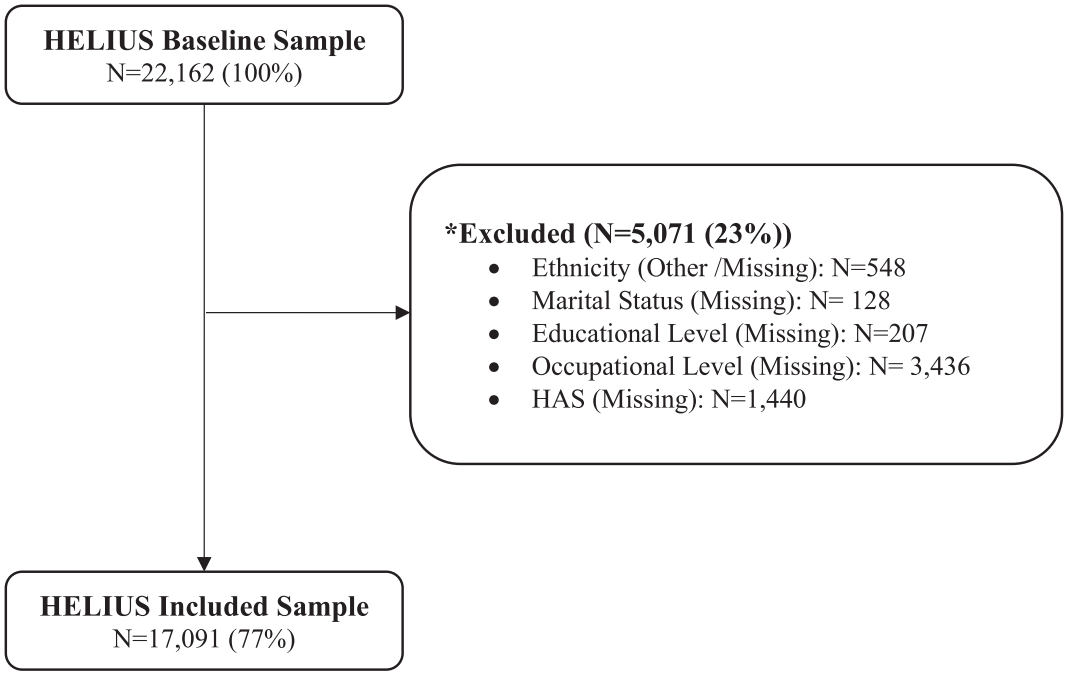

Fig. 1. Flowchart for excluded and included participants.
*Participants can have several missing covariates/outcome.

Table 1
Sociodemographic characteristics of included subjects stratified by ethnicity.

Ethnicity	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan	Total[a]
Frequency n (%)	4154 (24.3)	2529 (14.8)	3500 (20.5)	1722 (10.1)	2541 (14.9)	2645 (15.5)	17,091 (100)
Age mean (SD)	46.7 (13.5)	45.5 (12.8)	48.3 (12.0)	45.3 (10.7)	39.9 (11.5)	38.9 (12.1)	44.5 (12.8)
Sex n (%) *Women*	2231 (53.7)	1359 (53.7)	2129 (60.8)	1021 (59.3)	1236 (48.6)	1390 (52.6)	9366 (54.8)
Post menopause	885 (39.7)	459 (33.8)	948 (44.5)	333 (32.6)	223 (18.0)	153 (11.0)	3001 (32.0)
Marital status n (%)							
Married/registered partnership	1614 (38.9)	906 (35.8)	675 (19.3)	330 (19.2)	1577 (62.1)	1527 (57.7)	6629 (38.8)
Cohabiting	854 (20.6)	277 (11.0)	396 (11.3)	346 (20.1)	116 (4.6)	88 (3.3)	2077 (12.2)
Unmarried (never married)	1277 (30.7)	799 (31.6)	1849 (52.8)	529 (30.7)	525 (20.7)	746 (28.2)	5725 (33.5)
Divorced/separated	329 (7.9)	479 (18.9)	531 (15.2)	499 (29.0)	279 (11.0)	262 (9.9)	2379 (13.9)
Widowed	80 (1.9)	68 (2.7)	49 (1.4)	18 (1.1)	44 (1.7)	22 (0.8)	281 (1.6)
Educational level n (%)							
None/elementary	131 (3.2)	299 (11.8)	174 (5.0)	496 (28.8)	636 (25.0)	573 (21.7)	2309 (13.5)
Lower vocational/secondary	583 (14.0)	834 (33.0)	1246 (35.6)	695 (40.4)	661 (26.0)	504 (19.1)	4523 (26.5)
Intermediate vocational/secondary	868 (20.9)	767 (30.3)	1258 (35.9)	420 (24.4)	785 (30.9)	992 (37.5)	5090 (29.8)
Higher vocational/university	2572 (61.9)	629 (24.9)	822 (23.5)	111 (6.5)	459 (18.1)	576 (21.8)	5169 (30.2)
Occupational level n (%)							
Elementary	73 (1.8)	264 (10.4)	233 (6.7)	1088 (63.2)	499 (19.6)	469 (17.7)	2626 (15.4)
Lower	627 (15.1)	867 (34.3)	1240 (35.4)	403 (23.4)	1026 (40.4)	895 (33.8)	5058 (29.6)
Medium	962 (23.2)	794 (31.4)	1230 (35.1)	161 (9.4)	623 (24.5)	776 (29.3)	4546 (26.6)
Higher	1617 (38.9)	469 (18.5)	694 (19.8)	50 (2.9)	286 (11.3)	420 (15.9)	3536 (20.7)
Scientific	875 (21.1)	135 (5.3)	103 (2.9)	20 (1.2)	107 (4.2)	85 (3.2)	1325 (7.8)

[a] Totals and percentages are calculated by ethnicity (column).

and healthy (6.2 %) ageing scores. Poor ageing occurred most frequently in the South-Asian Surinamese (78.5 %) followed by the Turkish (74.3 %), while moderate and healthy ageing were more frequent among the Dutch (33.1 % and 10.6 % respectively) and African Surinamese (24.2 % and 6.6 % respectively). These differences were observed in the HAS [mean (SD)] [9.0 (2.6)] with lower scores for women [8.3 (2.5)] vs. men [(9.8 (2.4)] ($p < 0.001$) (Supplement 3). When adjusting for marital status and age (model 2), the highest odds for poor ageing was in Turkish women [aOR = 13.6 (6.46–28.65)] vs. men [aOR = 5.04 (3.87–6.57)] showing some significant associations with these sociodemographic factors. When adjusting for occupational and educational levels (model 3), the odds decreased but remained statistically significant for all ethnicities except for African Surinamese men and Ghanaian men and women. Here, ageing poorly was inversely associated with educational and occupational levels in both sexes, although less strongly in women. When comparing moderate to healthy ageing the associations were similar in direction but less pronounced for both sexes except for African Surinamese (model 2). The role of sociodemographic factors was not as significant (models 2 and 3) (Table 2).

3.3. Ethnic and sex differences in healthy ageing by age group (pre & post midlife)

We found similar sex differences in HAS as before, with significantly higher percentages of participants in the poor ageing categories post midlife (64.3 % and 84 %) than pre midlife (46.5 % and 75.6 %) in men and women respectively. This was also reflected in the HAS in men and women post midlife [(9.4 (2.5) and 7.8 (2.6) respectively] compared to pre midlife [10.4 (2.1) and 8.8 (2.3) respectively] ($p < 0.001$) (Fig. 2, Supplement 3). When adjusting for marital status (model 2), the odds of ageing poorly remained significantly high in both age groups except for African Surinamese (both sexes) and Ghanaians (women). However, the odds were higher post midlife compared to pre midlife in men, whereas higher pre midlife compared to post midlife in women. In the fully adjusted models (model 3), these associations held except for Ghanaians in both age groups and were inversely associated with higher educational and occupational levels in men. In women, these associations were lost pre midlife for Ghanaians, and held only for South-Asian Surinamese post midlife. Similar but less strong associations were observed when comparing moderate to healthy ageing in men in both age groups (models 2 and 3) but were not associated with sociodemographic factors. In women, some associations held in the pre midlife group in model 2, but none in model 3 (Tables 3a/3b).

3.4. Ethnic differences in HAS domains

Multinomial regression analyses showed consistent differences across the seven domains that were mostly similar in association and significance to those observed in the overall HAS. The highest odds of being in the poorest category were observed in Turkish and Moroccan men and women for quality of life and pain, and for South-Asian Surinamese women for cognition. For social support, there were smaller differences between ethnicities for men in the moderate category, but the sample was too small and did not have enough power to compare the poorest to the highest category in this domain (Supplement 4).

3.5. Exploratory and sensitivity analyses

Exploratory analyses by ethnicity and sex showed similar trends across all ethnicities in the strengths and directions of associations mainly when comparing poor ageing to healthy ageing. Menstruation status and HAS were not significantly associated in women across ethnicities. Sensitivity analyses did not reveal changes in direction and significance of associations when the participants with missing covariates were included in the models. Associations were generally similar in direction, significance, and strengths when the cognition proxy was removed, noting lower odds ratios and narrower confidence intervals in these analyses for women.

4. Discussion

4.1. Main findings

Ethnic minorities showed patterns of less healthy ageing compared to the host population. South-Asian Surinamese aged less healthily than the Turkish, followed by Moroccans, Ghanaians, and African Surinamese compared to the Dutch. Women aged less healthily than men across all ethnicities. After adjusting for sociodemographic factors, ethnic differences in healthy ageing were observed in both sexes in pre and post midlife, except for African Surinamese and Ghanaians. Age, marital status, educational, and occupational levels may play a role in healthy ageing as shown in the decreased associations or loss of statistical significance after adjusting for these factors. For moderate ageing, differences were less pronounced than in poor ageing. Ethnic groups differed

Table 2
Associations between ethnicity and healthy ageing categories stratified by sex.

Reference (healthy ageing)	Poor ageing				Moderate ageing			
	Men		Women		Men		Women	
Models (Model 1 not shown)[a]	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
	aOR (95%CI)		aOR (95%CI)		aOR (95%CI)		aOR (95%CI)	
Ethnicity	Reference (Dutch)							
South-Asian Surinamese	**4.30 (3.29–5.62)**	**2.96 (2.24–3.90)**	**10.05 (4.86–20.80)**	**6.88 (3.29–14.40)**	**1.75 (1.33–2.32)**	**1.48 (1.11–1.97)**	**2.97 (1.41–6.24)**	**2.54 (1.20–5.40)**
African Surinamese	**1.29 (1.04–1.61)**	0.85 (0.68–1.07)	**2.39 (1.62–3.53)**	**1.75 (1.16–2.64)**	1.01 (0.81–1.26)	0.82 (0.64–1.03)	1.46 (0.97–2.17)	1.27 (0.83–1.93)
Ghanaian	**2.22 (1.65–2.99)**	1.05 (0.74–1.49)	**7.26 (3.49–15.11)**	2.12 (0.92–4.90)	**1.63 (1.20–2.21)**	1.26 (0.89–1.80)	**2.75 (1.30–5.82)**	1.59 (0.68–3.73)
Turkish	**5.04 (3.87–6.57)**	**2.80 (2.11–3.73)**	**13.60 (6.46–28.65)**	**7.10 (3.31–15.24)**	**2.36 (1.80–3.10)**	**1.85 (1.38–2.48)**	**3.09 (1.44–6.63)**	**2.36 (1.08–5.15)**
Moroccan	**3.75 (2.91–4.82)**	**2.15 (1.64–2.82)**	**7.41 (4.24–12.97)**	**4.37 (2.22–7.82)**	**1.98 (1.53–2.56)**	**1.60 (1.21–2.11)**	**2.19 (1.23–3.90)**	1.75 (0.96–3.19)
Age category	Reference (18–35 years)							
36–45 years	**1.52 (1.23–1.88)**	**1.42 (1.14–1.76)**	**1.52 (1.02–2.27)**	1.29 (0.86–1.93)	1.06 (0.86–1.32)	1.05 (0.85–1.31)	1.11 (0.74–1.67)	1.03 (0.68–1.55)
46–55 years	**2.42 (1.95–3.01)**	**1.96 (1.57–2.45)**	**2.68 (1.74–4.14)**	**1.98 (1.27–3.09)**	1.18 (0.95–1.47)	1.12 (0.89–1.40)	1.27 (0.81–1.98)	1.11 (0.70–1.75)
56–65 years	**5.26 (4.03–6.86)**	**4.22 (3.21–5.53)**	**3.31 (1.99–5.52)**	**2.43 (1.44–4.08)**	**1.50 (1.14–1.98)**	**1.42 (1.07–1.89)**	1.27 (0.75–2.15)	1.10 (0.64–1.88)
>65 years	**7.98 (4.94–12.89)**	**5.89 (3.62–9.60)**	**20.24 (2.74–149.63)**	**13.17 (1.77–98.01)**	**1.83 (1.10–3.05)**	1.67 (1.00–2.80)	6.47 (0.86–48.70)	5.19 (0.69–39.31)
Marital status	Reference (married)							
Cohabiting	1.12 (0.89–1.41)	1.16 (0.92–1.46)	0.90 (0.59–1.39)	0.98 (0.64–1.51)	1.14 (0.90–1.45)	1.16 (0.92–1.47)	0.85 (0.54–1.33)	0.89 (0.57–1.39)
Unmarried (never married)	**1.49 (1.22–1.82)**	**1.39 (1.14–1.70)**	**1.82 (1.23–2.70)**	**1.82 (1.23–2.70)**	**1.29 (1.05–1.59)**	**1.24 (1.01–1.52)**	1.48 (0.99–2.23)	1.48 (0.99–2.22)
Divorced or separated	**1.55 (1.15–2.10)**	**1.48 (1.10–2.01)**	**3.05 (1.50–6.20)**	**2.83 (1.39–5.77)**	1.10 (0.80–1.52)	1.05 (0.76–1.45)	**2.31 (1.12–4.76)**	**2.22 (1.07–4.58)**
Widowed	0.93 (0.31–2.75)	0.77 (0.26–2.31)	1.67 (0.40–7.01)	1.42 (0.34–5.98)	1.71 (0.57–5.10)	1.54 (0.51–4.62)	1.42 (0.33–6.17)	1.34 (0.31–5.86)
Educational level	Reference (no/elementary schooling)							
Lower schooling (low vocational or low secondary)		**0.67 (0.47–0.94)**		0.47 (0.13–1.66)		1.03 (0.72–1.49)		0.61 (0.17–2.19)
Intermediate schooling (intermediate vocational or higher secondary)		**0.56 (0.40–0.80)**		0.37 (0.10–1.32)		0.92 (0.63–1.33)		0.54 (0.15–1.94)
Higher vocational schooling or university		**0.40 (0.27–0.59)**		**0.17 (0.05–0.61)**		0.72 (0.47–1.10)		**0.25 (0.07–0.93)**
Occupational level	Reference (elementary)							
Lower		0.77 (0.56–1.05)		0.44 (0.15–1.29)		1.09 (0.78–1.51)		0.59 (0.20–1.89)
Medium		**0.69 (0.49–0.97)**		0.35 (0.12–1.05)		1.18 (0.82–1.68)		0.63 (0.21–1.89)
Higher		**0.54 (0.37–0.80)**		0.49 (0.16–1.54)		0.90 (0.60–1.34)		1.09 (0.34–3.49)
Scientific		**0.38 (0.35–0.59)**		0.31 (0.10–1.00)		0.89 (0.57–1.39)		0.85 (0.26–2.80)

[a] Model 1 (unadjusted) is not shown. Model 2 is adjusted for age category and marital status, and model 3 is adjusted for marital status, age category, educational, and occupational levels. Associations are presented as adjusted odds ratios (aOR). Bold font highlights significant associations.

significantly across the seven HAS domains, with the widest differences observed for pain, quality of life, and cognition.

4.2. Findings compared to the literature

Similar to our findings, studies from Belgium, France, Spain, and the Netherlands have shown an advantaged health status in ageing for the host populations compared to migrants from other European countries, Asia, Africa, and America [6,7,34]. The sex differences have also been reported in the Rotterdam Study with less healthy scores for women vs. men mainly for mental health, pain, physical function, and quality of life, aligning with well-known sex/gender differences in health and disease [8,27,35]. However, we found lower scores for Dutch women [mean (SD)] [9.5 (2.1)] and men [10.6 (1.9)] than in the Rotterdam Study [(10.7 (2.3) and 11.1 (2.2) respectively]. Similarly, healthy ageing was less frequent in our study for Dutch women (4.8 %) and men (17.5 %) compared to the Rotterdam Study (24.8 % and 28.2 % respectively). For the domains, our findings are similar to some studies and different from others. Similar to our chronic diseases' domain, a higher prevalence of multimorbidity and Type 2 diabetes at an early age in adulthood has been reported in ethnic minorities compared to the Dutch, sometimes associated with sociodemographic factors [23,25] . Our study shows consistent ethnic differences in mental and physical health as well as social wellbeing, quality of life, and pain indicating that healthy or poor ageing cannot be attributed to only one domain. However, the Longitudinal Ageing Study in Amsterdam has previously shown better physical performance in ageing for the Dutch compared to Turkish and Moroccan migrants, but not for mental health [6,7]. In HELIUS, a higher prevalence of depressive symptoms was found in the Turkish and South-Asian Surinamese compared to the Dutch [36]. We noted large ethnic differences in two domains: quality of life and pain. These are subjective and self-reported measures, potentially indicating

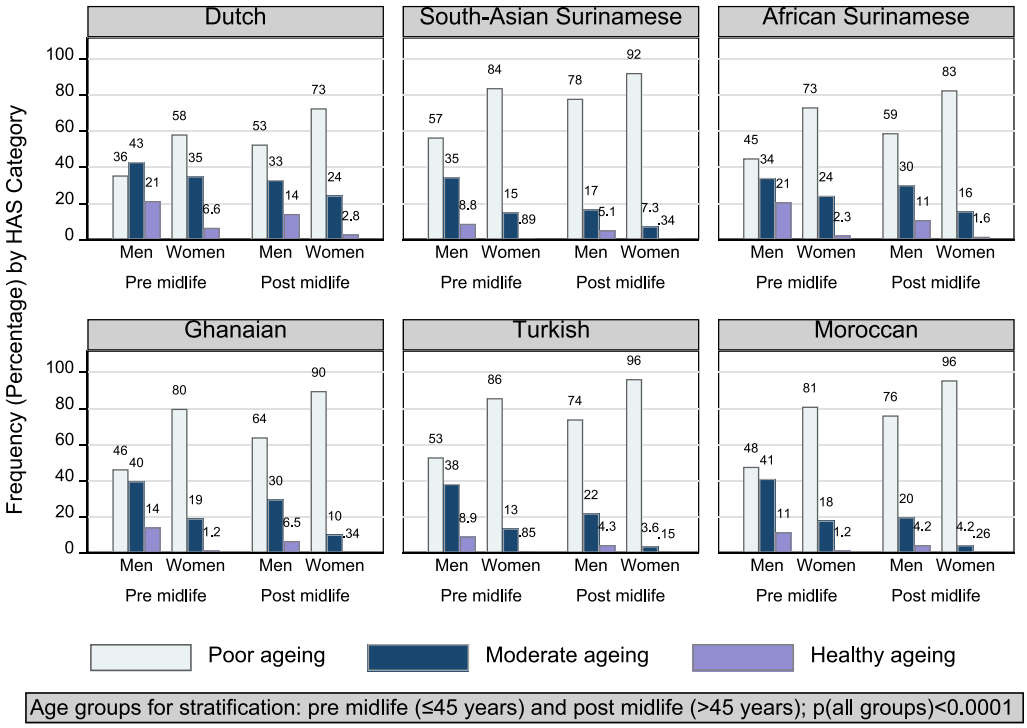

Fig. 2. Healthy ageing (HAS) categories (%) shown by ethnicity, sex, and age group (cut-off at 45 years).

underlying sociocultural differences in experiencing chronic conditions and in the perception and meaning of pain [37,38].

4.3. Insights into ethnic health disparities

Health disparities vary depending on ethnicity and country of settlement and can change over time [5,34,39,40]. The "healthy migrant effect" in the USA, Canada, and Australia is less common in Europe [5,34]. This benefit has been attributed to a health selection for migration, high fiber diets, younger epigenetic age, and enclave effect of living in ethnic neighborhoods, often lost after migration with negative acculturation, stress, and unhealthy behaviors [5]. One example in the Netherlands is the lower prevalence of hypertension among the Turkish and Moroccans vs. the Dutch two decades ago, reversed today and observed at a younger age in migrants [24]. Because traditional risk factors do not always explain these disparities, other ethnic-specific and cultural factors might be playing a role [23,41]. Ethnic minorities seem to have poorer self-reported health compared to host populations [42]. The living social and cultural contexts such as language and health literacy can negatively impact health seeking behaviour with consequences for healthy ageing. In HELIUS, social network has been found to weaken the associations between perceived ethnic discrimination and depression, requiring further investigation in the healthy ageing context [36]. Given that our sample is young compared to other studies, our finding that poor ageing is more common than moderate or healthy ageing is alarming. For instance, inequalities in disability-free life expectancy in migrants from African, Asian, and mixed ethnicities in the UK compared to the European British was not accompanied by inequalities in life expectancy [43]. This could indicate a deviation towards less healthy ageing early in adulthood and needs a better understanding of underlying behavioral, biological, and psychosocial factors.

4.4. Strengths and limitations

Our findings should be interpreted considering limitations. First, the HAS was only validated in the Dutch population. Because poor and moderate were more frequent than healthy ageing, cross-ethnic validation might reveal different cut-off values. Unlike for SF-12 and PHQ-9, the cross-cultural validity of the SSQT/SSQS in HELIUS is not known [22] . Furthermore, most HAS domains were based on self-reported measures that might be culturally sensitive [22]. Pain, physical function, and quality of life were derived from the same SF-12 which might have produced overlap. However, the correlation coefficients were < 0.6 between these domains, ruling out substantial overlap except between pain and physical function ($r = 0.7$). As we did not have a direct measure for cognition, we included the closest proxy: handgrip strength. We do not know how valid this is in our population, but it has been shown to widely correlate with cognition in other populations [31]. Handgrip strength did not highly correlate with the other domains, which was not expected particularly with physical functioning, but ruled out substantial overlap. Removing the cognition domain did not change our findings (although resulted in lower odds for women compared to the main analyses), indicating that our score is robust for the objective of our study. It is also important to note that odds ratios should be carefully interpreted in such studies as they tend to amplify associations in case of a highly prevalent health outcome. Furthermore, categorization was based on tertiles for the SF-12 domains as in previous studies, which is arbitrary and might have produced misclassifications [32].

Despite the limitations, the main study strength is the large sample and multiple ethnicities which enabled stratification and power to detect HAS differences by age group, sex, and ethnicity. It provides an initial multidimensional approach to describing healthy ageing in HELIUS, is a snapshot of psychosocial factors in ageing in this context and is complementary to findings on ethnic disparities in health and disease. It highlights the need for culturally appropriate tools in measuring non-biomedical domains of ageing in the living context. Our study and existing literature reveal a gap in research designed to understand multidimensional healthy ageing in multiethnic populations in their countries of origin and in host countries. Such studies are much needed to understand the interplay of biopsychosocial and environmental factors in ageing early in the life course and that might vary between contexts. Strategic research investments in this direction would improve our understanding and the evidence for policy and practice,

Table 3a
Associations between ethnicity and healthy ageing categories stratified by sex (Men) and age categories.

	Men							
Reference (Healthy Ageing)	Poor ageing				Moderate ageing			
	Pre Midlife (≤45 years)		Post Midlife (>45 years)		Pre Midlife (≤45 years)		Post Midlife	
Models (Model 1 not shown)[a]	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
	aOR (95%CI)		aOR (95%CI)		aOR (95%CI)		aOR (95%CI)	
Ethnicity	Reference (Dutch)							
South-Asian Surinamese	**3.57 (2.49–5.11)**	**2.53 (1.74–3.67)**	**4.04 (2.72–6.00)**	**2.72 (1.81–4.10)**	**1.93 (1.34–2.78)**	**1.60 (1.09–2.33)**	1.45 (0.94–2.24)	1.23 (0.79–1.93)
African Surinamese	1.30 (0.95–1.77)	0.81 (0.58–1.14)	1.31 (0.98–1.75)	0.87 (0.64–1.19)	0.84 (0.61–1.15)	0.65 (0.46–0.91)	1.15 (0.85–1.57)	0.96 (0.69–1.34)
Ghanaian	**1.58 (1.04–2.39)**	0.75 (0.47–1.22)	**2.57 (1.68–3.93)**	1.20 (0.72–2.01)	1.24 (0.81–1.87)	0.92 (0.57–1.48)	**2.12 (1.35–3.32)**	1.70 (1.00–2.91)
Turkish	**3.50 (2.52–4.88)**	**2.16 (1.51–3.08)**	**4.81 (3.06–7.56)**	**2.30 (1.41–3.75)**	**2.20 (1.58–3.07)**	**1.70 (1.19–2.43)**	**2.31 (1.43–3.74)**	**1.79 (1.06–3.01)**
Moroccan	**2.36 (1.73–3.22)**	**1.53 (1.10–2.15)**	**5.21 (3.25–8.35)**	**2.43 (1.45–4.05)**	**1.82 (1.34–2.49)**	**1.45 (1.04–2.03)**	**2.20 (1.33–3.64)**	**1.75 (1.02–3.02)**
Marital status	Reference (married)							
Cohabiting	1.00 (0.74–1.35)	1.05 (0.77–1.43)	0.86 (0.61–1.22)	0.90 (0.63–1.27)	1.17 (0.86–1.58)	1.19 (0.88–1.61)	0.93 (0.64–1.34)	0.95 (0.66–1.37)
Unmarried (never married)	1.12 (0.88–1.42)	1.10 (0.87–1.41)	**1.71 (1.23–2.36)**	**1.56 (1.13–2.17)**	1.14 (0.89–1.45)	1.10 (0.86–1.41)	**1.56 (1.11–2.21)**	**1.50 (1.06–2.12)**
Divorced or separated	**3.94 (1.79–8.67)**	**3.40 (1.54–7.53)**	1.28 (0.91–1.80)	1.21 (0.86–1.71)	**2.49 (1.11–5.62)**	**2.31 (1.02–5.22)**	0.88 (0.61–1.27)	0.84 (0.58–1.22)
Widowed	na	na	1.14 (0.38–3.37)	0.89 (0.30–2.66)	na	na	1.68 (0.56–5.08)	1.47 (0.48–4.45)
Educational level	Reference (no/elementary schooling)							
Lower schooling (low vocational or low secondary)		0.80 (0.47–1.36)		**0.62 (0.39–0.97)**		1.01 (0.58–1.77)		1.03 (0.63–1.69)
Intermediate schooling (intermediate vocational or higher secondary)		**0.57 (0.34–0.96)**		**0.60 (0.37–0.99)**		0.85 (0.50–1.47)		1.03 (0.60–1.74)
Higher vocational schooling or university		**0.39 (0.22–0.70)**		**0.41 (0.23–0.72)**		0.62 (0.34–1.13)		0.86 (0.47–1.56)
Occupational level	Reference (elementary)							
Lower		0.72 (0.46–1.12)		0.93 (0.60–1.47)		1.06 (0.66–1.68)		1.25 (0.77–2.03)
Medium		0.81 (0.50–1.29)		0.61 (0.37–1.00)		1.32 (0.81–2.15)		1.08 (0.63–1.84)
Higher		0.63 (0.37–1.06)		**0.48 (0.27–0.85)**		1.02 (0.59–1.74)		0.78 (0.43–1.44)
Scientific		**0.41 (0.23–0.74)**		**0.39 (0.20–0.76)**		0.94 (0.51–1.70)		0.88 (0.44–1.76)

[a] Model 1 (unadjusted) is not shown. Model 2 is adjusted for marital status, and model 3 is adjusted for marital status, educational, and occupational levels. Associations are presented as adjusted odds ratios (aOR). Bold font highlights significant associations. Numbers were too small in some categories to produce meaningful associations which were stated as "not available (na)".

enabling healthy ageing for all.

5. Conclusions

We observed large differences in healthy ageing by ethnicity and sex as early as pre midlife. These differences resonate across all biopsychosocial domains and are associated with sociodemographic factors. The findings of this study call for in-depth exploration of additional behavioral, biopsychosocial, and environmental factors that might be underlying these disparities early in the life course. This would help understand the ageing trajectories in different populations to devise interventions enabling healthy ageing.

Contributors

Marilyne Menassa participated in conceptualization and data analysis and interpretation, and wrote the initial draft of the paper.

Oscar H. Franco participated in conceptualization, data analysis supervision and interpretation, and critical revision of the paper.

Henrike Galenkamp participated in data acquisition, interpretation, and the critical revision of the paper.

Eric P. Moll van Charante participated in interpretation and the critical revision of the paper.

Bert-Jan H. van den Born participated in interpretation and critical revision of the paper.

Esther M.C. Vriend participated in the interpretation and critical revision of the paper.

Pedro Marques Vidal participated in the interpretation and critical revision of the paper.

Karien Stronks participated in conceptualization, data analysis supervision and interpretation, and critical revision of the paper.

All authors saw and approved the final version for intellectual content and no other person made a substantial contribution to the paper.

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Table 3b
Associations between ethnicity and healthy ageing categories stratified by sex (Women) and age categories.

	Women							
Reference (healthy ageing)	Poor ageing				Moderate ageing			
	Pre midlife (≤45 years)		Post midlife (>45 years)		Pre midlife (≤45 years)		Post midlife (>45 years)	
Models (Model 1 not shown)[a]	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
	aOR (95%CI)		aOR (95%CI)		aOR (95%CI)		aOR (95%CI)	
Ethnicity	Reference (Dutch)							
South Asian Surinamese	**10.22 (4.08–25.64)**	**6.83 (2.69–17.35)**	**8.65 (2.64–28.33)**	**6.20 (1.86–20.68)**	**3.50 (1.37–8.96)**	**2.90 (1.12–7.50)**	2.23 (0.66–7.51)	2.07 (0.60–7.11)
African Surinamese	**3.22 (1.88–5.54)**	**1.97 (1.11–3.50)**	1.59 (0.89–2.83)	1.37 (0.75–2.49)	**1.96 (1.12–3.43)**	1.53 (0.85–2.75)	0.97 (0.53–1.75)	0.97 (0.52–1.79)
Ghanaian	**6.08 (2.76–13.40)**	1.52 (0.62–3.71)	**14.00 (1.89–103.80)**	6.23 (0.66–58.76)	**2.51 (1.11–5.66)**	1.22 (0.49–3.04)	5.01 (0.66–37.84)	4.72 (0.49–45.85)
Turkish	**9.61 (4.46–20.72)**	**4.97 (2.26–10.92)**	na	na	**2.97 (1.35–4.75)**	2.16 (0.96–4.85)	na	na
Moroccan	**6.53 (3.54–12.05)**	**3.76 (1.99–7.10)**	**6.15 (1.46–25.85)**	3.01 (0.65–13.86)	**2.53 (1.35–4.75)**	1.90 (0.99–3.65)	0.85 (0.18–3.89)	0.68 (0.13–3.42)
Marital status	Reference (married)							
Cohabiting	0.73 (0.43–1.23)	0.85 (0.50–1.44)	0.84 (0.39–1.79)	0.92 (0.43–1.98)	0.81 (0.47–1.40)	0.88 (0.51–1.51)	0.86 (0.39–1.90)	0.86 (0.39–1.91)
Unmarried (never married)	1.22 (0.76–1.95)	1.29 (0.80–2.07)	**2.98 (1.45–6.12)**	**3.11 (1.52–6.36)**	1.28 (0.79–2.08)	1.29 (0.80–2.10)	1.97 (0.94–4.13)	2.05 (0.98–4.28)
Divorced or separated	**4.83 (1.14–20.45)**	**4.29 (1.01–18.21)**	**2.85 (1.23–6.59)**	**2.83 (1.22–6.56)**	3.32 (0.77–14.31)	3.11 (0.72–13.42)	2.19 (0.93–5.16)	2.22 (0.94–5.25)
Widowed	na	na	2.03 (0.48–8.58)	1.80 (0.42–7.67)	na	na	1.73 (0.39–7.58)	1.68 (0.38–7.41)
Educational level	Reference (no/elementary schooling)							
Lower schooling (low vocational or low secondary)		0.74 (0.15–3.63)		0.27 (0.03–2.33)		0.93 (0.18–4.72)		0.32 (0.04–2.84)
Intermediate schooling (intermediate vocational or higher secondary)		0.79 (0.17–3.79)		0.13 (0.01–1.09)		1.22 (0.25–6.01)		0.16 (0.02–1.44)
Higher vocational schooling or university		0.23 (0.05–1.10)		0.10 (0.01–1.00)		0.44 (0.09–2.23)		**1.00 (0.01–0.96)**
Occupational level	Reference (elementary)							
Lower		0.23 (0.05–1.11)		1.18 (0.27–5.17)		0.28 (0.06–1.40)		1.60 (0.35–7.30)
Medium		0.20 (0.04–1.00)		0.89 (0.21–3.83)		0.29 (0.06–1.51)		1.84 (0.41–8.28)
Higher		0.30 (0.06–1.58)		1.11 (0.22–5.51)		0.50 (0.09–2.73)		3.38 (0.64–17.69)
Scientific		**0.16 (0.03–0.88)**		1.03 (0.18–5.91)		0.32 (0.06–1.81)		4.48 (0.74–27.20)

[a] Model 1 (unadjusted) is not shown. Model 2 is adjusted for marital status, and model 3 is adjusted for marital status, educational, and occupational levels. Associations are presented as adjusted odds ratios (aOR). Bold font highlights significant associations. Numbers were too small in some categories to produce meaningful associations which were stated as "not available (na)".

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Ethical approval

The HELIUS study has been approved by the Institutional Review Board of the AMC at the University of Amsterdam. Written informed consent was obtained from all participants before the study started.

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Research data (data sharing and collaboration)

There are no linked research data sets for this paper. Additional information is provided in the supplementary material. No additional data is provided with this manuscript. The HELIUS data are owned by the Amsterdam University Medical Centers, location AMC in Amsterdam, The Netherlands. Any researcher can request the data by submitting a proposal to the HELIUS Executive Board as outlined at http://www.heliusstudy.nl/en/researchers/collaboration, by email: heliuscoordinator@amsterdamumc.nl. The HELIUS Executive Board will check proposals for compatibility with the general objectives, ethical approvals, and informed consent forms of the HELIUS study. There are no other restrictions to obtaining the data and all data requests will be processed in the same manner.

Declaration of competing interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2024.107972.

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