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1 **Prevalence and socio-demographic characteristics of persons who have never had a headache**  
2 **among healthy voluntary blood donors – a population-based study**

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23

## 24 **Abstract**

25 Introduction: Headache is an extremely prevalent disorder with a lifetime prevalence of 90-99%.

26 However, a small fraction of people never experiences a headache. Research on people without

27 headache could uncover protective factors in headache, but to our knowledge no study on

28 headache free individuals has been published. We aim to estimate the prevalence of headache

29 free individuals among Danish blood donors, and to describe the socio-demographics and health

30 factors of headache free participants.

31 Materials and Methods: 38,557 healthy volunteers were recruited as part of the Danish Blood

32 Donor Study. Headache free participants were identified based on the question "Have you ever

33 experienced a headache of any kind?". Utilizing the Danish registries and self-reported

34 questionnaires, we analyzed socio-demographic and lifestyle factors using logistic regression

35 adjusted for age and sex.

36 Results: The prevalence of headache free individuals was 4.1% (n = 1,362) with a female-male ratio

37 of 1:2.2. To be headache free was significantly associated with an employment status as a student,

38 a low level of income and a regular alcohol consumption.

39 Discussion: The prevalence of headache free individuals was comparable to population-wide  
40 studies of headache. To be headache free was not associated with a high socio-economic status.  
41 Further studies on people without headache will hopefully reveal protective factors in headache,  
42 and this novel approach might be useful in other very prevalent disorders.

43

#### 44 **Key words**

45 “Headache” “Protective Factors” “Life Style” “Prevalence” “Registries” “Blood Donors”

46

#### 47 **Introduction**

48 Headache is an extremely common illness that in population surveys has a lifetime prevalence of  
49 90-99%<sup>1-4</sup>. Tension-type headache is the 2<sup>nd</sup> most prevalent disorder in the world, followed by  
50 migraine that ranks as the 3<sup>rd</sup> most prevalent disorder<sup>5</sup>. Migraine has a lifetime prevalence of 16-  
51 25% and tension-type headache has a lifetime prevalence of 78-89% in the Danish population<sup>2,6,7</sup>.

52 Despite these high prevalences, there might be persons who will never encounter a headache.

53 People who are free from headache could be resistant to ever getting a headache. In infectious  
54 diseases there is a long tradition of research in individuals resistant or immune to a specific illness.

55 In 1796 Edward Jenner developed the first ever vaccine based on the observation that

56 milkmaidens were resistant to smallpox infection<sup>6,7</sup>. More recent is the development of the HIV-1

57 anti-viral drug Maraviroc, following the discovery of resistance to HIV-1 infection in individuals

58 homozygous for CCR5  $\Delta$ 32<sup>8,9</sup>. To our knowledge this paper is the first to examine people who have

59 never had a headache and research on people who are headache free could reveal protective  
60 factors in non-infectious disorders, like headaches.

61 Using the nationwide public health study, the Danish Blood Donor Study (DBDS), we identified  
62 participants that had never experienced a headache. So-called headache free individuals. The aim  
63 was to estimate the prevalence of headache free individuals among Danish blood donors and to  
64 describe the socio-demographics and health factors of headache free participants compared to  
65 non-headache free participants in the DBDS.

66

## 67 **Materials and methods**

68

### 69 **Study population**

70 This case-cohort study was conducted from November 2015 to March 2018. Voluntary participants  
71 were recruited as part of the Danish Blood Donor Study (DBDS). The DBDS is described in detail  
72 elsewhere<sup>8</sup>. In short, it is a scientific study based on the voluntary participation of more than  
73 100,000 blood donors<sup>8</sup>. It is an ongoing multicenter, public health study and biobank. Recurrent  
74 donors age 18 to 67 years were invited to participate in the present study in DBDS<sup>9</sup>. After oral and  
75 written informed consent donors answered a digital tablet-based questionnaire at the time of  
76 inclusion<sup>10</sup>. In this case-cohort study we included 38,557 Danish blood donors from the DBDS who  
77 had answered a questionnaire containing the question “Have you ever experienced a headache of  
78 any kind?”.

79 After exclusions, the resulting study population was 32,975 individuals, Figure 1.

80

## 81 **Exclusions**

82 We excluded 5,582 individuals. 5,327 individuals were excluded due to missing answers to the  
83 question “Have you ever experienced a headache of any kind?” and we subsequently excluded  
84 120 individuals who had answered positively to the question “Have you ever had a migraine?” or  
85 “Have you ever had visual disturbances with a duration of 5-60 minutes followed by a headache?”  
86 and negatively to the question “Have you ever experienced a headache of any kind?”. 135  
87 individuals were excluded due to missing information on age and gender. The excluded  
88 individuals were slightly younger (median age: 38 years, IQR=28-50 years) when compared to the  
89 study population (median age: 42 years, IQR=31-52 years) (Wilcoxon test,  $P$ -value<0.0001). The  
90 excluded individuals did not differ in sex distribution when compared to the study population (chi-  
91 squared test,  $P$ -value 0.15).

92

## 93 **Ethics statement**

94 The study was approved by the Danish Data Protection Agency (2007–58-0015) and the Ethical  
95 Committee of Central Denmark (M-20090237).

96

## 97 **The digital questionnaire**

98 From the DBDS digital questionnaire we extracted self-reported information on BMI (calculated by  
99 recall information on height and weight at the time of inclusion), alcohol consumption

100 (never/seldom, monthly, weekly or daily), smoking status (total pack years of cigarettes, pipe,  
101 cigar and cheroot) and self-reported physical and mental health from the Short Form-12 (SF-12)  
102 questionnaire<sup>11</sup>. The SF-12 is a 12 item questionnaire that is used to measure self-reported health-  
103 related quality of life. Through the SF-12 it is possible to calculate a physical component score  
104 (PCS) and a mental component score (MCS) where the 12 items are weighted and added to a  
105 constant<sup>12</sup>. A higher SF-12 score indicates a better health-related quality of life.

106

## 107 **Population registers**

108 In Denmark all individuals are identified through 10-digit Civil Registration System numbers, which  
109 have been assigned since 1968. Through the Civil Registration System numbers, we identified the  
110 participants from the nation-wide database Statistics Denmark. We extracted information from  
111 the years 2015 and 2016 from Statistics Denmark on sex, age, level of urbanization (<60, 60-200,  
112 200-1000, 1000-2000, >2000 persons per square kilometer), educational level (primary or lower  
113 secondary education, high school, short length education, middle length education or higher long  
114 term education), working status (working, retired, unemployed or studying) and level of income  
115 (low, low-middle, middle, high-middle and high expressed in DKK as <200,000 DKK/year, 200,000-  
116 <400,000 DKK/year, 400,000 - <600,000 DKK/year, 600,000 -<800,000 DKK/year and >800,000  
117 DKK/year). The conversion rate for DKK are approximately: 100 DKK = 14.87 USD = 13.38 EUR.

118 With the Danish 10-digit Civil Registration System numbers we identified the participants in the  
119 National Patient Register and the Register of Medicinal Products to extract data on numbers of  
120 contact to a hospital, numbers of admissions, time of admission and number of prescriptions of  
121 medicinal products. The National Patient Register contains information on all patients in public

122 and private somatic and psychiatric hospitals in Denmark in the time period 1994-2015. The  
123 Register of Medicinal Products contains information on all sales of human and veterinary  
124 medicinal products in Denmark in the time period 1995-2016. We did not include prescriptions to  
125 headache specific drugs, triptans and ergotamine, based on ATC codes. We did not include  
126 admissions or hospital contacts with a diagnose of ICD10 chapter G43, G44 or R50 in our grouped  
127 comparisons.

128

### 129 **Statistical analysis**

130 The study population was described using counts and percentages for categorical variables, mean  
131 and standard deviation (SD) for normally distributed data and median and interquartile range  
132 (IQR) for non-normally distributed data. Differences in distributions between participants were  
133 analyzed using chi-squared test or Mann-Whitney/Wilcoxon test. Logistic regression was used to  
134 analyze for association to headache resistance, adjusted for age and sex. Outcome was described  
135 with odds ratios (OR) and 95% confidence intervals (95%CI). We tested the assumptions of our  
136 adjusted logistic models by use of the Hosmer and Lemeshow goodness of fit test, which did not  
137 reject our model for neither men, women nor both. We only included complete cases in our  
138 adjusted logistic model. Missing information is presented in Table 1. A  $P$ -value $<0.01$  was  
139 considered statistically significant.

140 Statistical analysis was performed using computer software Stata/MP 14.2, StataCorp, College  
141 Station, TX.

142



143 **Results**

144 The study population consisted of 32,975 participants (median age: 42 year, IQR = 31 – 52) from  
145 the DBDS. We found a total of 1,362 headache free cases (female-male ratio: 1:2.2) and 31,613  
146 non-headache free controls (female-male ratio: 1:1.1). The prevalence of headache free  
147 individuals in our sample was 4,1%. There was a significant difference in age and sex distribution  
148 between cases and controls (Wilcoxon test for age  $P < 0.001$  and chi-squared test for sex  $P <$   
149  $0.001$ ).

150 Socio-demographic characteristics of the study population are presented in Table 2.

151

152 Male sex was positively associated with being headache free with  $OR=1.96$  (95%CI: 1.75-2.20), see  
153 Table 3. Headache free participants were older than controls, but when corrected for sex the  $OR$   
154 for age was only 1.01 (95%CI: 1.01-1.02).

155 In the multivariate regression analysis of socio-demographic register data, corrected for age and  
156 sex, to be headache free was positively associated with an employment status as a student  
157  $OR=1.91$  (95%CI: 1.57-2.31) and the lowest level of income, below 200,000 DKK/year with  $OR=1.47$   
158 (95%CI: 1.22-1.75). A high education of 5 or more years was negatively associated with being  
159 headache free with an  $OR=0.70$  (0.55-0.89).

160 Self-reported lifestyle measures showed that headache free participants had a more regular  
161 pattern of alcohol consumption (beer, wine or spirits) than controls, with more headache free  
162 participants reporting a daily consumption,  $OR=1.57$  (95%CI: 1.20-2.04). Headache free

163 participants had a slightly higher self-perceived physical health as measured by PCS than controls  
164 with OR=1.03 (95%CI: 1.02-1.05).

165 Data from the national registers on health showed that headache free participants had slightly less  
166 prescriptions than controls, OR=0.996 (95%CI: 0.995-0.998) and headache free participants had  
167 slightly fewer contacts to a hospital OR=0.99 (95%CI: 0.98-0.99). Even though we did not find any  
168 difference in numbers of admissions, participants without headache spent slightly less time  
169 hospitalized when they were admitted OR=0.99 (95%CI: 0.98-1.00).

170 There was no association between being headache free and level of urbanization, BMI, self-  
171 perceived mental health or smoking status in our multivariable regression analysis corrected for  
172 age and sex.

173

## 174 **Discussion**

175 We report for the first time the prevalence and socio-demographic characteristics of persons who  
176 have never encountered headache. The prevalence of headache free individuals was 4,1% among  
177 Danish blood donors. The prevalence of headache free individuals is compatible with previous  
178 epidemiological studies on lifetime prevalence of headache<sup>1-4</sup>. Our study population of Danish  
179 blood donors might be influenced by selection bias, so that it is not completely representative of  
180 the whole Danish population. Nevertheless, in 1991 Rasmussen et al. conducted a population  
181 study on headache in the Danish general population<sup>2</sup>. Of the 735 participants who were  
182 interviewed about headache, 31 participants (4,2%) reported not having had a headache<sup>13</sup>.

183 Although the numbers of people without headache were small, the prevalence is in line with our  
184 results.

185 Danish blood donors are healthier than the general population<sup>14,15</sup> However, Hansen et al. found a  
186 prevalence of migraine of 24,2% in the Danish blood donors<sup>16</sup>. This prevalence is comparable with  
187 previously epidemiological studies of migraine prevalence in the general population<sup>2,17-19</sup>.

188 Therefore, the prevalence of headache free individuals in our sample is not expected to be  
189 influenced by a lower migraine prevalence among healthy blood donors. We did not include  
190 participants with an age of 68 years or older and as some primary headaches, like hypnic headache  
191 and nummular headache, together with many secondary headache disorders, typically occur after  
192 50 years of age, we might underestimate lifetime prevalence of headache in our sample<sup>20-22</sup>. In  
193 addition, as our data on headache is based on self-reported questionnaires, we might  
194 overestimate the prevalence of headache free individuals due to memory bias of the participants.

195 Several clinical and epidemiological studies have shown that women experience more pain than  
196 men<sup>23</sup>. Many clinical pain conditions like fibromyalgia or reflex sympathetic dystrophy, as well as  
197 most types of headache have a higher prevalence in females compared with males<sup>23-27</sup>. In  
198 accordance, there was a lower prevalence of headache free individuals among women than men.  
199 As there are slightly more males in our study population compared to the entire Danish  
200 population, this could indicate a slight selection bias affecting the gender difference. Still, our  
201 results suggest that men are more than two-fold as likely to be headache free.

202 Previous studies have shown that headache prevalence increases as socioeconomic status  
203 decreases<sup>28,29</sup>. This pattern is common to many diseases and a higher socioeconomic status is  
204 thought to be protective of headache<sup>30-38</sup>. We found no indication that being headache free is

205 more prevalent in persons with higher socioeconomic status, high income, higher level of  
206 education or employment status. On the contrary, the prevalence of people without headache  
207 was lower among blood donors with a higher education of 5 years or more. There are two primary  
208 hypotheses of the impact of socioeconomic status on health<sup>29</sup>. The social selection hypothesis,  
209 that a disabling disease causes a decline in social status because an individual may underperform  
210 in studies and work, and the social causation hypothesis, that a low socioeconomic status is a  
211 stressor that increases the risk of disease<sup>29</sup>. The reason that being headache free is not affected by  
212 socioeconomic status might indicate that freedom from headache is not a strong advantage in life,  
213 and therefore does not heighten an individual's performance. It may also, or alternatively, imply  
214 that being headache free is primarily caused by genetic factors and not much affected by  
215 environmental factors. However, the interpretation must be cautious, as the prevalence of blood  
216 donors of low socioeconomic status is lower in our sample than in the general Danish population<sup>9</sup>.

217 The statistically significant differences between headache free participants and non-headache free  
218 participants in health factors as well as in self-perceived physical health were numerically small  
219 and have no clinical importance. However, as blood donors are healthier than the general  
220 population, the trend towards headache free individuals being healthier and not only unaffected  
221 by headache, might be bigger in the general population<sup>14,15</sup>. The difference in health between  
222 headache free participants and controls was not driven by differences in lifestyle factors. There  
223 was no difference in smoking status or BMI between the groups. Headache free participants  
224 reported more regular alcohol consumption than controls. We speculate, that this is because  
225 alcohol often induces migraine attacks and that participants with migraine or other types of  
226 headaches therefore drink less than participants who are headache free.

227 In this study we found a prevalence of headache free individuals of 4.1%. Being headache free was  
228 more prevalent in males with a female-male ratio of 1:2.2. Freedom from headache was not  
229 associated with a high socio-economic status. On the contrary, headache free individuals had a  
230 low level of income, an employment status as a student and a regular alcohol consumption.

231 We are the first to describe a cohort of persons who have never had a headache. We hope that  
232 further research on headache free individuals might reveal protective factors in headache. We  
233 intend in the future to conduct a range of pathophysiological and genetic studies on this cohort of  
234 headache free individuals. By further developing the concept we hope to create a methodology  
235 that can be applied to other extremely prevalent disorders.

236

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240 whose continued inclusion of blood donors into the DBDS makes this research possible. The  
241 authors have no conflicts of interest to declare.

242

### 243 **Article Highlights**

- 244 - The prevalence of persons who have never had a headache was 4,1% in our sample.
- 245 - The female-male ratio of headache free individuals was 1:2.2.
- 246 - Headache free individuals where more likely to have a low level of income, an employment  
247 status as a student and a regular alcohol consumption.

249 **References**

- 250 1. Boardman HF, Thomas E, Croft PR, et al. Epidemiology of headache in an English district.  
251 *Cephalalgia* 2003; 23: 129–37.
- 252 2. Rasmussen BK, Jensen R, Schroll M, et al. Epidemiology of headache in a general  
253 population-A prevalence study. *J Clin Epidemiol* 1991; 44: 1147–1157.
- 254 3. Nikiforow R. Headache in a Random Sample of 200 Persons: A Clinical Study of a Population  
255 in Northern Finland. *Cephalalgia* 1981; 1: 99–107.
- 256 4. Rasmussen BK, Olesen J. Symptomatic and nonsymptomatic headaches in a general  
257 population. *Neurology* 1992; 42: 1225–1225.
- 258 5. James SL, Abate D, Abate KH, et al. Global, regional, and national incidence, prevalence, and  
259 years lived with disability for 354 diseases and injuries for 195 countries and territories,  
260 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018;  
261 392: 1789–1858.
- 262 6. Le H, Tfelt-Hansen P, Skytthe A, et al. Increase in self-reported migraine prevalence in the  
263 Danish adult population: a prospective longitudinal population-based study. *BMJ Open*  
264 2012; 2: e000962.
- 265 7. Lyngberg AC, Rasmussen BK, Jørgensen T, et al. Has the prevalence of migraine and tension-  
266 type headache changed over a 12-year period? A Danish population survey. *European*  
267 *Journal of Epidemiology* 2005; 20: 243–249.

- 268 8. Pedersen OB, Erikstrup C, Kotzé SR, et al. The Danish Blood Donor Study: a large,  
269 prospective cohort and biobank for medical research. *Vox Sang* 2012; 102: 271–271.
- 270 9. Burgdorf KS, Simonsen J, Sundby A, et al. Socio-demographic characteristics of Danish blood  
271 donors. *PLoS One* 2017; 12: e0169112.
- 272 10. Burgdorf KS, Felsted N, Mikkelsen S, et al. Digital questionnaire platform in the Danish Blood  
273 Donor Study. Epub ahead of print 2016. DOI: 10.1016/j.cmpb.2016.07.023.
- 274 11. Ware J, Kosinski M, Keller S. A 12-Item Short-Form Health Survey: construction of scales and  
275 preliminary tests of reliability and validity. *Med Care* 1996; 34: 220–233.
- 276 12. Gandek B, Ware JE, Aaronson NK, et al. *Cross-Validation of Item Selection and Scoring for  
277 the SF-12 Health Survey in Nine Countries: Results from the IQOLA Project*. 1998.
- 278 13. Jensen R, Rasmussen BK, Pedersen B, et al. Muscle tenderness and pressure pain thresholds  
279 in headache. A population study. *Pain* 1993; 52: 193–9.
- 280 14. Atsma F, de Vegt F. The healthy donor effect: a matter of selection bias and confounding.  
281 *Transfusion* 2011; 51: 1883–1885.
- 282 15. Ullum H, Rostgaard K, Kamper-Jørgensen M, et al. Blood donation and blood donor  
283 mortality after adjustment for a healthy donor effect. *Transfusion* 2015; 55: 2479–2485.
- 284 16. Hansen TF, Hoeffding LK, Kogelman L, et al. Comorbidity of migraine with ADHD in adults.  
285 *BMC Neurol* 2018; 18: 147.
- 286 17. Russell MB, Rasmussen BK, Thorvaldsen P, et al. Prevalence and sex-ratio of the subtypes of  
287 migraine. *Int J Epidemiol* 1995; 24: 612–8.

- 288 18. Hagen K, Zwart J-A, Vatten L, et al. Prevalence of Migraine and Non-Migrainous Headache—  
289 Head-HUNT, A Large Population-Based Study. *Cephalalgia* 2000; 20: 900–906.
- 290 19. Dahlöf C, Linde M. One-Year Prevalence of Migraine in Sweden: A Population-Based Study in  
291 Adults. *Cephalalgia* 2001; 21: 664–671.
- 292 20. Olesen J. Headache Classification Committee of the International Headache Society (IHS)  
293 The International Classification of Headache Disorders, 3rd edition. *Cephalalgia* 2018; 38: 1–  
294 211.
- 295 21. Grosberg BM, Solomon S, Lipton RB. Nummular headache. *Current Pain and Headache*  
296 *Reports* 2007; 11: 310–312.
- 297 22. Sharma TL. Common Primary and Secondary Causes of Headache in the Elderly. *Headache*  
298 2018; 58: 479–484.
- 299 23. Fillingim RB, King CD, Ribeiro-Dasilva MC, et al. Sex, Gender, and Pain: A Review of Recent  
300 Clinical and Experimental Findings. *J Pain* 2009; 10: 447–485.
- 301 24. Lebedeva ER, Kobzeva NR, Gilev D, et al. Prevalence of primary headache disorders  
302 diagnosed according to ICHD-3 beta in three different social groups. *Cephalalgia* 2016; 36:  
303 579–588.
- 304 25. Russell MB, Levi N, Šaltytė-Benth J, et al. Tension-type Headache in Adolescents and Adults:  
305 A Population Based Study of 33,764 Twins. *Eur J Epidemiol* 2006; 21: 153–160.
- 306 26. Lykke Thomsen L, Kirchmann Eriksen M, Faerch Romer S, et al. An epidemiological survey of  
307 hemiplegic migraine. *Cephalalgia* 2002; 22: 361–375.



- 308 27. Hagen K, Åsberg AN, Uhlig BL, et al. The epidemiology of headache disorders: a face-to-face  
309 interview of participants in HUNT4. *J Headache Pain* 2018; 19: 25.
- 310 28. Le H, Tfelt-Hansen P, Skytthe A, et al. Association between migraine, lifestyle and  
311 socioeconomic factors: a population-based cross-sectional study. *J Headache Pain* 2011; 12:  
312 157–72.
- 313 29. Stewart WF, Roy J, Lipton RB. Migraine prevalence, socioeconomic status, and social  
314 causation. *Neurology* 2013; 81: 948–55.
- 315 30. Kyung Chu M, Kim D-W, Kim B-K, et al. Gender-specific influence of socioeconomic status on  
316 the prevalence of migraine and tension-type headache: the results from the Korean  
317 headache survey. *J Headache Pain* 2013; 14: 1.
- 318 31. Winter AC, Berger K, Buring JE, et al. Associations of socioeconomic status with migraine  
319 and non-migraine headache. *Cephalalgia*. Epub ahead of print 2011. DOI:  
320 10.1177/0333102411430854.
- 321 32. Holstein BE, Andersen A, Denbaek AM, et al. Short communication: Persistent socio-  
322 economic inequality in frequent headache among Danish adolescents from 1991 to 2014.  
323 *Eur J Pain* 2018; 22: 935–940.
- 324 33. McNamara CL, Balaj M, Thomson KH, et al. The socioeconomic distribution of non-  
325 communicable diseases in Europe: findings from the European Social Survey (2014) special  
326 module on the social determinants of health. *Eur J Public Health* 2017; 27: 22–26.
- 327 34. Gonzalez M, Artalejo FR, Calero J del R. Relationship between socioeconomic status and  
328 ischaemic heart disease in cohort and case-control studies: 1960-1993. *Int J Epidemiol* 1998;

329 27: 350–358.

330 35. Robbins JM, Vaccarino V, Zhang H, et al. Socioeconomic status and diagnosed diabetes  
331 incidence. *Diabetes Res Clin Pract* 2005; 68: 230–236.

332 36. Bråbäck L, Hjern A, Rasmussen F. Social class in asthma and allergic rhinitis: a national  
333 cohort study over three decades. *Eur Respir J* 2005; 26: 1064–1068.

334 37. Chen E, Martin AD, Matthews KA. Trajectories of socioeconomic status across children's  
335 lifetime predict health. *Pediatrics* 2007; 120: e297-303.

336 38. Jansson C, Nordenstedt H, Johansson S, et al. Relation between gastroesophageal reflux  
337 symptoms and socioeconomic factors: a population-based study (the HUNT Study). *Clin*  
338 *Gastroenterol Hepatol* 2007; 5: 1029–34.

339