**Association between intelligence quotient and disability: the role of socioeconomic status**

*Running title:* Intelligence quotient and disability

Louis Jacob, PhDa,b\*; Lee Smith, PhDc; Philippe Thoumie, MD-PhDd; Josep Maria Haro, MD-PhDb; Andrew Stickley, PhDe; Ai Koyanagi, MD-PhDb,g

a Faculty of Medicine, University of Versailles Saint-Quentin-en-Yvelines, Montigny-le-Bretonneux 78180, France

b Parc Sanitari Sant Joan de Déu, CIBERSAM, Dr. Antoni Pujadas, 42, Sant Boi de Llobregat, Barcelona 08830, Spain

c Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge, United Kingdom

d APHP Hôpital Rothschild and Sorbonne University Agathe INSERM U-1150, Service de Médecine Physique et Réadaptation, Paris, 75012, France

e Department of Preventive Intervention for Psychiatric Disorders, National Institute of Mental Health, National Center of Neurology and Psychiatry, Kodaira, Tokyo, Japan

g ICREA, Pg. Lluis Companys 23, Barcelona, Spain

**Abstract**

*Objectives:* No study has yet investigated the association between intelligence quotient (IQ) and disability [i.e., difficulties in activities of daily living (ADL) or instrumental activities of daily living (IADL)] in the general population. The goal of this nationally representative study was to therefore analyze the potential IQ-disability relationship in England, and to identify influential factors in this association.

*Methods:* Cross-sectional data were analyzed from the 2007 Adult Psychiatric Morbidity Survey (n=6872). IQ was assessed using the National Adult Reading Test (NART), a test that consists of a list of 50 words and is scored by counting the number of errors made in reading out the words. Disability was defined as having difficulties in at least one of the seven domains of ADL and IADL. Regression and mediation analyses were conducted to analyze the association between IQ and disability, and to identify potential factors involved in this relationship.

*Results:* The prevalence of disability increased from 27.7% in the IQ 120-129 group to 51.0% in the IQ 70-79 group. After adjusting for sex, age and ethnicity, compared to those with IQ scores of 120-129, scores of 110-119, 100-109, 90-99, 80-89, and 70-79 were associated with 1.22 [95% confidence interval (CI): 1.01-1.48], 1.42 (95%CI: 1.16-1.72), 1.86 (95%CI: 1.54-2.25), 2.41 (95%CI: 1.92-3.03), and 4.71 (95%CI: 3.56-6.17) times higher odds for disability, respectively. In addition, there was a positive association between a one SD decrease in IQ and disability (odds ratio=1.53, 95%CI: 1.43-1.63). Finally, income (mediated percentage=26.9%), social class (18.0%) and qualification (11.6%) were the strongest influential factors involved in the relationship between IQ and disability, and these socioeconomic factors collectively explained 37.1% of the association.

*Conclusions:* There was a positive association between low IQ and disability in England, and socioeconomic status explained more than one-third of this relationship.

**Keywords:** intelligence quotient; disability; England; epidemiology

**Introduction**

More than one billion people were affected by some form of disability in the world in 2018 [1]. Because of population ageing and the increasing burden of chronic conditions, the worldwide prevalence of disability is likely to rise in the next decades. Disability is associated with unmet health care needs [2], impaired quality of life [3] and mortality [4]. Therefore, identifying new risk factors for disability is a public health priority.

To the best of our knowledge, to date, there are no studies investigating the association between intelligence quotient (IQ) and disability [i.e., difficulties in activities of daily living (ADL) or instrumental activities of daily living (IADL)] in the general population, despite the fact that previous research has shown that low IQ has a major impact on health. For example, a longitudinal study showed that low IQ was a significant predictor of early mortality in a US population sample followed for several decades, and this association was largely explained by socioeconomic status [5]. Another study conducted in North East Scotland found that low mental ability at age 11 years was a risk factor for decreased functional independence at age 77 years [6]. Finally, there was a positive correlation between IQ and quality of life in a sample of almost 100 elderly patients [7]. It is possible that IQ may lead to disability via structural changes in the brain [8], while several socioeconomic factors (e.g., income [9,10], social class [11,12], education [10,13]) may also play an important mediating role in the IQ-disability relationship.

Given the lack of studies on IQ and disability, and the fact that disability is increasingly common in the UK [14], the goal of this nationally representative study was to investigate the association between IQ and disability in the English general population, and to quantify the extent to which this relationship can be explained by socioeconomic, physical, behavioral, and psychosocial factors.

**Methods**

*Study participants*

This study used data from 7403 people who participated in the 2007 Adult Psychiatric Morbidity Survey (APMS). Full details of the survey have been published elsewhere [15,16]. Briefly, this was a nationally representative survey of the English adult population (aged ≥16 years) living in private households. The National Center for Social Research and Leicester University undertook the survey fieldwork in October 2006 to December 2007 using a multistage stratified probability sampling design where the sampling frame consisted of the small user postcode address file, while the primary sampling units were postcode sectors. Participant information was obtained through face-to-face interviews where some of the questionnaire items were self-completed (with the use of a computer). Sampling weights were constructed to account for non-response and the probability of being selected so that the sample was representative of the English adult household population. The survey response rate was 57%. Ethical permission for the study was obtained from the Royal Free Hospital and Medical School Research Ethics Committee. All participants provided informed consent before their inclusion.

*Measures*

*Intelligence quotient (independent variable)*

Verbal IQ was estimated using the National Adult Reading Test (NART). The NART, a brief measure administered only to native English speakers and widely used in the world, consists of a list of 50 words and is scored by counting the number of errors made in reading out the words [17]. The reliability of the NART has been assessed by a split-half technique (Cronbach α) which gave a reliability coefficient of 0.93 compared with the Wechsler Adult Intelligence Scale (WAIS). Previous research has also shown that NART scores are largely unaffected by psychiatric and neurological disorders, underlying the interest of this test in the context of the 2007 APMS [17]. There were 531 participants who were not administered the test (e.g., English not their first language, eyesight problems, dyslexia, refusal). The scores ranged from 70 to 130, and this variable was analyzed as a continuous (scores based on standard deviations), six-category (i.e., 70–79, 80–89, 90–99, 100–109, 110–119, 120–129) or dichotomous variable (i.e., ≤102.5, >102.5; 102.5=mean IQ of the weighted sample) [17]. Verbal IQ is referred to as IQ in this manuscript for the sake of brevity.

*Disability (dependent variable)*

Disability was assessed with seven questions about difficulties in ADL and IADL. Specifically, these questions were on personal care, getting out and about or using transport, medical care, household activities, practical activities, paperwork, and managing money (see **Appendix 1** for details). Disability was used as a binary variable (at least one difficulty in one of the seven ADL/IADL domains: yes or no).

*Control variables*

The present study controlled for sex, age and ethnicity (British White: yes or no).

*Influential variables*

These variables were selected from past literature [9–13,18–29].

*Sociodemographic factors.* These variables included marital status (married/cohabiting or single/widowed/divorced/separated), qualification (i.e., degree, non-degree, A-level, GCSE, other: yes or no), social class (i.e., professional occupations, managerial and technical occupations, skilled occupations – non-manual, skilled occupations – manual, partly skilled occupations, unskilled occupations, armed forces), and income (highest ≥£29826, middle £14057–<£29826 or lowest <£14,057; equivalized income tertiles).

*Obesity.* Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared based on self-reported weight and height. Using the standard World Health Organization (WHO) definition, obesity was defined as ≥30 kg/m2.

*Smoking status.* Smoking was assessed by the question “Have you ever smoked a cigarette?” with answer options “yes” or “no”.

*Alcohol dependence.* Excessive alcohol consumption was screened using the Alcohol Use Disorders Identification Test (AUDIT). Alcohol dependence was assessed with the Severity of Alcohol Dependence Questionnaire (SADQ-C) in participants with an AUDIT score of 10 or above. Scores of four or above indicated alcohol dependence in the past six months [17].

*Drug use.* Each individual was asked if he/she had used in the past year one of the following drugs: cannabis, amphetamines, cocaine, crack, ecstasy, heroin, acid or LSD, magic mushrooms, methadone or physeptone, tranquilizers, amyl nitrate, anabolic steroids, and glues. Those who consumed any of these drugs were considered to be drug users.

*Social support.* This was assessed with a 7-item measure. Using answer options “not true” (score=0), “partly true” (score=1), and “certainly true” (score=2), participants responded to statements which inquired if family and friends did things to make them happy, made them feel loved, could be relied on no matter what, would see that they were taken care of no matter what, accepted them just the way they are, made them feel an important part of their lives, and gave them support and encouragement. Responses were added to create a scale score that could range from 0 to 14. The internal consistency of the scale was good: Cronbach’s a=0.89.

*Statistical analyses*

Differences in the sample characteristics by disability (absent versus present) and IQ (≤102.5 versus >102.5) were tested with Chi-squared tests for categorical variables and Student’s t-tests for continuous variables.

We conducted logistic regression analyses to assess the association between IQ (independent variable: continuous and six-category variable) and disability (dependent variable). These analyses were adjusted for sex, age and ethnicity. Sex and ethnicity were included as categorical variables in the model, while age was included as a continuous variable.

A mediation analysis was further conducted to assess the specific contribution of each potential influential factor in the association between IQ and disability. The khb (Karlson Holm Breen) command in Stata was used for this analysis. This method can be applied in logistic regression models and decomposes the total effect of a variable into direct and indirect effects. Using this method, the percentage of the main association explained by the influential factor can also be calculated (mediated percentage). The mediation analysis was adjusted for sex, age and ethnicity.

The sample weighting and the complex study design were taken into account in all analyses. The level of statistical significance was set at p <0.05. All analyses were performed with Stata version 13.1 (Stata Corp LP, College Station, Texas, USA).

**Results**

This study included 6872 participants [mean age (SD) 46.9 (18.9) years; 51.8% of women]. The prevalence of disability was 32.5% in the overall sample, and mean IQ (SD) was 102.4 (15.4). The characteristics of the population are shown in **Table 1**. Single/widowed/divorced/separated, no qualification, low income, obesity, and smoking were significantly more common among those with a disability or low IQ, while social support was also lower in these two groups. The prevalence of disability increased from 27.7% in the IQ 120-129 group to 51.0% in the IQ 70-79 group (**Figure 1**). After adjusting for sex, age and ethnicity, compared with those with IQ scores of 120-129, scores of 110-119, 100-109, 90-99, 80-89, and 70-79 were associated with 1.22 [95% confidence interval (CI): 1.01-1.48], 1.42 (95%CI: 1.16-1.72), 1.86 (95%CI: 1.54-2.25), 2.41 (95%CI: 1.92-3.03), and 4.71 (95%CI: 3.56-6.17) times higher odds for disability, respectively (**Figure 2**). In addition, there was a positive association between a one SD decrease in IQ and disability [odds ratio (OR)=1.53, 95%CI: 1.43-1.63; data only shown in the text). Finally, income (mediated percentage=26.9%), social class (18.0%) and qualification (11.6%) were the most influential factors in the relationship between IQ and disability (**Table 2**). Collectively, these socioeconomic factors explained 37.1% of the association (data only shown in text).

**Discussion**

*Main findings*

We found in this nationally representative study including almost 6900 adults from England that the prevalence of disability ranged from around 28% in the IQ 120-129 group to 51% in the IQ 70-79 group. Furthermore, after adjusting for sex, age and ethnicity, there was a significant and negative association between IQ and disability. Finally, approximately 37% of the association between IQ and disability was explained by socioeconomic status (i.e., income, social class, qualification). To the best of our knowledge, this is the first study that investigates the association between IQ and disability (i.e., difficulties in ADL and IADL) in the general population.

*Interpretation of the findings*

In line with previous studies showing that socioeconomic factors are major mediators in the association between IQ and health, we observed that these factors explained a substantial share of the IQ-disability relationship. A meta-analysis of 16 studies found that a one SD increase in cognitive test scores undertaken in youth led to a 24% lower risk of all-cause mortality later in life, and that controlling for adult socioeconomic status significantly attenuated the association by 34% [30]. A study conducted among more than 700 individuals from Luxembourg further revealed that childhood intelligence positively predicted functional, subjective and physical health in adulthood, and that this association was entirely mediated by socioeconomic status and education [31]. Finally, it was reported in an UK cohort of more than 17,000 participants followed for several decades that the adjustment for markers of socioeconomic position reduced the strength of the association between high cognitive ability in childhood and healthy diet in adulthood [32].

Low IQ may have a substantial impact on several socioeconomic factors. Previous research showed that cognitive ability at age 11 was correlated with educational achievement at age 16, and accounted variances ranged from 58.6% in Mathematics to 18.1% in Art and Design [13]. IQ at age 12 was further found to have significant effects on occupational status and individual income 40 years later, and between 32% and 48% of this association was mediated by education [33]. Moreover, in a large cohort of Norwegian men, those with low IQ (below 85) were found to have a 4.1-fold increased risk for dropping out of work before the age of 35, and this risk was multiplied by three in the presence of mental health problems [34]. In addition, a study conducted among older persons in China suggested that attending primary school protected against the transition from no disability to disability, and this relationship may have involved a high level of leisure activities [35]. Furthermore, it was observed in another study that four socioeconomic factors (i.e., personal income, average income for the area, income inequality for area, education) significantly predicted disability in several domains (i.e., self-care, hearing, vision, ambulatory function, cognitive function, independent living) [10]. The income-disability relationship may be explained by barriers to care, unhealthy behaviors and perceived stress, while educated individuals may be less likely to develop disability because of a better understanding of health information and the making of informed decisions regarding health.

That being said, more than 60% of the association between intelligence and limitations in ADL and IADL was not explained by these socioeconomic factors. Moreover, the other variables included in the mediation analysis (i.e., marital status, obesity, smoking status, alcohol dependence, drug use, social support) explained less than 10% of this relationship. Thus, it is likely that IQ has a direct effect on disability or that there are other mediators which were not assessed in this current study. For example, physical injuries may be an important mediator in the association between IQ and disability. One cohort study including more than 1,109,000 Swedish men found that a one SD decrease in IQ in early adulthood led to a 1.15-fold increase in the risk of any unintentional injury [36]. This association may involve lower processing skills, lack of psychomotor coordination and unhealthy behaviors. On the other hand, the prevalence of impairments and disabilities is high in survivors of severe physical injuries [37]. Besides, we believe that several unhealthy behaviors not available in the 2007 APMS dataset may be key players in the IQ-disability relationship. It was observed in a cohort from the UK that childhood mental ability was significantly associated with adulthood dietary patterns, and that children with low IQ were less likely to consume vegetables or fruits and were more likely to have a higher intake of chips, cakes or biscuits later in life than those with high IQ [32]. Moreover, a recent French cohort study including elderly persons living in the community showed that, compared with an healthy diet, eating biscuits and snacking led to an increase in the subsequent risk of restricted mobility and IADL limitations in men and of ADL limitations in women [38]. Regarding physical activity, another longitudinal study with approximately 5300 participants found that there was a positive relationship between youth IQ and moderate cardiovascular activity and strength training at middle age [39], while doing exercise or playing sports protected against the risk for ADL difficulties in a five-year survey conducted in Japan [40].

*Clinical implications and directions for future research*

We found that people with low IQ may be at a particular risk for disability and ADL and IADL limitations. Before going further, one has to bear in mind that IQ is rarely assessed in the general adult population. Nevertheless, this score is frequently measured in youths with developmental problems and adults affected by psychiatric conditions. One key measure to prevent disability in low IQ individuals is to act on education and to allow these individuals to receive appropriate health-related information even if they do not attend high school or college. In addition, people with low cognitive abilities should be offered employment suited to their skills, and they should be regularly followed by occupational physicians. Regarding future research, studies of longitudinal design are warranted to corroborate our results. Additional analyses are also needed to investigate the potential influential factors that were not available in the dataset used in this study (e.g., physical injury, dietary behavior, physical activity). Finally, randomized controlled trials should be conducted to assess the effects of educational interventions on the risk of disability in people with low IQ. These educational interventions may be implemented at different levels (e.g., individual, community), while these programs may rely on various channels (e.g., booklets, face-to-face, internet) [41].

*Strengths and limitations*

The use of nationally representative data and the large sample size are two strengths of this study. However, although these findings are of particular interest, there are several limitations that should be acknowledged. First, verbal IQ, which was measured with the NART, was used as a proxy of intelligence, and other components (e.g., numerical, spatial, logical) were not investigated. Second, disability was assessed with seven questions on ADL and IADL only, and there was no data on the type or the severity of disability. More detailed information would have allowed a better estimation of the association between IQ and disability. Third, since this was a cross-sectional study, it was not possible to determine causality or the temporal association of the IQ-disability relationship. Of note, mediation and confounding are distinguishable only on conceptual and not on statistical grounds [42], and thus it was not possible to determine if covariates were mediating or confounding factors.

*Conclusions*

There was a positive association between low IQ and disability in England, and socioeconomic status explained more than one-third of this relationship. Studies of longitudinal design are warranted to corroborate our findings, and future research should focus on additional potential factors involved in this association.

**Acknowledgements**

We would like to thank the National Center for Social Research and the University of Leicester who were the Principal Investigators of this survey. In addition, we would also like to thank the UK Data Archive, the National Center for Social Research, and other relevant bodies for making these data publically available. They bear no responsibility for this analysis or interpretation of this publically available dataset.

**Data availability statement**

The dataset on which the present study was based is publicly available to all interested researchers but they must make a formal request to the UK data service data repository (https://www.ukdataservice.ac.uk/) where the dataset is stored.

**Conflict of interests**

We have no conflict of interest.

**Funding**

None.

**Contributors**

Louis Jacob and Ai Koyanagi designed the study, managed the literature search, undertook the statistical analysis, and wrote the first draft of the manuscript. Lee Smith, Philippe Thoumie, Josep Maria Haro, and Andrew Stickley contributed to the design of the study and the intellectual content. All authors contributed to and have approved the final manuscript.

**References**

[1] World Health Organization. Disability and health 2018. https://www.who.int/news-room/fact-sheets/detail/disability-and-health (accessed March 2, 2019).

[2] McColl MA, Jarzynowska A, Shortt SED. Unmet health care needs of people with disabilities: population level evidence. Disabil Soc 2010;25:205–18. doi:10.1080/09687590903537406.

[3] Wynia K, Middel B, van Dijk JP, De Keyser JHA, Reijneveld SA. The impact of disabilities on quality of life in people with multiple sclerosis. Mult Scler Houndmills Basingstoke Engl 2008;14:972–80. doi:10.1177/1352458508091260.

[4] Majer IM, Nusselder WJ, Mackenbach JP, Klijs B, van Baal PHM. Mortality Risk Associated With Disability: A Population-Based Record Linkage Study. Am J Public Health 2011;101:e9–15. doi:10.2105/AJPH.2011.300361.

[5] Jokela M, Elovainio M, Singh-Manoux A, Kivimäki M. IQ, socioeconomic status, and early death: The US National Longitudinal Survey of Youth. Psychosom Med 2009;71:322–8. doi:10.1097/PSY.0b013e31819b69f6.

[6] Starr JM, Deary IJ, Lemmon H, Whalley LJ. Mental ability age 11 years and health status age 77 years. Age Ageing 2000;29:523–8.

[7] Seymour DG, Starr JM, Fox HC, Lemmon HA, Deary IJ, Prescott GJ, et al. Quality of life and its correlates in octogenarians. Use of the SEIQoL-DW in Wave 5 of the Aberdeen Birth Cohort 1921 Study (ABC1921). Qual Life Res Int J Qual Life Asp Treat Care Rehabil 2008;17:11–20. doi:10.1007/s11136-007-9291-4.

[8] Kilgour AHM, Starr JM, Whalley LJ. Associations between childhood intelligence (IQ), adult morbidity and mortality. Maturitas 2010;65:98–105. doi:10.1016/j.maturitas.2009.09.021.

[9] Irwing P, Lynn R. The relation between childhood IQ and income in middle age. J Soc Polit Econ Stud 2006;31:191–6.

[10] Seto J, Davis J, Taira DA. Examining the Association Between Different Aspects of Socioeconomic Status, Race, and Disability in Hawaii. J Racial Ethn Health Disparities 2018;5:1247–53. doi:10.1007/s40615-018-0471-4.

[11] Clark CD, Gist NP. Intelligence as a Factor in Occupational Choice. Am Sociol Rev 1938;3:683–94. doi:10.2307/2084687.

[12] Ramsay SE, Whincup PH, Morris RW, Lennon LT, Wannamethee SG. Extent of Social Inequalities in Disability in the Elderly: Results From a Population-based Study of British Men. Ann Epidemiol 2008;18:896–903. doi:10.1016/j.annepidem.2008.09.006.

[13] Deary IJ, Strand S, Smith P, Fernandes C. Intelligence and educational achievement. Intelligence 2007;35:13–21. doi:10.1016/j.intell.2006.02.001.

[14] Guzman-Castillo M, Ahmadi-Abhari S, Bandosz P, Capewell S, Steptoe A, Singh-Manoux A, et al. Forecasted trends in disability and life expectancy in England and Wales up to 2025: a modelling study. Lancet Public Health 2017;2:e307–13. doi:10.1016/S2468-2667(17)30091-9.

[15] Jenkins R, Meltzer H, Bebbington P, Brugha T, Farrell M, McManus S, et al. The British Mental Health Survey Programme: achievements and latest findings. Soc Psychiatry Psychiatr Epidemiol 2009;44:899–904. doi:10.1007/s00127-009-0112-7.

[16] McManus S, Meltzer H, Brugha T, Bebbington P, Jenkins R. Adult Psychiatric Morbidity in England, 2007: Results of a Household Survey. London: The NHS Information Centre for Health and Social Care; 2009.

[17] Jacob L, Haro JM, Koyanagi A. Association between intelligence quotient and violence perpetration in the English general population. Psychol Med 2018:1–8. doi:10.1017/S0033291718001939.

[18] Jiang J, Tang Z, Meng XJ, Futatsuka M. Demographic determinants for change in activities of daily living: a cohort study of the elderly people in Beijing. J Epidemiol 2002;12:280–6.

[19] Moore AA, Endo JO, Carter MK. Is there a relationship between excessive drinking and functional impairment in older persons? J Am Geriatr Soc 2003;51:44–9.

[20] Taylor MD, Hart CL, Smith GD, Whalley LJ, Hole DJ, Wilson V, et al. Childhood IQ and marriage by mid-life: the Scottish Mental Survey 1932 and the Midspan studies. Personal Individ Differ 2005;38:1621–30. doi:10.1016/j.paid.2004.09.021.

[21] Lippold T, Burns J. Social support and intellectual disabilities: a comparison between social networks of adults with intellectual disability and those with physical disability. J Intellect Disabil Res JIDR 2009;53:463–73. doi:10.1111/j.1365-2788.2009.01170.x.

[22] Henry BL, Minassian A, Perry W. Effect of methamphetamine dependence on everyday functional ability. Addict Behav 2010;35:593–8. doi:10.1016/j.addbeh.2010.01.013.

[23] Takashima N, Miura K, Hozawa A, Okamura T, Hayakawa T, Okuda N, et al. Cigarette smoking in middle age and a long-term risk of impaired activities of daily living: NIPPON DATA80. Nicotine Tob Res Off J Soc Res Nicotine Tob 2010;12:944–9. doi:10.1093/ntr/ntq121.

[24] Wennerstad KM, Silventoinen K, Tynelius P, Bergman L, Kaprio J, Rasmussen F. Associations between IQ and cigarette smoking among Swedish male twins. Soc Sci Med 1982 2010;70:575–81. doi:10.1016/j.socscimed.2009.10.050.

[25] Backholer K, Wong E, Freak-Poli R, Walls HL, Peeters A. Increasing body weight and risk of limitations in activities of daily living: a systematic review and meta-analysis. Obes Rev Off J Int Assoc Study Obes 2012;13:456–68. doi:10.1111/j.1467-789X.2011.00970.x.

[26] White J, Mortensen LH, Batty GD. Cognitive ability in early adulthood as a predictor of habitual drug use during later military service and civilian life: the Vietnam Experience Study. Drug Alcohol Depend 2012;125:164–8. doi:10.1016/j.drugalcdep.2012.03.024.

[27] Kanazawa S. Childhood intelligence and adult obesity. Obesity 2013;21:434–40. doi:10.1002/oby.20018.

[28] Torres JL, Dias RC, Ferreira FR, Macinko J, Lima-Costa MF, Torres JL, et al. Functional performance and social relations among the elderly in Greater Metropolitan Belo Horizonte, Minas Gerais State, Brazil: a population-based epidemiological study. Cad Saúde Pública 2014;30:1018–28. doi:10.1590/0102-311X00102013.

[29] Sjölund S, Hemmingsson T, Allebeck P. IQ and Level of Alcohol Consumption—Findings from a National Survey of Swedish Conscripts. Alcohol Clin Exp Res 2015;39:548–55. doi:10.1111/acer.12656.

[30] Calvin CM, Deary IJ, Fenton C, Roberts BA, Der G, Leckenby N, et al. Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. Int J Epidemiol 2011;40:626–44. doi:10.1093/ije/dyq190.

[31] Wrulich M, Brunner M, Stadler G, Schalke D, Keller U, Chmiel M, et al. Childhood intelligence and adult health: The mediating roles of education and socioeconomic status. Intelligence 2013;41:490–500. doi:10.1016/j.intell.2013.06.015.

[32] Batty GD, Deary IJ, Schoon I, Gale CR. Childhood mental ability in relation to food intake and physical activity in adulthood: the 1970 British Cohort Study. Pediatrics 2007;119:e38-45. doi:10.1542/peds.2006-1831.

[33] Spengler M, Brunner M, Damian RI, Lüdtke O, Martin R, Roberts BW. Student characteristics and behaviors at age 12 predict occupational success 40 years later over and above childhood IQ and parental socioeconomic status. Dev Psychol 2015;51:1329–40. doi:10.1037/dev0000025.

[34] Lie SA, Tveito TH, Reme SE, Eriksen HR. IQ and mental health are vital predictors of work drop out and early mortality. Multi-state analyses of Norwegian male conscripts. PloS One 2017;12:e0180737. doi:10.1371/journal.pone.0180737.

[35] Chen H, Hu H. The relationship and mechanism between education and functional health status transition among older persons in China. BMC Geriatr 2018;18:89. doi:10.1186/s12877-018-0785-4.

[36] Whitley E, Batty GD, Gale CR, Deary IJ, Tynelius P, Rasmussen F. Intelligence in early adulthood and subsequent risk of unintentional injury over two decades: cohort study of 1,109,475 Swedish men. J Epidemiol Community Health 2010;64:419–25. doi:10.1136/jech.2009.100669.

[37] Anke AG, Stanghelle JK, Finset A, Roaldsen KS, Pillgram-Larsen J, Fugl-Meyer AR. Long-term prevalence of impairments and disabilities after multiple trauma. J Trauma 1997;42:54–61.

[38] Pilleron S, Pérès K, Jutand M-A, Helmer C, Dartigues J-F, Samieri C, et al. Dietary patterns and risk of self-reported activity limitation in older adults from the Three-City Bordeaux Study. Br J Nutr 2018;120:549–56. doi:10.1017/S0007114518001654.

[39] Wraw C, Der G, Gale CR, Deary IJ. Intelligence in youth and health behaviours in middle age. Intelligence 2018;69:71–86. doi:10.1016/j.intell.2018.04.005.

[40] Monma T, Takeda F, Noguchi H, Takahashi H, Tamiya N. The Impact of Leisure and Social Activities on Activities of Daily Living of Middle-Aged Adults: Evidence from a National Longitudinal Survey in Japan. PLOS ONE 2016;11:e0165106. doi:10.1371/journal.pone.0165106.

[41] Ramôa Castro A, Oliveira NL, Ribeiro F, Oliveira J. Impact of educational interventions on primary prevention of cardiovascular disease: A systematic review with a focus on physical activity. Eur J Gen Pract 2017;23:59–68. doi:10.1080/13814788.2017.1284791.

[42] MacKinnon DP, Krull JL, Lockwood CM. Equivalence of the Mediation, Confounding and Suppression Effect. Prev Sci Off J Soc Prev Res 2000;1:173.

**Table 1.** Sample characteristics (overall, by disability, and by intelligence quotient)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Disability | | | Intelligence quotienta | | |
| Characteristics | Category | Overall | Absent | Present | P-valueb | ≤102.5 | >102.5 | P-valueb |
| Sex | Male | 48.2 | 49.2 | 46.0 | 0.019 | 48.7 | 47.7 | 0.452 |
| Female | 51.8 | 50.8 | 54.0 | 51.3 | 52.3 |
| Age (years) | Mean (SD) | 46.9 (18.9) | 43.0 (16.4) | 55.0 (21.2) | <0.001 | 43.8 (19.6) | 49.7 (17.6) | <0.001 |
| British White | No | 8.2 | 9.0 | 6.7 | 0.003 | 10.5 | 6.2 | <0.001 |
| Yes | 91.8 | 91.0 | 93.3 | 89.5 | 93.8 |
| Marital status | Single/widowed/divorced/separated | 36.9 | 33.9 | 43.2 | <0.001 | 43.9 | 30.5 | <0.001 |
| Married/cohabiting | 63.1 | 66.1 | 56.8 | 56.1 | 69.5 |
| Qualification | No | 23.7 | 16.7 | 38.2 | <0.001 | 33.9 | 14.4 | <0.001 |
| Yes | 76.3 | 83.3 | 61.8 | 66.1 | 85.6 |
| Social class | Professional occupations | 5.0 | 6.1 | 2.8 | <0.001 | 2.3 | 7.5 | <0.001 |
| Managerial and technical occupations | 31.6 | 35.0 | 24.6 | 20.1 | 42.2 |
| Skilled occupations – non-manual | 21.5 | 21.7 | 21.2 | 20.6 | 22.4 |
| Skilled occupations – manual | 17.2 | 14.8 | 22.2 | 22.6 | 12.3 |
| Partly skilled occupations | 15.0 | 13.8 | 17.6 | 20.1 | 10.3 |
| Unskilled occupations | 4.2 | 3.2 | 6.2 | 6.9 | 1.7 |
| Armed forces | 0.3 | 0.3 | 0.1 | 0.2 | 0.3 |
| Not applicable | 5.1 | 5.1 | 5.2 | 7.2 | 3.2 |
| Income | Highest | 36.8 | 43.3 | 23.2 | <0.001 | 24.8 | 47.0 | <0.001 |
| Middle | 32.8 | 33.0 | 32.3 | 33.8 | 31.9 |
| Lowest | 30.4 | 23.7 | 44.6 | 41.4 | 21.2 |
| Obesity | No | 82.2 | 84.9 | 76.6 | <0.001 | 80.8 | 83.5 | 0.008 |
| Yes | 17.8 | 15.1 | 23.4 | 19.2 | 16.5 |
| Smoking status | Never | 33.2 | 35.6 | 28.3 | <0.001 | 31.2 | 35.1 | 0.004 |
| Quit/Current | 66.8 | 64.4 | 71.7 | 68.8 | 64.9 |
| Alcohol dependence | No | 91.9 | 91.9 | 92.0 | 0.975 | 91.0 | 92.8 | 0.021 |
| Yes | 8.1 | 8.1 | 8.0 | 9.0 | 7.2 |
| Drug use | No | 90.5 | 90.6 | 90.1 | 0.528 | 88.7 | 92.0 | <0.001 |
| Yes | 9.5 | 9.4 | 9.9 | 11.3 | 8.0 |
| Social supportc | Mean (SD) | 13.2 (1.9) | 13.4 (1.6) | 12.9 (2.4) | <0.001 | 13.0 (2.1) | 13.4 (1.6) | <0.001 |

Disability was assessed with seven questions about difficulties in activities of daily living (ADL) and instrumental activities of daily living (IADL) and referred to having difficulty in at least one of the seven items.

a Intelligence quotient (IQ) scores were dichotomized based on the mean IQ of the weight sample (≤102.5 versus >102.5).

b P-values were based on Chi-squared tests except for age and social support (t-tests).

c The variable on social support ranged from 0 to 14, with higher scores representing higher levels of social support.

**Table 2.** Influential factors in the association between intelligence quotient (independent variable) and disability (dependent variable)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total effect | | Direct effect | | Indirect effect | |  |
|  | OR [95%CI] | P-value | OR [95%CI] | P-value | OR [95%CI] | P-value | %Mediated |
| Marital status | 1.54 [1.44,1.64] | <0.001 | 1.49 [1.39,1.58] | <0.001 | 1.04 [1.03,1.05] | <0.001 | 8.4 |
| Qualification | 1.52 [1.43,1.63] | <0.001 | 1.45 [1.35,1.56] | <0.001 | 1.05 [1.03,1.08] | <0.001 | 11.6 |
| Social class | 1.53 [1.43,1.63] | <0.001 | 1.42 [1.32,1.52] | <0.001 | 1.08 [1.05,1.10] | <0.001 | 18.0 |
| Income | 1.56 [1.45,1.68] | <0.001 | 1.39 [1.28,1.49] | <0.001 | 1.13 [1.10,1.16] | <0.001 | 26.9 |
| Obesity | 1.52 [1.42,1.63] | <0.001 | 1.51 [1.41,1.61] | <0.001 | 1.01 [1.00,1.02] | <0.001 | 2.4 |
| Smoking status | 1.53 [1.44,1.63] | <0.001 | 1.52 [1.43,1.62] | <0.001 | 1.01 [1.00,1.01] | 0.008 | 1.4 |
| Alcohol dependence | 1.53 [1.43,1.63] | <0.001 | 1.53 [1.43,1.63] | <0.001 | 1.00 [1.00,1.00] | 0.828 | NAa |
| Drug use | 1.54 [1.44,1.64] | <0.001 | 1.54 [1.44,1.64] | <0.001 | 1.00 [0.99,1.01] | 0.922 | NAa |
| Social support | 1.53 [1.44,1.64] | <0.001 | 1.49 [1.40,1.59] | <0.001 | 1.03 [1.02,1.04] | <0.001 | 6.1 |

Abbreviations: OR Odds ratio; CI Confidence interval.

Intelligence quotient (IQ) was assessed using the National Adult Reading Test (NART). The standardized continuous IQ variable was used as the exposure variable. Thus, the OR represents the change in OR associated with a 1 standard deviation decrease in IQ scores.

Disability was assessed with seven questions about difficulties in activities of daily living (ADL) and instrumental activities of daily living (IADL) and referred to having difficulty in at least one of the seven items.

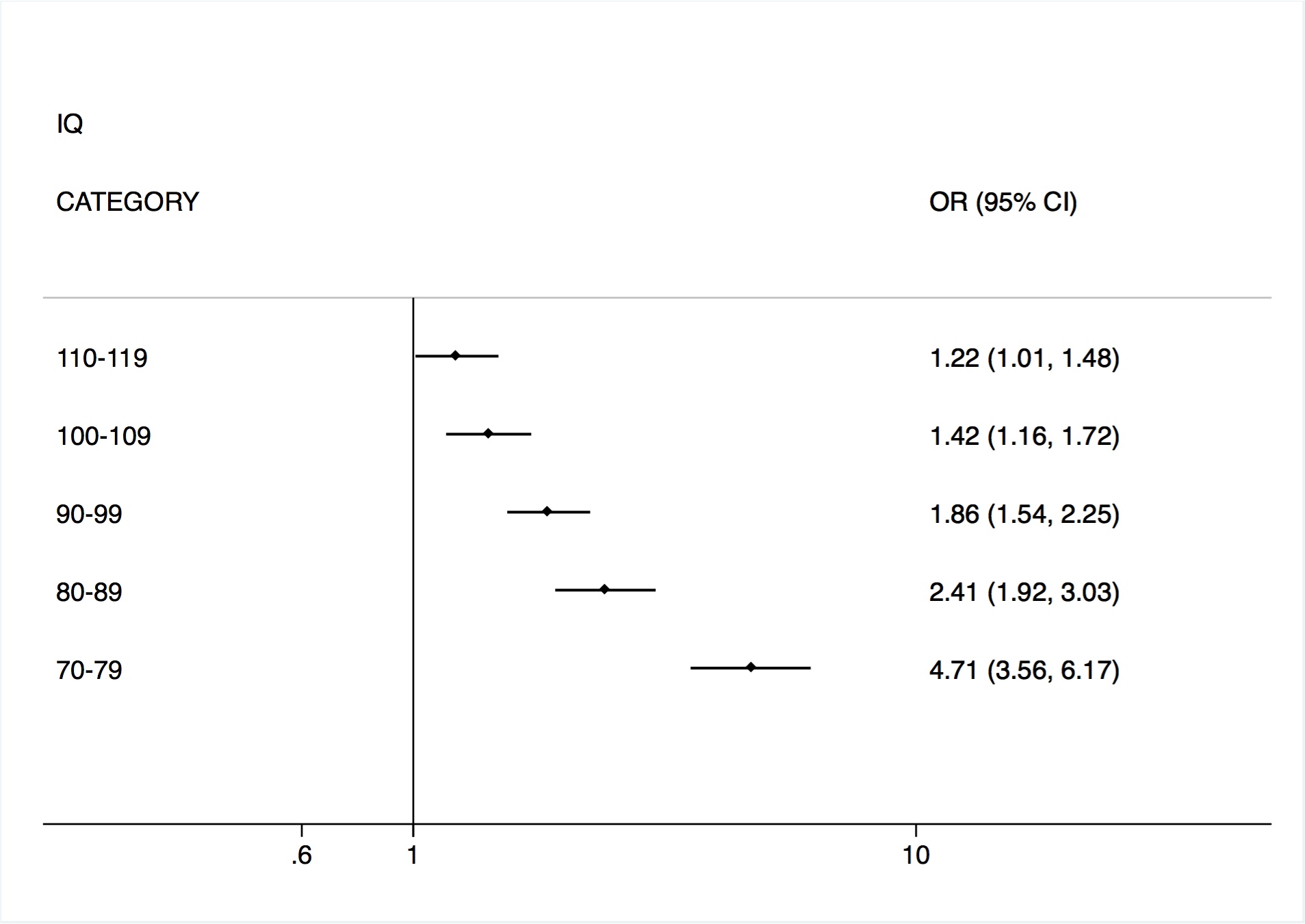
Model was adjusted for sex, age and ethnicity.

a Mediated percentage was only calculated when the indirect effect was significant (P<0.05).

**Figure 1.** Prevalence of disability by intelligence quotient (IQ) score.

IQ was assessed using the National Adult Reading Test (NART).

Disability was assessed with seven questions about difficulties in activities of daily living (ADL) and instrumental activities of daily living (IADL) and referred to having difficulty in at least one of the seven items.



**Figure 2.** Association between intelligence quotient (IQ) and disability estimated by adjusted logistic regression.

Abbreviations: OR, odds ratio; CI, confidence interval.

IQ was assessed using the National Adult Reading Test (NART). Reference category is IQ 120-129.

Disability was assessed with seven questions about difficulties in activities of daily living (ADL) and instrumental activities of daily living (IADL). Disability was used as a binary variable (“0” coded as “0” and “≥1” coded as “1”).

The model was adjusted for sex, age and ethnicity.