



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Intelligence in Early Adulthood and Subsequent Hospitalization for Mental Disorders

Citation for published version:

Gale, CR, Batty, GD, Tynelius, P, Deary, IJ & Rasmussen, F 2010, 'Intelligence in Early Adulthood and Subsequent Hospitalization for Mental Disorders', *Epidemiology*, vol. 21, no. 1, pp. 70-77.
<https://doi.org/10.1097/EDE.0b013e3181c17da8>

Digital Object Identifier (DOI):

[10.1097/EDE.0b013e3181c17da8](https://doi.org/10.1097/EDE.0b013e3181c17da8)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Epidemiology

Publisher Rights Statement:

© Gale, C. R., Batty, G. D., Tynelius, P., Deary, I. J., & Rasmussen, F. (2010). Intelligence in Early Adulthood and Subsequent Hospitalization for Mental Disorders. *Epidemiology*, 21(1), 70-77.
[10.1097/EDE.0b013e3181c17da8](https://doi.org/10.1097/EDE.0b013e3181c17da8)

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



In press Epidemiology 2009

Intelligence in early adulthood and subsequent hospitalisation and admission rates for the whole range of mental disorders: longitudinal study of 1,049,663 men

Catharine R. Gale^a, G. David Batty^{b,c}, Per Tynelius^d,
Ian J. Deary^c, Finn Rasmussen^d

^aMRC Epidemiology Resource Centre, University of Southampton, Southampton, UK

^bMRC Social & Public Health Sciences Unit, University of Glasgow, Glasgow, UK

^cUniversity of Edinburgh Centre for Cognitive Ageing and Cognitive Epidemiology,
Department of Psychology, University of Edinburgh, Edinburgh, UK

^dDepartment of Public Health Sciences, Karolinska Institute, Stockholm, Sweden

Pre-publication correspondence to: Catharine Gale, MRC Epidemiology Resource Centre (University of Southampton), Southampton General Hospital, Southampton, SO16 6YD, UK. Tel: 44 23 8076 4080. Fax: 44 23 80704021.

Email: crg@mrc.soton.ac.uk

Post-publication correspondence to: Finn Rasmussen, Department of Public Health Sciences, Karolinska Institutet, Norrbacka, SE-17176 Stockholm Sweden. Tel: +46-8-7373827. Fax: +46-8-7373840.

E-mail: finn.rasmussen@ki.se

Running head: IQ and hospitalisation for the range of mental disorders

Financial support: The University of Edinburgh Centre for Cognitive Ageing and Cognitive Epidemiology is supported by the Biotechnology and Biological Sciences Research Council, the Economic and Social Research Council, the Engineering and Physical Sciences Research Council and the Medical Research Council, as part of the Lifelong Health and Wellbeing Initiative. The Medical Research Council (MRC) Social and Public Health Sciences Unit receives funding from the MRC and the Chief Scientist Office at the Scottish Government Health Directorates. David Batty is a UK Wellcome Trust Fellow (WBS U.1300.00.006.00012.01). Finn Rasmussen is supported by the Swedish Council for Working Life and Social Research.

ABSTRACT

Background: Lower intelligence is a risk factor for several specific mental disorders, but it is unclear whether it is a risk factor for all mental disorder or whether it is associated with illness severity. We examined the relation between pre-morbid intelligence and risk of hospital admission and total admission rates for the whole range of mental disorders.

Methods: Participants were 1,049,663 Swedish men who took tests of intelligence on conscription into military service and were followed up for hospital admissions for mental disorder for a mean of 22.6 years. *International Classification of Diseases* diagnoses were recorded at discharge from hospital.

Results: Risk of hospital admission for all categories of disorder rose with each point decrease in the nine-point IQ score. For a standard deviation decrease in IQ, age-adjusted hazard ratios (95% CI) were 1.60 (1.55, 1.65) for schizophrenia, 1.49 (1.45, 1.53) for other non-affective psychoses, 1.50 (1.47, 1.51) for mood disorders, 1.51 (1.48, 1.54) for neurotic disorders, 1.60 (1.56, 1.64) for adjustment disorders, 1.75 (1.70, 1.80) for personality disorders, 1.75 (1.73, 1.77) for alcohol-related and 1.85 (1.82, 1.88) for other substance use disorders. Lower intelligence was associated with greater comorbidity. Associations changed little on adjustment for potential confounders. Men with lower intelligence had higher total admission rates, a possible marker of clinical severity.

Conclusions: Lower intelligence is a risk factor for the whole range of mental disorders and for illness severity.

Introduction

Findings from longitudinal studies suggest that poorer performance on tests of cognitive ability in childhood or adolescence may indicate vulnerability to some forms of mental disorder. Lower scores on standard tests of intelligence have consistently been associated with an increased risk of schizophrenia,¹ and, more recently, with risk of post-traumatic stress disorder.²⁻⁵ There is less evidence on whether cognitive ability in early life is related to risk of other specific mental disorders, though some studies have found links between poorer cognition and later onset of severe depression,^{3,6,7} generalized anxiety disorder,^{3,7,8} social phobia,⁷ non-affective psychoses,⁶ and alcohol or other substance use abuse or dependence.^{3,9}

Observations in a Danish cohort suggest that IQ scores may indicate risk for a wider range of mental disorders.¹⁰ In this small study, comparison of IQ test scores at around age 19 showed that men subsequently admitted to hospital for schizophrenia, other psychoses, personality disorders, adjustment disorders, alcohol and other substance use disorders gained lower scores than those who had not been hospitalised.

Whether cognitive ability in early life is a risk factor not just for the occurrence of mental disorder, but also for severity of illness is unclear. In 806 men admitted to hospital for psychoses, no associations were found between IQ scores in late adolescence and number of hospital admissions.⁶ However, there is evidence that people with a lower IQ in childhood are more likely to have contact with psychiatric services.¹¹ This observation, coupled with findings linking IQ with several forms of mental disorder,^{3,10} and with comorbidity,^{3,7} suggests that it may be a risk factor for more severe illness. People with psychiatric comorbidity experience higher levels of distress,¹² greater functional

disability,¹³ make more use of psychiatric services,^{12,14} and have a longer duration of illness.¹⁵

We used data on over one million Swedish men who took tests of cognitive ability in early adulthood and were followed up for psychiatric hospital admissions for an average of 22.6 years. We examined the relation between IQ and risk of admission and admission rates for mental disorders across the diagnostic spectrum.

Methods

Study participants and record-linkage of registers

The record linkage methods used to generate this cohort study have been reported previously.^{16,17} In brief, the cohort comprised all non-adopted men born in Sweden from 1950 to 1976 for whom both biological parents could be identified in the Multi-Generation Register. Using unique personal identification numbers we linked the Multi-Generation Register with the Military Service Conscription Register, Population and Housing Censuses records (1960 and 1970), the Cause of Death Register, and the National Hospital Discharge Register. This resulted in 1,346,545 successful matches. Study approval was obtained from the Regional Ethics Committee, Stockholm.

Conscription examination

The military service conscription examination involves a structured, standard medical assessment of physical and mental health, and cognitive function. During the years covered by this study, the law required this examination; only men of foreign citizenship or those with severe disability were excused. This dataset covers examinations from 15

September 1969 to 31 December 1994, after which procedures for measuring IQ changed. Average age at examination was 18.3 years (range: 16 to 25).

IQ was measured by four written subtests representing verbal, logical, spatial, and technical abilities.⁶ All test scores – including a total IQ score derived from summing the subtests results – were standardized to give a Gaussian-distributed score between 1 and 9. Higher values indicate greater intellectual capacity. The logical test measures capacity to understand written instructions and apply them to solving a problem. Items from the spatial test depicted a plan drawing of an object in its pre-assembled, two-dimensional state. Respondents were required to identify, from drawings of fully-assembled, three-dimensional objects, which it represented. The verbal test measures knowledge of synonyms. Respondents were required to determine which out of four alternatives is the synonym of a given word. The technical test measures knowledge of chemistry and physics and implies the assessment of a component of general knowledge. Correlation coefficients among the four IQ subtests ranged from 0.48 to 0.70, $p < 0.001$. As associations between the subtests and the study outcomes were very similar to those obtained using the total IQ score, we present results for total IQ score only.

Men underwent a medical examination, including a structured interview by a psychologist. A psychiatrist assessed men who reported psychiatric symptoms. Diagnoses were made according to the *International Classification of Disease (ICD)* versions 8 or 9.

Inpatient episodes

The Swedish National Hospital Discharge Register has covered virtually all in-patient care for psychiatric disorders (including hospital admissions at forensic psychiatric clinics) since 1973, with the exception of admissions in a few counties during some of the early years of data collection.¹⁸ Admissions were coded according to the *International Classification of Disease* versions 8, 9 or 10. We extracted data on psychiatric admissions from 1968 to December 31st 2004. We grouped diagnoses (primary and secondary) into the following categories: 1) schizophrenia (ICD-8/9: 295; ICD-10: F20); 2) other non-affective psychotic disorders (excluding alcohol or drug psychoses) (ICD-8/9: 297, 298.2-9; ICD-10: F21-F29); 3) mood disorders (ICD-8/9: 296, 298.0, 298.1; ICD-9: 311; ICD-10: F30-F39); 4) neurotic and somatoform disorders (excluding adjustment disorders) (ICD-8: 305; ICD-8/9: 300; ICD-9:306; ICD-10: F40-F42 and F44-F49); 5) adjustment disorders (ICD-8: 307, 308.4; ICD-9: 308-309; ICD-10: F43); 6) personality disorders (ICD-8/9: 301; ICD-10: F60-F61, F69). 7) alcohol-related disorders (including alcoholic psychoses) (ICD-8/9: 291, 303; ICD-9: 305.0; ICD-10: F10); 8) other substance use disorders (including drug psychoses) (ICD-8: 294.3; ICD-9: 292, 305.1-8; ICD-8/9: 304; ICD-10: F11-F19; and 9) all diagnoses of mental disorder not included in the above eight categories, but excluding diagnoses of mental retardation.

Analytical sample

Of 1,346,545 men whose records were matched, 1,138,048 had complete data on IQ and psychiatric diagnoses from the conscription examination, together with data from the Population and Housing Censuses on parental age and socioeconomic status. As prior psychiatric disorder might have affected performance on the IQ test, we excluded men diagnosed with psychiatric disorder at conscription or admitted to hospital with a

psychiatric disorder before conscription (n=88,385). Analyses are based on the remaining 1,049,663 men.

Statistical methods

We used ANOVA and the χ^2 to examine the relation between the nine-point total IQ score and study covariates. We used Cox proportional hazards regression to calculate relative risks of hospital admission for each diagnostic category per standard deviation (SD) decrease in the nine-point total IQ score and by IQ categories. Survival time in days was calculated from date of conscription to date of first hospital admission for the diagnosis being considered, date of death, date of emigration, or 31st December 2004, whichever occurred first. 90.1% of the participants were followed up to 31st December 2004. We adjusted for age at conscription, conscription testing centre, and year of testing, and then in addition for the potential confounding factors, parental age at birth¹⁹ and parental socioeconomic status. The latter variable was based on the highest socioeconomic status of either parent in the 1960 or 1970 Census, classified in 5 categories: nonmanual (high/intermediate), nonmanual (low), skilled, unskilled, and other. (As the presence of severe mental disorder is likely to have affected the men's educational attainment and adult socioeconomic status, we did not adjust for these factors). We defined comorbidity as having received diagnoses from two or more different diagnostic categories, either simultaneously or sequentially. We used logistic regression to examine the relation between IQ and risk of comorbidity. We calculated survival time and total number of admissions in each diagnostic category for each of the nine-point IQ categories. From these, we calculated total admissions per 1000 person-years. We compared observed admissions with those expected (the rate of admissions assuming no difference between

IQ categories). We calculated 95% confidence intervals (CI) on the assumption that the observed values had a Poisson distribution.²⁰

Results

Table 1 shows the distribution of the participants according to the nine-point total IQ scale, and the correlation between the IQ scale and the study covariates. Men with higher IQ scores were less likely to have parents in unskilled occupations. Higher IQ was also associated with older age at conscription and with older maternal and paternal age at birth.

During the follow-up period, 52,487 men (5.0%) had at least one admission to hospital. Median length of stay was 4 days (interquartile range 1-12). 53% of men received diagnoses from more than one category. Table 2 shows the number of men in each diagnostic category and, for each category, the three most frequent comorbid disorders.

Table 3 shows the hazard ratios for having at least one admission for each type of mental disorder per SD decrease in IQ score. In analyses adjusting for age at conscription, birth year and conscript testing centre, lower IQ was associated with an increase in risk of admission for all types of disorder. Further adjustment for parental age had little or no effect on these estimates. Adjustment for parental socioeconomic status slightly strengthened associations between IQ and risk of admission for schizophrenia, other non-affective psychoses, and disorders not otherwise categorized, but had little or no attenuating effect on the other associations. The estimates remained unchanged on full adjustment for all covariates. Additional adjustment for parental education in the subset (95%) with these data had little effect on these estimates (data not shown). To investigate whether any of these associations were explained by the link between IQ and other,

comorbid disorders, we re-ran the fully-adjusted models after the exclusion of men with comorbidity. This exclusion had no effect on the association between IQ and risk of admission from other substance use disorders, and very little attenuating effect on the association between IQ and risk of admission for schizophrenia. Estimates for the relation between IQ and risk of admission for all other diagnostic categories were attenuated to a larger degree but all associations remained strong.

As undiagnosed psychiatric disorder present at the time of conscription might have affected IQ scores, we repeated our analyses excluding men who were admitted to hospital within five years of conscription. This had essentially no effect on our findings.

We examined whether the relation between IQ and risk of admission for each type of disorder varied over time by stratifying according to whether first admission occurred up to 1981, 1982-93, or 1994-2004. Risk estimates differed little according to period of admission.

The relation between IQ and risk of hospital admission for each diagnostic category was evident across the range of IQ scores, with the largest increase in risk observed in men with the lowest IQ (Figure 1).

Lower IQ was associated with an increased risk of dual or multiple diagnoses. For a SD decrease in IQ, the age-adjusted odds ratios for receiving diagnoses in two or more, four or more, or six or more diagnostic categories were 1.71 (95% CI 1.68, 1.73), 1.95 (95% CI 1.88, 2.04), and 2.06 (1.91, 2.22) respectively.

Figure 2 shows for each diagnostic category, the total admissions rate per 1000 person-years in each of the IQ categories, and the ratio of the observed rate to the rate that would be expected, assuming no difference by IQ. In general, there was a consistent dose-response relation, such that the admissions rate for each type of disorder was highest in those with the lowest IQ and fell with each one-point increment in IQ category. The steepest gradients in rate of admissions across IQ categories were for other substance use and alcohol-related disorders, followed by personality disorders: men with the lowest IQ had risks of admissions for these three types of disorder that were respectively 27.8, 20.5 and 17.8 times higher than men with the highest IQ. Observed/expected ratios showed that for all types of disorder, men in the lowest four IQ categories had admission rates that were higher than expected from rates in the whole study population, while those in the highest five IQ categories had lower than expected admission rates. Men with the lowest IQ had admissions for the various types of disorder that were between 2.70 (95% CI 2.60, 2.80) and 4.77 (95% CI 4.55, 5.01) times higher than expected. Men with the highest IQ had admissions that were between 0.13 (95% CI 0.12, 0.14) and 0.60 (95% CI 0.54, 0.65) those expected (see on-line appendix).

Discussion

In this study, lower pre-morbid IQ was associated with a higher risk of being admitted to hospital for the whole spectrum of mental disorders. Men with lower IQ appeared to be at increased risk of more severe illness: for each diagnostic category, total number of admissions per 1000 person-years of follow-up were highest in men with the lowest IQ and fell as IQ increased.

Previous studies

Most investigations into the relation between IQ in early life and subsequent psychiatric disorder have concentrated on one or two disorders, limiting insights into specificity of association. However, these studies have demonstrated consistently that lower IQ is linked with an increased risk of schizophrenia¹ and post-traumatic stress disorder.^{2-5,21} There have been fewer studies of other disorders. Lower cognitive ability has been associated with increased risk of depression,^{3,6,7} generalized anxiety disorder,^{3,7,8} anxiety disorders in general,⁷ psychological distress,^{22,23} bipolar disorder,²⁴ non-affective psychoses,^{6,24} and alcohol or other substance abuse or dependence,^{3,9} although some studies have found no such associations.^{6,25} In two UK birth cohorts, alcohol problems were associated with a higher IQ in childhood,^{23,26} contrary to the results of other studies.^{3,9}

Some indication that IQ in early life might be a risk factor for psychiatric disorders in general has come from observations in Denmark that men admitted to hospital for several different types of disorder had poorer prior cognition.¹⁰ Mood and neurotic disorders were not linked with IQ, but the study may have lacked power to detect such differences. A further limitation of this study was that it is impossible to rule out the possibility that the lower IQ of men later admitted to hospital was a consequence of existing illness. A similar caveat applies to a cross-sectional study of Swedish conscripts born 1949-51 in which the prevalence of several types of psychiatric disorder was higher in men with lower IQ.²⁷ The present study, based on considerably larger numbers and excluding men with prior illness, suggests that IQ is a risk factor for the whole range of mental disorders.

Few studies have examined the relation between cognitive ability and illness severity. In a study of 50,087 men, there was no correlation between number of hospital admissions for psychoses and prior IQ, but the authors did not investigate whether admission rates varied according to IQ.⁶ We found that men with a lower IQ had higher than expected total admission rates for all categories of disorder. This suggests that lower IQ may be a risk factor not just for the presence of mental illness *per se*, but also for greater clinical severity. Perhaps this is unsurprising given the strength of the association here between IQ and comorbidity.

Plausible mechanisms

The mechanisms underlying the link between IQ and later risk of psychiatric disorder are unclear. Although the greatest elevations in risk were seen in men at the lowest end of the distribution, each association showed a clear dose-response, with risk falling as IQ score increased. One explanation might be that IQ provides an indicator of the vulnerability of the brain. Lower IQ might be a reflection of impaired neurodevelopment that itself affects the development of psychiatric disorder.^{6,28} Adjustment for birthweight has little or no effect on associations between IQ and risk of psychiatric disorder,^{22,28} though this might be because birthweight is a crude measure of fetal neurodevelopment. Most studies have had limited information on circumstances in early life that might affect cognitive development and future risk of mental illness, but the associations appear robust to adjustment for parental socioeconomic status,^{6,8,10,28} parental psychiatric history,^{6,8,10} and paternal age⁶. A further potential mechanism might be that individuals with lower IQ are more likely as adults to experience socioeconomic disadvantage.²⁹

The apparent vulnerability associated with lower IQ may have genetic causes. There is considerable sharing of genetic risk factors across psychiatric disorders.³⁰⁻³² An investigation of the structure of genetic and environmental risk factors for 10 psychiatric syndromes in twins concluded that whereas shared environmental factors contributed to risk of conduct disorder and adult antisocial behaviour, comorbidity of common psychiatric and substance use disorders resulted predominantly from genetic factors.³³ In the only twin study to examine the extent to which genetic factors might account for the association between IQ and psychiatric disorder, the variance in post-traumatic stress disorder explained by pre-morbid IQ was accounted for entirely by common genetic factors.⁵

Another possible explanation might be that people with a lower IQ are less well equipped to deal with potential stressors. Evidence in children suggests that those with higher intelligence have a more internal locus of control.³⁴ Having a lower perception of control over one's life increases the risk of disorders such as anxiety, depression, and post-traumatic stress disorder,^{35,36} and has been linked with greater use of mental health services.³⁷ It is also possible that people with greater cognitive resources are better able to find a cognitive 'way out' of potentially stressful situations, thus obviating the emotional response, because the stressor has been 'solved'. Children and adolescents of higher intelligence tend to be more resilient to stress.^{38,39} Greater ability to deal with potential stressors may not only reduce the risk of mental health problems, but also enable individuals to deal with acute psychiatric crises without the need for hospital admission. This might help to explain the link between lower IQ and increased admissions.

Strengths and limitations

The main strengths of this study lie in its size. This, coupled with the length of follow-up, gave us more statistical power than previous studies, enabling us to examine the relation of pre-morbid IQ not only with risk of hospital admission for the whole spectrum of mental disorders, but also with admission rates.

The study also has limitations. Firstly, cases of psychiatric disorder during the follow-up period were defined on the basis of hospital admission. While most people with schizophrenia are likely to be admitted to hospital at some stage,⁴⁰ inpatient care for non-psychotic disorders is less common. The men identified as having these disorders in our study are therefore likely to be predominantly those with more severe illness, and, perhaps, those whose coping skills or lack of support networks make them more liable to be offered inpatient treatment. One interpretation of our findings linking IQ to risk of admission for all types of psychiatric disorder might be that people with lower IQ are more likely than those of higher IQ to be offered inpatient care, regardless of the nature of their illness. However, the fact that IQ predicts risk of depression and anxiety,^{3,7,8,22} post-traumatic stress disorder²⁻⁵ and alcohol abuse or dependence³ as defined by structured diagnostic interview or validated questionnaire in non-clinical samples suggests that our findings are a reflection of the greater vulnerability of people with lower IQ to mental disorder in general, and not solely a consequence of the treatment options offered to them.

The second limitation of our study is that it is based on men only. Whether all these findings can be extrapolated to women is uncertain, though similar associations between IQ and subsequent psychological distress have been observed in men and women.²²

Thirdly, despite the exclusion of men with psychiatric disorder at conscription,

undiagnosed illness might have affected performance on the cognitive tests. However, exclusion of men who were admitted to hospital in the first five years of follow-up had little effect, suggesting that reverse causality is unlikely. Fourthly, a subset of this cohort were the subject of previous research into IQ and psychiatric disorder.^{6,27} Although the present study uses the same conscription register, there is virtually no overlap between the study populations: the earlier studies were based on men born 1949-51 and represent around 2% of the present study population, born between 1950 and 1976. Finally, 208,497 men were excluded due to missing data. However, in the 17,169 excluded men with data on IQ, associations were similar to those found in the analytical sample (for example, the age-adjusted HR for alcohol-related disorders, the most common cause of admittance, was 1.82 (95% CI 1.64, 2.00) vs 1.75 (1.73, 1.77) per SD decrease in IQ). This suggests that selection bias is not a major concern.

Our findings imply that many individuals who seek help for mental health problems may have poorer cognitive function that is a reflection of premorbid ability, rather than a consequence of their disorder. Prior cognitive ability might, in the course of mental disorder, affect the success with which people access professional help, the ability to cope with symptoms, and the compliance with treatment.⁴¹

The observation that intelligence is linked to risk of the whole range of mental disorder underlines the importance of investigating whether this association is causal or due to shared aetiology. This shared aetiology might be genes or early experiences that make the brain more vulnerable. To explore this question we need cohort studies that include detailed data on early life circumstances and genetic information. Studies of twins may be particularly informative. To understand whether intelligence is causally linked to

mental disorder, we need to explore psychosocial factors in adult life that might mediate the association. Understanding the extent to which its influence on risk of mental disorder operates via exposure to the various stresses of socioeconomic disadvantage, or via cognitive processes in response to potentially stressful circumstances may point the way to interventions.

References

1. Maccabe JH. Population-based Cohort Studies on Premorbid Cognitive Function in Schizophrenia. *Epidemiol Rev* 2008; **30**:77-83.
2. Breslau N, Lucia VC, Alvarado GF. Intelligence and other predisposing factors in exposure to trauma and posttraumatic stress disorder: a follow-up study at age 17 years. *Arch Gen Psychiatry* 2006; **63**:1238-45.
3. Gale CR, Deary IJ, Boyle SH, et al. Cognitive ability in early adulthood and risk of five specific psychiatric disorders in mid life: the Vietnam Experience Study. *Arch Gen Psychiatry* 2008; **65**:1410-8.
4. Koenen KC, Moffitt TE, Poulton R, Martin J, Caspi A. Early childhood factors associated with the development of post-traumatic stress disorder: results from a longitudinal birth cohort. *Psychol Med* 2007; **37**:181-92.
5. Kremen WS, Koenen KC, Boake C, et al. Pretrauma cognitive ability and risk for posttraumatic stress disorder: a twin study. *Arch Gen Psychiatry* 2007; **64**:361-8.

6. Zammit S, Allebeck P, David AS, et al. A longitudinal study of premorbid IQ Score and risk of developing schizophrenia, bipolar disorder, severe depression, and other nonaffective psychoses. *Arch Gen Psychiatry* 2004; **61**:354-60.
7. Koenen KC, Moffitt TE, Roberts AL, et al. Childhood IQ and Adult Mental Disorders: A Test of the Cognitive Reserve Hypothesis. *Am J Psychiatry* 2008.
8. Martin LT, Kubzansky LD, Lewinn KZ, et al. Childhood cognitive performance and risk of generalized anxiety disorder. *Int J Epidemiol* 2007; **36**:769-75.
9. Osler M, Nordentoft M, Andersen AM. Childhood social environment and risk of drug and alcohol abuse in a cohort of Danish men born in 1953. *Am J Epidemiol* 2006; **163**:654-61.
10. Mortensen EL, Sorensen HJ, Jensen HH, Reinisch JM, Mednick SA. IQ and mental disorder in young men. *Br J Psychiatry* 2005; **187**:407-15.
11. Walker NP, McConville PM, Hunter D, Deary IJ, Whalley LJ. Childhood mental ability and lifetime psychiatric contact - A 66-year follow-up study of the 1932 Scottish Mental Ability Survey. *Intelligence* 2002; **30**:233-45.
12. Andrews G, Slade T, Issakidis C. Deconstructing current comorbidity: data from the Australian National Survey of Mental Health and Well-Being. *Br J Psychiatry* 2002; **181**:306-14.

13. Bijl RV, Ravelli A. Current and residual functional disability associated with psychopathology: findings from the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Psychol Med* 2000; **30**:657-68.
14. Kessler RC. Epidemiology of psychiatric comorbidity. In: Tsuang M, Tohen M, Zahner G, editors. Textbook in psychiatric epidemiology. New York: Wiley-Liss; 1995. 179-198.
15. Kessler RC, McGonagle KA, Zhao S, et al. Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. Results from the National Comorbidity Survey. *Arch Gen Psychiatry* 1994; **51**:8-19.
16. Gunnell D, Magnusson PK, Rasmussen F. Low intelligence test scores in 18 year old men and risk of suicide: cohort study. *BMJ* 2005; **330**:167.
17. Batty GD, Wennerstad KM, Smith GD, et al. IQ in early adulthood and later cancer risk: cohort study of one million Swedish men. *Ann Oncol* 2007; **18**:21-8.
18. Epidemiologiskt Centrum S. Patientregistret. Utskrivningar från slutenvård 1964-2005. Kvalitet och innehåll. Stockholm: Socialstyrelsen; 2006.
19. Ekeus C, Olausson PO, Hjern A. Psychiatric morbidity is related to parental age: a national cohort study. *Psychol Med* 2006; **36**:269-76.
20. Gardner MJ, Altman DG. Statistics with confidence. London: British Medical Journal.; 1989.

21. Macklin ML, Metzger LJ, Litz BT, et al. Lower precombat intelligence is a risk factor for posttraumatic stress disorder. *J Consult Clin Psychol* 1998; **66**:323-6.
22. Gale CR, Hatch SL, Batty GD, Deary IJ. Intelligence in childhood and risk of psychological distress in adulthood: the 1958 National Child Development Survey and the 1970 British Cohort Study. *Intelligence*. In press 2008.
23. Hatch SL, Jones PB, Kuh D, et al. Childhood cognitive ability and adult mental health in the British 1946 birth cohort. *Soc Sci Med* 2007; **64**:2285-96.
24. Tiihonen J, Haukka J, Henriksson M, et al. Premorbid intellectual functioning in bipolar disorder and schizophrenia: results from a cohort study of male conscripts. *Am J Psychiatry* 2005; **162**:1904-10.
25. Fergusson DM, Horwood LJ, Ridder EM. Show me the child at seven II: Childhood intelligence and later outcomes in adolescence and young adulthood. *J Child Psychol Psychiatry* 2005; **46**:850-8.
26. Batty GD, Deary IJ, Schoon I, et al. Childhood mental ability in relation to alcohol drinking problems and consumption in adulthood: the 1970 British Cohort Study. *Am J Public Health* 2008; **98**:2237-43.
27. David AS, Zammit S, Lewis G, Dalman C, Allebeck P. Impairments in cognition across the spectrum of psychiatric disorders: evidence from a Swedish conscript cohort. *Schizophr Bull* 2008; **34**:1035-41.

28. Batty GD, Mortensen EL, Osler M. Childhood IQ in relation to later psychiatric disorder: evidence from a Danish birth cohort study. *Br J Psychiatry* 2005; **187**:180-1.
29. Muntaner C, Eaton WW, Miech R, O'Campo P. Socioeconomic position and major mental disorders. *Epidemiol Rev* 2004; **26**:53-62.
30. Hettema JM, Neale MC, Myers JM, Prescott CA, Kendler KS. A population-based twin study of the relationship between neuroticism and internalizing disorders. *Am J Psychiatry* 2006; **163**:857-64.
31. Middeldorp CM, Cath DC, Van DR, Boomsma DI. The co-morbidity of anxiety and depression in the perspective of genetic epidemiology. A review of twin and family studies. *Psychol Med* 2005; **35**:611-24.
32. Kendler KS, Myers J, Prescott CA, Neale MC. The genetic epidemiology of irrational fears and phobias in men. *Arch Gen Psychiatry* 2001; **58**:257-65.
33. Kendler KS, Prescott CA, Myers J, Neale MC. The structure of genetic and environmental risk factors for common psychiatric and substance use disorders in men and women. *Arch Gen Psychiatry* 2003; **60**:929-37.
34. Gale CR, Batty GD, Deary IJ. Locus of control at age 10 years and health outcomes and behaviors at age 30 years: The 1970 British Cohort Study. *Psychosom Med* 2008; **70**:397-403.

35. Molinari V, Khanna P. Locus of Control and Its Relationship to Anxiety and Depression. *Journal of Personality Assessment* 1981; **45**:314-9.
36. Heinrichs M, Wagner D, Schoch W, et al. Predicting posttraumatic stress symptoms from pretraumatic risk factors: a 2-year prospective follow-up study in firefighters. *Am J Psychiatry* 2005; **162**:2276-86.
37. McWilliams LA, Cox BJ, Enns MW, Clara IP. Personality correlates of outpatient mental health service utilization: findings from the U.S. national comorbidity survey. *Soc Psychiatry Psychiatr Epidemiol* 2006; **41**:357-63.
38. Masten AS, Coatsworth JD, Neemann J, et al. The structure and coherence of competence from childhood through adolescence. *Child Dev* 1995; **66**:1635-59.
39. Fergusson DM, Lynskey MT. Adolescent resiliency to family adversity. *J Child Psychol Psychiatry* 1996; **37**:281-92.
40. Geddes JR, Kendell RE. Schizophrenic subjects with no history of admission to hospital. *Psychol Med* 1995; **25**:859-68.
41. Deary IJ, Gale CR, Stewart MC, Fowkes FG, Murray GD, Batty GD, Price JF. Intelligence and persisting with medication for two years: prospective analysis of a randomized controlled trial of aspirin for asymptomatic atherosclerosis. *Intelligence*. In press 2009.

Table 1: Distribution of IQ scores in 1,049,663 men at conscription and their relation with the study covariates

Covariates	IQ score category								
	1	2	3	4	5	6	7	8	9
No of men	23,018	63,541	102,314	152,104	238,628	188,109	143,368	89,386	49,195
Parent in unskilled occupation, no (%)	9,270 (40.3)	23,293 (36.7)	34,807 (34.0)	46,623 (30.7)	62,991 (26.4)	42,232 (22.5)	26,906 (18.8)	13,542 (15.2)	5,934 (12.1)
Maternal age, mean (SD)	26.9 (6.1)	26.7 (6.0)	26.8 (5.9)	27.0 (5.9)	27.1 (5.7)	27.5 (5.6)	27.7 (5.5)	28.0 (5.3)	28.2 (5.1)
Paternal age, mean (SD)	30.7 (7.3)	30.3 (7.0)	30.2 (6.9)	30.3 (6.8)	30.2 (6.6)	30.6 (6.5)	30.8 (6.4)	31.0 (6.3)	31.1 (6.2)
Age at conscription, mean (SD)	18.2 (0.5)	18.2 (0.5)	18.2 (0.5)	18.3 (0.5)	18.3 (0.5)	18.3 (0.5)	18.4 (0.5)	18.4 (0.5)	18.4 (0.5)

Table 2: Psychiatric diagnoses received during hospital admission (n=52,487)

Diagnostic category	No	Three most common comorbid diagnostic categories (%)
Schizophrenia	4,522	Other non-affective psychoses (46.0) Mood disorders (40.2), Personality disorders (20.0)
Other non-affective psychoses	6071	Mood disorders (43.7), Schizophrenia (34.3), Other substance use disorders (21.8)
Mood disorders	22,146	Alcohol-related disorders (43.4), Other substance use disorders (29.2) Neuroses (20.0)
Neurotic & somatoform disorders	10,472	Mood disorders (42.3), Alcohol-related disorders (30.5), Other substance use disorders (22.3)
Adjustment disorders	7,368	Mood disorders (31.7), Alcohol-related disorders (27.0), Other substance use disorders (19.2)
Personality disorders	5,146	Mood disorders (50.3), Alcohol-related disorders (39.3), Other substance use disorders (35.7)
Alcohol-related disorders	22,804	Other substance use disorders (42.2), Mood disorders (42.2), Neuroses (13.8)
Other substance use disorders	14,712	Alcohol-related disorders (65.4), Mood disorders (43.9), Neuroses (15.9)
Any other diagnoses	6,485	-

Table 3: Hazard ratios (95% CI) for admission to hospital for each category of psychiatric disorder per SD decrease in total IQ score at conscription (n=1,049,663)

Diagnostic category	No of cases (%)	Hazard Ratios (95% CI)				
		Adjustments				
		Age at conscription	Age at conscription and parental age	Age at conscription, and parental socioeconomic status	All covariates	Adjusted for all covariates and excluding cases with comorbidity¶
Schizophrenia	4,522 (0.43)	1.60 (1.55, 1.65)	1.61(1.56, 1.66)	1.66 (1.61, 1.71)	1.66 (1.61, 1.71)	1.64 (1.55, 1.74)
Other non-affective psychoses	6071 (0.57)	1.49 (1.45, 1.53)	1.48 (1.45, 1.53)	1.53 (1.49, 1.57)	1.53 (1.49, 1.57)	1.35 (1.27, 1.44)
Mood disorders	22,146 (2.1)	1.50 (1.47, 1.51)	1.49 (1.47, 1.51)	1.49 (1.47, 1.51)	1.49 (1.47, 1.51)	1.19 (1.16, 1.22)
Neurotic & somatoform disorders	10,472 (1.0)	1.51 (1.48, 1.54)	1.51 (1.48, 1.54)	1.51 (1.48, 1.54)	1.51 (1.48, 1.54)	1.32 (1.27, 1.37)
Adjustment disorders	7,368 (0.70)	1.60 (1.56, 1.64)	1.60 (1.56, 1.64)	1.58 (1.54, 1.62)	1.58 (1.54, 1.62)	1.48 (1.42, 1.53)
Personality disorders	5,146 (0.49)	1.75 (1.70, 1.80)	1.74 (1.69, 1.79)	1.74 (1.69, 1.80)	1.74 (1.68, 1.79)	1.50 (1.39, 1.62)
Alcohol-related disorders	22,804 (2.2)	1.75 (1.73, 1.77)	1.74 (1.72, 1.77)	1.72 (1.69, 1.74)	1.72 (1.69, 1.74)	1.64 (1.60, 1.68)
Other substance use disorders	14,712 (1.40)	1.85 (1.82, 1.88)	1.84 (1.80, 1.87)	1.82 (1.79, 1.86)	1.82 (1.79, 1.85)	1.82 (1.75, 1.90)
Any other diagnoses	6,485 (0.62)	1.55 (1.51, 1.59)	1.55 (1.51, 1.59)	1.58 (1.54, 1.62)	1.58 (1.54, 1.62)	-

*all adjustments include birth year and conscription testing centre. ¶ After exclusion of men with comorbidity, number of cases were: 1333 (schizophrenia), 1219 (other non-affective psychoses), 5120 (mood disorders), 3172 (neuroses), 3142 (adjustment disorders), 745 (personality disorders), 6632 (alcohol-related disorders), and 2476 (other substances use disorders).

**Online appendix: Total admissions for each diagnostic category per 1000 person-years according to IQ score at conscription
(n=1,049,663)**

Diagnostic category	IQ score category								
	1	2	3	4	5	6	7	8	9
Schizophrenia – total admissions	2606	4264	5456	5395	6418	4368	2963	1608	733
Person-years	504607	1416110	206927	3459586	5132428	4206359	3194577	1981144	1078043
Admissions per 1000 person-yrs	5.16	3.01	2.64	1.56	1.25	1.04	0.93	0.81	0.68
Observed/expected (95% CI)	3.56	2.07	1.59	1.07	0.86	0.71	0.64	0.56	0.47
	(3.42, 3.70)	(2.01, 2.14)	(1.55, 1.64)	(1.04, 1.11)	(0.84, 0.88)	(0.69, 0.74)	(0.61, 0.66)	(0.53, 0.59)	(0.43, 0.50)
Other psychoses – total admissions	1385	1954	2437	286	3555	2479	1500	848	484
Person-years	504778	1417279	2307565	3459928	5131438	4206147	3194594	1981162	1077861
Admissions per 1000 person-yrs	2.74	1.38	1.06	0.83	0.69	0.59	0.47	0.43	0.45
Observed/expected (95% CI)	3.65	1.83	1.40	1.10	0.92	0.78	0.62	0.57	0.60
	(3.45, 3.85)	(1.75, 1.92)	(1.35, 1.47)	(1.06, 1.14)	(0.89, 0.96)	(0.75, 0.82)	(0.59, 0.66)	(0.53, 0.61)	(0.54, 0.65)
Mood disorders – total admissions	2992	5948	7752	8899	10297	7113	4450	2679	1129
Person-years	499920	1406305	2294364	3443005	5113801	4194079	3186310	1976931	1075817
Admissions per 1000 person-yrs	5.98	4.23	3.38	2.58	2.01	1.70	1.40	1.36	1.05
Observed/expected (95% CI)	2.70	1.91	1.52	1.17	0.91	0.77	0.63	0.61	0.47

	(2.60, 2.80)	(1.86, 1.96)	(1.48, 1.56)	(1.14, 1.19)	(0.89, 0.93)	(0.75, 0.78)	(0.61, 0.65)	(0.59, 0.64)	(0.45, 0.50)
Neuroses – total admissions	1477	2757	3400	3783	4142	2887	1855	863	345
Person-years	501820	1408842	2296586	3446154	5117945	4196373	3187463	1977871	1076730
Admissions per 1000 person-yrs	2.94	1.96	1.48	1.09	0.80	0.69	0.58	0.44	0.32
Observed/expected (95% CI)	3.18	2.11	1.60	1.18	0.87	0.74	0.63	0.47	0.35
	(3.01, 3.35)	(2.03, 2.20)	(1.54, 1.66)	(1.14, 1.23)	(0.84, 0.90)	(0.71, 0.77)	(0.60, 0.66)	(0.44, 0.50)	(0.31, 0.38)
Adjustment disorders – total admissions	619	1164	1570	1820	1936	1263	733	417	173
Person-years	505013	1415784	2304707	3456452	5129618	4206027	3195130	1981507	1078339
Admissions per 1000 person-yrs	1.23	0.80	0.68	0.53	0.38	0.30	0.23	0.21	0.16
Observed/expected (95% CI)	2.94	1.97	1.65	1.26	0.91	0.72	0.55	0.51	0.39
	(2.71, 3.19)	(1.86, 2.10)	(1.55, 1.72)	(1.20, 1.33)	(0.86, 0.95)	(0.68, 0.76)	(0.50, 0.59)	(0.46, 0.56)	(0.33, 0.45)
Personality disorders – total admissions	1788	2857	2608	3052	3098	1941	1240	578	218
Person-years	503320	1414557	2305783	3458174	5132484	4206054	3195104	1981897	1078328
Admissions per 1000 person-yrs	3.55	2.02	1.13	0.88	0.60	0.46	0.39	0.29	0.20
Observed/expected (95% CI)	4.77	2.72	1.52	1.18	0.81	0.62	0.50	0.40	0.27
	(4.55, 5.01)	(2.61, 2.83)	(1.46, 1.58)	(1.14, 1.23)	(0.78, 0.84)	(0.59, 0.65)	(0.46, 0.52)	(0.36, 0.42)	(0.24, 0.31)
Alcohol-related disorders – total	7920	15981	17865	20456	19525	12031	6869	2942	836

admissions									
Person-years	493990	1393278	2280758	3427212	5102876	4189311	3185006	1978604	1077009
Admissions per 1000 person-yrs	16.0	11.4	7.83	5.97	3.83	2.87	2.16	1.49	0.78
Observed/expected (95% CI)	3.55	2.53	1.74	1.32	0.85	0.64	0.48	0.33	0.17
	(3.47, 3.63)	(2.49, 2.57)	(1.71, 1.76)	(1.30, 1.34)	(0.84, 0.86)	(0.62, 0.65)	(0.46, 0.49)	(0.32, 0.34)	(0.16, 0.18)
Other substance-use disorders – total	3757	8009	9331	9181	10065	5181	2471	1127	295
admissions									
Person-years	499676	1403491	2290001	3440996	5113042	4196770	3189737	1979992	1077897
Admissions per 1000 person-yrs	7.52	5.71	4.07	2.67	1.97	1.23	0.77	0.57	0.27
Observed/expected (95% CI)	3.53	2.68	1.91	1.26	0.92	0.58	0.36	0.27	0.13
	(3.41, 3.65)	(2.62, 2.74)	(1.87, 1.96)	(1.22, 1.28)	(0.90, 0.94)	(0.56, 0.60)	(0.35, 0.38)	(0.25, 0.28)	(0.12, 0.14)
Any other diagnoses – total admissions	1200	1783	1963	2146	2521	1696	1169	638	285
Person-years	503218	1413461	2302896	3454889	5127080	4202675	3192299	1979972	1077507
Admissions per 1000 person-yrs	2.38	1.23	0.85	0.62	0.49	0.40	0.37	0.32	0.26
Observed/expected (95% CI)	4.13	2.19	1.48	1.08	0.85	0.70	0.64	0.56	0.46
	(3.90, 4.39)	(2.08, 2.30)	(1.41, 1.55)	(1.03, 1.13)	(0.82, 0.89)	(0.67, 0.74)	(0.60, 0.67)	(0.52, 0.61)	(0.41, 0.52)

Figure legends

Figure 1a & b: Hazard ratios for admission for different categories of psychiatric disorder according to nine-point IQ scale. Highest IQ score (coded as 9) is the reference group. Estimates are adjusted for age at conscription, birth year, conscription testing centre, parental age and parental socioeconomic status. (n=1,049,663)

Figure 2a: Total number of admissions for schizophrenia, other non-affective psychoses, mood disorders and neuroses & somatoform disorders per 1000 person-years according to nine-point IQ scale, and the observed to expected ratio of total number of admissions. (n=1,049,663)

Figure 2b: Total number of admissions for personality disorders, alcohol-related and other substance use disorders, adjustment disorders, and any diagnoses not otherwise categorized per 1000 person-years according to nine-point IQ scale, and the observed to expected ratio of total number of admissions. (n=1,049,663)

Figure 1a and b

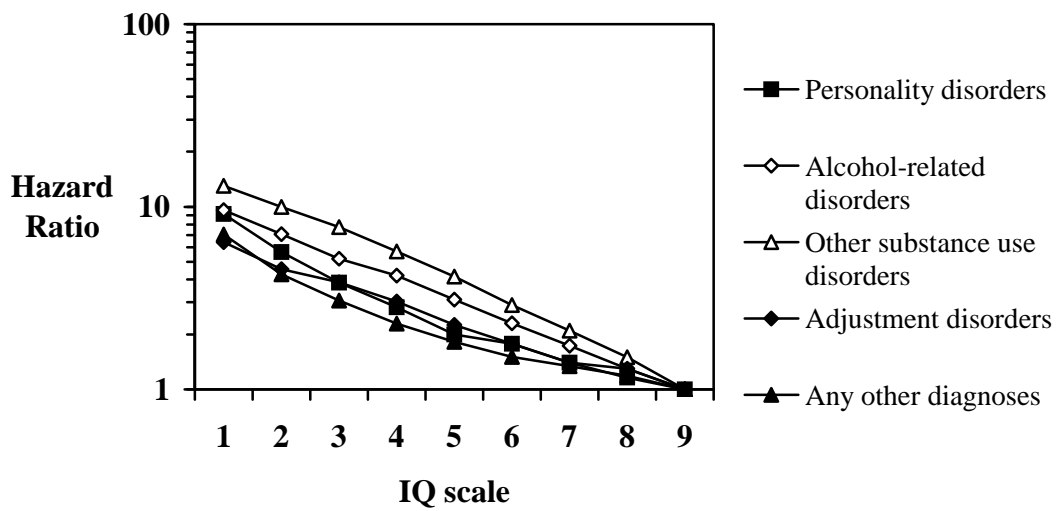
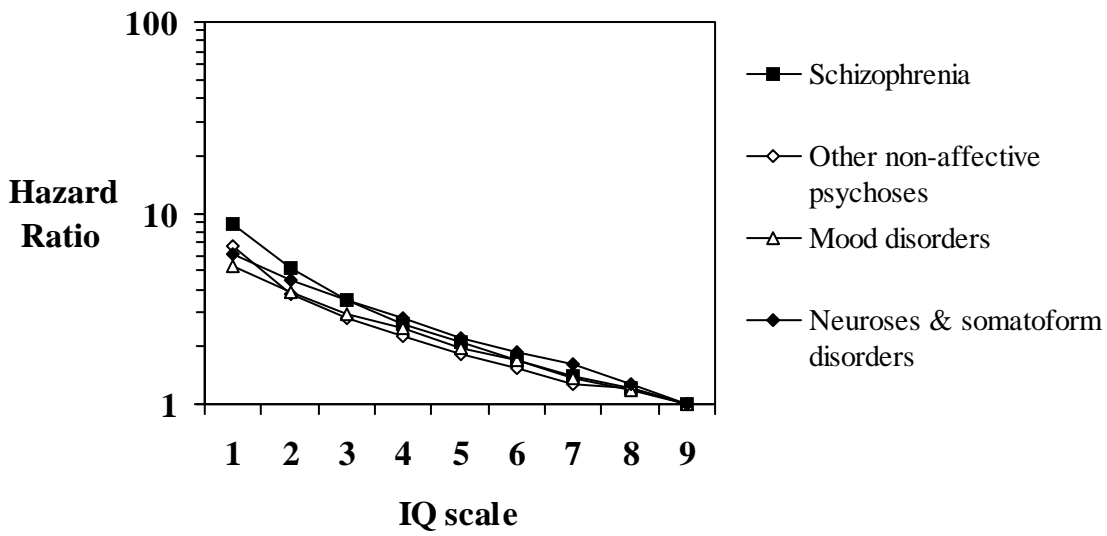


Figure 2a

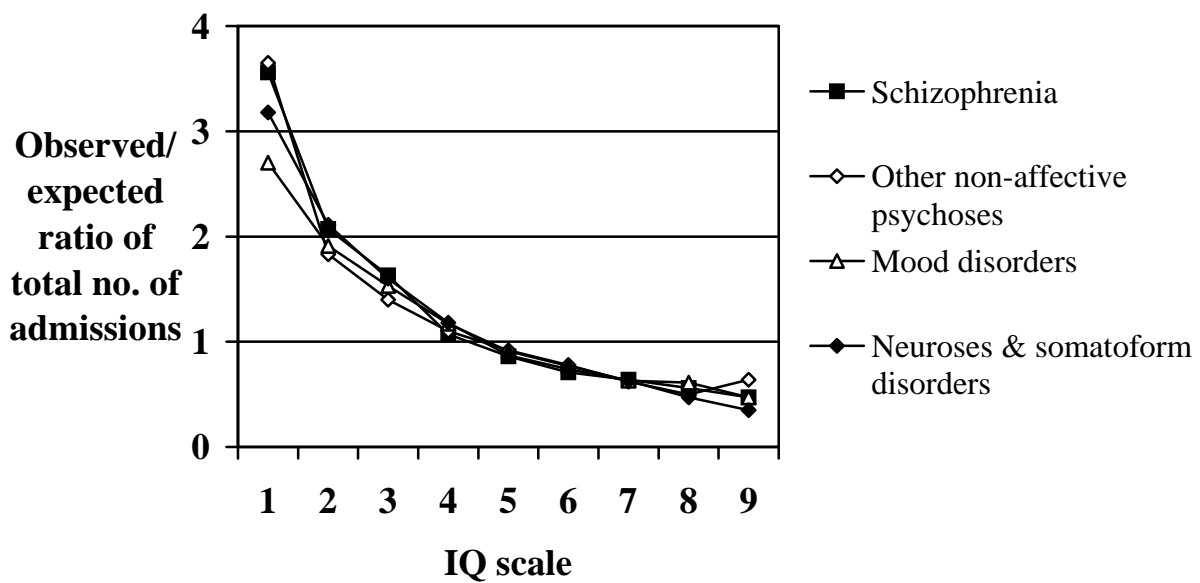
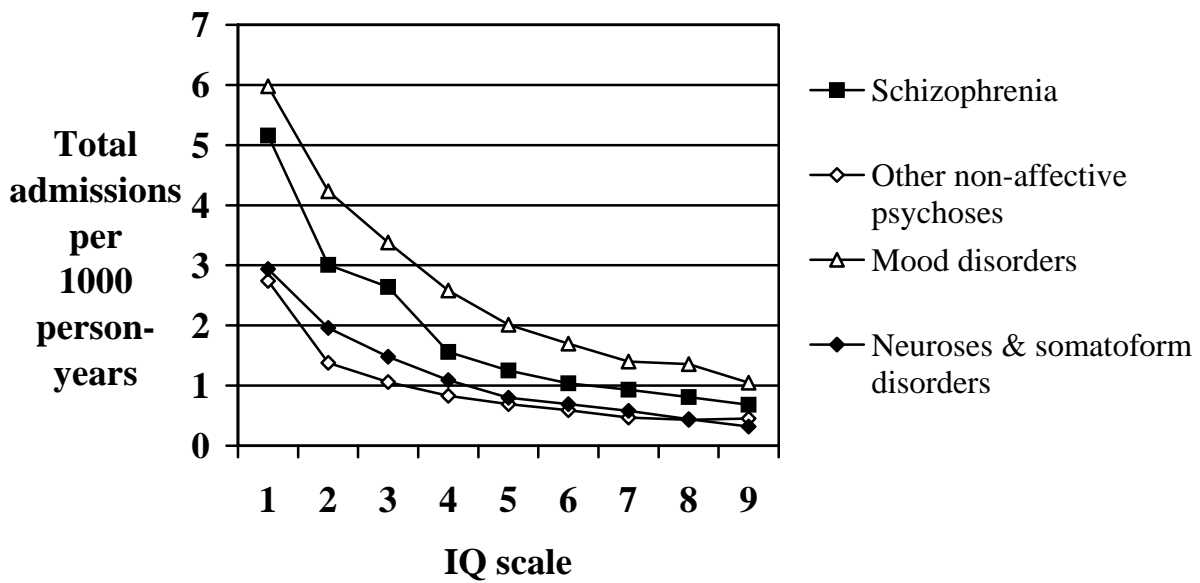


Figure 2b

