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Supplementary Information for

Childhood green space is associated with lower risk of psychiatric disorders

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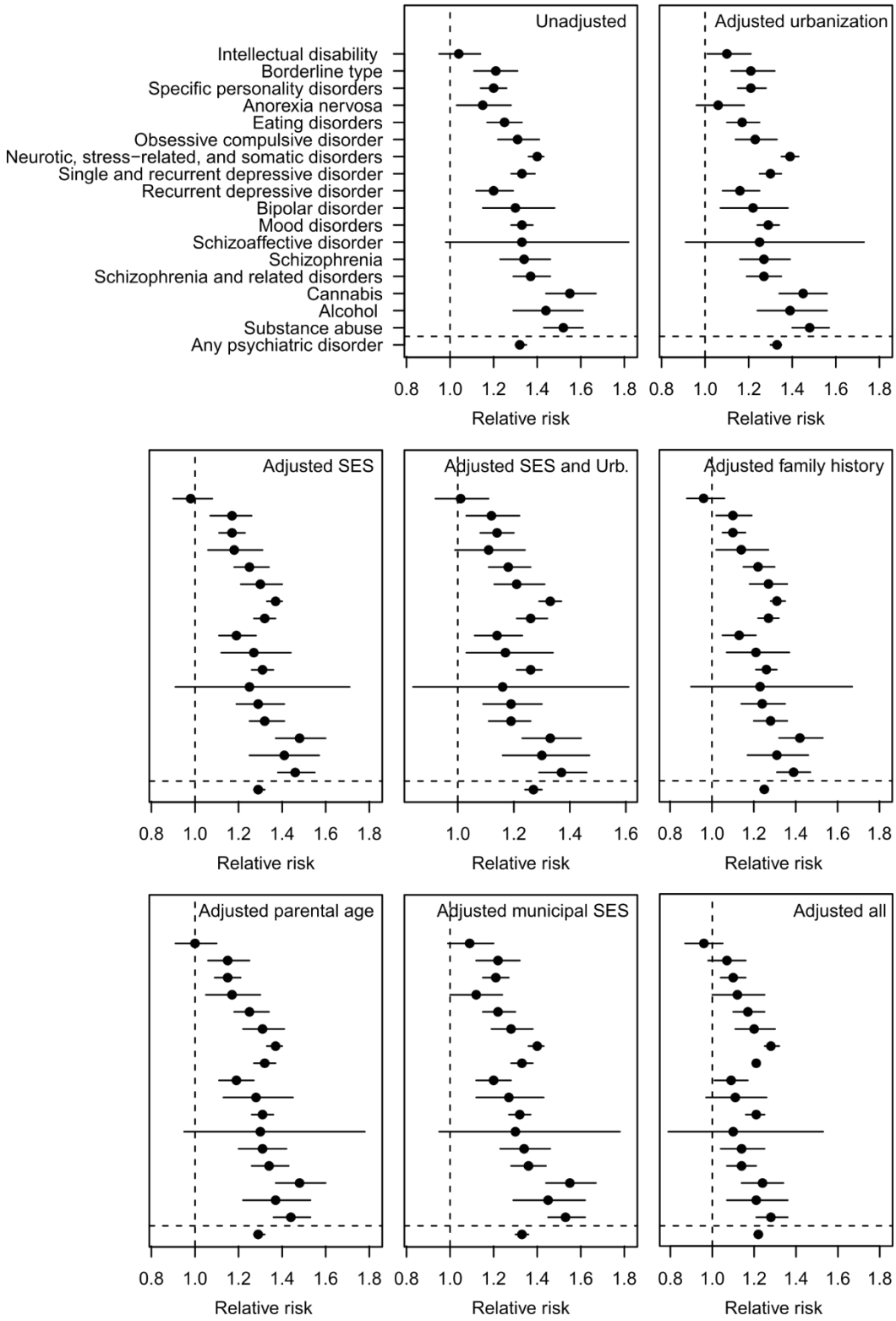

Fig. S1 Effect of potential confounding factors on the association between childhood green space presence and the relative risk of developing a psychiatric disorder later in

life. Green space presence was measured as the mean normalized difference vegetation index (NDVI) within a 210×210m square around place of residence (N = 943 027). Relative risk estimates are relative to the reference level (set to the highest NDVI decile) for NDVI fitted as numeric deciles in classes of ten. Estimates above the hatched line indicate higher risk of developing a given psychiatric disorder for children living at the lowest compared to the highest decile of NDVI. Seven additional models were fitted to test the potential confounding effects of other known risk factors: urbanization (from rural to capital city centre); parents socioeconomic status (SES); the combined effect of urbanization and SES; family history of mental illness measured as previous diagnosis of any of the psychiatric disorders for one or both parents; parental age at birth; municipal SES; and the combined effect of all of these risk factors. Estimates were adjusted for age, year of birth, and gender and plotted with 95% confidence intervals.

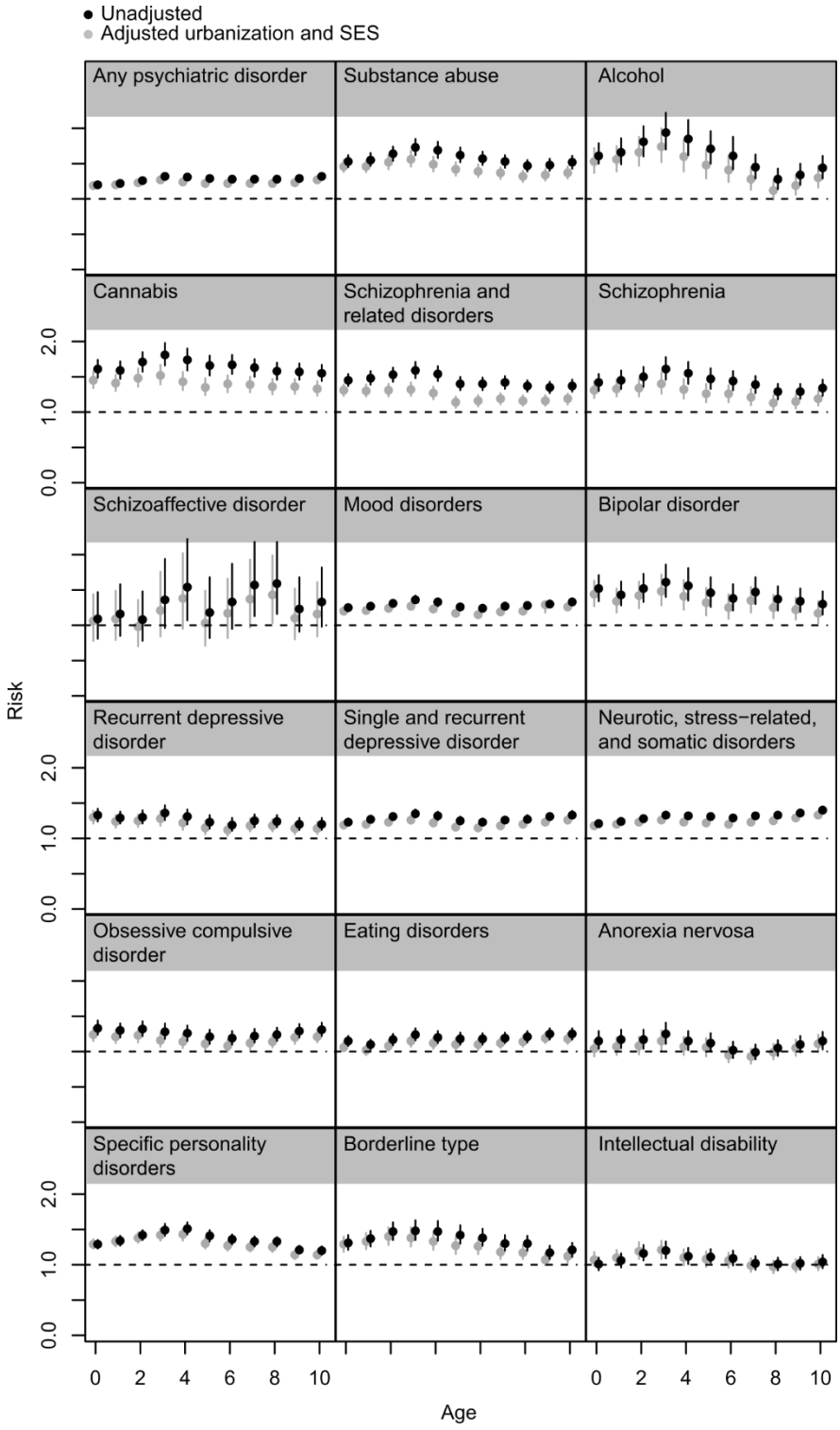

Fig. S2 Relative risk of developing a psychiatric disorder from adolescence into adulthood for childhood green space presence measured at different ages. Separate models were fitted for each age from birth to the 10th birthday (N = 943 027) with mean

NDVI measured each year at place of residence. Additional models were fitted to adjust for urbanization and parental socioeconomic status. Estimates of incidence rate ratio from all models were adjusted for age, year of birth, and gender and plotted with 95% confidence intervals. All estimates are relative to the reference level (set to the highest decile) for NDVI fitted as numeric deciles in classes of ten.

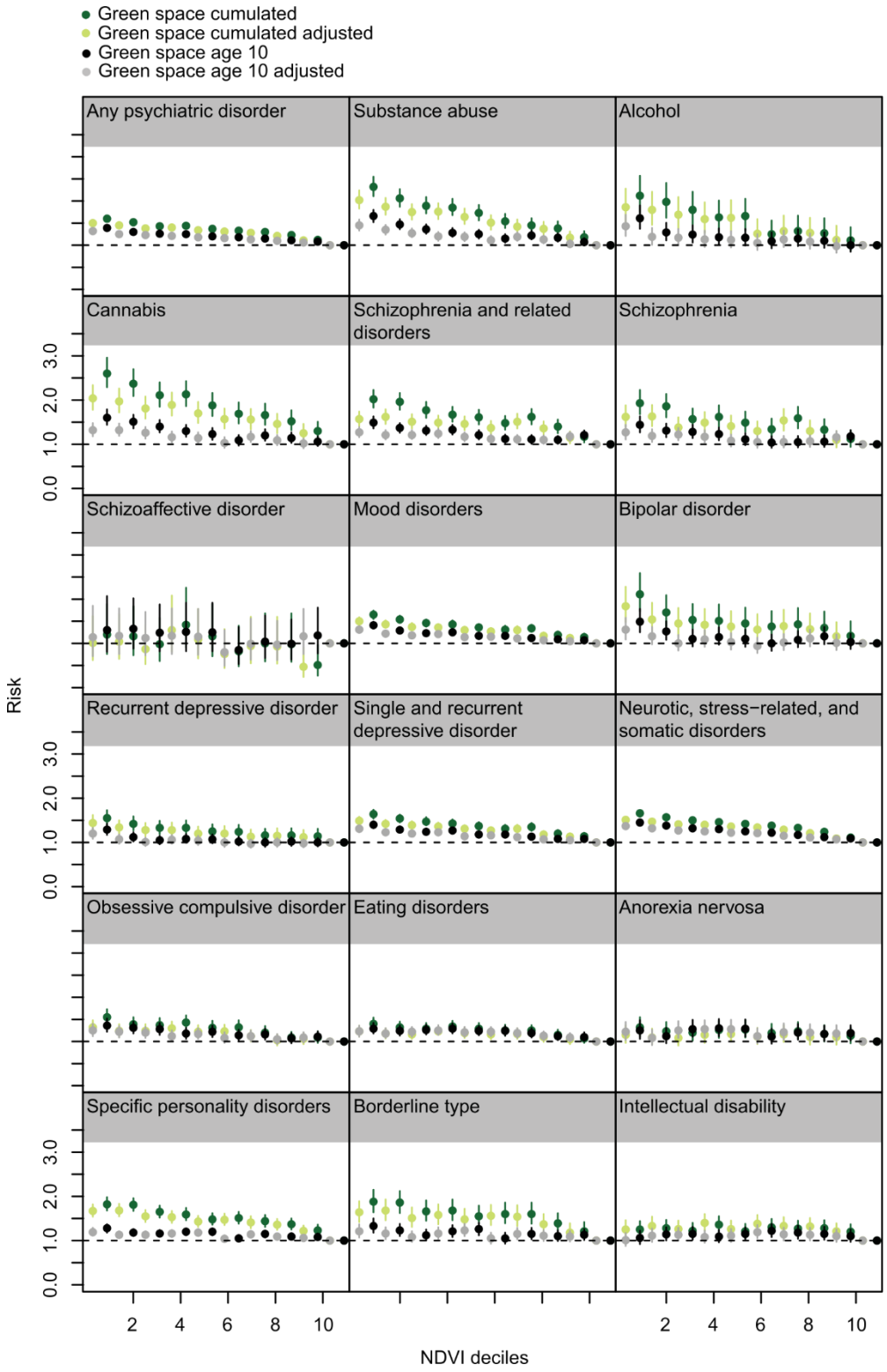

Fig. S3 The association between the relative risk of developing a psychiatric disorder from adolescence into adulthood and green space presence at age 10 compared to

cumulated green space presence. Two models were fitted for each psychiatric disorder to compare green space presence measured as mean NDVI at the 10th birthday (N = 943 027) and the cumulated mean NDVI from birth to the 10th birthday (N = 904 295) both at place of residence. Two additional models were fitted to adjust for urbanization and parents' socioeconomic status for each measure of NDVI. Estimates of incidence rate ratio from all models were adjusted for age, year of birth, and gender and plotted with 95% confidence intervals. All estimates are relative to the reference level set to the highest NDVI decile and shown with the same y-axis for easy comparison between disorders.

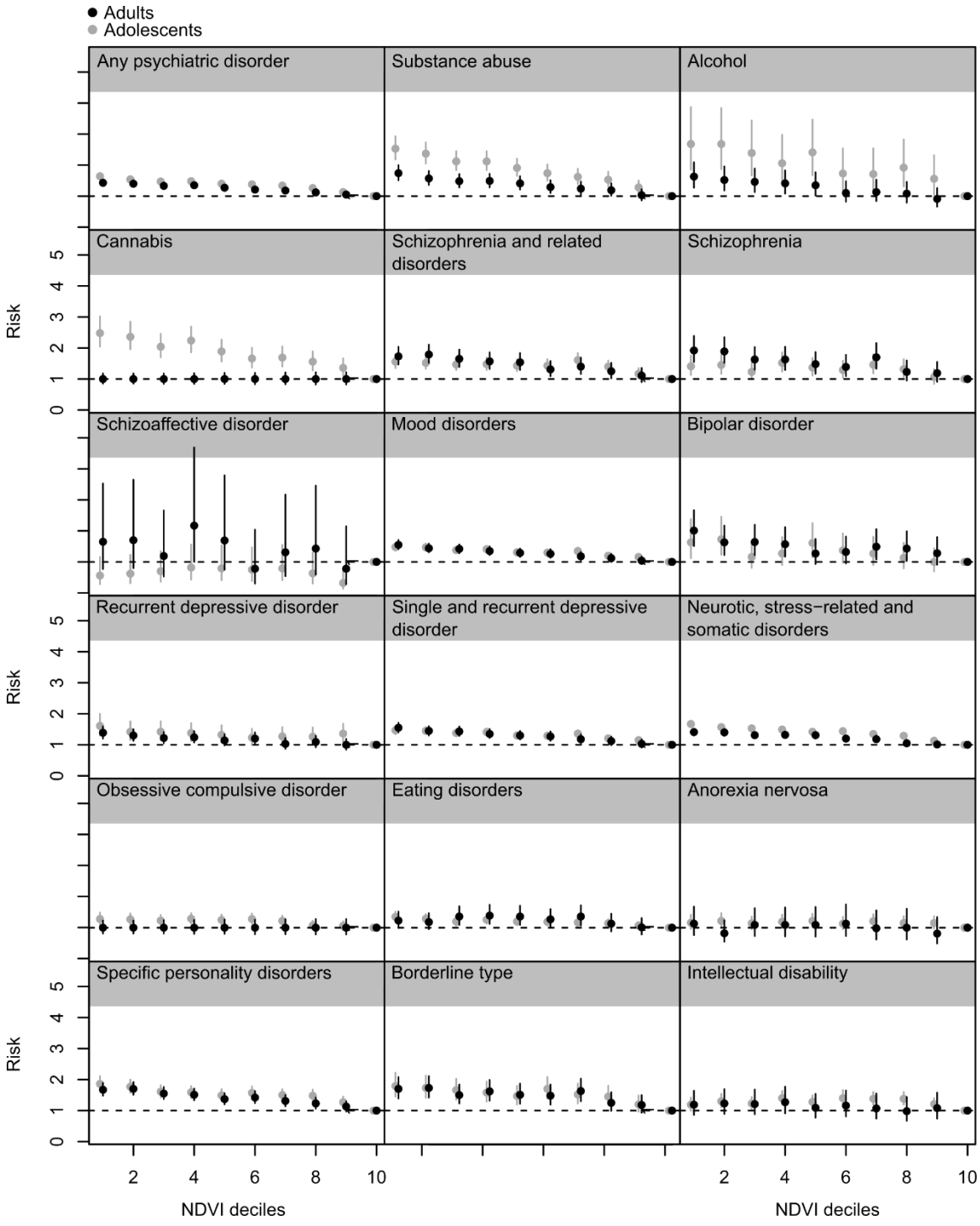

Fig. S4 The association between green space and relative risk of developing a psychiatric disorder for persons diagnosed in adolescence compared to persons diagnosed in adulthood. Two models were fitted for each psychiatric disorder to compare risk for

persons diagnosed in adolescence (age 13-19) (N =879 364) and for persons diagnosed in adulthood (age >19) (N = 840 177). Green space was measured as the cumulated normalized difference vegetation index (NDVI) from birth to age 10 within a 210×210m square around the place of residence. Both models were fitted to adjust for urbanization and parents' socioeconomic status. Estimates of incidence rate ratio from both models were adjusted for age, year of birth, and gender and plotted with 95% confidence intervals. All estimates are relative to the reference level set to the highest NDVI decile and shown with the same y-axis for easy comparison between disorders. We note that sample sizes for some disorders diagnosed in either adolescence or adulthood were relatively small (Table S3).

Table S1 Population attributable risk for risk factors of psychiatric disorders

Psychiatric disorder	ICD-10	NDVI	Urb.	SES_m	SES_f	Fhist_m	Fhist_F	Age_m	Age_f
Any psychiatric disorder	F00-F99	12	2	13	15	10	6	6	3
Substance abuse	F10-F19	12	7	17	22	13	9	13	5
Alcohol	F10	8	6	17	21	15	9	13	5
Cannabis	F12	9	14	16	23	14	9	9	5
Schizophrenia and related disorders	F20-F29	12	13	1	14	11	8	2	4
Schizophrenia	F20	9	1	8	13	11	8	5	4
Schizoaffective disorder	F25	5	3	-2	19	14	9	-11	12
Mood disorders	F30-F39	11	5	8	1	10	5	2	3
Bipolar disorder	F30-F31	4	5	0	4	14	8	0	5
Recurrent depressive disorder	F33	1	5	4	8	11	6	1	3
Single and recurrent depressive disorder	F32-F33	11	5	8	10	10	5	2	2
Neurotic, stress-related, and somatic disorders	F40-F48	15	2	15	15	11	7	4	3
Obsessive compulsive disorder	F42	12	8	13	1	7	4	-6	2
Eating disorders	F50	14	9	-8	-13	5	2	-3	3
Anorexia nervosa	F50.0	16	8	-19	-31	4	1	-4	-1
Specific personality disorders	F60	8	2	15	19	13	9	12	4
Borderline type	F60.31	8	2	19	22	14	10	15	4
Intellectual disability	F70-F79	7	-1	26	29	11	8	7	4

NDVI: The normalized difference vegetation index; Urb.: degree of urbanization; SES_m: Socioeconomic status of the mother; SES_f: Socioeconomic status of the father; Fhist_m: family history of mental illness of the mother; Fhist_f: family history of mental illness of the father; Age_m: age of mother at birth; Age_f: age of father at birth. Estimates of attributable risk show the percent risk attributable to each risk factor adjusted for all other risk factors based on incidence rate ratios from separate Cox regressions fitted for

each psychiatric disorder. Negative attributable risks may occur if persons in the reference category do not have lowest risks. In such situations, the population attributable risk refers to an increase in the population occurrence of the disease in question. All estimates of incidence rate ratio were adjusted for age, year of birth, and gender.

Table S2. Mean, minimum, and maximum values of the Normalized Difference Vegetation Index (NDVI) within each urbanization category for all four quadratic presence zone sizes around place of residence

Urbanization category	NDVI		
210×210m (7×7 cells)	Mean	Min	Max
Capital center	0.25	-0.72	0.75
Capital suburb	0.38	-0.73	0.82
Provincial city	0.34	-0.72	0.82
Provincial town	0.36	-0.75	0.85
Rural	0.43	-0.74	0.89
330×330m (11×11 cells)			
Capital center	0.25	-0.70	0.76
Capital suburb	0.38	-0.68	0.82
Provincial city	0.35	-0.68	0.84
Provincial town	0.37	-0.72	0.84
Rural	0.44	-0.73	0.84
570×570m (19×19 cells)			
Capital center	0.26	-0.68	0.75
Capital suburb	0.39	-0.64	0.81
Provincial city	0.36	-0.68	0.83
Provincial town	0.38	-0.72	0.84
Rural	0.45	-0.69	0.86
930×930m (31×31 cells)			
Capital center	0.26	-0.65	0.75
Capital suburb	0.40	-0.56	0.79
Provincial city	0.37	-0.63	0.80

Provincial town	0.39	-0.64	0.81
Rural	0.46	-0.62	0.81

NDVI: The normalized difference vegetation index; Min: Minimum; Max: Maximum. Data were split between each of the five urbanization classes (Capital center N = 56 650, Capital suburb N = 124 193, Provincial city N= 90 648, Provincial town N = 265 570, and Rural N = 376 525). Mean, minimum, and maximum values of NDVI were calculated for mean NDVI measured at 210×210m, 330×330m, 570×570m, and 930×930m size quadrats around each individual's residence.

Table S3 Number and proportion of cases diagnosed in each year of adolescence

Psychiatric disorder	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19
Any psychiatric disorder	21 792 (20.3)	30 433 (28.4)	39 981 (37.3)	48 844 (45.6)	57 424 (53.6)	65 581 (61.2)	73 151 (68.3)
Substance abuse	71 (0.6)	306 (2.5)	827 (6.7)	1610 (13.0)	2708 (21.8)	4085 (32.9)	5615 (45.2)
Alcohol	8 (0.2)	35 (1.1)	113 (3.5)	216 (6.7)	371 (11.5)	673 (20.9)	1036 (32.2)
Cannabis	36 (0.5)	182 (2.6)	501 (7.1)	958 (13.5)	1590 (22.4)	2385 (33.6)	3234 (45.5)
Schizophrenia and related disorders	518 (4.7)	1072 (9.8)	1790 (16.3)	2536 (23.0)	3391 (30.9)	4487 (40.9)	5586 (50.9)
Schizophrenia	67 (1.2)	233 (4.3)	437 (8.0)	676 (12.4)	1009 (18.6)	1646 (30.3)	2267 (41.7)
Schizoaffective disorder	7 (1.7)	14 (3.4)	34 (8.1)	67 (16.0)	98 (23.4)	142 (34.0)	175 (41.9)
Mood disorders	1730 (5.9)	3209 (10.9)	5338 (18.2)	7652 (26.0)	10 216 (34.7)	12 814 (43.6)	15 480 (52.6)
Bipolar disorder	24 (0.9)	70 (2.6)	142 (5.3)	242 (9.1)	388 (14.6)	552 (20.7)	758 (28.5)
Recurrent depressive disorder	108 (1.3)	198 (2.3)	362 (4.3)	598 (7.1)	887 (10.5)	1499 (17.7)	2239 (26.5)
Single and recurrent depressive disorder	1619 (6.0)	3010 (11.2)	5020 (18.6)	7198 (26.7)	9596 (35.6)	12 038 (44.6)	14 485 (53.7)
Neurotic, stress-related, and somatic disorders	7179 (12.8)	11 490 (20.4)	16 517 (29.4)	21 402 (38.1)	26 206 (46.6)	30 683 (54.6)	35 059 (62.4)
Obsessive compulsive disorder	1795 (25.0)	2403 (33.4)	2948 (40.9)	3462 (48.1)	3906 (54.2)	4312 (59.9)	4743 (65.9)
Eating disorders	1413 (14.0)	2437 (24.4)	3579 (35.8)	4325 (46.2)	5568 (55.6)	6416 (64.1)	7117 (71.1)
Anorexia nervosa	737 (21.0)	1184 (34.3)	1636 (47.4)	2001 (58.0)	2304 (66.8)	2576 (74.6)	2763 (80.1)
Specific personality disorders	221 (1.3)	667 (4.1)	1427 (8.7)	2404 (14.6)	3579 (21.7)	5374 (32.6)	7227 (43.9)
Borderline type	74 (1.2)	241 (3.9)	491 (8.0)	810 (13.2)	1203 (19.6)	1817 (29.6)	2549 (41.6)
Intellectual disability	1412 (29.5)	1892 (39.5)	2393 (50.0)	2834 (59.2)	3174 (66.3)	3443 (71.9)	3705 (77.4)

Each column shows the number of persons diagnosed at that age or younger with a given psychiatric disorder, and numbers in parentheses show the cumulative proportion of cases diagnosed in a given age group or earlier relative to the total number of cases.

Table S4 Relative risk of developing a psychiatric disorder from adolescence into adulthood in relation to childhood green space presence (NDVI) within different quadratic presence zone sizes around place of residence

			210×210m (7×7 cells)		330×330m (11×11 cells)		570×570m (19×19 cells)		930×930m (31×31 cells)	
Psychiatric disorder	ICD-10	Cases	IRR	(95% CI)	IRR	(95% CI)	IRR	(95% CI)	IRR	(95% CI)
Any psychiatric disorder	F00-F99	107 319	1.27	(1.24-1.30)	1.26	(1.24-1.29)	1.26	(1.23-1.28)	1.24	(1.21-1.26)
Substance abuse	F10-F19	13 079	1.37	(1.29-1.46)	1.36	(1.28-1.45)	1.36	(1.28-1.44)	1.34	(1.26-1.42)
Alcohol abuse	F10	3367	1.30	(1.16-1.47)	1.31	(1.16-1.48)	1.32	(1.17-1.49)	1.33	(1.18-1.50)
Cannabis abuse	F12	7526	1.33	(1.23-1.44)	1.32	(1.22-1.43)	1.31	(1.21-1.42)	1.30	(1.20-1.40)
Schizophrenia and related disorders	F20-F29	11 675	1.19	(1.11-1.26)	1.19	(1.12-1.27)	1.19	(1.11-1.27)	1.17	(1.10-1.25)
Schizophrenia	F20	5701	1.19	(1.09-1.30)	1.18	(1.08-1.29)	1.17	(1.07-1.29)	1.16	(1.06-1.27)
Schizoaffective disorder	F25	426	1.16	(0.84-1.61)	1.12	(0.81-1.55)	1.00	(0.72-1.40)	0.95	(0.68-1.32)
Mood disorders	F30-F39	30 371	1.26	(1.21-1.30)	1.25	(1.21-1.30)	1.24	(1.20-1.29)	1.22	(1.18-1.27)
Bipolar disorder	F30-F31	2741	1.17	(1.03-1.34)	1.17	(1.03-1.33)	1.15	(1.01-1.32)	1.13	(0.99-1.29)
Recurrent depressive disorder	F33	8694	1.14	(1.06-1.23)	1.14	(1.06-1.22)	1.12	(1.05-1.21)	1.10	(1.02-1.18)
Single and recurrent depressive disorder	F32-F33	27 814	1.26	(1.21-1.32)	1.26	(1.21-1.32)	1.25	(1.20-1.30)	1.23	(1.18-1.28)
Neurotic, stress-related and somatic disorders	F40-F48	58 358	1.33	(1.29-1.37)	1.32	(1.29-1.36)	1.31	(1.28-1.35)	1.29	(1.25-1.33)
Obsessive compulsive disorder	F42	7619	1.21	(1.13-1.31)	1.23	(1.14-1.33)	1.21	(1.12-1.30)	1.18	(1.09-1.28)
Eating disorders	F50	10 187	1.18	(1.11-1.26)	1.19	(1.11-1.27)	1.18	(1.11-1.26)	1.18	(1.11-1.26)
Anorexia nervosa	F50.0	3505	1.11	(0.99-1.24)	1.14	(1.02-1.27)	1.14	(1.02-1.27)	1.12	(1.01-1.26)
Specific personality disorders	F60	17 070	1.14	(1.08-1.20)	1.12	(1.06-1.18)	1.11	(1.05-1.17)	1.10	(1.04-1.16)

Borderline type	F60.31	6347	1.12	(1.03-1.22)	1.10	(1.01-1.20)	1.10	(1.01-1.19)	1.08	(0.99-1.18)
Intellectual disability	F70-F79	5498	1.01	(0.92-1.11)	1.01	(0.92-1.11)	1.01	(0.92-1.11)	1.01	(0.91-1.11)

NDVI: The normalized difference vegetation index; IRR: Incidence rate ratio; 95% CI: 95% confidence interval. NDVI was calculated as the mean for a 210×210m, 330×330m, 570×570m, and 930×930m quadrats around each individual's place of residence at age 10. Estimates of IRRs show the risk of children living at the lowest level of NDVI relative to the reference level (set to the highest decile of NDVI). IRRs were based on all persons born in Denmark 1985-2003 who lived in Denmark on their 10th birthday (N = 943 027) and were followed for the development of a psychiatric disorder from 1985 to 2016. The number of persons who developed a given psychiatric disorder is shown in the column Cases. Separate Cox regressions were fitted for each psychiatric disorder with NDVI fitted as numeric deciles. All estimates of incidence rate ratio were adjusted for urbanization, parents' socioeconomic status, age, year of birth, and gender.

Table S5 ICD10 codes of psychiatric disorders and number of cases

Psychiatric disorder	Code	Cases
Any psychiatric disorder	ICD10: F00-F99 and equivalent ICD-8 codes	107 112
Substance abuse	ICD10: F10-F19 and equivalent ICD-8 codes	12 425
Alcohol	ICD10: F10 and equivalent ICD-8 codes	3 214
Cannabis	ICD10: F12 and equivalent ICD-8 codes	7 101
Schizophrenia and related disorders	ICD10: F20-F29 and equivalent ICD-8 codes	10 977
Schizophrenia	ICD10: F20 and equivalent ICD-8 codes	5 437
Schizoaffective disorder	ICD10: F25 and equivalent ICD-8 codes	418
Mood disorders	ICD10: F30-F39 and equivalent ICD-8 codes	29 410
Bipolar disorder	ICD10: F30-F31 and equivalent ICD-8 codes	2 661
Recurrent depressive disorder	ICD10: F33 and equivalent ICD-8 codes	8 455
Single and recurrent depressive disorder	ICD10: F32-F33 and equivalent ICD-8 codes	26 962
Neurotic, stress-related and somatic disorders	ICD10: F40-F48 and equivalent ICD-8 codes	56 205
Obsessive compulsive disorder	ICD10: F42 and equivalent ICD-8 codes	7 201
Eating disorders	ICD10: F50 and equivalent ICD-8 codes	10 008
Anorexia nervosa	ICD10: F50.0 and equivalent ICD-8 codes	3 451
Specific personality disorders	ICD10: F60 and equivalent ICD-8 codes	16 476
Borderline type	ICD10: F60.31 and equivalent ICD-8 codes	6 133
Intellectual disability	ICD10: F70-79 and equivalent ICD-8 codes	4 787

Cases show the number of individuals in the study population diagnosed with a given disorder

Table S6. Overview of Landsat satellite date used to calculate green space presence as the normalized difference vegetation index (NDVI) for Denmark.

Year	Satellite	Number of scenes	Resolution	RED band	NIR band
2013	L8 OLI/TIRS	12	30m	4	5
2012	L4-5 MS	19	30m	3	4
2011	L4-5 TM	12	30m	3	4
2010	L4-5 TM	14	30m	3	4
2009	L4-5 TM	11	30m	3	4
2008	-	-	-	-	-
2007	L4-5 TM	7	30m	3	4
2006	L4-5 TM	13	30m	3	4
2005	L4-5 TM	12	30m	3	4
2004	L4-5 TM	14	30m	3	4
2003	L4-5 TM	13	30m	3	4
2002	L7 ETM+	15	30m	3	4
2001	L7 ETM+	11	30m	3	4
2000	L7 ETM+	11	30m	3	4
1999	L7 ETM+	13	30m	3	4
1998	L4-5 TM	12		3	4
1997	-	-	-	-	-
1996	-	-	-	-	-
1995	-	-	-	-	-
1994	-	-	-	-	-

1993	-	-	-	-	-
1992	-	-	-	-	-
1991	-	-	-	-	-
1990	L4-5 TM	14		3	4
1989	L4-5 TM	13		3	4
1988	L4-5 TM	19		3	4
1987	L4-5 TM	12		3	4
1986	L4-5 TM	19		3	4
1985	L4-5 TM	13		3	4

NDVI: The normalized difference vegetation index; RED: the red band capturing reflectance within 0.63-0.69 wavelength (micrometers); NIR: the near-infrared band capturing reflectance within 0.76-0.90 wavelength (micrometers). NDVI is calculated as the difference between light absorbed (RED) and reflected (NIR) by vegetation. Settings for sensors differ slightly between different satellites and more details can be found at the U.S. Geological Survey homepage (https://landsat.usgs.gov/what-are-band-designations-landsat-satellites).

Table S7. Cut-off values of mean and cumulated normalized difference vegetation index (NDVI)

	210×210m (7×7 cells)		330×330m (11×11 cells)		570×570m (19×19 cells)		930×930m (31×31 cells)	
Decile	Min	Max	Min	Max	Min	Max	Min	Max
NDVI age 10								
0.0	-0.75	0.04	-0.73	0.07	-0.72	0.10	-0.65	0.12
0.1	0.04	0.22	0.07	0.24	0.10	0.26	0.12	0.27
0.2	0.22	0.32	0.24	0.33	0.26	0.34	0.27	0.35
0.3	0.32	0.39	0.33	0.39	0.34	0.40	0.35	0.40
0.4	0.39	0.44	0.39	0.44	0.40	0.45	0.40	0.45
0.6	0.44	0.48	0.44	0.49	0.45	0.49	0.45	0.50
0.7	0.48	0.53	0.49	0.53	0.49	0.54	0.50	0.54
0.8	0.53	0.57	0.53	0.58	0.54	0.58	0.54	0.59
0.9	0.57	0.63	0.58	0.63	0.58	0.63	0.59	0.63
1.0	0.63	0.89	0.63	0.85	0.63	0.86	0.63	0.83
NDVI cumulated								
	Min	Max	Min	Max	Min	Max	Min	Max
0.0	-0.56	0.07	-0.5	0.09	-0.39	0.12	-0.34	0.14
0.1	0.07	0.18	0.09	0.19	0.12	0.21	0.14	0.23
0.2	0.18	0.25	0.19	0.26	0.21	0.28	0.23	0.29
0.3	0.25	0.31	0.26	0.32	0.28	0.33	0.29	0.35
0.4	0.31	0.36	0.32	0.37	0.33	0.38	0.35	0.39
0.6	0.36	0.40	0.37	0.41	0.38	0.42	0.39	0.43
0.7	0.40	0.44	0.41	0.45	0.42	0.46	0.43	0.46
0.8	0.44	0.48	0.45	0.49	0.46	0.49	0.46	0.50
0.9	0.48	0.53	0.49	0.53	0.49	0.54	0.50	0.54
1.0	0.53	0.79	0.53	0.76	0.54	0.76	0.54	0.72

NDVI: The normalized difference vegetation index; Min: Minimum; Max: Maximum.

NDVI age 10 was calculated as the mean for 210×210m, 330×330m, 570×570m, and 930×930m quadrats around each individual's place of residence at the 10th birthday (N = 943 027). NDVI cumulated was calculated at place of residence as the mean of NDVI for each year from birth to the 10th birthday (N = 904 295). For each measure of NDVI, values were reclassified as deciles in classes of ten and cut-off values show the minimum and maximum values of NDVI within each decile.

Table S8. Associations by gender between green space measured as the normalized difference vegetation index (NDVI) and incidence rate ratio of psychiatric disorders.

	Overall		Male		Female	
Psychiatric disorder	IRR	(95% CI)	IRR	(95% CI)	IRR	(95% CI)
Any psychiatric disorder	1.32	(1.29-1.35)	1.29	(1.25-1.32)	1.35	(1.31-1.38)
Substance abuse	1.52	(1.43-1.60)	1.47	(1.38-1.58)	1.61	(1.46-1.77)
Alcohol abuse	1.41	(1.27-1.58)	1.40	(1.22-1.61)	1.43	(1.20-1.72)
Cannabis abuse	1.55	(1.44-1.67)	1.52	(1.39-1.66)	1.62	(1.42-1.84)
Schizophrenia and related disorders	1.38	(1.30-1.46)	1.32	(1.22-1.43)	1.44	(1.33-1.57)
Schizophrenia	1.33	(1.22-1.44)	1.37	(1.22-1.54)	1.28	(1.13-1.44)
Schizoaffective disorder	1.31	(0.97-1.79)	1.38	(0.82-2.31)	1.28	(0.88-1.88)
Mood disorders	1.33	(1.28-1.38)	1.34	(1.26-1.43)	1.32	(1.27-1.38)
Bipolar disorder	1.31	(1.16-1.48)	1.44	(1.18-1.75)	1.25	(1.07-1.45)
Recurrent depressive disorder	1.19	(1.11-1.27)	1.19	(1.05-1.34)	1.19	(1.10-1.29)
Single and recurrent depressive disorder	1.34	(1.29-1.39)	1.33	(1.24-1.42)	1.34	(1.28-1.40)
Neurotic, stress-related and somatic disorders	1.39	(1.36-1.43)	1.33	(1.28-1.39)	1.43	(1.39-1.48)
Obsessive compulsive disorder	1.31	(1.22-1.40)	1.29	(1.15-1.46)	1.31	(1.20-1.44)
Eating disorders	1.25	(1.17-1.33)	1.10	(0.86-1.41)	1.26	(1.18-1.34)
Anorexia nervosa	1.15	(1.03-1.27)	1.05	(0.68-1.63)	1.15	(1.03-1.29)
Specific personality disorders	1.19	(1.14-1.25)	1.27	(1.16-1.40)	1.17	(1.11-1.24)
Borderline type	1.21	(1.11-1.31)	1.06	(0.80-1.41)	1.22	(1.12-1.32)
Intellectual disability	1.06	(0.97-1.15)	1.03	(0.92-1.15)	1.10	(0.96-1.25)

NDVI: The normalized difference vegetation index; IRR: Incidence rate ratio; 95% CI: 95% confidence interval. Estimates of IRRs show the risk of children living at the lowest decile of NDVI relative to the highest decile of NDVI. NDVI was calculated as the mean for a 210×210m quadrat around each individual's place of residence at age 10. Estimates of IRRs were based on all persons born in

Denmark 1985-2003 who lived in Denmark on their 10th birthday (N = 943 027) who were followed for the development of a psychiatric disorder from 1985 to 2016. Two separate Cox regressions were fitted for each psychiatric disorder: 1) results in the Overall column provide the associations with NDVI fitted as numeric deciles and 2) results in the Male and Female columns provide the association with NDVI for each gender separately. All estimates of incidence rate ratio were adjusted for age, year of birth, and gender.