Supplementary Table A Hazard ratios of type 2 diabetes according to individual lifestyle factor

	NHS	NHSII	Pooled*
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Cigarette smoking			
Never	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Past	1.14 (1.08 to 1.21)	1.11 (1.04 to 1.18)	1.13 (1.08 to 1.18)
Current 1-14/day	1.34 (1.16 to 1.54)	1.16 (1.01 to 1.32)	1.24 (1.08 to 1.43)
Current 15-24/day	1.19 (1.02 to 1.39)	1.34 (1.17 to 1.55)	1.27 (1.13 to 1.43)
Current ≥25/day	1.62 (1.34 to 1.95)	1.53 (1.27 to 1.85)	1.57 (1.38 to 1.80)
Current smoker vs. non-smoker	1.13 (1.03 to 1.24)	1.13 (1.04 to 1.24)	1.13 (1.06 to 1.21)
Physical activity (hours/week)			
0	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
0.1-0.9	0.94 (0.88 to 1.00)	0.92 (0.86 to 0.98)	0.93 (0.88 to 0.97)
1.0-3.4	0.88 (0.82 to 0.95)	0.78 (0.73 to 0.84)	0.83 (0.74 to 0.94)
3.5-5.9	0.81 (0.72 to 0.90)	0.75 (0.67 to 0.84)	0.78 (0.72 to 0.84)
≥6	0.67 (0.58 to 0.77)	0.80 (0.71 to 0.91)	0.73 (0.61 to 0.88)
<3.5 vs. ≥3.5	1.49 (1.36 to 1.63)	1.48 (1.36 to 1.60)	1.48 (1.40 to 1.57)
Alternative healthy eating index			
Fifth 1	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Fifth 2	0.95 (0.88 to 1.03)	0.99 (0.92 to 1.07)	0.97 (0.92 to 1.03)
Fifth 3	0.93 (0.86 to 1.01)	0.88 (0.81 to 0.96)	0.91 (0.86 to 0.96)
Fifth 4	0.91 (0.84 to 0.99)	0.89 (0.82 to 0.97)	0.9 (0.85 to 0.96)
Fifth 5	0.80 (0.73 to 0.87)	0.83 (0.76 to 0.91)	0.81 (0.76 to 0.87)
Lower three-fifths vs. upper two-fifths	1.16 (1.10 to 1.23)	1.24 (1.17 to 1.32)	1.20 (1.13 to 1.28)
Body mass index (kg/m^2)			
18.5-22.9	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
23-24.9	1.87 (1.62 to 2.17)	2.27 (1.81 to 2.85)	2.02 (1.68 to 2.43)
25-29.9	4.47 (3.97 to 5.04)	7.30 (6.08 to 8.76)	5.68 (3.52 to 9.18)
30-34.9	9.71 (8.59 to 10.9)	21.4 (17.9 to 25.6)	14.4 (6.62 to 31.2)
≥35	16.2 (14.3 to 18.4)	47.3 (39.6 to 56.5)	27.6 (9.67 to 78.9)
≥25 vs. <25	5.13 (4.74 to 5.55)	12.4 (11.1 to 13.9)	7.98 (3.35 to 19.0)
Number of high-risk factors			
≤1	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
2	2.43 (2.20 to 2.68)	3.01 (2.71 to 3.36)	2.70 (2.19 to 3.34)
≥3	4.42 (4.02 to 4.86)	6.58 (5.93 to 7.29)	5.39 (3.65 to 7.95)

Models were adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9, and ≥30), and total energy intake (quintile).

All covariates, except ethnicity and family history of diabetes, were time-varying.

Individual lifestyle factors were mutually adjusted for each other.

*Results were pooled with the use of the random effects model.

Supplementary Table B Hazard ratios of type 2 diabetes according to joint categories of rotating night shift work duration and unhealthy lifestyle score

Unhealthy Lifestyle Score[‡]	Duration of rotating night shift work (years)			
	Never	<5	5-9	≥10
NHS (1988-2012)				
≤1 Cases/ Person-years (PY)	176/132865	224/137979	38/18550	69/26774
Crude Incidence/10^5PY	132	162	205	258
Hazard Ratio (95%CI)[*]	1.00 (ref.)	1.22 (1.00 to 1.49)	1.45 (1.02 to 2.06)	1.76 (1.33 to 2.33)
Hazard Ratio (95%CI)[#]	1.00 (ref.)	1.21 (1.00 to 1.48)	1.40 (0.98 to 1.99)	1.71 (1.29 to 2.26)
2 Cases/ Person-years (PY)	686/182834	743/183295	142/28888	260/43845
Crude Incidence/10^5PY	375	405	492	593
Hazard Ratio (95%CI)[*]	2.68 (2.27 to 3.16)	2.83 (2.40 to 3.34)	3.26 (2.61 to 4.06)	3.81 (3.14 to 4.61)
Hazard Ratio (95%CI)[#]	2.39 (2.02 to 2.82)	2.51 (2.13 to 2.96)	2.84 (2.28 to 3.55)	3.25 (2.68 to 3.94)
≥3 Cases/ Person-years (PY)	1206/154419	1233/156282	225/26525	472/47341
Crude Incidence/10^5PY	781	789	848	997
Hazard Ratio (95%CI)[*]	5.12 (4.37 to 6.01)	5.14 (4.39 to 6.03)	5.45 (4.47 to 6.65)	6.12 (5.14 to 7.28)
Hazard Ratio (95%CI)[#]	4.13 (3.52 to 4.85)	4.17 (3.56 to 4.89)	4.39 (3.60 to 5.35)	4.88 (4.10 to 5.81)
NHS2 (1991-2013)				
≤1 Cases/ Person-years (PY)	116/179921	205/292127	44/59440	54/39807
Crude Incidence/10^5PY	64	70	74	136
Hazard Ratio (95%CI)[*]	1.00 (ref.)	1.1 (0.88 to 1.38)	1.12 (0.79 to 1.59)	1.7 (1.23 to 2.35)
Hazard Ratio (95%CI)[#]	1.00 (ref.)	1.1 (0.88 to 1.39)	1.10 (0.78 to 1.56)	1.67 (1.21 to 2.30)
2 Cases/ Person-years (PY)	424/213370	750/335409	215/73009	244/53155
Crude Incidence/10^5PY	199	224	294	459
Hazard Ratio (95%CI)[*]	2.88 (2.34 to 3.53)	3.21 (2.64 to 3.90)	4.01 (3.20 to 5.03)	5.14 (4.12 to 6.41)

	Hazard Ratio (95%CI)[#]	2.45 (1.99 to 3.01)	2.69 (2.21 to 3.27)	3.27 (2.61 to 4.10)	4.12 (3.30 to 5.14)
≥3	Cases/ Person-years (PY)	833/153040	1628/259099	474/65569	454/54774
	Crude Incidence/10^5PY	544	628	723	829
	Hazard Ratio (95%CI)[*]	6.57 (5.41 to 7.98)	7.46 (6.18 to 9.01)	8.24 (6.72 to 10.1)	8.19 (6.67 to 10.1)
	Hazard Ratio (95%CI)[#]	4.64 (3.82 to 5.64)	5.25 (4.34 to 6.35)	5.83 (4.75 to 7.15)	5.72 (4.66 to 7.03)
Pooled[†]					
≤1	Hazard Ratio (95%CI)[*]	1.00 (ref.)	1.17 (1.01 to 1.36)	1.28 (0.99 to 1.64)	1.73 (1.40 to 2.14)
	Hazard Ratio (95%CI)[#]	1.00 (ref.)	1.17 (1.00 to 1.35)	1.24 (0.97 to 1.59)	1.69 (1.37 to 2.09)
2	Hazard Ratio (95%CI)[*]	2.76 (2.42 to 3.14)	2.98 (2.63 to 3.38)	3.61 (2.94 to 4.43)	4.40 (3.28 to 5.90)
	Hazard Ratio (95%CI)[#]	2.41 (2.12 to 2.74)	2.59 (2.28 to 2.93)	3.04 (2.60 to 3.57)	3.64 (2.89 to 4.58)
≥3	Hazard Ratio (95%CI)[*]	5.77 (4.52 to 7.35)	6.17 (4.29 to 8.89)	6.70 (4.47 to 10.0)	7.04 (5.29 to 9.37)
	Hazard Ratio (95%CI)[#]	4.33 (3.83 to 4.90)	4.65 (3.72 to 5.83)	5.05 (3.83 to 6.67)	5.23 (4.48 to 6.11)

CI=confidence interval; PY=person-year.

[*]Adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9, and ≥30), and total energy intake (quintile).

[#]Further adjusted for prevalent hypertension and hyperlipidemia, and medication use for high blood pressure and lipid levels.

All covariates, except ethnicity and family history of diabetes, were time-varying.

[†]Results were pooled with the use of the random effects model.

[‡]Unhealthy lifestyles include currently smoking, exercise <30 min/d at moderate intensity, diet in bottom three fifths of Alternate Healthy Eating Index score, and body mass index ≥25 kg/m^2.

Supplementary Table C Attributing effects to additive interaction between rotating night shift work and weighed lifestyle score on risk of type 2 diabetes

	Nurses' Health Study	Nurses' Health Study II	Pooled results	P for heterogeneity[†]
Main effects				
Rotating night shift work duration (per 5-year)	1.17 (1.08, 1.27)	1.10 (0.96, 1.27)	1.15 (1.07, 1.24)	0.496
Unhealthy lifestyle[‡] (per score)	1.81 (1.75, 1.87)	2.25 (2.15, 2.35)	2.02 (1.63, 2.50)	<0.001
Joint effect	2.06 (1.98, 2.14)	2.48 (2.34, 2.61)	2.26 (1.89, 2.70)	<0.001
Relative excess risk due to interaction				
Relative excess risk due to interaction	0.08 (0.05, 0.12)	0.12 (0.02, 0.23)	0.09 (0.06, 0.13)	0.578
P value	<0.001	0.026	<0.001	/
Attributable proportion, %				
Rotating night shift work	15.9 (9.3, 22.6)	7.1 (-2.1, 16.2)	15.8 (10.2, 24.5)	0.668
Unhealthy lifestyle[‡]	76.2 (71.5, 80.9)	84.5 (78.6, 90.4)	80.2 (72.5, 88.7)	0.031
Additive interaction	7.8 (5.7, 9.9)	8.4 (2.9, 13.9)	7.9 (6.1, 10.2)	0.858

CI=confidence interval; PY=person-year.

*Adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9 and ≥30), and total energy intake (quintile).
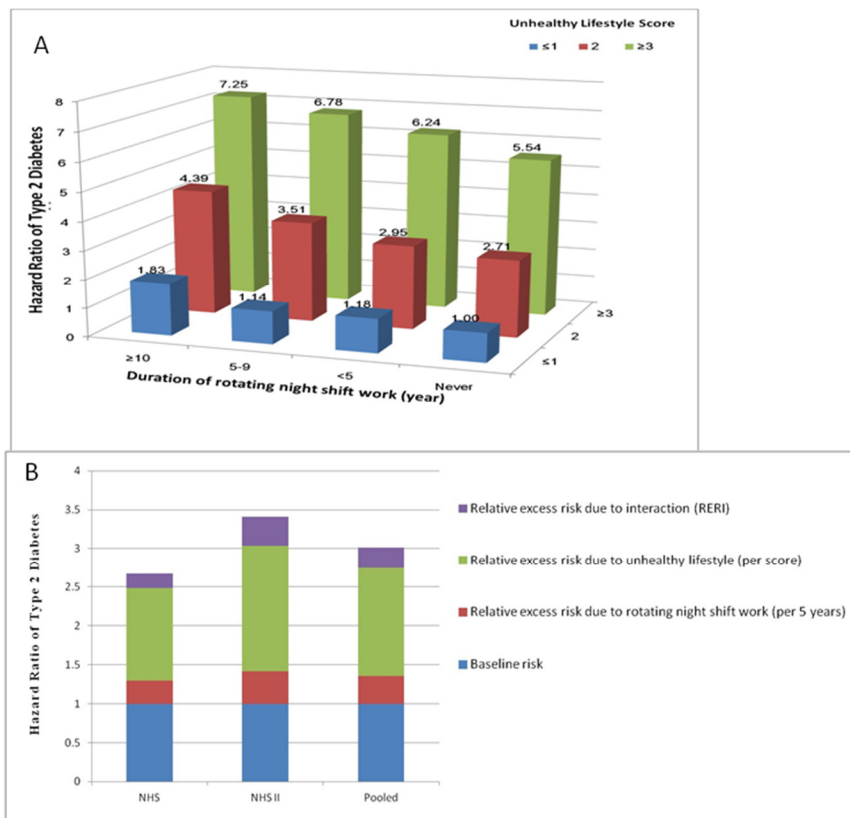
#Further adjusted for prevalent hypertension and hyperlipidemia, and medication use for high blood pressure and lipid levels.

All covariates, except ethnicity and family history of diabetes, were time-varying.

[†]Results were pooled with the use of the random effects model.

[‡]Unhealthy lifestyles score was created by assigning weights to each unhealthy lifestyle factor (currently smoking, exercise <30 min/d at moderate intensity, diet in bottom three fifths of the Alternate Healthy Eating Index score, and body mass index ≥25 kg/m^2), based on the coefficients from multivariable regression models include.

Supplementary Figure A. Study flow diagram illustrating cohort exclusions in the Nurses' Health Study (1988) and Nurses' Health Study II (1991)

Supplementary Figure B Joint association of rotating night shift work and unhealthy lifestyle with risk of symptomatic type 2 diabetes. A: Pooled multivariable hazard ratio of symptomatic type 2 diabetes according to joint categories of rotating night shift work duration and number of unhealthy lifestyle factors. B: Multivariable hazard ratio of symptomatic type 2 diabetes attributable to rotating night shift work, to unhealthy lifestyle and to their interaction.
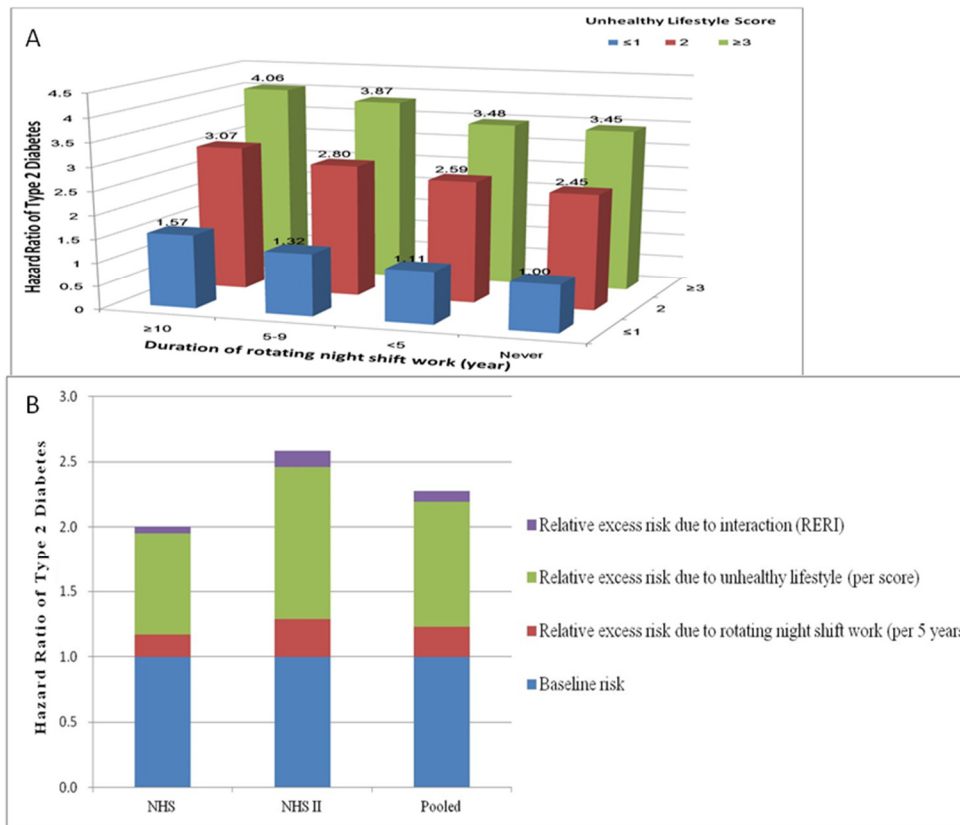

Multivariable model adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9 and ≥30), and total energy intake (quintile).

All covariates, except ethnicity and family history of diabetes, were time-varying.

Unhealthy lifestyles include currently smoking, exercise <30 min/d at moderate intensity, diet in bottom three fifths of Alternate Healthy Eating Index score, and body mass index ≥25. Results were pooled with the use of the random effects model.

Supplementary Figure C Joint association of rotating night shift work and baseline unhealthy lifestyle with risk of type 2 diabetes. A: Pooled multivariable hazard ratio of type 2 diabetes according to joint categories of rotating night shift work duration and number of unhealthy lifestyle factors. B: Multivariable hazard ratio of type 2 diabetes attributable to rotating night shift work, to unhealthy lifestyle and to their interaction.
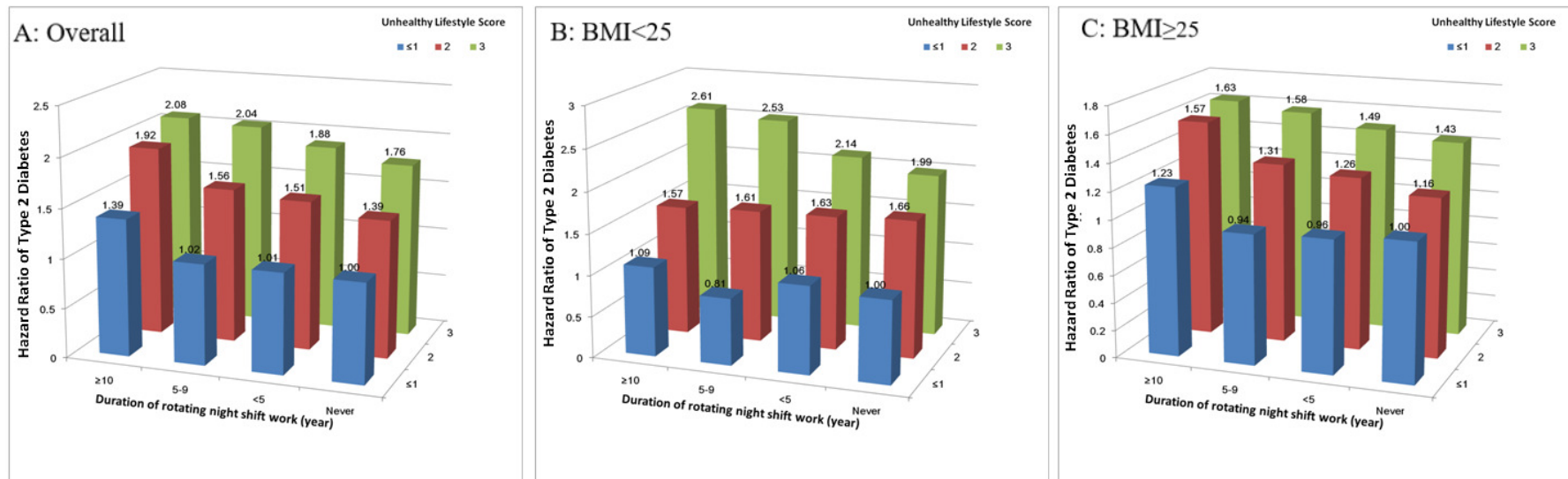

Multivariable model adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9 and ≥30), and total energy intake (quintile).

All covariates, except ethnicity and family history of diabetes, were time-varying.

Unhealthy lifestyles include currently smoking, exercise <30 min/d at moderate intensity, diet in bottom three fifths of Alternate Healthy Eating Index score, and body mass index ≥25.

Results were pooled with the use of the random effects model.

Supplementary Figure D Pooled multivariable hazard ratio of type 2 diabetes according to joint category of rotating night shift work and unhealthy lifestyle factors among overall (A), BMI<25 (B) and BMI ≥25(C) populations.

Multivariable model adjusted for age, calendar year, ethnicity (White, African-American, Hispanic, or Asian), marital status (married, divorced/separate/single, widowed); living status (alone or not), family history of diabetes (yes/no), menopausal status (pre or postmenopausal (never, past or current menopausal hormone use), oral contraceptives use (never, past or current use (NHS II only)), alcohol drinking (g/d: 0, 0.1-4.9, 5.0-14.9, 15.0-19.9, 20.0-29.9 and ≥30), total energy intake (quintile), and baseline BMI (continuous).

All covariates, except ethnicity and family history of diabetes, were time-varying.

Unhealthy lifestyles include currently smoking, exercise <30 min/d at moderate intensity, and diet in bottom three fifths of Alternate Healthy Eating Index score.

Results were pooled with the use of the random effects model.