

Online-Only Supplemental Material

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Supplemental Text S1.China Kadoorie Biobank collaborative group

International Steering Committee: Junshi Chen, Zhengming Chen (PI), Rory Collins, Liming Li (PI), Richard Peto. **International Co-ordinating Centre, Oxford:** Daniel Avery, Derrick Bennett, Ruth Boxall, Fiona Bragg, Yumei Chang, Yiping Chen, Zhengming Chen, Robert Clarke, Huaidong Du, Simon Gilbert, Alex Hacker, Mike Hill, Michael Holmes, Andri Iona, Christiana Kartsonaki, Rene Kerosi, Ling Kong, Om Kurmi, Garry Lancaster, Sarah Lewington, Kuang Lin, John McDonnell, Iona Millwood, Qunhua Nie, Jayakrishnan Radhakrishnan, Paul Ryder, Sam Sansome, Dan Schmidt, Paul Sherliker, Rajani Sohoni, Becky Stevens, Iain Turnbull, Robin Walters, Jenny Wang, Lin Wang, Neil Wright, Ling Yang, Xiaoming Yang. **National Co-ordinating Centre, Beijing:** Zheng Bian, Ge Chen, Yu Guo, Xiao Han, Can Hou, Jun Lv, Pei Pei, Shuzhen Qu, Yunlong Tan, Canqing Yu. **10 Regional Co-ordinating Centres:** **Qingdao** Qingdao CDC: Zengchang Pang, Ruqin Gao, Shaojie Wang, Yongmei Liu, Ranran Du, Yajing Zang, Liang Cheng, Xiaocao Tian, Hua Zhang. Licang CDC: Silu Lv, Junzheng Wang, Wei Hou. **Heilongjiang** Provincial CDC: Jiyuan Yin, Ge Jiang, Xue Zhou. Nangang CDC: Liqiu Yang, Hui He, Bo Yu, Yanjie Li, Huaiyi Mu, Qinai Xu, Meiling Dou, Jiaojiao Ren. **Hainan** Provincial CDC: Shanqing Wang, Ximin Hu, Hongmei Wang, Jinyan Chen, Yan Fu, Zhenwang Fu, Xiaohuan Wang. Meilan CDC: Min Weng, Xiangyang Zheng, Yilei Li, Huimei Li, Yanjun Wang. **Jiangsu** Provincial CDC: Ming Wu, Jinyi Zhou, Ran Tao, Jie Yang. Suzhou CDC: Chuanming Ni, Jun Zhang, Yihe Hu, Yan Lu, , Liangcai Ma, Aiyu Tang, Shuo Zhang, Jianrong Jin, Jingchao Liu. **Guangxi** Provincial CDC: Zhenzhu Tang, Naying Chen, Ying Huang. Liuzhou CDC: Mingqiang Li, Jinhuai Meng, Rong Pan, Qilian Jiang, Weiyuan Zhang, Yun Liu, Liuping Wei, Liyuan Zhou, Ningyu Chen, Hairong Guan. **Sichuan** Provincial CDC: Xianping Wu, Ningmei Zhang, Xiaofang Chen, Xuefeng Tang. Pengzhou CDC: Guojin Luo, Jianguo Li, Xiaofang Chen, Xunfu Zhong, Jiaqiu Liu, Qiang Sun. **Gansu** Provincial CDC: Pengfei Ge, Xiaolan Ren, Caixia Dong. Maiji CDC: Hui Zhang, Enke Mao, Xiaoping Wang, Tao Wang, Xi Zhang. **Henan** Provincial CDC: Ding Zhang, Gang Zhou, Shixian Feng, Liang Chang, Lei Fan. Huixian CDC: Yulian Gao, Tianyou He, Huarong Sun, Pan He, Chen Hu, Qiannan Lv, Xukui Zhang. **Zhejiang** Provincial CDC: Min Yu, Ruying Hu, Hao Wang. Tongxiang CDC: Yijian Qian, Chunmei Wang, Kaixue Xie, Lingli Chen, Yidan Zhang, Dongxia Pan. **Hunan** Provincial CDC: Yuelong Huang, Biyun Chen, Li Yin, Donghui Jin, Huilin Liu, Zhongxi Fu, Qiaohua Xu. Liuyang CDC: Xin Xu, Hao Zhang, Youping Xiong, Huajun Long, Xianzhi Li, Libo Zhang, Zhe Qiu.

Supplemental Table S1. Correlations* between adiposity measures

		Adiposity at baseline							BMI25 [†]	BMI change [†]	Proportional change in BMI [†]
		Weight	BMI	WC	HC	WHR	WHtR	BF%			
Height	Men:	0.53	0.07	0.27	0.42	0.02	-0.06	0.04	-0.19	0.19	0.20
	Women:	0.48	0.03	0.20	0.36	-0.04	-0.12	-0.0006	-0.14	0.13	0.13
Weight	Men:		0.88	0.85	0.84	0.54	0.71	0.70	0.17	0.72	0.68
	Women:		0.89	0.83	0.85	0.46	0.68	0.78	0.24	0.68	0.63
BMI	Men:			0.86	0.76	0.63	0.86	0.80	0.31	0.74	0.70
	Women:			0.84	0.78	0.54	0.84	0.89	0.34	0.70	0.65
WC	Men:				0.81	0.81	0.95	0.74	0.15	0.71	0.68
	Women:				0.77	0.79	0.95	0.78	0.23	0.64	0.60
HC	Men:					0.32	0.70	0.62	0.12	0.64	0.62
	Women:					0.23	0.67	0.70	0.19	0.61	0.57
WHR	Men:						0.84	0.58	0.12	0.52	0.50
	Women:						0.81	0.53	0.17	0.39	0.37
WHtR	Men:							0.75	0.21	0.68	0.64
	Women:							0.79	0.27	0.61	0.56
BF%	Men:								0.15	0.66	0.63
	Women:								0.25	0.67	0.63
BMI25[†]	Men:									-0.42	-0.45
	Women:									0.43	-0.48
BMI change[†]	Men:										0.98
	Women:										0.99

*Pearson partial correlation coefficients, adjusted for age and study area; [†]Data missing for 77 745 participants. BF%, body fat percentage; BMI, body mass index; BMI25, BMI at 25 years; HC, hip circumference; WC, waist circumference; WHR, waist-hip ratio; WHtR, waist-height ratio.

Supplemental Table S2. Mean BMI and waist circumference at baseline and second resurvey among 25,041 participants

	Mean baseline to resurvey interval (y)	BMI (kg/m ²)				WC (cm)			
		Baseline		Second resurvey*		Baseline		Second resurvey*	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Urban	7.8	24.3	0.01	24.7	0.40	82.0	0.02	86.1	1.08
Rural	8.1	23.2	0.01	23.7	0.40	78.9	0.02	83.3	1.15

*Standardised to age, sex and study area structure of baseline China Kadoorie Biobank population. BMI, body mass index; WC, waist circumference.

Supplemental Table S3. Adiposity measures by age and sex

	No. of participants	Mean (SD)										
		Height (m)	Weight (kg)	BMI (kg/m ²)	WC (cm)	HC (cm)	WHR	WHtR	BF%	BMI25 [†]	BMI change [†] (kg/m ²)	Proportional change in BMI [†] (%)
Men												
35-39 y	29099	167.6 (5.9)	66.4 (10.4)	23.6 (3.3)	82.0 (9.4)	91.2 (6.2)	0.90 (0.06)	0.49 (0.05)	23.2 (6.3)	21.6 (2.4)	2.2 (2.9)	10.4 (15.4)
40-49 y	56942	166.4 (5.9)	65.6 (9.9)	23.6 (3.1)	82.5 (9.2)	91.1 (5.9)	0.90 (0.06)	0.50 (0.05)	22.9 (5.9)	21.6 (2.2)	2.2 (3.1)	10.9 (15.1)
50-59 y	59816	164.8 (5.8)	63.8 (9.6)	23.4 (3.0)	81.7 (9.0)	90.4 (5.8)	0.90 (0.06)	0.50 (0.05)	21.8 (5.7)	22.0 (2.3)	1.6 (3.3)	8.2 (15.8)
60-69 y	37980	163.2 (5.8)	61.4 (9.7)	23.0 (3.1)	81.2 (9.4)	89.9 (6.0)	0.90 (0.07)	0.50 (0.06)	20.5 (5.8)	22.2 (2.4)	0.9 (3.6)	5.2 (16.7)
70-79 y	14737	162.2 (6.0)	59.2 (9.6)	22.5 (3.2)	80.4 (9.5)	89.3 (6.2)	0.90 (0.07)	0.50 (0.06)	19.1 (6.0)	22.6 (2.6)	0.0 (3.7)	1.0 (16.7)
Total	198574	165.3 (5.8)	64.1 (9.7)	23.3 (3.1)	81.8 (9.1)	90.6 (5.9)	0.90 (0.06)	0.49 (0.06)	22.0 (5.9)	21.9 (2.3)	1.7 (3.2)	8.0 (16.3)
Women												
35-39 y	47702	156.1 (5.5)	56.0 (8.6)	23.0 (3.2)	75.0 (8.2)	90.1 (6.0)	0.83 (0.06)	0.48 (0.05)	30.7 (6.6)	21.4 (2.5)	1.6 (2.8)	7.9 (13.3)
40-49 y	90570	155.5 (5.3)	57.7 (8.5)	23.8 (3.2)	78.0 (8.4)	91.4 (5.9)	0.85 (0.06)	0.50 (0.05)	32.1 (6.5)	21.6 (2.5)	2.3 (3.1)	11.4 (15.2)
50-59 y	86984	153.8 (5.3)	57.1 (8.9)	24.1 (3.4)	80.2 (9.3)	91.4 (6.3)	0.88 (0.07)	0.52 (0.06)	32.6 (7.0)	22.0 (2.7)	2.2 (3.7)	11.1 (18.1)
60-69 y	44262	151.6 (5.3)	54.8 (9.3)	23.8 (3.6)	80.6 (10.0)	90.6 (6.8)	0.89 (0.07)	0.53 (0.06)	31.9 (7.5)	22.4 (3.2)	1.6 (4.3)	8.5 (20.3)
70-79 y	14497	149.6 (5.6)	52.0 (9.4)	23.1 (3.8)	79.9 (10.8)	89.7 (7.2)	0.89 (0.08)	0.53 (0.07)	30.7 (8.1)	22.8 (4.0)	0.6 (5.4)	4.2 (24.0)
Total	284015	154.1 (5.3)	56.4 (8.8)	23.7 (3.3)	78.7 (9.0)	91.0 (6.2)	0.86 (0.07)	0.51 (0.06)	31.9 (6.9)	21.9 (2.7)	1.9 (3.6)	10.1 (17.0)

^{*}Adjusted for study area; [†]Data missing for 77,745 participants. BF%, body fat; BMI, body mass index; BMI25, BMI at 25 years; HC, hip circumference; WC, waist circumference; WHR, waist-hip ratio; WHtR, waist-height ratio.

Supplemental Table S4. Number of cases of diabetes, standardised diabetes incidence rates and adjusted hazard ratios (95% CI) by BMI and waist circumference at baseline

	Men			Women		
	No. of cases	Rate (95% CI) per 100 000	Hazard ratio (95% CI) [†]	No. of cases	Rate (95% CI) per 100 000	Hazard ratio (95% CI) [†]
BMI (kg/m²)						
Underweight (<18.5)	104	108.1 (74.0-142.2)	0.81 (0.67-0.99)	182	117.9 (89.9-145.9)	0.78 (0.67-0.90)
Normal weight (18.5-22.9)	1139	134.3 (125.9-142.6)	1.00 (0.94-1.06)	1733	153.1 (145.6-160.5)	1.00 (0.95-1.05)
Overweight (23.0-27.4)	2518	356.8 (342.7-371.0)	2.51 (2.42-2.60)	3968	368.9 (357.3-380.5)	2.18 (2.11-2.25)
Obese (≥27.5)	1323	851.1 (829.4-872.8)	5.76 (5.44-6.10)	2449	826.5 (811.1-841.9)	4.45 (4.27-4.64)
Waist circumference (cm)						
Normal [‡]	3046	158.2 (149.3-167.2)	Ref	2914	116.7 (109.9-123.5)	Ref
Abdominal obesity [§]	2038	716.4 (703.8-729.0)	3.26 (3.07-3.46)	5418	574.1 (568.2-580.0)	2.77 (2.64-2.90)

[†]Standardised to age and study area structure of China Kadoorie Biobank population; [†]Stratified by age and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes; [‡]Men: ≤90.0 cm, women: ≤80.0 cm; [§]Men: >90.0 cm, women: >80.0 cm. Analyses restricted to participants who developed diabetes between 35 and 70 years- excludes 1 incident diabetes case at ages <35 years and 236 at ages ≥80 years. BMI, body mass index.

Supplemental Table S5. Adjusted hazard ratios (95% CI) for diabetes by baseline and usual levels of adiposity measures in men and women

Adiposity measure	Men* (Events=5084)	Women* (Events=8332)
BMI		
Baseline	1.91 (1.86-1.96)	1.70 (1.67-1.76)
Usual	1.98 (1.93-2.04)	1.77 (1.73-1.81)
WC		
Baseline	1.99 (1.94-2.04)	1.78 (1.75-1.81)
Usual	2.13 (2.07-2.19)	1.91 (1.87-1.95)
HC		
Baseline	1.76 (1.71-1.82)	1.49 (1.46-1.53)
Usual	2.05 (1.98-2.14)	1.65 (1.61-1.70)
WHR		
Baseline	1.33 (1.31-1.35)	1.27 (1.26-1.29)
Usual	1.53 (1.50-1.55)	1.45 (1.43-1.48)
WHtR		
Baseline	1.95 (1.90-2.00)	1.78 (1.74-1.82)
Usual	2.10 (2.03-2.16)	1.91 (1.87-1.96)
BF%		
Baseline	1.76 (1.72-1.81)	1.69 (1.66-1.73)
Usual	2.19 (2.11-2.27)	1.96 (1.92-2.01)

*HR per 1 SD higher, stratified by age and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes. Analyses restricted to participants who developed diabetes between 35 and 70 years- excludes 1 incident diabetes case at ages <35 years and 236 at ages ≥80 years. BF%, body fat percent; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist-hip ratio; WHtR, waist-height ratio.

Supplemental Table S6. Adjusted hazard ratios (95% CI) for diabetes per 1 SD higher baseline BMI and waist circumference with different adjustments or exclusions

	Men		Women	
	No. of cases	Hazard ratio* (95% CI)	No. of cases	Hazard ratio* (95% CI)
BMI				
Additionally adjusted for				
Systolic blood pressure	5084	1.86 (1.81-1.91)	8332	1.63 (1.59-1.66)
Dietary factors [†]	5084	1.91 (1.86-1.96)	8332	1.70 (1.67-1.74)
Menopausal status	N/A	N/A	8332	1.70 (1.67-1.73)
Additionally excluding cancer diagnosed prior to diabetes diagnosis	4923	1.92 (1.87-1.97)	8084	1.70 (1.67-1.73)
Waist circumference				
Additionally adjusted for				
Systolic blood pressure	5084	1.93 (1.87-2.00)	8332	1.70 (1.66-1.74)
Dietary factors [†]	5084	1.99 (1.92-2.05)	8332	1.78 (1.75-1.81)
Menopausal status	N/A	N/A	8332	1.78 (1.75-1.81)
Additionally excluding cancer diagnosed prior to diabetes diagnosis	4923	1.99 (1.94-2.05)	8084	1.78 (1.75-1.81)

*Stratified by age-at-risk and study area, and adjusted for education, household income, occupation, smoking, alcohol consumption, physical activity and family history of diabetes. [†]Fresh fruit, fresh vegetable, meat, rice, soybean product and wheat consumption. BMI, body mass index.

Supplemental Table S7. Adjusted hazard ratios (95% CI) for diabetes by combinations of BMI at 25 years of age and BMI at baseline

BMI25 (kg/m ²)	BMI at baseline (kg/m ²)									
	Q1		Q2		Q3		Q4		Per 1 kg/m ²	
	Events	HR* (95%CI)	Events	HR* (95%CI)	Events	HR* (95%CI)	Events	HR* (95%CI)	Events	HR* (95%CI)
Men										
Q1	168	1.00 [†] (0.86-1.16)	172	1.50 (1.29-1.74)	354	3.07 (2.76-3.41)	421	5.64 (5.12-6.21)	1115	1.25 (1.22-1.27)
Q2	130	0.96 (0.81-1.17)	153	1.29 (1.10-1.51)	308	2.43 (2.17-2.72)	500	5.00 (4.58-5.46)	1091	1.25 (1.23-1.28)
Q3	111	0.93 (0.77-1.12)	132	1.04 (0.87-1.23)	273	2.16 (1.92-2.44)	577	4.70 (4.33-5.10)	1093	1.24 (1.22-1.27)
Q4	79	0.97 (0.78-1.22)	143	1.18 (1.00-1.39)	255	1.89 (1.67-2.14)	802	4.91 (4.58-5.27)	1279	1.21 (1.19-1.23)
<i>Per 1 kg/m²</i>	<i>488</i>	<i>0.97 (0.93-1.02)</i>	<i>600</i>	<i>0.95 (0.91-0.99)</i>	<i>1190</i>	<i>0.93 (0.90-0.95)</i>	<i>2300</i>	<i>0.99 (0.98-1.01)</i>		
Women										
Q1	273	1.00 [†] (0.89-1.13)	357	1.95 (1.75-2.16)	426	2.97 (2.70-3.26)	532	5.26 (4.83-5.73)	1588	1.20 (1.18-1.21)
Q2	197	0.95 (0.82-1.09)	282	1.50 (1.33-1.69)	467	2.62 (2.39-2.86)	655	4.38 (4.05-4.73)	1601	1.18 (1.16-1.20)
Q3	158	0.92 (0.79-1.08)	248	1.33 (1.18-1.51)	442	2.23 (2.03-2.45)	824	4.07 (3.80-4.35)	1672	1.18 (1.16-1.19)
Q4	120	1.04 (0.87-1.24)	192	1.14 (0.99-1.32)	425	1.98 (1.80-2.18)	1260	4.14 (3.92-4.38)	1997	1.16 (1.15-1.18)
<i>Per 1 kg/m²</i>	<i>748</i>	<i>0.99 (0.96-1.02)</i>	<i>1079</i>	<i>0.92 (0.90-0.95)</i>	<i>1760</i>	<i>0.94 (0.92-0.95)</i>	<i>3271</i>	<i>0.98 (0.97-0.99)</i>		

[†]Stratified by age and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes; [†]Reference group. BMI Q1: men <21.0 kg/m², women <21.3 kg/m²; BMI Q2: men 21.0 to <23.1 kg/m², women 21.3 to <23.5 kg/m²; BMI Q3: men 23.1 to <25.5 kg/m², women 23.5 to <25.8 kg/m²; BMI Q4: men ≥25.5 kg/m², women ≥25.8 kg/m². BMI25 Q1: men <20.4 kg/m², women <19.9 kg/m²; BMI25 Q2: men 20.4 to <21.7 kg/m², women 19.9 to <21.6 kg/m²; BMI25 Q3: men 21.7 to <23.3 kg/m², women 21.6 to <23.5 kg/m²; BMI25 Q4: men ≥23.3 kg/m², women ≥23.5 kg/m². 77 745 participants with missing data for BMI25 are excluded from the analyses. Analyses restricted to participants who developed diabetes between 35 and 70 years- excludes 7 incident diabetes cases at ages <35 years and 161 at ages ≥80 years. BMI, body mass index; BMI25, BMI at 25 years.

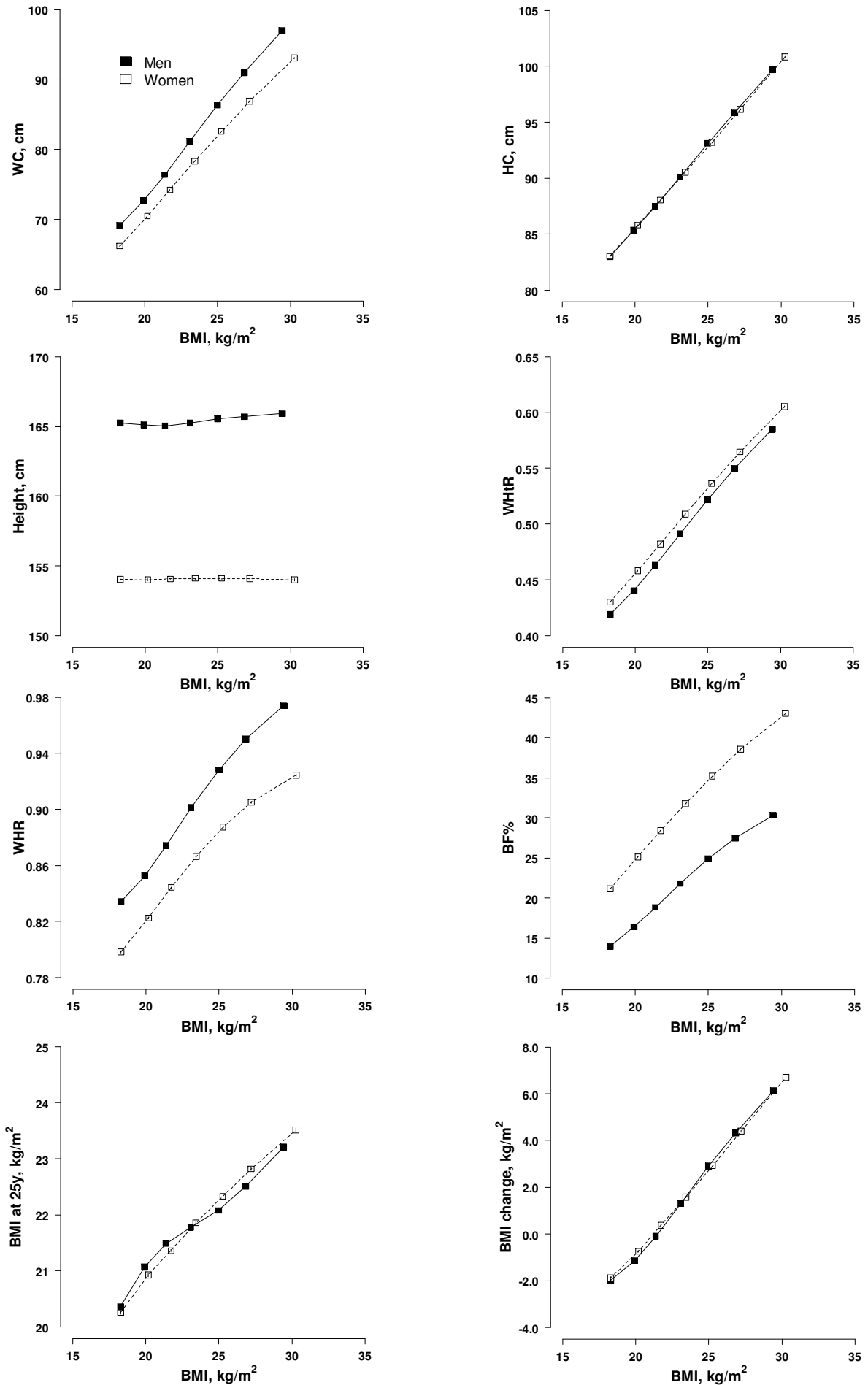
Supplemental Table S8. Age-specific prevalence of diabetes in CKB versus nationally representative surveys in China

Age group (y)	Diabetes prevalence, % (95% CI)								
	CKB resurvey population (n=14,881)			2010 China survey*			2013 China survey†		
	Diagnosed‡	Undiagnosed‡	Total§	Diagnosed	Undiagnosed	Total	Diagnosed	Undiagnosed	Total
40-49	5.5 (4.8-6.1)	4.7 (4.1-5.3)	10.2 (9.3-11.1)	3.2 (2.9-3.4)	8.1 (7.7-8.6)	11.3 (10.8-11.8)	N/A	N/A	N/A
50-59	8.5 (7.7-9.3)	5.5 (4.9-6.2)	14.0 (13.1-15.0)	5.9 (5.5-6.2)	11.8 (11.2-12.3)	17.6 (17.0-18.3)	N/A	N/A	N/A
60-69	11.5 (10.2-12.7)	6.3 (5.4-7.3)	17.8 (16.3-19.3)	8.3 (7.8-8.9)	14.1 (13.4-14.9)	22.5 (21.6-23.4)	N/A	N/A	N/A
≥70	10.7 (8.2-13.2)	5.2 (3.2-7.1)	15.8 (12.8-18.9)	8.0 (7.3-8.8)	15.5 (14.4-16.6)	23.5 (22.3-24.7)	N/A	N/A	N/A
<40	2.7 (1.9-3.4)	2.5 (1.8-3.1)	5.1 (4.2-6.1)	N/A	N/A	N/A	1.3 (1.0-1.7)	4.5 (4.1-4.9)	5.9 (5.1-6.6)
40-59	7.1 (6.6-7.6)	5.1 (4.7-5.6)	12.2 (11.5-12.8)	N/A	N/A	N/A	5.0 (4.7-5.4)	7.8 (7.5-8.1)	12.9 (12.3-13.5)
≥60	11.3 (10.2-12.4)	6.1 (5.3-7.0)	17.5 (16.1-18.8)	N/A	N/A	N/A	8.8 (8.0-9.5)	11.4 (10.8-12.0)	20.2 (19.1-21.2)

*Xu Y, Wang L, He J, et al. Prevalence and control of diabetes in Chinese adults. JAMA. 2013;310(9):948-959; †Wang L, Gao P, Huang Z, et al. Prevalence and Ethnic Pattern of Diabetes and Prediabetes in China in 2013. JAMA 2017;317(24):2515-2523; ‡Diabetes at baseline or incident diabetes (identified through disease surveillance system, health insurance system or death registries); †Self-reported or screen-detected diabetes in first or second resurvey, no diabetes at baseline and no incident diabetes (identified through disease surveillance system, health insurance system or death registries); §Diabetes at baseline, first or second resurvey or incident diabetes (identified through disease surveillance system, health insurance system or death registries);

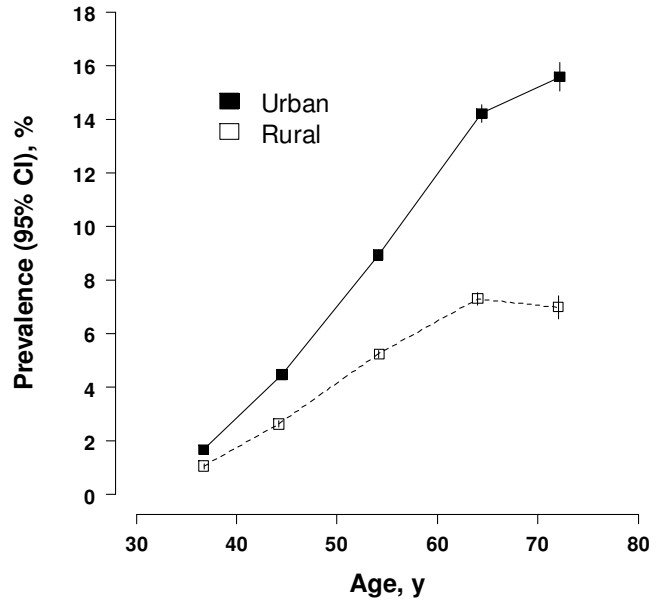
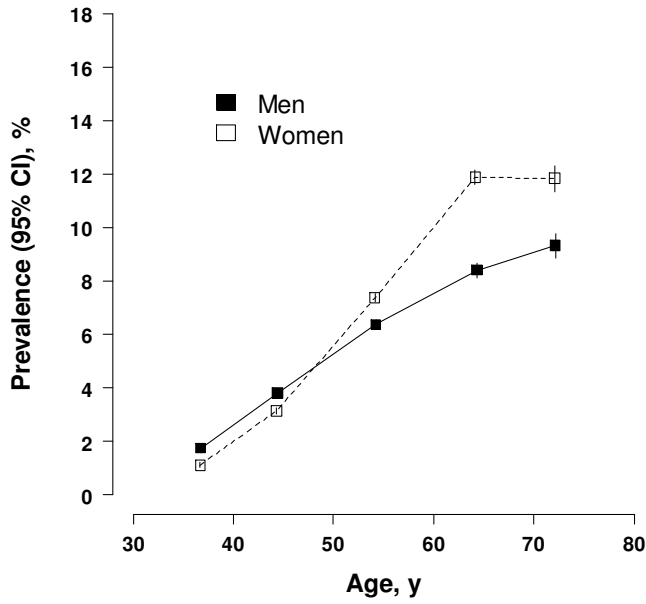
Supplemental Figure S1. Associations of BMI with other adiposity measures in men and women

Standardised to age and study area structure of China Kadoorie Biobank population. BF%, body fat percent; BMI, body mass index; HC, hip circumference; WC, waist circumference; WHR, waist-hip ratio; WHtR, waist-height ratio.

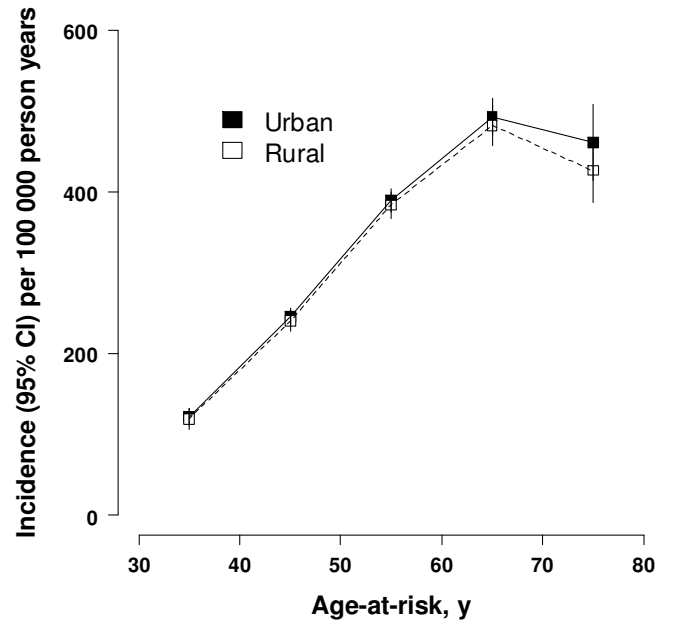
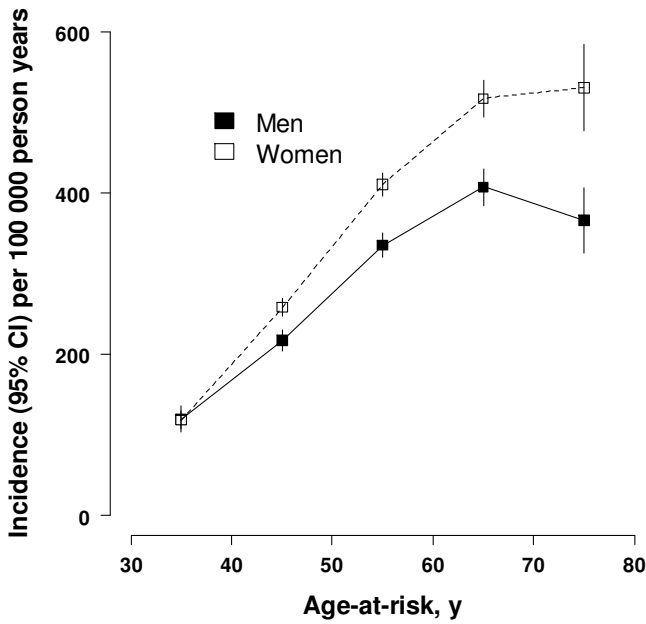


Supplemental Figure S2. Diabetes prevalence and incidence by age, sex and area

A. Prevalence

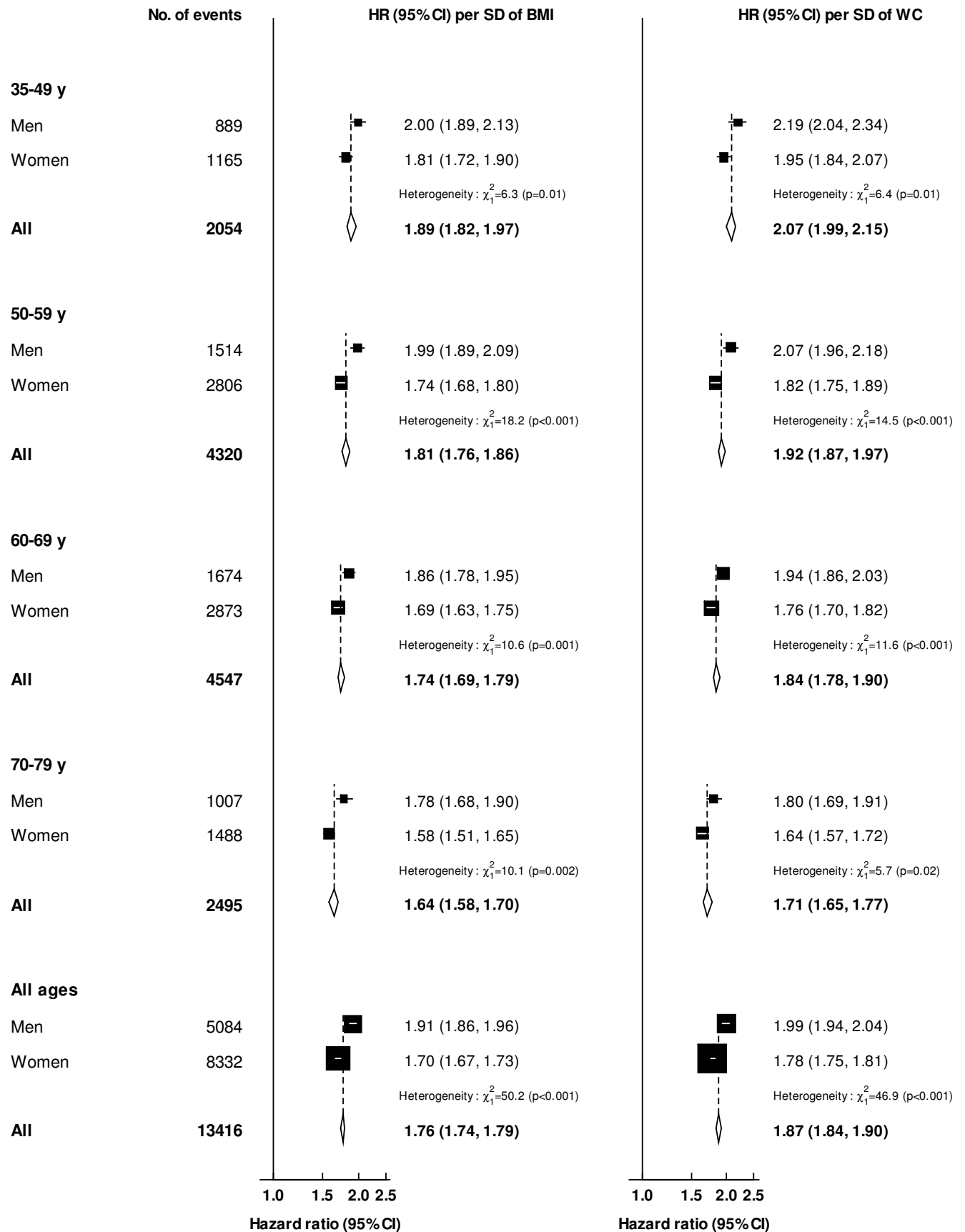


B. Incidence



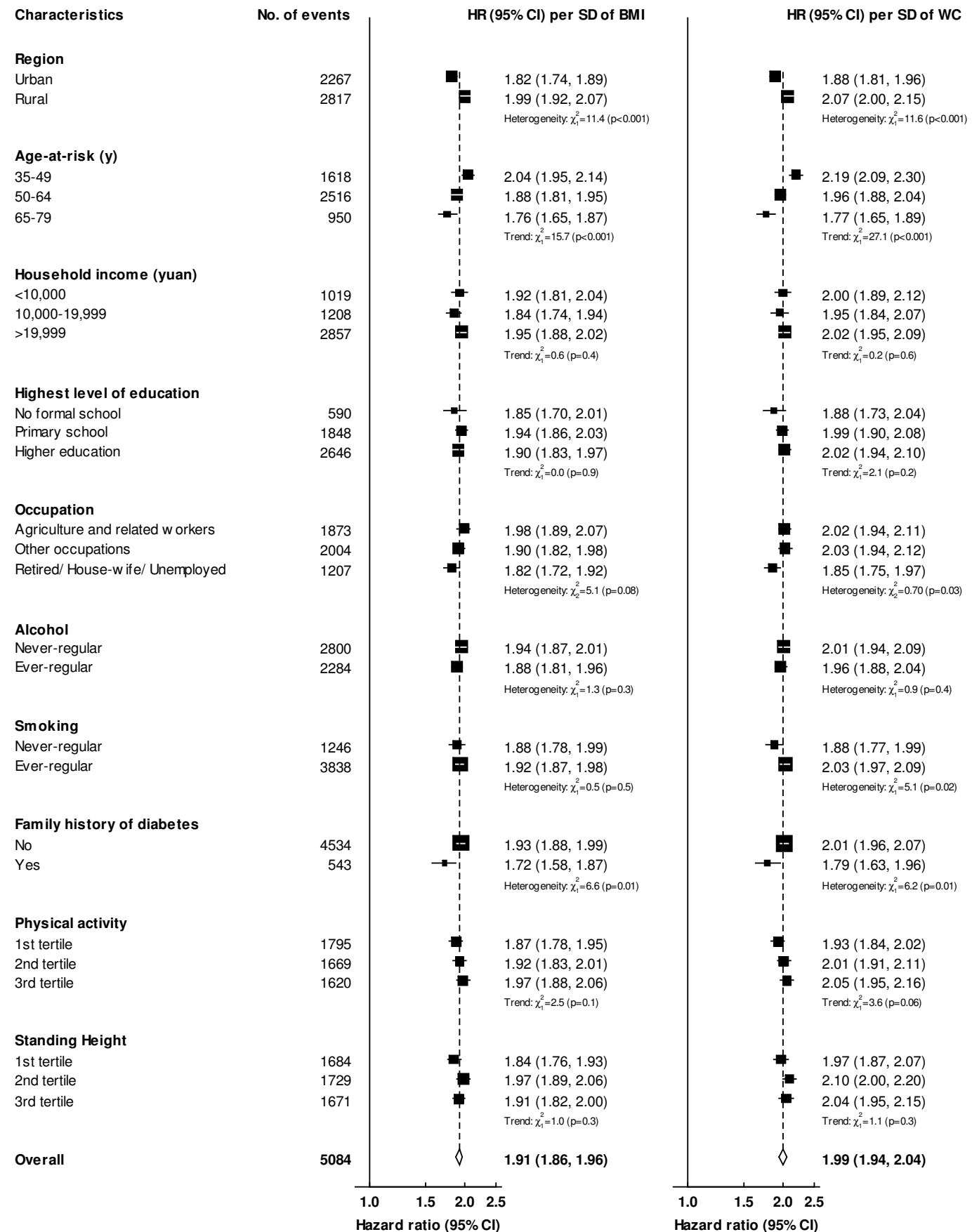
Supplemental Figure S3. Adjusted hazard ratios (95% CI) for diabetes per 1 SD higher baseline BMI and waist circumference by age and sex

Stratified by age-at-risk and study area and adjusted for income, education, occupation, alcohol consumption, smoking, physical activity, family history of diabetes. BMI, body mass index; WC, waist circumference.



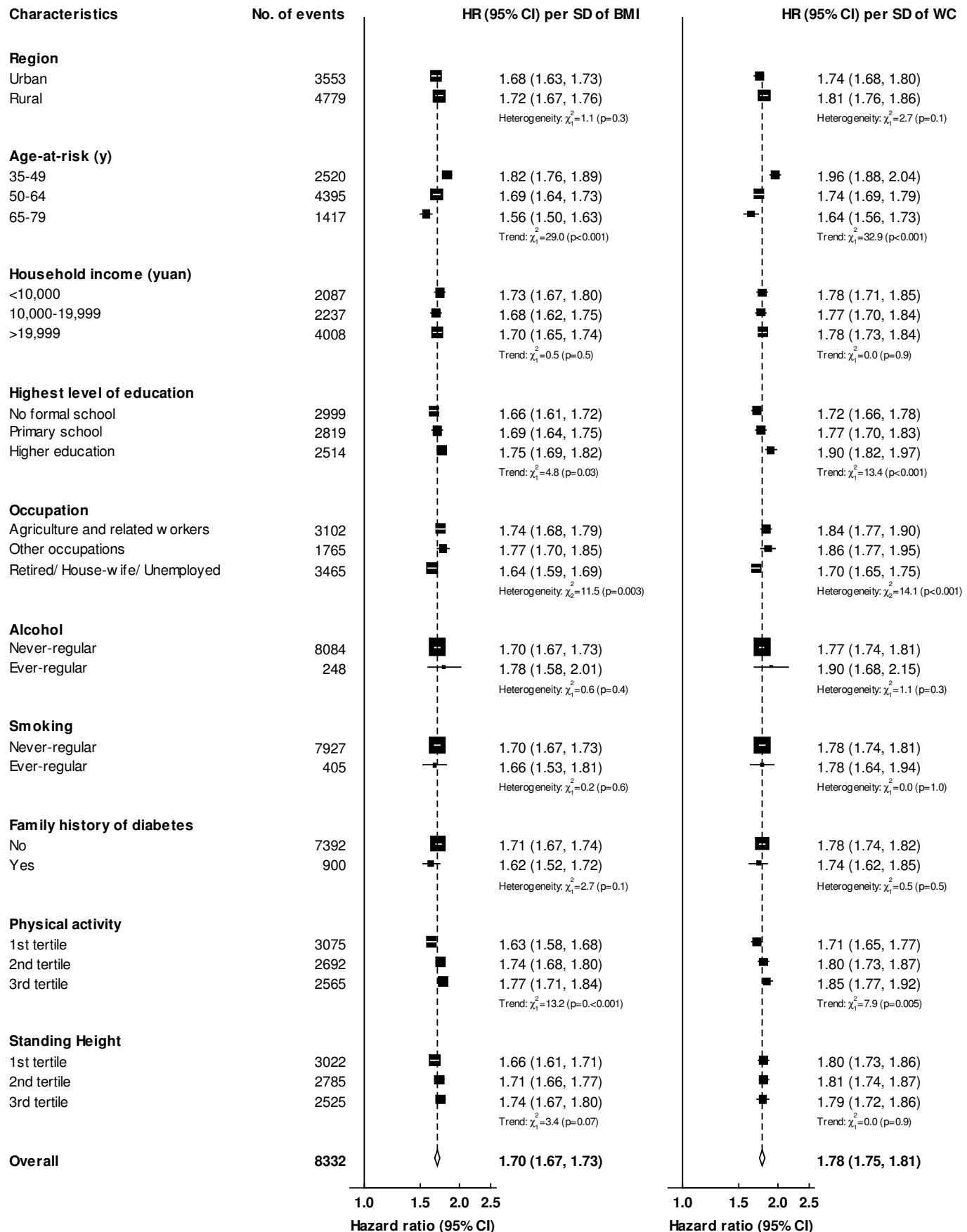
Supplemental Figure S4. Adjusted hazard ratios (95% CI) for diabetes per 1 SD higher baseline BMI and waist circumference in men

Stratified by age-at-risk and study area and adjusted (except where it is the variable of interest) for income, education, occupation, alcohol consumption, smoking, physical activity, family history of diabetes. BMI, body mass index; WC, waist circumference.



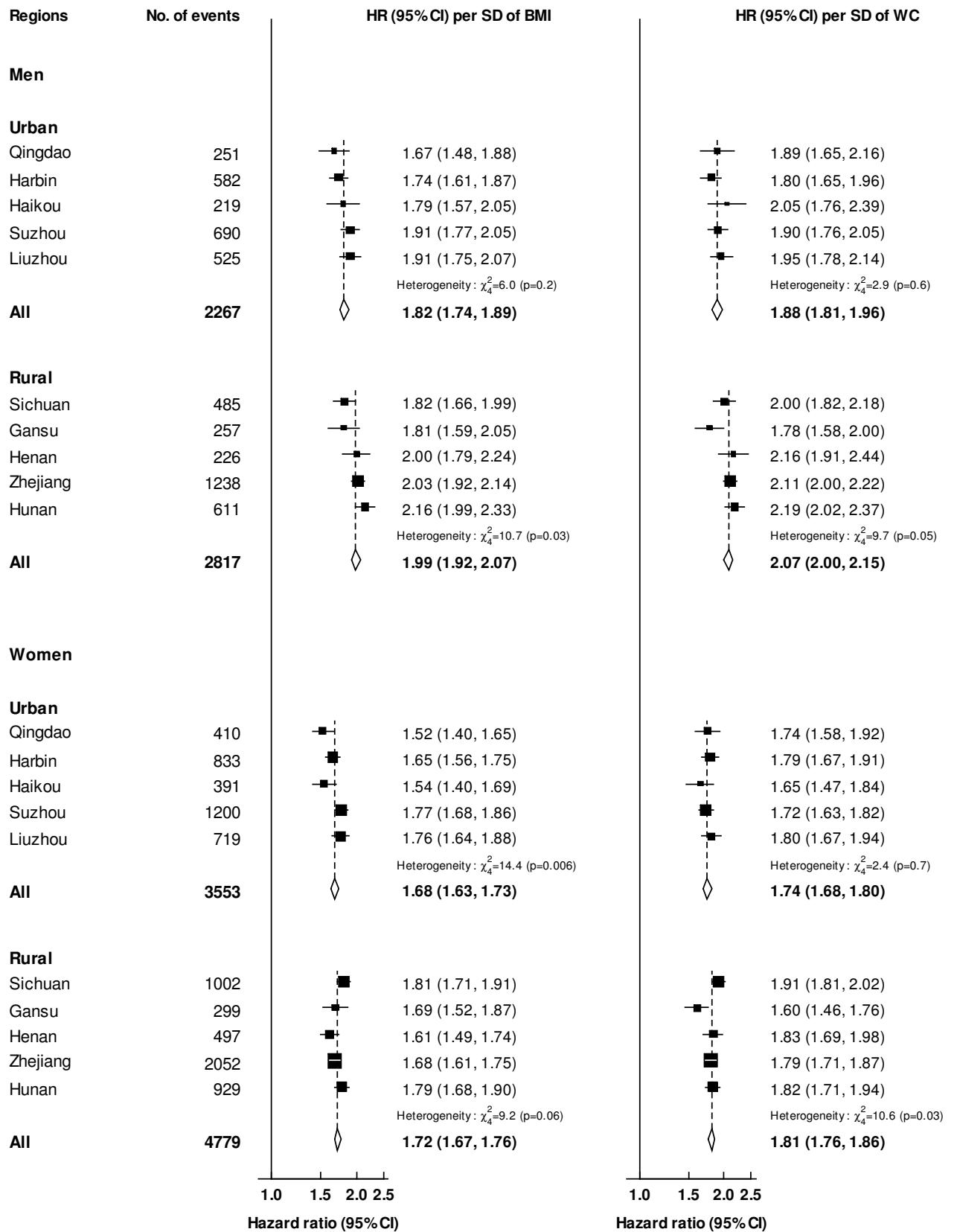
Supplemental Figure S5. Adjusted hazard ratios (95% CI) for diabetes per 1 SD higher baseline BMI and waist circumference in women

Stratified by age-at-risk and study area and adjusted (except where it is the variable of interest) for income, education, occupation, alcohol consumption, smoking, physical activity, family history of diabetes. BMI, body mass index; WC, waist circumference.



Supplemental Figure S6. Adjusted hazard ratios (95% CI) for diabetes per 1 SD higher baseline BMI and waist circumference by region

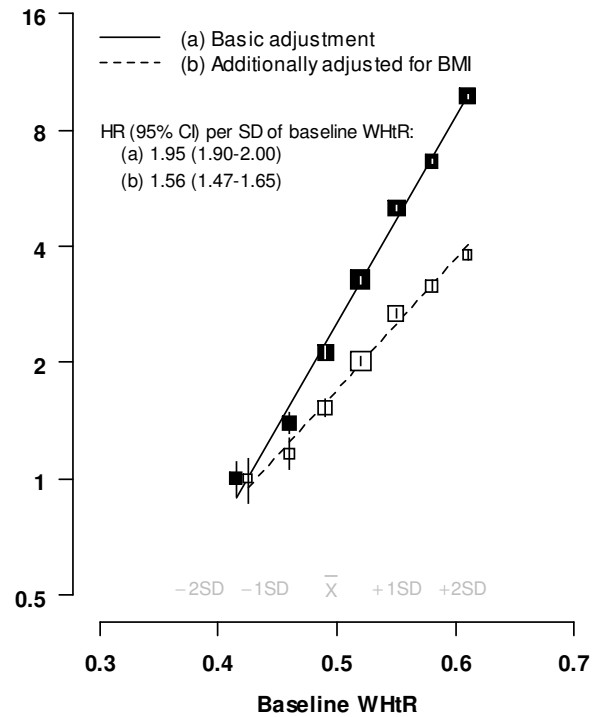
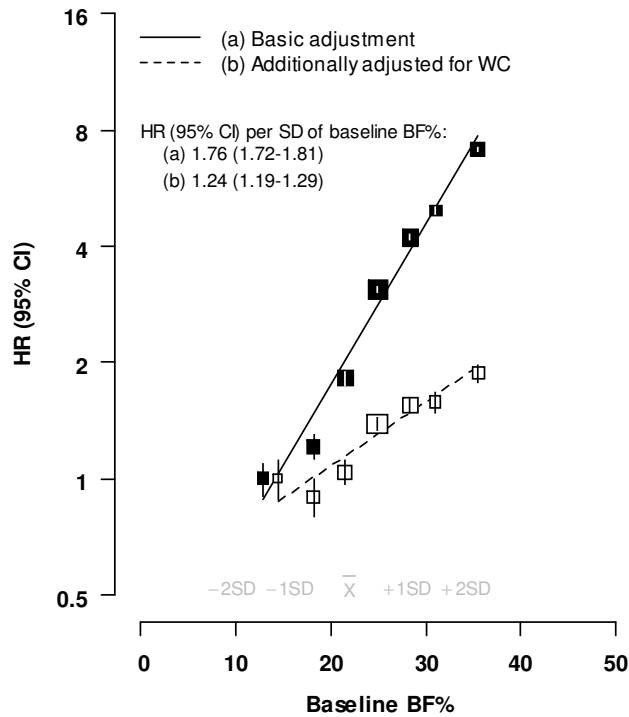
Stratified by age-at-risk and adjusted for income, education, occupation, alcohol consumption, smoking, physical activity, family history of diabetes. BMI, body mass index; WC, waist circumference.



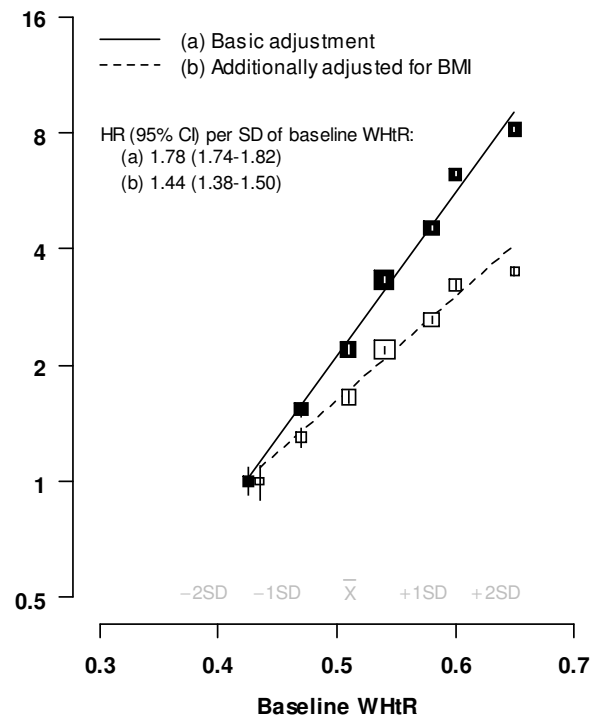
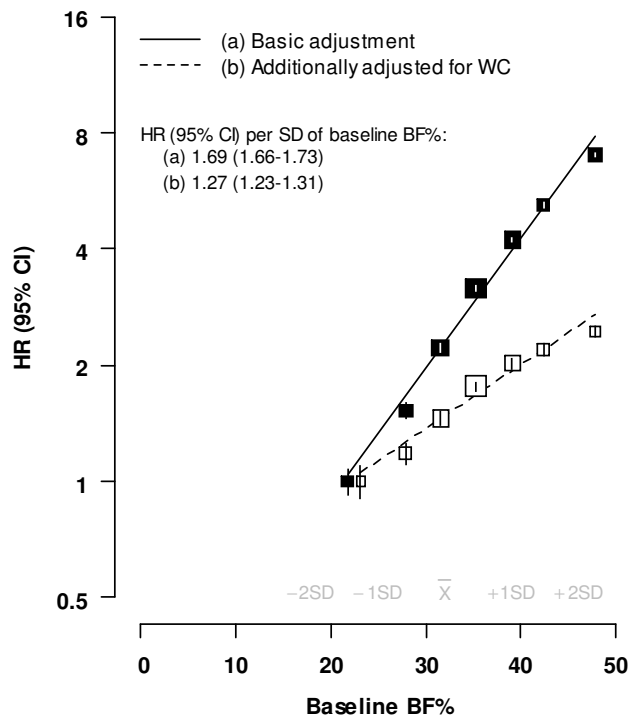
Supplemental Figure S7. Adjusted hazard ratios (95% CI) for diabetes by baseline body fat percent and waist-height ratio

Stratified by age-at-risk and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes. BF%, body fat percent; BMI, body mass index; WC, waist circumference, WHtR, waist-height ratio.

Men (5084 events)



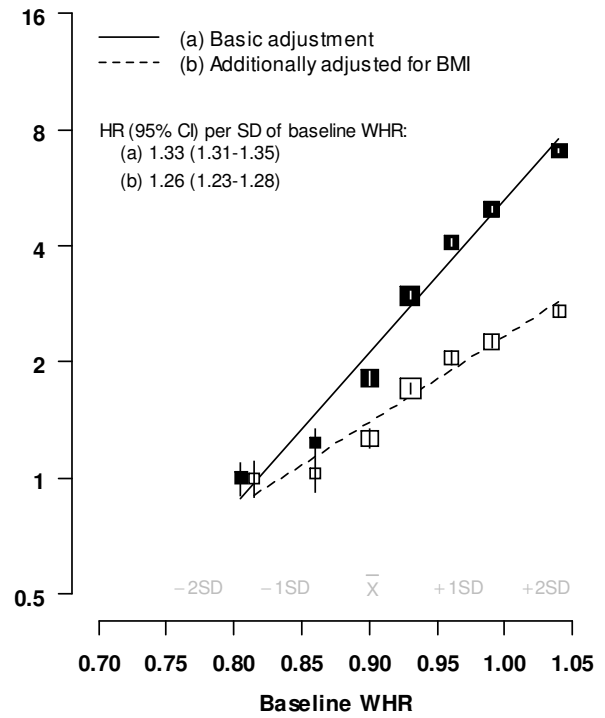
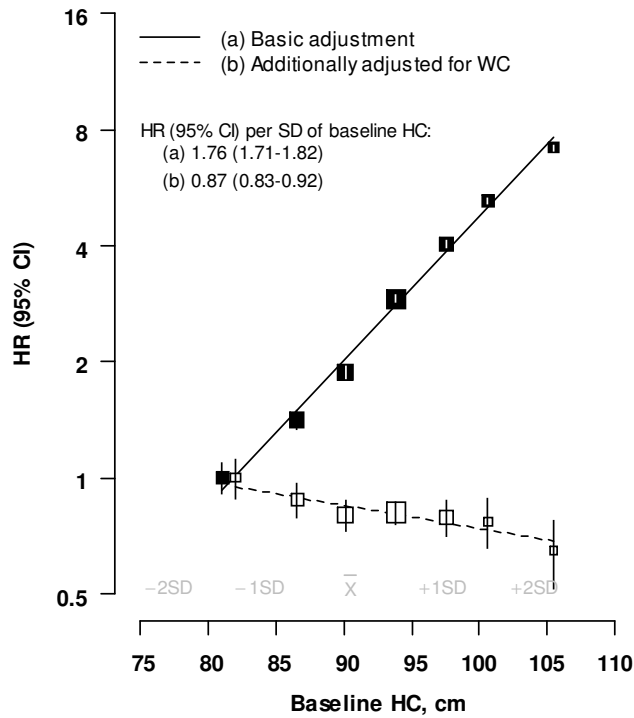
Women (8332 events)



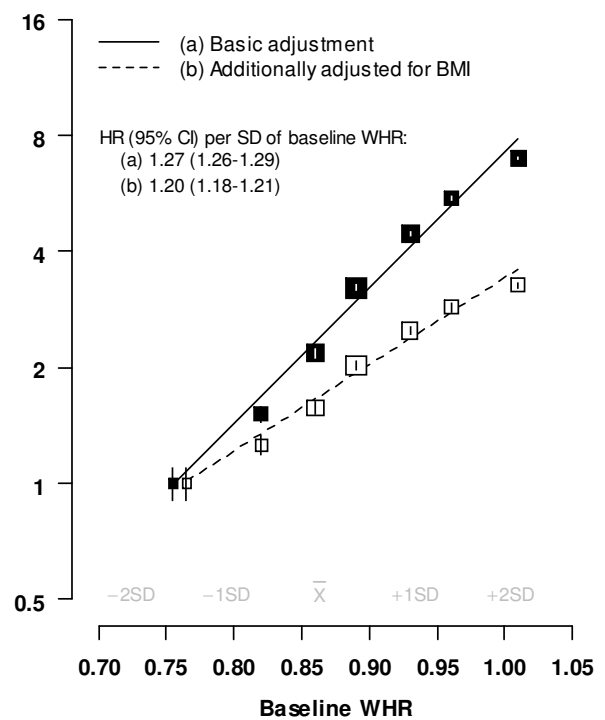
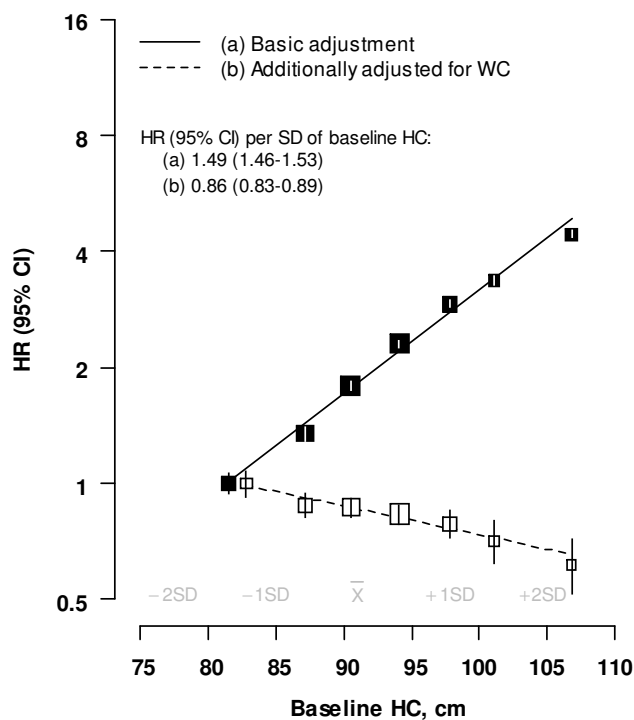
Supplemental Figure S8. Adjusted hazard ratios (95% CI) for diabetes by baseline hip circumference and waist-hip ratio

Stratified by age-at-risk and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes. BMI, body mass index; HC, hip circumference; WC, waist circumference, WHR, waist-hip ratio.

Men (5084 events)

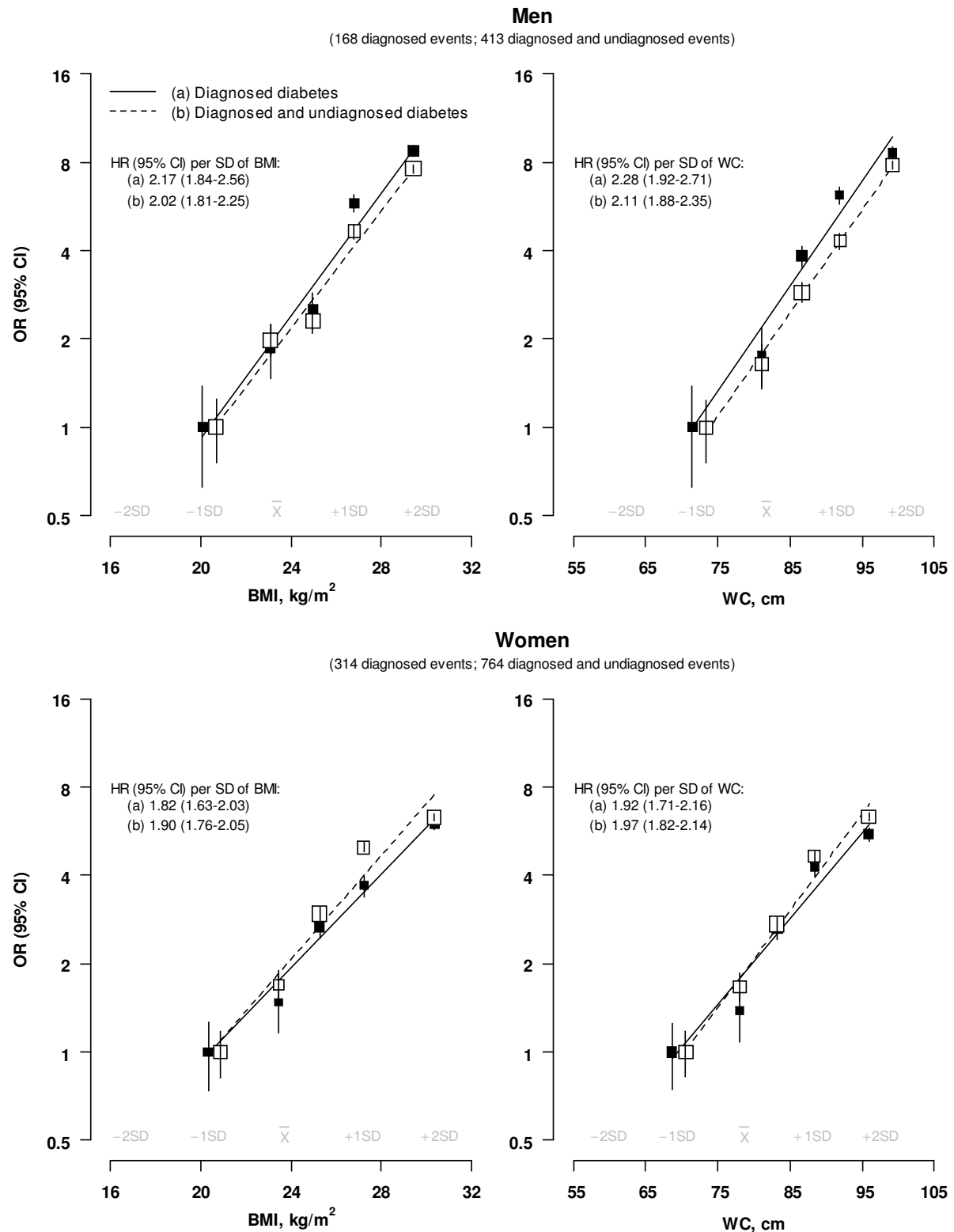


Women (8332 events)



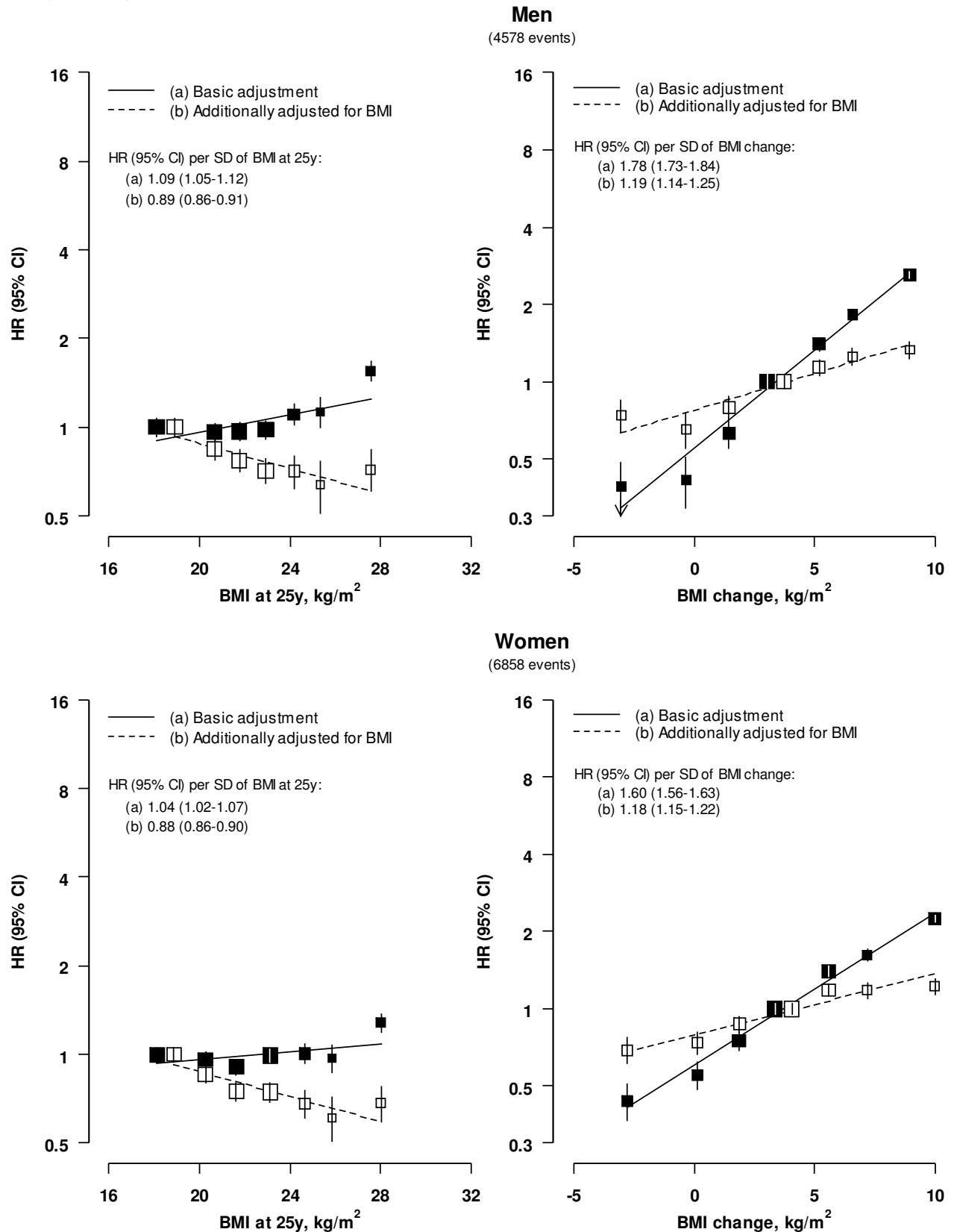
Supplemental Figure S9. Adjusted odds ratios (95% CI) for diagnosed and undiagnosed diabetes by baseline BMI and waist circumference

Based on population included in both first and second resurveys (n=14,881). Diagnosed diabetes: incident diabetes identified through disease surveillance system, health insurance system or death registries and no self-reported or screen-detected diabetes at baseline. Undiagnosed diabetes: self-reported or screen-detected diabetes in first or second resurvey but no self-reported or screen-detected diabetes at baseline or incident diabetes identified through disease surveillance system, health insurance system or death registries.



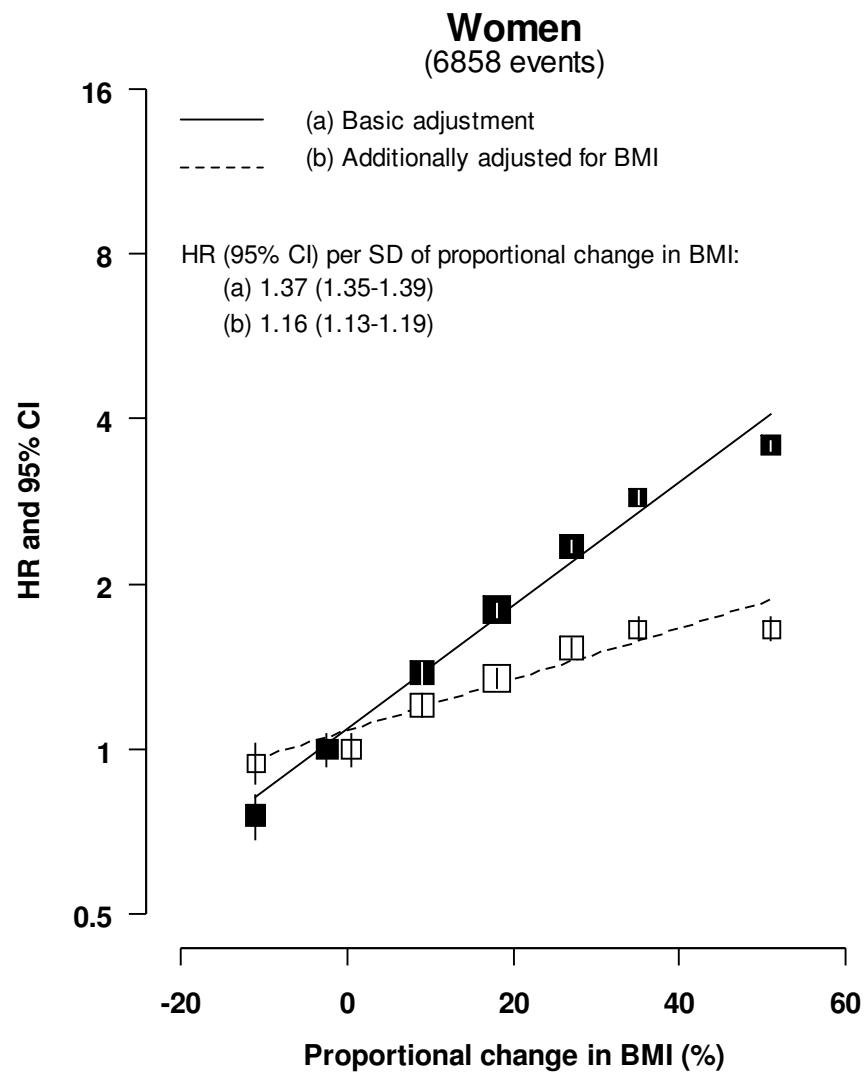
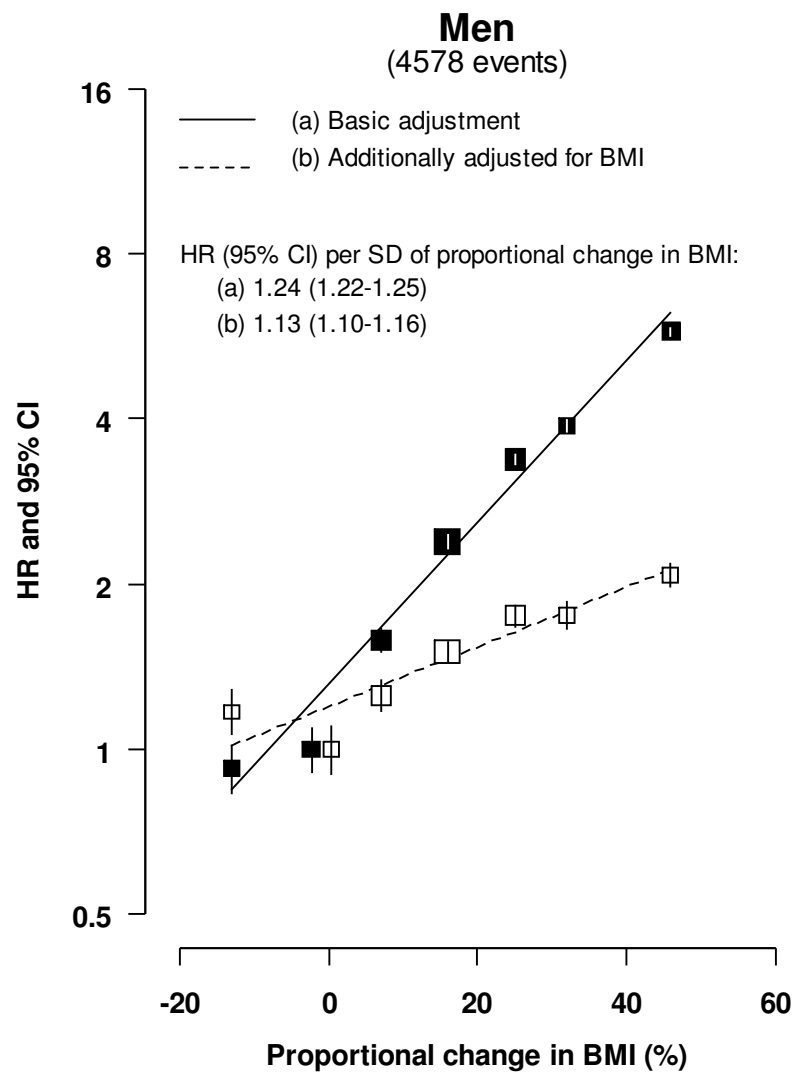
Supplemental Figure S10. Adjusted hazard ratios (95% CI) for diabetes by BMI at 25 years of age and BMI change

Sensitivity analyses examining the association of BMI₂₅ with incident major coronary event (fatal ischaemic heart disease or non-fatal myocardial infarction) showed no attenuation after additional adjustment for BMI at baseline. Men: basic adjustment HR 1.08 (95% CI 1.04-1.12) per 1 SD BMI₂₅; additionally adjusted for BMI at baseline 1.09 (1.05-1.13). Women: basic adjustment 1.09 (95% CI 1.05-1.14); additionally adjusted for BMI at baseline 1.10 (1.05-1.15).



Supplemental Figure S11. Adjusted hazard ratios (95% CI) for diabetes by proportional change in BMI since age 25 years

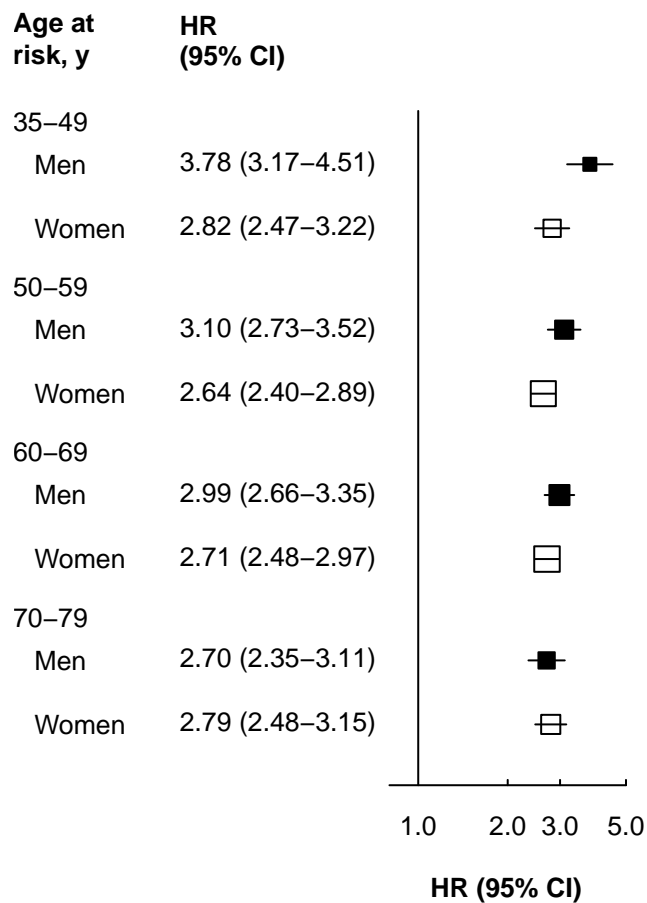
Stratified by age-at-risk and study area and adjusted for education, income, occupation, smoking, alcohol consumption, physical activity, family history of diabetes. 77 745 participants with missing data for BMI at 25 years are excluded from the analyses. BMI, body mass index.



Supplemental Figure S12. Adjusted hazard ratios (95% CI) for diabetes and diabetes cases due to excess adiposity (i.e. BMI 23+)

(A) Hazard ratios (HRs) are calculated for overweight or obese (BMI 23+) participants vs absence of overweight or obesity (BMI <23) participants. HRs are stratified by age and study area and adjusted for education, household income, occupation, smoking, alcohol consumption, physical activity and family history of diabetes. Squares represent the HR with area inversely proportional to the variance of the log HR and error bars indicate the 95%CI. (B) Diabetes cases attributable to excess adiposity (overweight or obese) in 2010 is calculated by applying population-attributable fractions (PAF) to the estimated age- and sex-specific number of diabetes cases in China in 2010.

A



B

