Overweight/obesity with low skeletal muscle mass and metabolic unhealthiness additionally increases the risk of developing diabetes and early-onset diabetes: evidence from a retrospective multicenter cohort study

Supplementary Table 1 Comparison of baseline characteristics of study and excluded participants

	DM cohort	Missing data	SMD
N	117249	94584	
Age, years	44.06 (12.92)	39.67 (11.86)	0.35
Height, cm	166.29 (8.31)	166.60 (8.34)	0.04
Weight, kg	64.87 (12.11)	64.44 (12.36)	0.03
BMI, kg/m^2	23.34 (3.30)	23.10 (3.39)	0.07
SBP, mmHg	119.40 (16.67)	118.65 (16.00)	0.05
DBP, mmHg	74.43 (10.97)	73.87 (10.61)	0.05
FPG, mmol/L	4.94 (0.61)	4.88 (0.61)	0.10
TC, mmol/L	4.79 (0.90)	4.60 (0.89)	0.21
TG, mmol/L	1.37 (1.04)	1.29 (1.02)	0.08
HDL, mmol/L	1.37 (0.31)	1.28 (0.27)	0.31
LDL, mmol/L	2.77 (0.68)	2.87 (0.65)	0.15
ALT, U/L	23.82 (21.81)	24.12 (22.52)	0.01
AST, U/L	24.07 (12.53)	24.10 (12.14)	0.00
BUN, mmol/L	4.68 (1.18)	4.62 (1.20)	0.05
SCR, μmol/L	70.34 (15.81)	69.69 (15.78)	0.04
Gender			0.05
Females	54183 (46.21%)	41527 (43.90%)	
Males	63066 (53.79%)	53057 (56.10%)	
Smoking			0.03
Never	24797 (21.15%)	20799 (21.99%)	
Ever	1334 (1.14%)	1225 (1.30%)	
Current	6688 (5.70%)	5387 (5.70%)	
Unknown	84430 (72.01%)	67173 (71.02%)	
Drinking			0.08
Never	26387 (22.51%)	23536 (24.88%)	
Ever	5554 (4.74%)	3402 (3.60%)	
Current	878 (0.75%)	473 (0.50%)	
Unknown	84430 (72.01%)	67173 (71.02%)	
Family history of DM	2657 (2.27%)	1687 (1.78%)	0.03
DM incident	2689 (2.29%)	1485 (1.57%)	0.05

SMD standardized mean difference, other abbreviations can be found in **Table 1.**

Supplementary Table 2 Collinearity test for covariates

	VIF					
DM cohort						
Obesity phenotype	1.5					
BMI		1.3				
OO			1.2			
SMI				5.6		
Pre-sarcopenia					1.4	
MS						1.4
Age	1.3	1.2	1.2	1.6	1.4	1.2
Gender	1.1	1.1	1.1	5.4	1.2	1.1
FPG	1.1	1.1	1.1	1.1	1.1	1.1
ALTgroup	1.1	1.1	1.1	1.1	1.1	1.1
ASTgroup	1	1	1	1	1	1
BUNgroup	1.5	1.5	1.5	1.5	1.5	1.5
SCRgroup	1.5	1.5	1.5	1.5	1.5	1.5
Dyslipidemia	1.3	1.2	1.2	1.2	1.1	1.3
Smoking	1	1	1	1	1	1
Family history of DM	1	1	1	1	1	1
Early-onset DM cohort						
Obesity phenotype	1.4					
BMI		1.4				
OO			1.3			
SMI				4.1		
Pre-sarcopenia					1.1	
MS						1.3
Age	1	1	1	1.1	1	1
Gender	1.1	1.2	1.2	4.5	1.1	1.1
FPG	1	1	1	1	1	1
ALTgroup	1.2	1.2	1.2	1.2	1.1	1.1
ASTgroup	1	1	1	1	1	1
BUNgroup	2.3	2.3	2.3	2.3	2.3	2.3
SCRgroup	2.3	2.3	2.3	2.3	2.3	2.3
Dyslipidemia	1.3	1.2	1.1	1.2	1.1	1.3
Smoking	1	1	1	1	1	1
Family history of DM	1	1	1	1	1	1

VIF variance inflation factor, MS Metabolic status, other abbreviations can be found in **Table 1**

Supplementary Table 3 Post hoc comparisons for metabolic indicators by obesity phenotypes

	NWNSMH	OONSMH	NWPSMH	OOPSMH	NMNSMU	OONSMU	NWPSMU	OOPSMU
DM cohort								
TC, mmol/L				‡	§		**	**
TG, mmol/L	-						**	**
HDL, mmol/L	-					‖	‖,**	‖,**,††
LDL, mmol/L	-		‡	‡,§	‡,§,¶			§
ALT, U/L	-		‡				¶,**	
AST, U/L	-		‡	§	‡,§,¶		¶,**	††
SCR, μmol/L	-		‡	‡,§		†,§	‡,§,¶,**	†,§,**,††
BUN, mmol/L	-		‡	‡,§			†,‡,**	**,††
METS-IR	-							
Early-onset DM cohort								
TC, mmol/L	-		†	‡	‡,¶		†,‡,§,¶,‖,**	
TG, mmol/L	-		†				‖,**	††
HDL, mmol/L	-		‡	§			‖	**
LDL, mmol/L	-		†	‡	‡,¶		†,‡,§,¶,‖,**	**,††
ALT, U/L	-				§		†,‡,§,¶,‖,**	
AST, U/L	-		†		‡,§	¶	†,‡,§,¶,‖,**	††
SCR, μmol/L	-		†,‡	†,‡,§	†,§,¶	†,‡,§,¶,‖	†,‡,§,¶,‖,**,††	†,§,¶,‖,**,††
BUN, mmol/L	-		†,‡	†,‡,§		‖	†,‡,§,¶,‖,**	†,§,**,††
METS-IR	-						¶,**	

The analyses of categorical variables among eight groups were performed by pearson's qui-squared test. The analyses of continuous among eight groups were performed by Bonferroni test: †, $P \geq 0.05$ versus NWNSMH; ‡, $P \geq 0.05$ versus OONSMH; §, $P \geq 0.05$ versus NWPSMH; ¶, $P \geq 0.05$ versus OOPSMH; ‖, $P \geq 0.05$ versus NMNSMU; **, $P \geq 0.05$ versus OONSMU; ††, $P \geq 0.05$ versus NWPSMU. Abbreviations can be found in **Table 1.**

Supplementary Table 4 Cox regression analysis of obesity phenotypes with DM and early-onset DM

	HR (95%CI)		
	Non-adjusted model	**Adjusted model I**	**Adjusted model II**
DM cohort			
BMI	1.22 (1.21, 1.23)	1.19 (1.18, 1.21)	1.09 (1.08, 1.11)
OO	3.90 (3.59, 4.25)	2.70 (2.47, 2.94)	1.60 (1.46, 1.75)
SMI	0.93 (0.92, 0.94)	0.65 (0.64, 0.67)	0.80 (0.77, 0.82)
Pre-sarcopenia	4.64 (4.26, 5.05)	3.12 (2.84, 3.43)	1.78 (1.62, 1.96)
MU	6.57 (6.09, 7.10)	4.33 (3.99, 4.70)	1.59 (1.44, 1.75)
Obesity phenotype			
NWNSMH	Reference	Reference	Reference
OONSMH	1.98 (1.58, 2.47)	1.80 (1.44, 2.25)	1.36 (1.09, 1.71)
NWPSMH	2.63 (2.14, 3.24)	1.78 (1.43, 2.22)	1.51 (1.21, 1.88)
OOPSMH	6.19 (5.34, 7.18)	3.77 (3.24, 4.39)	2.57 (2.20, 2.99)
NMNSMU	10.00 (8.33, 11.99)	6.39 (5.31, 7.69)	2.48 (2.04, 3.02)
OONSMU	6.74 (5.51, 8.25)	5.54 (4.51, 6.80)	2.07 (1.66, 2.57)
NWPSMU	18.97 (15.40, 23.38)	8.73 (6.98, 10.92)	2.72 (2.15, 3.45)
OOPSMU	21.07 (18.38, 24.16)	10.76 (9.33, 12.42)	3.12 (2.66, 3.67)
P for trend	1.49 (1.47, 1.52)	1.37 (1.35, 1.39)	1.14 (1.12, 1.17)
Early-onset DM cohort			
BMI	1.32 (1.29, 1.35)	1.32 (1.28, 1.35)	1.19 (1.15, 1.23)
OO	7.74 (5.62, 10.67)	6.27 (4.45, 8.82)	2.77 (1.92, 4.00)
SMI	0.91 (0.87, 0.95)	0.54 (0.51, 0.57)	0.65 (0.60, 0.71)
Pre-sarcopenia	8.60 (6.54, 11.32)	7.99 (6.06, 10.54)	3.16 (2.33, 4.27)
MU	8.12 (6.19, 10.66)	6.32 (4.71, 8.49)	1.69 (1.18, 2.43)
Obesity phenotype			
NWNSMH	Reference	Reference	Reference
OONSMH	3.34 (1.98, 5.64)	2.61 (1.51, 4.51)	1.92 (1.11, 3.33)
NWPSMH	-	-	-
OOPSMH	11.44 (7.36, 17.79)	10.21 (6.55, 15.92)	5.19 (3.26, 8.25)
NMNSMU	8.80 (4.72, 16.41)	7.15 (3.78, 13.51)	2.86 (1.45, 5.63)
OONSMU	9.13 (5.21, 16.02)	6.76 (3.75, 12.18)	2.19 (1.15, 4.17)
NWPSMU	27.41 (3.75, 200.33)	27.57 (3.73, 203.65)	9.68 (1.26, 74.59)
OOPSMU	37.38 (24.79, 56.38)	28.54 (18.45, 44.16)	5.80 (3.43, 9.79)
P for trend	1.60 (1.52, 1.68)	1.55 (1.47, 1.63)	1.25 (1.17, 1.34)

Adjusted model I: adjusted for age and gender;

Adjusted model II: adjusted for age, gender, SBP, FPG, ALT, AST, SCR, BUN, and smoking status;

HR hazard ratio, CI confidence interval, other abbreviations can be found in **Table 1.**

Supplementary Table 5 Segmental Cox regression analysis of BMI, SMI and DM

	HR （95%CI) *P*-value	*P* for log-likehood ratio
BMI		<0.001
< 27.6 kg/m^2	1.12 (1.10, 1.14) <0.001	
≥ 27.6 kg/m^2	1.06 (1.03, 1.08) <0.001	
SMI		<0.001
< 28.1%	0.71 (0.67, 0.75) <0.001	
≥ 28.1%	0.82 (0.80, 0.85) <0.001	

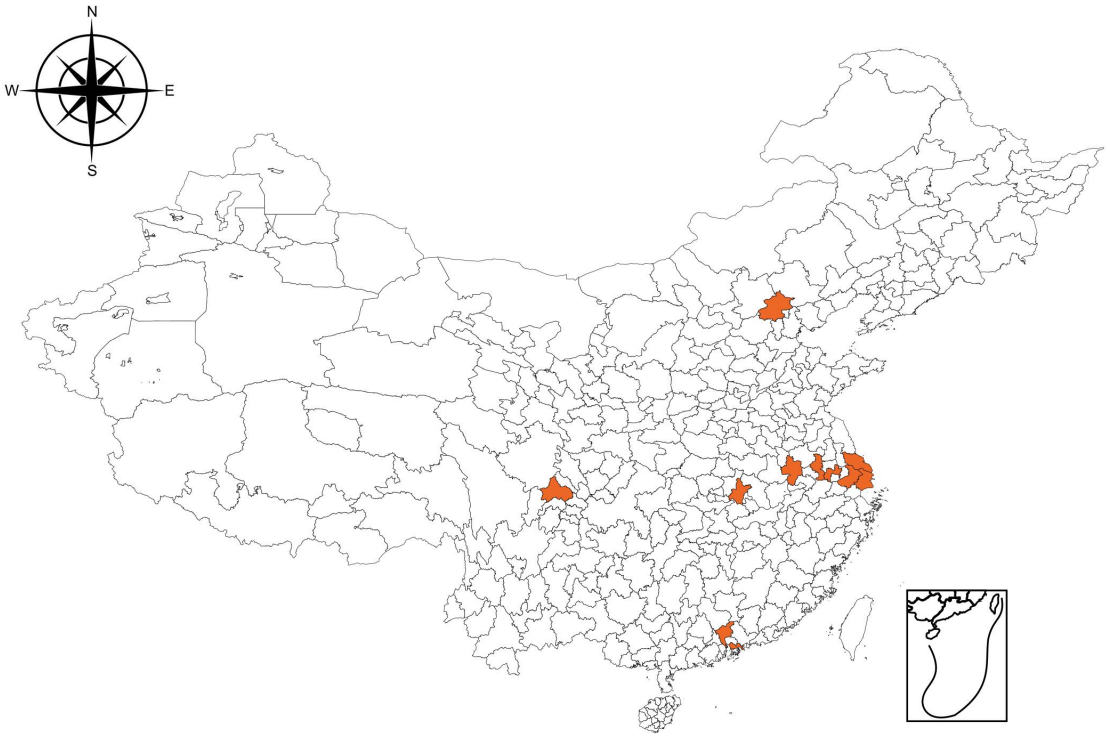
Adjusted for age, gender, SBP, FPG, ALT, AST, SCR, BUN, and smoking status; HR hazard ratio, CI confidence interval, other abbreviations can be found in **Table 1.**

Supplementary Table 6 Subgroup analysis of obesity phenotypes and DM

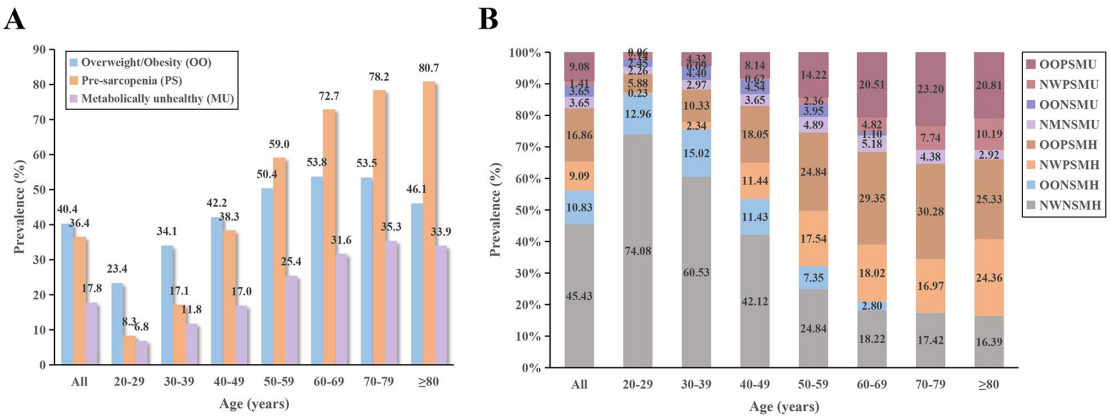
	HR (95% CI)						
	Age (years)			$P_{interaction}$	Gender		$P_{interaction}$
	20-39	40-59	≥60		females	males	
N	53 459	46 851	16 939		54 183	63 066	
BMI	1.15 (1.12, 1.19)	1.11 (1.09, 1.13)	1.04 (1.02, 1.06)	< 0.001	1.09 (1.07, 1.11)	1.09 (1.08, 1.11)	0.385
OO	2.26 (1.65, 3.11)	1.64 (1.43, 1.88)	1.32 (1.16, 1.50)	< 0.001	1.78 (1.54, 2.06)	1.48 (1.32, 1.65)	0.003
SMI	0.71 (0.65, 0.76)	0.76 (0.73, 0.79)	0.87 (0.83, 0.91)	0.008	0.74 (0.69, 0.79)	0.82 (0.79, 0.84)	< 0.001
Pre-sarcopenia	2.52 (1.93, 3.29)	1.95 (1.73, 2.21)	1.33 (1.12, 1.56)	< 0.001	2.35 (1.79, 3.08)	1.73 (1.56, 1.91)	< 0.001
MS	1.79 (1.30, 2.47)	1.78 (1.54, 2.05)	1.48 (1.28, 1.71)	< 0.001	1.72 (1.44, 2.05)	1.55 (1.38, 1.75)	< 0.001
Obesity phenotype				< 0.001			< 0.001
NWNSMH	Reference	Reference	Reference		Reference	Reference	
OONSMH	1.64 (0.99, 2.71)	1.39 (1.03, 1.88)	1.02 (0.56, 1.85)		4.54 (1.81, 11.36)	1.06 (0.84, 1.35)	
NWPSMH	0.53 (0.07, 3.85)	1.73 (1.25, 2.39)	0.74 (0.53, 1.03)		2.04 (1.45, 2.86)	1.45 (0.74, 2.85)	
OOPSMH	3.72 (2.45, 5.64)	2.65 (2.11, 3.31)	1.35 (1.06, 1.71)		3.39 (2.47, 4.67)	2.28 (1.91, 2.72)	
NWNSMU	2.71 (1.50, 4.89)	2.53 (1.91, 3.35)	1.53 (1.12, 2.08)		3.89 (2.13, 7.10)	2.18 (1.77, 2.70)	
OONSMU	2.14 (1.23, 3.72)	2.02 (1.52, 2.69)	0.55 (0.24, 1.26)		-	1.75 (1.40, 2.21)	
NWPSMU	5.03 (0.66, 38.32)	3.43 (2.26, 5.19)	1.59 (1.16, 2.18)		3.60 (2.47, 5.26)	1.84 (1.05, 3.21)	
OOPSMU	4.72 (2.97, 7.50)	3.61 (2.87, 4.55)	1.76 (1.38, 2.23)		4.86 (3.43, 6.89)	2.68 (2.23, 3.21)	

Adjusted for age, sex, SBP, FPG, ALT, AST, SCR, BUN, and smoking status, except for the stratification variable;

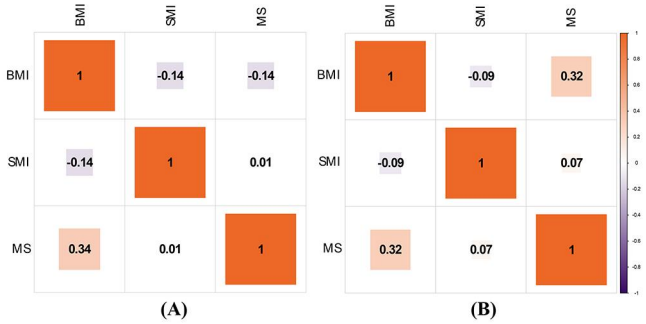
HR hazard ratio, CI confidence interval, other abbreviations can be found in **Table 1.**



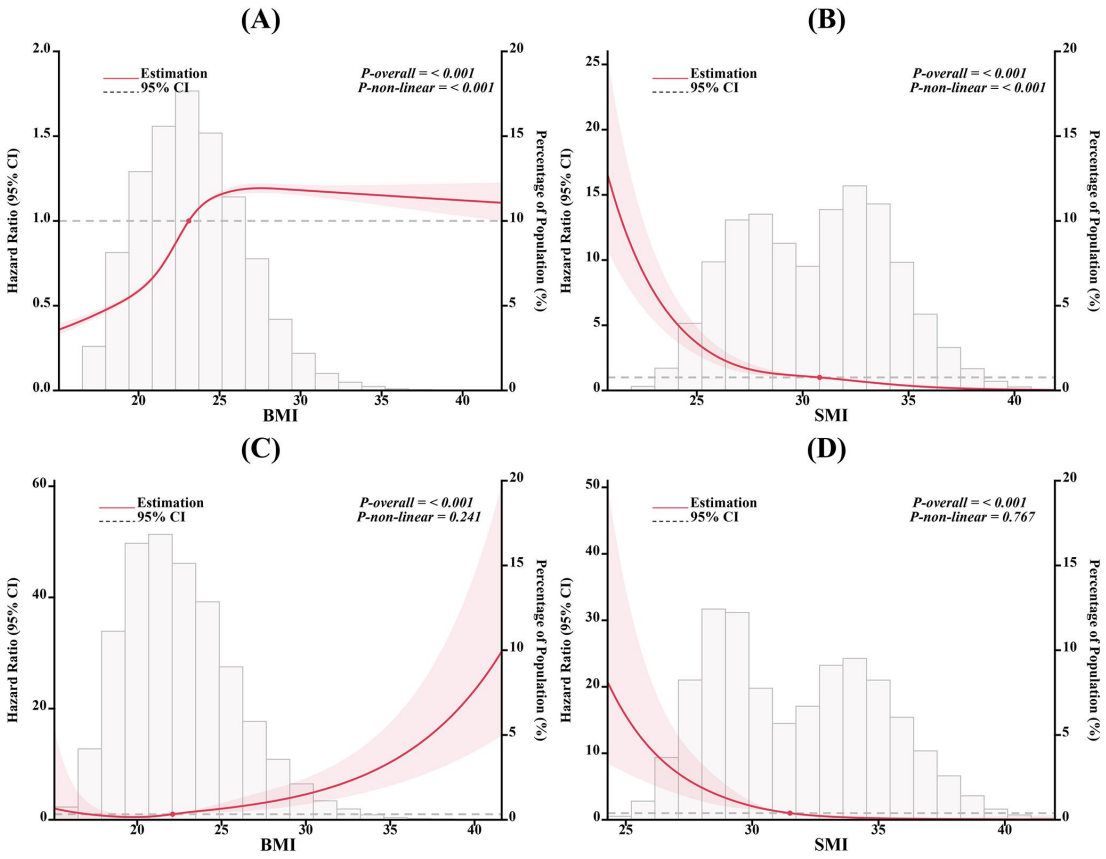
Supplementary Fig. 1 Map of the cities where the study participants are located. (Shanghai, Beijing, Nanjing, Suzhou, Shenzhen, Changzhou, Chengdu, Guangzhou, Hefei, Wuhan, Nantong)



Supplementary Fig. 2 Proportion of obesity phenotypes according to age. A: obesity phenotype components; B: obesity phenotypes. Abbreviations can be found in **Table 1.**



Supplementary Fig. 3 Heatmap of correlations between components of the obesity phenotype. (A) DM; (B) early-onset DM. Abbreviations can be found in **Table 1.**



Supplementary Fig. 4 Curve fitting of BMI and SMI with DM and early-onset DM. **(A)** BMI: DM; **(B)** SMI: DM; **(C)** BMI: early-onset DM; **(D)** SMI: early-onset DM. HR hazard ratio, CI confidence interval, other abbreviations can be found in **Table 1.**

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3,4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4,5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4,5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4,5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,6
Bias	9	Describe any efforts to address potential sources of bias	5,6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5,6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6,7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	-
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7,8
		(b) Give reasons for non-participation at each stage	7,8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8-10 - -
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15,16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15,16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.