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Association between diabetes, metabolic syndrome and heart attack in US adults: a cross-sectional analysis using the Behavioral Risk Factor Surveillance System 2015

Guang-Ran Yang,[1,2] Timothy D Dye,[2] Dongmei Li[2]

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[1]Department of Endocrinology, Beijing Tongren Hospital, Capital Medical University, Beijing, China
[2]Clinical and Translational Science Institute, School of Medicine and Dentistry, University of Rochester, Rochester, New York, USA

Correspondence to
Dr Guang-Ran Yang; gr.yang@ccmu.edu.cn

Professor Dongmei Li; Dongmei_li@URMC.rochester.edu

ABSTRACT

Objectives Diabetes mellitus (DM) and metabolic syndrome (MS) are both associated with heart attack. Evidence regarding which condition—MS or DM—is better associated with heart attack, however, is limited. The purpose of this study is to examine DM and MS, and their comparative associations with heart attack, using the 2015 Behavioral Risk Factor Surveillance System (BRFSS).

Design Cross-sectional study.

Methods A total of 332 008 subjects aged over 18 years were included in the analysis. All subjects were classified into four groups based on their DM and MS status: neither DM nor MS, DM without MS, MS without DM, and both DM and MS. A weighted hierarchical logistic regression was used to examine the difference between the four groups in their association with the risk of a heart attack.

Results Differences in weighted frequency distributions of gender, age category (over 45 years or not), smoking status, education, race, physical activity and daily vegetable and fruit consumption were significantly different across the four groups (p<0.05). The weighted prevalence of heart attack was 5.2% for neither DM nor MS group, 8.5% for DM without MS group, 11.0% for MS without DM group and 16.1% for both DM and MS group. The weighted prevalence of heart attack in MS without DM group was significantly higher than that in the DM without MS group (p<0.01). After adjusting for confounding variables, DM without MS and MS without DM were both found to be independently associated with heart attack compared with those without DM nor MS (DM without MS, OR=2.09; MS without DM, OR=2.58, all p<0.01).

Conclusion The BRFSS 2015 data indicated that MS without DM and DM without MS had comparable effects on heart attack, and the odds of risk are doubled than US adults with neither DM nor MS.

Strengths and limitations of this study

- ► Behavioral Risk Factor Surveillance System is a routine health-related telephone survey assessing a range of conditions.
- ► Weighted frequency distributions and summary statistics were used to describe the sample characteristics in each group.
- ► Limitation: chronic diseases were self-reported by answers.

BACKGROUND

Coronary heart disease (CHD) is the leading cause of morbidity and mortality worldwide. CHD alone caused approximately 1 of every 7 deaths in the USA with 366 801 deaths due to CHD in 2015.[1] Each year, around 660 000 Americans are estimated to have a new heart attack (defined as first hospitalised heart attack or CHD death) and around 305 000 Americans have a recurrent attack. Furthermore, an additional 160 000 silent heart attacks are estimated to occur each year.[2]

Diabetes mellitus (DM), especially type 2 diabetes, is associated with clustered risk factors for CHD. Among adults with DM, the prevalence of hypertension, hypercholesterolaemia and obesity is ranged 75%–85%, 70%–80% and 60%–70%, respectively.[2–4] Patients with DM had higher morbidity and mortality of CHD, including heart attack. In a subgroup analysis of the FRagmin during InStability in Coronary artery disease (FRISC) II trial, patients with diabetes with unstable coronary artery disease had a significantly higher rate of heart attack than non-diabetic patients.[5]

Metabolic syndrome (MS) is a multicomponent risk factor for CHD that includes a cluster of individual cardiometabolic risk factors related to abdominal obesity and insulin resistance. Clinically, MS is a useful entity for communicating the nature of lifestyle-related cardiometabolic risk for both patients and clinicians.[2] MS is a risk factor for heart attack in both women and men, from all regions and ethnic groups worldwide.[6]

DM and MS are both associated with heart attack. Evidence regarding whether MS without DM has stronger association with heart attack than DM without MS, however, is limited. The ongoing Behavioral Risk Factor Surveillance System (BRFSS) assesses chronic conditions, such as DM, hypertension, hypercholesterolaemia and heart attack.[7] The objective of the present study was to determine whether the risk of heart attack differs in people with DM without MS and MS without DM using the 2015 BRFSS database.

METHODS

Participants

BRFSS is the nation's premier system of health-related telephone surveys that collect state data about US residents regarding their health-related risk behaviours, chronic health conditions and use of preventive services. BRFSS completes more than 400 000 adult interviews each year, making it the largest continuously conducted health survey system in the world.[8] In 2015, fifty states, the District of Columbia, Guam and Puerto Rico collected data from interviews conducted both by landline telephone and cellular telephone. Questions used in this study in 2015 BRFSS survey include heart attack history, diabetes history, physical activity, dyslipidaemia, hypertension awareness, chronic health conditions, alcohol consumption, fruits and vegetables and currently smoking.[9]

There were 441 456 subjects in the 2015 BRFSS survey. The response rate from cellular telephone is 47.2%, which is slightly lower than that from landline telephone (48.2%).[10] Unknown responses or non-responses were coded as missing in questions included in the study, and there were 332 008 subjects included in the analysis after removing missing values.

Measures

Sociodemographic variables, such as age (18–44 years or 45+ years), race, ethnicity (Hispanic, Latino/Latina, or Spanish origin or no), education, smoking status (current smoker or not) and annual household income, were categorised according to the original variables.

Respondents' lifestyles were assessed by questions on their physical activity, fruit consumption and vegetable consumption. Fruit consumption was categorised as 'consumed fruit one or more times per day' or 'consumed fruit less than one time per day'. Vegetable consumption was categorised as 'consumed vegetables one or more times per day' or 'consumed vegetables one or more times per day'. Physical activity index was categorised as whether 'meet aerobic recommendations' or not.

In the 2015 BRFSS, chronic diseases were self-reported by answers to questions on chronic diseases history. Heart attack was defined as yes to the question, 'Has a doctor, nurse, or other health professional ever told you had a heart attack, also called a myocardial infarction?' Diabetes was defined by a yes answer to the question, 'Has a doctor, nurse, or other health professional ever told you have diabetes?' Respondents with pre-diabetes, borderline diabetes or gestational diabetes were excluded. Body mass index (BMI) was calculated by self-reported height and weight. Similarly, hypertension was defined as a yes answer to the question, 'Have you ever been told by a doctor, nurse or other health professional that you have high blood pressure?' Borderline hypertension, prehypertension and gestational hypertension were all excluded from the study. Dyslipidaemia was defined as a yes answer to the question, 'Have you ever been told by a doctor, nurse or other health professional that your blood cholesterol is high?' Stroke was defined as yes to the question of 'ever told you had a stroke'. Depression was a yes answer to the question of 'ever told you that you have a depressive disorder, including depression, major depression, dysthymia, or minor'.

MS was diagnosed based on the Adult Treatment Panel III (ATP-III) definition.[11] The components of MS were abdominal obesity (waist circumference >40 inches in men or >35 inches in women), triglycerides ≥150 mg/dL, high-density lipoprotein cholesterol <40 mg/dL in men or <50 mg/dL in women, blood pressure ≥130/85 mm Hg and fasting glucose ≥110 mg/dL. There were no available data on waist circumference, blood pressure, fasting glucose and lipid profile. The diagnosis of MS was revised based on the questions in the BRFSS. The revised components of MS included diabetes, hypertension, BMI≥25.0 kg/m^2 and dyslipidaemia. Respondents who had at least three components were regarded as having MS. In this study, the 'MS without DM' group means that respondents had the other three components of MS excluding diabetes.

Statistical analysis

Each record in the 2015 BRFSS data was weighted using raking weighting methodology.[12] Raking adjusted the BRFSS data to allow under-represented groups in the sample to be more accurately represented in the final data set. Final weights were assigned to each respondent. All statistical analyses and prevalence estimates have been weighted. Weighted percentages of respondents who ever had heart attack were calculated.

Weighted χ^2 tests were performed to determine respondents' characteristic differences across groups. A weighted hierarchical logistic regression was used to examine the difference between the four groups in their association with the risk of a heart attack. ORs and corresponding 95% CIs were derived from weighted hierarchical logistic regression analysis. Survey-related procedures in SAS V.9.4 (SAS Institute) were used for all data analyses. The significance level was set at $p<0.05$, and all tests were two sided.

Patient and public involvement

This study was an analysis of the 2015 BRFSS database. The database was downloaded via the US Centers for Disease Control and Prevention website.

RESULTS

Demographic characteristics

There were 332008 respondents involved in this study. All respondents were categorised into four groups as follows: neither DM nor MS, DM without MS (having DM without MS), MS without DM (having MS without DM) and DM plus MS. There were 237334 respondents with neither DM nor MS, 45191 respondents with DM without MS, 8416 respondents with MS without DM and 41067 respondents with both DM and MS (table 1). Differences in the percentages of gender, age category, smoking status, education level, race, ethnicity and annual household income were statistically significant among the four groups (p<0.01). In addition, the above characteristics were significantly different between DM without MS and MS without DM groups (p<0.001). In both MS and DM group, 91% were aged over 45 years, and 21.5% did not graduate high school, which were higher than the other three groups. Moreover, 17.6% of respondents in the MS and DM group had annual household incomes lower than $15000 and the low income percentage is much higher than the other three groups. Less people were white in the DM without MS group (71.4%) compared with that in the MS without DM group (80.4%). However, more respondents were of Hispanic, Latino, or Spanish origin in the DM without MS group (19.3%) than in the MS without DM group (10.3%, p<0.001), and more respondents were current smokers in the DM without MS group (16.0%) compared with the MS without DM group (15.3%, p<0.001, table 1).

Lifestyle

Lifestyle measurements were also compared in the four groups (table 1). The percentage of physical activity index, daily fruit consumption and vegetable consumption were all significantly different across the four groups. The physical activity index in the DM without MS and MS without DM groups was 48.2% and 47.6%, respectively (p<0.001). The DM and MS group had the least percentage of respondents whose physical activity met the aerobic recommendations. The percentage of respondents who consumed fruit one or more times per day was higher in the DM without MS group, compared with that in the MS without DM group (58.8% vs 56.8%, p<0.001). However, daily vegetable consumption was similar between the DM without MS and the MS without DM groups (76.9% vs 76.8%, p=0.019). In the DM and MS group, the percentage of daily vegetable consumption is the least among the four groups (73.4%).

MS components and chronic diseases

Among the 332008 respondents, 21896 had heart attack, accounting for the prevalence of 5.2%. MS without DM had higher prevalence of heart attack than that in DM without MS (11.0% and 8.5%, respectively, p<0.001). The prevalence of heart attack in the DM plus MS group was the highest (16.1%, table 2). The overall prevalence of dyslipidaemia, hypertension, diabetes and BMI≥25.0 kg/m^2 was 36.6%, 37.5%, 13.2% and 67.2%, respectively (table 2). In the DM without MS group, 83% respondents had one component of MS other than DM, with 17% people having no other components of MS besides DM.

The overall prevalence of stroke was 3.6%. The prevalence of stroke was significantly different between the DM without MS and MS without DM groups (4.8% vs 6.6%, p<0.001). The prevalence of stroke in the DM plus MS group was the highest among the four groups (9.7%). The overall prevalence of depression was 18.2%. Compared with DM without MS, MS without DM had significantly higher prevalence of depression (16.4% vs 24.1%, p<0.001). The highest prevalence of depression was observed in the DM plus MS group (27.7%).

Logistic regression

Logistic regression was conducted to compare the difference among the four groups in their association with heart attack, using the neither DM nor MS group as the reference (table 3). Results from unadjusted logistic regression analysis showed that both DM without MS (OR=3.28, 95% CI 2.81 to 3.82) and MS without DM (OR=4.37, 95% CI 4.06 to 4.70) groups had significantly elevated odds of heart attack than neither DM nor MS group. The DM plus MS group had the highest odds of heart attack among the three groups (OR=6.79, 95% CI 6.33 to 7.28).

To identify an independent relationship between DM, MS and heart attack, hierarchical logistic regression analysis was performed. After adjusting for confounders (gender, age, education, smoking, race, physical activity index, daily fruit consumption, daily vegetable consumption, stroke and depression) DM without MS and MS without DM were found to have independently increased odds of heart attack compared with the neither DM nor MS group (DM without MS, adjusted OR=2.09, 95% CI 1.72 to 2.54; MS without DM, adjusted OR=2.58, 95% CI 2.36 to 2.81). The DM plus MS group had the highest odds of heart attack (adjusted OR=3.45, 95% CI 3.16 to 3.77, all p<0.001, table 3).

DISCUSSION

In the 2015 BRFSS data, respondents with MS without DM and DM without MS were both associated with elevated risk of heart attack and the amount of increase is doubled compared with respondents with neither DM nor MS. MS did not appear to be a greater odds for heart attack than DM from our analysis results. MS combined with DM increased more risk of heart attack by over 3.4-fold compared with respondents with neither DM nor MS.

MS is a cluster of risk factors contributing to the pathogenesis of atherosclerosis.[13] There are several definitions of MS and different definitions of MS had different components.[11 14 15] Many large-scale clinical trials and meta-analyses have reported that the presence of MS is a strong predictor for heart attack in many different populations.[6 16–18] In the INTERHEART case–control study involving 26903 subjects from 52 countries, MS was associated with an increased risk of heart attack, both using

Table 1 Demographic and lifestyle characteristics among the four groups according to the presence of metabolic syndrome and diabetes

	Total	Neither DM nor MS	DM without MS	MS without DM	DM plus MS	P value
n	332 008	237 334	8416	45 191	41 067	
Gender						<0.01
Male, n (weighted %)	144 458 (49.9)	98 983 (48.4)	4049 (56.4)	22 377 (57.1)	19 049 (51.8)	
Female, n (weighted %)	187 550 (50.1)	138 351 (51.6)	4367 (43.6)	22 814 (42.9)*	22 018 (48.2)	
Age						<0.01
<45 years, n (weighted %)	67 420 (36.9)	61 527 (44.7)	944 (20.4)	3054 (14.6)	1895 (9.0)	
≥45 years, n (weighted %)	264 588 (63.1)	175 807 (55.3)	7472 (79.6)	42 137 (85.4)*	39 172 (91.0)	
Annual household income						<0.01
<15 000, n (weighted %)	26 368 (9.8)	15 248 (8.3)	1009 (15.2)	4100 (10.9)	6011 (17.6)	
15 000–25 000, n (weighted %)	42 954 (15.2)	27 083 (13.6)	1459 (21.8)	6503 (17.3)	7909 (22.9)	
25 000–35 000, n (weighted %)	29 733 (9.9)	19 853 (9.4)	877 (11.5)	4533 (11.0)	4470 (12.0)	
35 000–50 000, n (weighted %)	40 705 (13.6)	28 453 (13.5)	1039 (13.3)	6103 (14.7)	5110 (13.7)	
>50 000, n (weighted %)	144 082 (51.5)	112 776 (55.2)	2616 (38.2)	17 422 (46.1)*	11 268 (33.8)	
Ethnicity (Hispanic, Latino/Latina, or Spanish origin or no)						<0.01
Yes, n (weighted %)	22 487 (13.8)	16 018 (14.0)	853 (19.3)	2257 (10.3)*	3359 (15.0)	
No, n (weighted %)	307 115 (86.2)	219 670 (86.0)	7490 (80.7)	42 626 (89.7)	37 329 (85.0)	
Race						<0.01
White, n (weighted %)	279 446 (77.8)	202 115 (78.4)	6730 (71.4)	38 756 (80.4)*	31 845 (72.7)	
African-American, n (weighted %)	26 653 (12.4)	16 453 (11.4)	740 (13.9)	3815 (12.9)	5645 (18.1)	
American-Indian, n (weighted %)	5718 (1.7)	3673 (1.6)	263 (3.3)	670 (1.5)	1112 (2.5)	
Asian, n (weighted %)	7092 (4.8)	5688 (5.2)	243 (7.3)	535 (2.5)	626 (3.5)	
Native Hawaiian, n (weighted %)	1872 (0.4)	1338 (0.4)	49 (0.5)	213 (0.3)	272 (0.3)	
Other race, n (weighted %)	4058 (2.7)	4058 (2.7)	215 (3.5)	647 (2.2)	839 (2.6)	
No preferred race, n (weighted %)	745 (0.3)	577 (0.3)	14 (0.1)	60 (0.2)	94 (0.2)	
Multiracial but preferred race not answered, n (weighted %)	6 (0.0)	4 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)	
Education						<0.01
Did not graduate high school, n (weighted %)	21 989 (11.8)	12 296 (9.7)	917 (20.3)	3607 (14.9)	5169 (21.5)	
Graduated high school, n (weighted %)	88 636 (26.9)	58 399 (25.6)	2672 (29.4)	14 028 (31.2)	13 537 (31.1)	
Attended college or technical school, n (weighted %)	90 001 (31.5)	63 868 (32.0)	2238 (28.1)	12 302 (30.3)	11 593 (30.2)	
Graduated from college or technical school, n (weighted %)	130 722 (29.8)	102 289 (32.7)	2561 (22.3)	15 185 (23.6)*	10 687 (17.2)	

Continued

Table 1 Continued

	Total	Neither DM nor MS	DM without MS	MS without DM	DM plus MS	P value
Currently smoking						<0.01
No, n (weighted %)	280 808 (84.5)	200 158 (84.4)	6944 (84.0)	38 788 (84.7)	34 918 (85.4)	
Yes, n (weighted %)	43 947 (15.5)	31 827 (15.6)	1230 (16.0)	5547 (15.3)*	5343 (14.6)	
Physical activity index						<0.01
Meet aerobic recommendations, n (weighted %)	164 390 (52.8)	124 593 (55.4)	3712 (48.2)	20 530 (47.6)	15 555 (40.8)	
Did not meet aerobic recommendations, n (weighted %)	136 791 (47.2)	90 370 (44.6)	3735 (51.8)	20 831 (52.4)*	21 855 (59.2)	
Fruit						<0.01
Consumed fruit one or more times per day, n (weighted %)	195 725 (61.4)	143 690 (62.9)	4795 (58.8)	25 173 (56.8)	22 067 (56.0)	
Consumed fruit less than one time per day, n (weighted %)	111 948 (38.6)	76 183 (37.1)	2854 (41.2)	16 897 (43.2)*	16 014 (44.0)	
Vegetable						<0.01
Consumed vegetables one or more times per day, n (weighted %)	243 504 (79.7)	177 711 (81.0)	5766 (76.9)	32 262 (76.8)	27 765 (73.4)	
Consumed vegetables less than one time per day, n (weighted %)	58 881 (20.3)	38 567 (19.0)	1691 (23.1)	9081 (23.2)	9542 (26.6)	

*Compared with DM without MS group, p<0.05.
DM, diabetes mellitus; MS, metabolic syndrome.

Table 2 Chronic diseases among the four groups according to the presence of metabolic syndrome and diabetes

Chronic diseases	Total	Neither DM nor MS	DM without MS	MS without DM	DM plus MS	P value
Heart attack, n (weighted %)	21 896 (5.2)	8863 (2.7)	851 (8.5)	5310 (11.0)*	6872 (16.1)	<0.01
Hypertension, n (weighted %)	147 655 (37.5)	64 705 (21.9)	1411 (13.9)	45 191 (100.0)*	36 348 (87.6)	<0.01
Dyslipidaemia, n (weighted %)	140 653 (36.6)	62 526 (22.2)	1102 (12.2)	45 191 (100.0)*	31 834 (77.6)	<0.01
BMI≥25.0 kg/m^2, n (weighted %)	223 112 (67.2)	135 589 (59.1)	4551 (56.8)	45 191 (100.0)*	37 781 (92.3)	<0.01
Stroke, n (weighted %)	15 013 (3.6)	6910 (2.2)	544 (4.8)	3228 (6.6)*	4331 (9.7)	<0.01
Depression, n (weighted %)	64 290 (18.3)	40 520 (16.1)	1574 (16.4)	10 687 (24.1)*	11 509 (27.7)	<0.01

*Compared with DM without MS group, p<0.05.
BMI, body mass index; DM, diabetes mellitus; MS, metabolic syndrome.

the WHO definition (OR=2.69) and the International Diabetes Federation (IDF) definition (OR=2.20) .The direction of associations was similar across all regions and ethnic groups.[6] A large family study in Finland and Sweden of 4483 subjects also identified the association between MS and an increased risk of heart attack in all subjects using the WHO definition.[18] Similar results were observed when the 2001 National Cholesterol Education Program (NCEP) and 2004 revised NCEP definitions were used.[16 17] In our analysis, the association between MS and heart attack was consistent. MS, regardless of its definition, was associated with heart attack.

Table 3 The OR and 95% CIs of DM and MS related to heart attack in the hierarchy logistic regression analysis

	OR	95% CI	P value
Model 1 (n=332 008)			
DM without MS	3.28	2.81 to 3.82	<0.01
MS without DM	4.37	4.06 to 4.70	<0.01
DM plus MS	6.79	6.33 to 7.28	<0.01
Model 2 (n=319 712)			
DM without MS	2.10	1.77 to 2.49	<0.01
MS without DM	2.85	2.64 to 3.09	<0.01
DM plus MS	4.06	3.76 to 4.38	<0.01
Model 3 (n=282 332)			
DM without MS	2.12	1.75 to 2.56	<0.01
MS without DM	2.82	2.59 to 3.07	<0.01
DM plus MS	3.99	3.66 to 4.34	<0.01
Model 4 (n=280 977)			
DM without MS	2.09	1.72 to 2.54	<0.01
MS without DM	2.58	2.36 to 2.81	<0.01
DM plus MS	3.45	3.16 to 3.77	<0.01

Model 1: unadjusted.
Model 2: adjusted for gender, age (45 years or not), education, current smoking, race.
Model 3: adjusted for gender, age (45 years or not), education, current smoking, race, physical activity index, fruits consumed one or more times per day, vegetable consumed one or more times per day.
Model 4: adjusted for gender, age (45 years or not), education, current smoking, race, physical activity index, fruits consumed one or more times per day, vegetable consumed one or more times per day, stroke and depression.
DM, diabetes mellitus; MS, metabolic syndrome.

DM is one of the components in most definitions of MS. The risk for cardiovascular disease (CVD) is twofold to eightfold higher in the diabetic population than that in the non-diabetic population of a similar age, sex and ethnicity, and CVD is the leading cause of morbidity and mortality among patients with type 2 diabetes.[19–21]

Previous researchers have investigated the effects of DM on heart attack. Consistent with our findings, it has been reported that DM was associated with an increased heart attack risk in both men and women.[22]A cohort study using the UK General Practice Research Database showed a much larger relative risk of heart attack in DM.[23]

Both DM and MS were associated with an increased risk of heart attack. However, evidence regarding whether MS without DM is better than DM without MS for evaluating heart attack is limited. There were studies to evaluate the relationship between MS and DM on CVD events. Results from different studies regarding differences in CVD events between DM and MS were conflicting. The Ansung-Ansan cohort study showed there was no difference in the risk of incident CVD between individuals with DM without MS and MS without DM.[24] Yet, in the REduction of Atherothrombosis for Continued Health (REACH) registry, presence of newly detected DM but not MS was associated with an increased risk of CVD events.[25] Besides the difference in population characteristics in these studies, the sample size and the definitions of CVD may affect the results.

There were fewer studies conducted in US adults to compare the effects of MS and DM on heart attack. In the logistic analysis of this study, MS without DM and DM without MS were found to have similar odds of heart attack. This showed that MS and DM may have similar effects on heart attack in the US adults, which was different from the results of previous study in US population.[26] Our results indicated that to prevent heart attack or CVD, even a diabetic person does not meet the criteria of MS, much more attention should be paid to control metabolic abnormalities.

DM typically copresents with at least one metabolic abnormality. In our analysis, the weighted prevalence of hypertension, dyslipidaemia and overweight in DM without MS group was 13.9%, 12.2% and 56.8%, respectively. Of the respondents with DM, 83% had at least one or more components of MS other than DM. As shown in a population-based cohort study, DM with only one component of MS had more than twofold higher CVD risk than those with DM only.[27] These associations may be helpful to explain in this study why DM and MS had similar effects on heart attack. Further studies were needed to evaluate the association between MS without DM and DM without MS with heart attack

There were some limitations in our study. First, the definition of MS was revised according to the contents of 2015 BRFSS. MS was diagnosed based on the ATP-III definition.[11] The components of MS were diabetes, hypertension, BMI≥25.0 kg/m^2 and dyslipidaemia. Respondents who had at least three components were regarded as having MS. According to the ATP-III definition, central obesity was diagnosed based on waist circumference. We used BMI≥25.0 kg/m^2 to classify individuals because waist circumference was not available. The MS definition from the American College of Endocrinology recommends that BMI>25 kg/m^2 or a waist circumference >40 inches for men, >35 inches for women was regarded as obesity.[28] Therefore, in the present study, we used BMI≥25 kg/m^2 as a component of MS. Second, in the 2015 BRFSS, there were no data on triglyceride and high-density lipoprotein. Dyslipidaemia was assessed by whether respondents had ever been told their blood cholesterol was high. Third, the self-reported nature of the cross-sectional study may lead to underestimate the actual prevalence of heart attack. In this study, 13.2% of respondents had diabetes. However, some diabetic respondents may have silent heart attack without any symptoms. In the BRFSS survey the data of fatal heart attack are not included, which may also underestimate the actual prevalence of heart attack. Fourth, gestational diabetes and pre-diabetes were excluded. These two conditions are both important risk factors for DM that has been excluded from the study. In this study, 24.8% of subjects in the 2015 BRFSS data with unknown responses or non-responses in questions included in the study were excluded from the analysis under the assumption of missing completely at random, which might result in some bias of the results when the assumption is not valid.

In conclusion, even though the weighted percentage of heart attack in MS without DM was higher than that in DM without MS, MS and DM had similar effects on heart attack, which could double the risk of heart attack. Furthermore, when MS is combined with DM, the risk of heart attack will be increased by over 3.4-fold. Considering the nature of the cross-sectional study in the 2015 BRFSS data, prospective studies are needed to confirm the association between MS without DM and DM without MS with heart attack.

Contributors GRY and DL designed the study and analysed the data. GRY drafted the manuscript. DL and TDD revised the manuscript. All authors read and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The 2015 BRFSS annual survey data do not include any identifiable information and are publicly available from the Centers for Disease Control and Prevention website (https://www.cdc.gov/brfss/annual_data/annual_2015.html).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All the data are publicly available from the Centers for Disease Control and Prevention website (https://www.cdc.gov/brfss/annual_data/annual_2015.html).

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