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Health Insurance Status and Type Associated with Varying Levels of Glycemic Control in the US: The Multi-Ethnic Study of Atherosclerosis (MESA)

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Abstract

Aims: To investigate associations of health insurance with measures of glucose metabolism, and whether associations vary by diabetes status or insurance type.

Methods: Cross-sectional analysis of baseline data from the Multi-Ethnic Study of Atherosclerosis. Cohort a priori stratified by age <65 (*N*=3,665) and ≥65 years (*N*=2,924). Multivariable linear and logistic regression assessed associations between insurance and fasting glucose, HOMA-IR, and prevalent diabetes, controlling for relevant confounders, including age, sex, race/ethnicity, income, and education.

Results: In participants <65, compared to uninsured, having any insurance was associated with lower fasting glucose in participants with diabetes (Mean Difference=−20.4 mg/dL, *P*=0.01), but not in participants without diabetes. Compared to Private insurance, uninsured participants had higher fasting glucose (Mean Difference=3.8 mg/dL, *P*=0.03), while participants with Medicaid

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COMPETING INTERESTS
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had higher HOMA-IR (Mean Difference=3.5 mg/dL, $P<0.01$). In participants ≥65, compared to Private insurance, uninsured participants (Mean Difference=7.5 mg/dL, $P=0.02$), and participants with Medicaid only (Mean Difference=19.9 mg/dL, $P<0.01$) or Medicare + Medicaid (Mean Difference=5.2 mg/dL, $P=0.03$) had higher fasting glucose.

Conclusions: In this large multiethnic cohort, having any insurance was associated with significantly lower fasting glucose for individuals with diabetes. Levels of fasting glucose and insulin resistance varied across different insurance types.

Keywords

Health insurance; Health services research; Diabetes mellitus; Glycemic control; Insulin resistance; Race/ethnicity

INTRODUCTION

Diabetes is a leading cause of morbidity and mortality in the United States (US), with over 24 million individuals diagnosed in 2017 and accounting for $327 billions of healthcare spending [1]. Diabetes is a chronic condition associated with numerous complications, including renal disease, blindness, amputation, and an increased risk for cardiovascular disease and stroke [2]. However, preventive care and proper management can lead to improved glycemic control, which is not only associated with fewer complications [3–5], but also reduced medical costs [6–8], suggesting examination of healthcare systems that improve diabetes care could benefit both patients and healthcare payers.

One factor that may influence patient access and care, and thereby glycemic control, is possession of health insurance. Previous work examining data from the US National Health and Nutrition Examination Survey (NHANES) found that uncontrolled diabetes was associated with a lack of health insurance [9]. Additionally, uninsured individuals with diabetes were twice as likely to be previously undiagnosed compared to those with insurance [10,11]. Similarly, racial and economic disparities in diabetes outcomes may be partially explained by differences in healthcare access due to insurance status. Low income and racial/ethnic minority patients have a higher prevalence of diabetes and are more likely to suffer from diabetes complications [12–14]. Moreover, non-Hispanic Black and Hispanic patients have historically reported more inconsistent access to care and barriers to obtaining health insurance compared to non-Hispanic White patients [15].

Although previous studies have demonstrated that health insurance is related to increased diagnosis of diabetes [16] and increased preventive care (annual eye examination, foot examination, hemoglobin A1c testing [HbA1c], daily blood glucose monitoring) [17], it is less clear whether insurance coverage is associated with measures of glycemic control and insulin resistance. Studies examining the relationships between insurance, glycemic control, and race/ethnicity are essential given the diverse US population, growing prevalence of diabetes [18], and continued evaluation of the US healthcare model. Therefore, the purpose of this study was to investigate associations between insurance status and measures of glucose regulation within a diverse cohort of participants, and whether these associations

varied by diabetes status. We also assessed whether associations varied between different types of insurance.

METHODS

Participants.

The Multi-Ethnic Study of Atherosclerosis (MESA) is a longitudinal cohort study of adults of African, Chinese, Hispanic, and non-Hispanic White background. Details about the MESA study design have previously been published [19]. In brief, 6,814 men and women aged 45 to 84 years were recruited from six US regions between July 2000 and August 2002. Individuals with a history of the following diagnoses and/or invasive procedures for cardiovascular disease (CVD) were excluded: angina, myocardial infarction, heart failure, stroke or transient ischemic attack; coronary artery bypass graft, angioplasty, valve replacement or pacemaker placement. Each study site's IRB approved MESA and all participants provided written informed consent.

Data Collection.

Standardized questionnaires were used to obtain sociodemographic information, smoking and alcohol use history, past medical history and medication use, usual site of medical care, and insurance provider. Health insurance status was based on the question: "To help pay for your medical care, do you now have: (check all that apply) HMO or other private insurance such as Blue Cross, Aetna, 1199 Fund, etc.; Medicare; Medicaid; Military or Veteran's Administration sponsored; None; Other." For participants <65 years old, we first examined insurance status (any insurance vs. uninsured), then stratified insured participants into four mutually exclusive insurance groups to assess different types of insurance: Private only, Medicare only, Medicaid only, and Other (a combination of Military or Veteran's Administration sponsored, and individuals who selected more than one insurance type). For participants ≥65 years old, given the high rates of any insurance coverage, we only examined different insurance types by stratifying insured participants into six mutually exclusive insurance groups: Private only, Medicare only, Medicaid only, Medicare + Medicaid, Medicare + Private, Other (as previously described).

Participants self-reported frequency and time spent in sedentary behavior or various physical activities during a typical week in the previous month using the Typical Week Physical Activity Survey, which was adapted from the Cross-Cultural Activity Participation Study [20]. Usual site of medical care was defined as doctor's office/clinic, hospital/emergency room, or other. Smoking and alcohol use were defined as current, former, or never. BMI was calculated as weight in kilograms divided by height in meters squared. Blood pressure was measured with an automated monitor after 5 minutes of seated rest; the last two of three readings were averaged and recorded. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg or current use of antihypertensive medication.

Laboratory.

Venous blood was collected after a 12-hour fast. Participants were instructed to take their usual medications before the clinic visit. Total and high-density lipoprotein (HDL) cholesterol, triglycerides, glucose and insulin were measured as previously reported [19]. Dyslipidemia was defined as a Total/HDL cholesterol ratio >5.0 or current use of cholesterol-reducing medication. Estimated glomerular filtration rate (eGFR) was computed using the CKD–Epi equation [21]. Diabetes was defined as fasting glucose ≥126mg/dL or current use of diabetes medication (insulin or oral hypoglycemic). Undiagnosed diabetes was defined as fasting glucose ≥126mg/dL, not taking diabetes medication, and never being diagnosed by a provider (per self-report). Insulin resistance was estimated by the homeostasis model assessment of insulin resistance (HOMA-IR), which was calculated according to the formula: HOMA-IR = fasting insulin (mIU/L) × fasting blood glucose (mg/dL)/405 [22].

Statistical analysis.

Among the 6,814 potential participants, 40 were missing values for insurance status, 147 participants entered only “Other” for insurance type, and 38 were missing values for fasting glucose, insulin or diabetes medication use. These 225 participants were excluded, resulting in a final study sample of 6,589 participants, of which 3,665 (55.6%) were <65 years old. In multivariable regression models, we were missing values for select covariates, thereby leaving a final analytic sample of 6,321 participants, of which 3,572 (56.5%) were <65 years old. Given age of Medicare eligibility and high rates of any insurance coverage above the age of 65, the study cohort was *a priori* stratified by age <65 and ≥65 years.

The distribution of each continuous variable was examined for normality. Descriptive statistics of the population characteristics were described with mean and standard deviation for continuous variables or count and percentages for categorical variables.

For individuals <65 years, we first assessed associations of insurance status among the general cohort and then stratified by diabetes status. Next, we assessed associations across different insurance types. For individuals ≥65 years, only associations of different insurance types were assessed. Linear regression models were used to assess the association between insurance status and type with fasting glucose and HOMA-IR, while logistic regression models were used for diabetes status. We performed multivariable modeling to assess the aforementioned associations using four adjustment models. The initial model adjusted for age, race/ethnicity, sex, study site, education, and income (Model 1). Models were subsequently adjusted for alcohol consumption, tobacco use, moderate to vigorous physical activity (Model 2), dyslipidemia, hypertension, BMI, eGFR (Model 3), and use of diabetes medication (Model 4). Assumptions of normality, homoscedasticity, linearity, and multicollinearity were met for multivariable regression models for fasting glucose and HOMA-IR.

All statistical analyses were conducted using SPSS Statistics (Version 25). A two-tailed *P* value of .05 was considered statistically significant.

RESULTS

Table 1 provides the characteristics of study cohort participants <65 years by insurance status and diabetes status. For both insurance groups, the average age was 54.5 years and a little more than 50% were female. The insured group had a larger proportion of White (41.7%) and African American (28.2%) participants, while the uninsured group had a larger proportion of Chinese (23.9%) and Hispanic (42.6%) participants. The mean BMI for both groups was approximately 28 kg/m^2. The insured group had a higher prevalence of hypertension (36.1%), but the prevalence of dyslipidemia was similar across insurance groups (approximately 32%). The uninsured group had a higher prevalence of current smokers (20.5%). A higher proportion of uninsured participants had diabetes overall (16.5%), as well as undiagnosed diabetes (5.0%). Uninsured individuals had higher mean fasting glucose (110.5 mg/dL) and HOMA-IR (3.1 mg/dL).

Participants with diabetes were older on average (mean age 56.1 years), compared to those without diabetes. A smaller proportion of participants with diabetes were female (48.7%) or White (18.3%), while a larger proportion were African American (38.3%) or Hispanic (32.0%). Participants with diabetes had higher prevalence of other comorbidities, such as hypertension (60.8%) and dyslipidemia (47.1%), as well as higher mean BMI (31.8 kg/m^2) and a higher proportion of current (19.5%) or former smokers (33.9%). On average, participants with diabetes had higher mean fasting glucose (162.7 mg/dL) and HOMA-IR (6.3 mg/dL).

The characteristics of the insured group were further described by specific insurance type and are provided in online supplemental material. In those <65 years, 498 (13.6%) participants were uninsured, while 2,909 (79.4%) had Private only, 66 had Medicare only (1.8%), 51 (1.4%) had Medicaid only, and 141 (3.8%) had Other types of insurance (Supplemental Table 1). The Medicare group had the highest prevalence of hypertension (45.5%), while Medicaid had the highest prevalence of dyslipidemia (45.1%). Nearly 20% of participants with Medicare had diabetes, compared to 10.4% of Private. Uninsured participants had the highest mean fasting glucose (110.5 mg/dL), while Private had the lowest (101.0 mg/dL). HOMA-IR was highest among participants with Medicaid (6.5 mg/dL).

Among participants ≥65 years, only 97 (3.3%) participants were uninsured, while 415 (14.2%) had Private only, 760 (26.0%) had Medicare only, 53 (1.8%) had Medicaid only, 236 (8.1%) had Medicare + Medicaid, 1,088 had Medicare + Private (37.2%) and 275 (9.4%) had Other types of insurance (Supplemental Table 2). Approximately 63% of participants over the age of 65 had hypertension. The Medicare + Medicaid group had the highest prevalence of dyslipidemia (42.8%). The Medicaid only group had the highest prevalence diabetes (30.2%), while the Uninsured group had the lowest (13.4%). Mean fasting glucose was highest for the Medicaid group (126.0 mg/dL) and lowest for the Medicare + Private group (103.2 mg/dL). Mean HOMA-IR was approximately 3.0 mg/dL, which did not vary substantially by insurance type.

Associations between having any insurance and measures of glucose metabolism

In the <65 subgroup, minimally adjusted models (Model 1) showed that compared to the Uninsured, Insured participants had lower mean fasting glucose (Mean Difference= −4.6 mg/dL, CI: −8.0 to −1.1, *P*=0.01) (Table 2). With full adjustment for relevant covariates (Model 4), this association remained significant (Mean Difference=−3.8 mg/dL, CI: −7.0 to −0.5, *P*=0.02). When stratified by diabetes status, the associations were null for participants without diabetes, while among participants with diabetes, having any form of insurance continued to be associated with significantly lower fasting glucose in both minimally (Mean Difference=−22.7 mg/dL, CI: −39.6 to −5.8, *P*=0.01) and fully adjusted models (Mean Difference=−20.4 mg/dL, CI: −36.7 to −4.1, *P*=0.01). There were no significant associations between insurance status and HOMA-IR or prevalent diabetes.

Associations between insurance type and measures of glucose metabolism

Among participants <65, compared to Private only, Uninsured individuals had significantly higher fasting glucose in both minimally (Mean Difference=4.7 mg/dL, CI: 1.1 to 8.3, *P*=0.01) and fully adjusted models (Mean Difference=3.8 mg/dL, CI: 0.4 to 7.2, *P*=0.03) (Table 3). With regards to HOMA-IR, compared to Private only, Medicaid was associated with significantly higher HOMA-IR in both minimally (Mean Difference=3.4 mg/dL, CI: 2.3 to 4.6, *P*<0.01) and fully adjusted models (Mean Difference=3.5 mg/dL, CI: 2.4 to 4.6, *P*<0.01). There were no significant associations between insurance type and prevalent diabetes.

Among participants ≥65, compared to Private only, in minimally adjusted models Medicaid was associated with significantly higher fasting glucose (Mean Difference=17.5 mg/dL, CI: 8.9 to 26.0, *P*<0.01) (Table 4). With full adjustment for relevant confounders, Medicaid continued to be significantly associated (Mean Difference=19.9 mg/dL, CI: 11.8 to 27.9, *P*<0.01), and Medicare + Medicaid (Mean Difference=5.2 mg/dL, CI: 0.6 to 9.8, *P*=0.03), as well as Uninsured (Mean Difference=7.5 mg/dL, CI: 1.2 to 13.8, *P* =0.02), became significantly associated with higher fasting glucose. There were no significant associations between insurance type and HOMA-IR or prevalent diabetes.

DISCUSSION

In this large multiethnic cohort, among participants <65 years, compared to the uninsured, having any form of insurance was associated with lower fasting glucose only among participants with diabetes. These findings were robust to multivariable adjustment, including income and education. There were no significant associations between insurance status and prevalent diabetes, but uninsured participants did have a higher unadjusted proportion of undiagnosed diabetes. These findings add to the expanding literature showing insurance coverage is relevant towards improving diagnosis and management of diabetes, as well as glycemic control [9–11,15–17,23,24].

Our study also highlights the nuances of this relationship, suggesting all types of insurance may not be equivalent. For example, in those <65, when the insured group was further stratified into different insurance types, compared to Private only, uninsured individuals had

significantly higher fasting glucose, while participants with Medicaid had significantly higher HOMA-IR. Moreover, in those ≥65, compared to Private only, uninsured participants and those with Medicaid only or Medicare + Medicaid had significantly higher fasting glucose. Our findings differ from a study analyzing the 2000 Behavioral Risk Factor Surveillance System data, which found few differences in diabetes quality indicators (annual eye examination, foot examination, HbA1c testing, daily blood glucose monitoring) between Medicare, Medicaid, or the Department of Veterans Affairs as compared with Private insurance [23]. However, this study's outcome variables differed from our study and relied on self-reported data rather than laboratory measures.

On the other hand, a 2009 study of US community health centers found that compared to the uninsured, patients with any type of insurance were more likely to have their HbA1c tested and less likely to have poor HbA1c control (>9.5%) [24]. When different types of insurance were individually assessed, this study found the Private group was most likely to receive better quality care, while patients with only Medicaid had very similar outcomes compared to the uninsured. This study concluded that patients with different types of insurance may receive dissimilar quality of care and therefore have disparate health outcomes [24], which is consistent with our findings. Moreover, a 2011 analysis of Philadelphia diabetes-related hospital admissions data found that uninsured and Medicaid-insured patients were more likely than privately-insured patients to be admitted for emergency or urgent diabetes complications [25]. As such, this study cautioned against the assumption that all insured patients with diabetes are able to manage their disease and receive care in the correct setting [25]. In this regard, in our study a higher proportion of uninsured (19.7% <65 years, 26.0% ≥65 years) and Medicaid only insured (13.7% <65 years) participants listed the hospital or emergency room as their usual site of care, whereas Private insured participants almost exclusively utilized the clinic (97.1% <65 years, 96.1% ≥65 years). Several studies have shown that primary care appointment availability and wait times vary significantly by insurance type [26,27], which may impede some individuals from accessing appropriate care in a timely fashion.

Uninsured, Medicaid, and Medicare + Medicaid insured individuals may be particularly vulnerable to cost as a barrier to care and diabetes management compared to other health insurance types [28]. Our study found a smaller proportion of uninsured (18.7% <65 years, 18.7% ≥65 years), Medicaid only (8.0% <65 years, 14.3% ≥65 years), and Medicare + Medicaid (7.9% ≥65 years) insured participants had an annual salary ≥$35,000, compared to Private insured participants (76.3% <65 years, 51.9% ≥65 years). A 2012 study found that patients with perceived diabetes-related financial burdens were more likely to be non-adherent to medications, even after controlling for patients' health insurance status [29]. This study also showed that despite having insurance coverage, low-income patients still faced significant financial burdens. Importantly, cost-related medication underuse is associated with higher HbA1c levels [30]. Costs related to glycemic control extend beyond medications to the price of ambulatory visits, taking time off work, diet and exercise. For example, one study found uninsured adults were more likely to be inactive than insured adults [9] and food insecurity can impede diabetes self-management [31]. Furthermore, a 2018 study found that individuals with diabetes who were uninsured, had less than a college degree, or an annual income <$24,999 were all less likely to have received diabetes self-

management education [32]. In our study's <65 subgroup, a smaller proportion of participants with diabetes reported graduating high school or having an annual income ≥ $35,000. This may have contributed to the large difference in fasting glucose levels noted between insured and uninsured participants with diabetes.

Our study has several limitations. First, we were unable to assess continuity, duration or temporal changes of insurance coverage, which may have impacted findings, as irregular insurance coverage has been associated with poor health in middle age and near-elderly patients [33,34]. Second, the MESA recruited participants using a convenience sample rather than a randomized sample. As such, our analytic sample is not nationally representative and may not be representative of the population it was drawn from. Similarly, we were missing covariate data for 268 participants, who were excluded from the final analytic sample. On average, excluded individuals were older, a higher proportion were African American, and a smaller proportion had graduated high school. This may further limit the generalizability of findings. Third, although analyses controlled for numerous socio-demographic and health risk factors, our findings may be impacted by residual confounding. Fourth, Medicaid qualifications vary by state, and both insurance status and type had significant variance with regards to study site enrollment; namely more than half of uninsured participants were enrolled through the UCLA study site. Finally, the Medicaid only group had the smallest number of participants; as such our findings should be interpreted with appropriate caution.

CONCLUSIONS

For participants with diabetes, having any form of health insurance was associated with significantly lower fasting glucose, suggesting insurance coverage is relevant for glycemic control. Moreover, fasting glucose and insulin resistance levels varied by insurance type. Future studies should examine the relationship and possible pathways between health insurance and glycemic control using a longitudinal design. In clinical practice, primary care providers should be aware of possible barriers faced by uninsured and under-insured patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Health insurance associated with lower fasting glucose in patients with diabetes.
- Health insurance is relevant towards improving glycemic control.
- Levels of fasting glucose and insulin resistance vary by insurance type.
- All types of health insurance may not be equivalent.

Table 1.

Demographics and unadjusted measures of glucose metabolism by insurance status and diabetes status, participants <65 years (*N*=3,665).[a]

	Cohort (*N* =3,665)	Uninsured (*n* =498)	Insured (*n* =3,167)	Participants without Diabetes (*n* =3,234)	Participants with Diabetes (*n* =431)
Age (yr)	54.5 (5.7)	54.5 (5.7)	54.5 (5.6)	54.3 (5.7)	56.1 (5.4)
Female	1957 (53.4)	255 (51.2)	1702 (53.7)	1747 (54.0)	210 (48.7)
Race/ethnicity					
White	1381 (37.7)	61 (12.2)	1320 (41.7)	1302 (40.3)	79 (18.3)
Chinese	427 (11.7)	119 (23.9)	308 (9.7)	378 (11.7)	49 (11.4)
African American	999 (27.3)	106 (21.3)	893 (28.2)	834 (25.8)	165 (38.3)
Hispanic	858 (23.4)	212 (42.6)	646 (20.4)	720 (22.3)	138 (32.0)
Education					
≥High School Education	3160 (86.2)	313 (62.9)	2847 (89.9)	2825 (87.4)	335 (77.7)
Income[b]					
Annual Family Income ≥ $35,000	2347 (64.0)	90 (18.7)	2257 (72.8)	2133 (67.4)	214 (51.3)
Health behaviors					
Cigarette Smoking					
Current	625 (17.1)	102 (20.5)	523 (16.5)	541 (16.7)	84 (19.5)
Former	1210 (33.0)	150 (30.1)	1060 (33.5)	1064 (32.9)	146 (33.9)
Alcohol Intake[c]					
Current	2196 (59.9)	224 (45.2)	1972 (62.4)	2008 (62.2)	188 (43.8)
Former	811 (22.1)	118 (23.8)	693 (21.9)	668 (20.7)	143 (33.3)
MVPA ($METxminxwk^{-1}$)[d]	6736 (6611)	6286 (6604)	6807 (6610)	6766 (6640)	6514 (6394)
Medical conditions					
Hypertension	1296 (35.4)	153 (30.7)	1143 (36.1)	1034 (32.0)	262 (60.8)
Dyslipidemia	1168 (31.9)	163 (32.7)	1005 (31.7)	965 (29.8)	203 (47.1)
eGFR ($mLxmin^{-1}$ per 1.73 m^2)	83.7 (14.7)	87.8 (14.2)	83.1 (14.7)	83.1 (14.1)	88.1 (18.5)
BMI (kg/m^2)	28.8 (5.7)	28.1 (5.5)	28.9 (5.8)	28.3 (5.5)	31.8 (6.4)
Glucose metabolism					
Diabetes (all)	431 (11.8)	82 (16.5)	349 (11.0)		
Diabetes (undiagnosed)	103 (2.8)	25 (5.0)	78 (2.5)		
Fasting Glucose (mg/dL)	102.6 (31.9)	110.5 (47.3)	101.4 (28.5)	94.6 (9.6)	162.7 (62.1)
Insulin (mU/L)	10.4 (8.7)	10.8 (6.5)	10.3 (9.0)	9.7 (5.6)	15.9 (19.5)
HOMA-IR (mg/dL)	2.8 (4.0)	3.1 (2.9)	2.7 (4.1)	2.3 (1.5)	6.3 (10.2)
Usual site of medical care[e]					
Clinic	3350 (91.4)	320 (64.9)	3030 (96.0)	2966 (92.0)	384 (89.9)
ER/Hospital	151 (4.1)	97 (19.7)	54 (1.7)	126 (3.9)	25 (5.9)
Other	149 (4.1)	76 (15.4)	73 (2.3)	131 (4.1)	18 (4.2)

	Cohort (*N* =3,665)	Uninsured (*n* =498)	Insured (*n* =3,167)	Participants without Diabetes (*n* =3,234)	Participants with Diabetes (*n* =431)
Study Site					
Wake Forest University	576 (15.7)	33 (6.6)	543 (17.1)	507 (15.7)	69 (16.0)
Columbia University	616 (16.8)	30 (6.0)	586 (18.5)	545 (16.9)	71 (16.5)
Johns Hopkins University	512 (14.0)	35 (7.0)	477 (15.1)	447 (13.8)	65 (15.1)
University of Minnesota	651 (17.8)	83 (16.7)	568 (17.9)	578 (17.9)	73 (16.9)
Northwestern University	635 (17.3)	58 (11.6)	577 (18.2)	589 (18.2)	46 (10.7)
University of California Los Angeles	675 (18.4)	259 (52.0)	416 (13.1)	568 (17.6)	107 (24.8)

Abbreviations: eGFR, estimated glomerular filtration rate; ER, emergency room; HOMA-IR, homeostatic model assessment of insulin resistance; min, minute; MVPA, moderate to vigorous physical activity; wk, week; yr, year.

[a]Mean (standard deviation) or Frequency (column percentages) shown.

[b]Data available for *N*=3,584.

[c]Data available for *N*=3,655.

[d]Data available for *N*=3,663.

[e]Data available for *N*=3,650.

Table 2.

Associations between insurance status and measures of glucose metabolism, participants <65 years, stratified by diabetes status.

	Fasting Glucose[a] Mean Difference (95% CI)	*P* value	HOMA-IR[a] Mean Difference (95% CI)	*P* value	Diabetes Status Odds Ratio (95% CI)	*P* value
Cohort (*N* =3,572)						
Insured						
Model 1	−4.6 (−8.0 to −1.1)	**0.01**	0.3 (−0.2 to 0.7)	0.26	1.0 (0.7 to 1.3)	0.85
Model 2	−4.6 (−8.0 to −1.2)	**0.01**	0.3 (−0.1 to 0.7)	0.19	1.0 (0.7 to 1.4)	0.99
Model 3	−4.8 (−8.1 to −1.5)	**<0.01**	0.2 (−0.3 to 0.6)	0.48	1.0 (0.7 to 1.3)	0.75
Model 4	−3.8 (−7.0 to −0.5)	**0.02**	0.2 (−0.2 to 0.6)	0.34		
Participants with Diabetes (*n* =414)						
Insured						
Model 1	−22.7 (−39.6 to −5.8)	**0.01**	1.9 (−1.0 to 4.8)	0.20		
Model 2	−23.4 (−40.1 to −6.7)	**0.01**	1.8 (−1.1 to 4.7)	0.22		
Model 3	−19.6 (−35.9 to −3.3)	**0.02**	1.3 (−1.5 to 4.2)	0.36		
Model 4	−20.4 (−36.7 to −4.1)	**0.01**	1.3 (−1.6 to 4.2)	0.37		
Participants without Diabetes (*n* =3,158)						
Insured						
Model 1	0.1 (−1.1 to 1.2)	0.91	0.1 (−0.1 to 0.3)	0.39		
Model 2	0.1 (−1.1 to 1.2)	0.93	0.1 (−0.1 to 0.3)	0.29		
Model 3	−0.2 (−1.2 to 0.9)	0.74	<0.1 (−0.1 to 0.2)	0.90		
Model 4	−0.2 (−1.2 to 0.9)	0.75	<0.1 (−0.1 to 0.2)	0.88		

Abbreviations: HOMA-IR, homeostatic model assessment of insulin resistance.

Bold values indicate statistical significance (P <0.05).

Reference category: Uninsured.

Model 1: age, race/ethnicity, sex, study site, education, income.

Model 2: Model 1 + alcohol use, tobacco use, moderate to vigorous physical activity.

Model 3: Model 2 + dyslipidemia, hypertension, BMI, eGFR.

Model 4: Model 3 + use of diabetes medication (insulin or oral hypoglycemic).

[a]Results are expressed as mg/dL.

Table 3.

Associations between insurance type and measures of glucose metabolism, participants <65 years old (*N* =3,572).

	Fasting Glucose[a] Mean Difference (95% CI)	*P* value	HOMA-IR[a] Mean Difference (95% CI)	*P* value	Diabetes Status Odds Ratio (95% CI)	*P* value
Medicare Only						
Model 1	0.6 (−7.5 to 8.7)	0.88	1.0 (0.0 to 2.0)	0.06	1.1 (0.5 to 2.1)	0.85
Model 2	0.6 (−7.4 to 8.6)	0.88	1.0 (0.0 to 2.0)	0.06	1.0 (0.5 to 2.0)	0.92
Model 3	<0.1 (−7.7 to 7.7)	>0.99	0.9 (−0.1 to 1.8)	0.09	1.0 (0.5 to 2.0)	0.91
Model 4	0.6 (−7.0 to 8.2)	0.88	0.9 (−0.1 to 1.9)	0.08		
Medicaid Only						
Model 1	1.2 (−7.8 to 10.3)	0.79	3.4 (2.3 to 4.6)	**<0.01**	0.9 (0.4 to 1.9)	0.78
Model 2	1.3 (−7.6 to 10.3)	0.77	3.3 (2.2 to 4.5)	**<0.01**	0.9 (0.4 to 1.9)	0.69
Model 3	3.1 (−5.6 to 11.7)	0.49	3.5 (2.4 to 4.6)	**<0.01**	1.0 (0.4 to 2.3)	>0.99
Model 4	2.6 (−6.0 to 11.1)	0.56	3.5 (2.4 to 4.6)	**<0.01**		
Uninsured						
Model 1	4.7 (1.1 to 8.3)	**0.01**	<0.1 (−0.4 to 0.5)	0.94	1.0 (0.8 to 1.5)	0.77
Model 2	4.7 (1.2 to 8.3)	**0.01**	<0.1 (−0.5 to 0.4)	0.87	1.0 (0.7 to 1.4)	0.95
Model 3	4.9 (1.5 to 8.3)	**0.01**	0.1 (−0.3 to 0.5)	0.65	1.1 (0.8 to 1.5)	0.73
Model 4	3.8 (0.4 to 7.2)	**0.03**	<0.1 (−0.4 to 0.5)	0.83		
Other						
Model 1	<0.1 (−5.4 to 5.5)	0.99	<0.1 (−0.7 to 0.7)	0.99	1.3 (0.8 to 2.1)	0.28
Model 2	0.1 (−5.4 to 5.5)	0.98	−0.1 (−0.8 to 0.6)	0.80	1.2 (0.8 to 2.0)	0.38
Model 3	−1.2 (−6.4 to 4.0)	0.66	−0.2 (−0.9 to 0.5)	0.58	1.2 (0.7 to 1.9)	0.59
Model 4	−1.8 (−6.9 to 3.4)	0.50	−0.2 (−0.9 to 0.4)	0.52		

Abbreviations: HOMA-IR, homeostatic model assessment of insulin resistance.

Bold values indicate statistical significance (*P* <0.05).

Reference category: Private insurance only.

Model 1: age, race/ethnicity, sex, study site, education, income.

Model 2: Model 1 + alcohol use, tobacco use, moderate to vigorous physical activity.

Model 3: Model 2 + dyslipidemia, hypertension, BMI, eGFR.

Model 4: Model 3 + use of diabetes medication (insulin or oral hypoglycemic).

[a]Results are expressed as mg/dL.

Table 4.

Associations between insurance type and measures of glucose metabolism, participants ≥65 years old (*N* =2,749).

	Fasting Glucose[a] Mean Difference (95% CI)	*P* value	HOMA-IR[a] Mean Difference (95% CI)	*P* value	Diabetes Status Odds Ratio (95% CI)	*P* value
Medicare Only						
Model 1	2.2 (−1.3 to 5.8)	0.22	−0.2 (−1.4 to 1.0)	0.77	1.0 (0.7 to 1.4)	>0.99
Model 2	2.3 (−1.2 to 5.9)	0.19	−0.2 (−1.4 to 1.0)	0.79	1.0 (0.7 to 1.4)	0.96
Model 3	2.2 (−1.2 to 5.7)	0.21	−0.1 (−1.3 to 1.1)	0.82	1.0 (0.7 to 1.4)	0.99
Model 4	2.0 (−1.3 to 5.7)	0.23	−0.2 (−1.3 to 1.0)	0.80		
Medicaid Only						
Model 1	17.5 (8.9 to 26.0)	**<0.01**	−0.6 (−3.5 to 2.3)	0.68	1.2 (0.6 to 2.4)	0.59
Model 2	16.9 (8.3 to 25.4)	**<0.01**	−0.7 (−3.6 to 2.2)	0.63	1.2 (0.6 to 2.3)	0.68
Model 3	19.4 (11.0 to 27.8)	**<0.01**	−0.2 (−3.0 to 2.7)	0.91	1.5 (0.7 to 3.1)	0.28
Model 4	19.9 (11.8 to 27.9)	**<0.01**	−0.1 (−3.0 to 2.7)	0.93		
Medicare + Medicaid						
Model 1	3.8 (−1.1 to 8.6)	0.13	−0.4 (−2.0 to 1.2)	0.63	1.0 (0.6 to 1.5)	0.90
Model 2	3.5 (−1.4 to 8.4)	0.16	−0.5 (−2.1 to 1.2)	0.58	0.9 (0.6 to 1.5)	0.81
Model 3	4.2 (−0.5 to 9.0)	0.08	−0.4 (−2.0 to 1.3)	0.67	1.0 (0.6 to 1.5)	0.93
Model 4	5.2 (0.6 to 9.8)	**0.03**	−0.3 (−1.9 to 1.4)	0.74		
Medicare + Private						
Model 1	0.7 (−2.7 to 4.0)	0.70	−0.7 (−1.9 to 0.4)	0.20	0.9 (0.7 to 1.3)	0.55
Model 2	0.9 (−2.4 to 4.3)	0.59	−0.7 (−1.9 to 0.4)	0.21	0.9 (0.7 to 1.3)	0.63
Model 3	0.4 (−2.9 to 3.7)	0.83	−0.8 (−1.9 to 0.3)	0.16	0.9 (0.6 to 1.2)	0.41
Model 4	0.3 (−2.9 to 3.4)	0.86	−0.8 (−1.9 to 0.3)	0.16		
Uninsured						
Model 1	4.0 (−2.6 to 10.6)	0.24	−0.7 (−2.9 to 1.5)	0.54	0.5 (0.3 to 1.0)	**0.04**
Model 2	3.1 (−3.6 to 9.7)	0.37	−0.8 (−3.1 to 1.4)	0.47	0.4 (0.2 to 0.9)	**0.02**
Model 3	5.9 (−0.7 to 12.4)	0.08	−0.5 (−2.7 to 1.8)	0.68	0.6 (0.3 to 1.1)	0.09
Model 4	7.5 (1.2 to 13.8)	**0.02**	−0.4 (−2.6 to 1.9)	0.76		
Other						
Model 1	2.6 (−1.9 to 7.1)	0.26	−0.9 (−2.4 to 0.7)	0.27	1.2 (0.8 to 1.8)	0.41
Model 2	3.1 (−1.4 to 7.6)	0.18	−0.8 (−2.3 to 0.7)	0.32	1.2 (0.8 to 1.9)	0.30
Model 3	2.1 (−2.3 to 6.5)	0.35	−0.9 (−2.4 to 0.6)	0.26	1.2 (0.8 to 1.8)	0.51
Model 4	1.5 (−2.8 to 5.7)	0.50	−0.9 (−2.4 to 0.6)	0.23		

Abbreviations: HOMA-IR, homeostatic model assessment of insulin resistance.

Bold values indicate statistical significance ($P<0.05$).

Reference category: Private insurance only.

Model 1: age, race/ethnicity, sex, study site, education, income.

Model 2: Model 1 + alcohol use, tobacco use, moderate to vigorous physical activity.

Model 3: Model 2 + dyslipidemia, hypertension, BMI, eGFR.

Model 4: Model 3 + use of diabetes medication (insulin or oral hypoglycemic).

[a]Results are expressed as mg/dL.