Conversion (cross-walking) of metrics of blood glucose or diabetes

NCD-RisC work on diabetes pools and analyses population-based studies that measure fasting plasma glucose (FPG) and/or glycated haemoglobin (HbA1c) in people aged 18 years and older to estimate diabetes prevalence and treatment coverage in 200 countries and territories. Consistent with clinical guidelines, we define diabetes as having a FPG of 7.0 mmol/L or higher, having a HbA1c of 6.5% or higher, or taking medications for diabetes.

In 29% of studies, data are either only available on diabetes prevalence based on a different definition from the above primary definition, e.g., one study used FPG ≥7.8 mmol/L and another used HbA1c ≥10%, or only available on mean levels of FPG or HbA1c. The majority of these were from a previous global pooling study,[1] or extracted from published reports and papers. This group also includes studies that did not collect data on treatment and hence provided information on mean FPG, mean HbA1c or prevalence of people with elevated levels of these markers, but not on treatment. To use these sources in the prevalence model while keeping the definition of diabetes consistent, we used regressions that converted data from these sources to the primary outcome for diabetes prevalence, as described below.

Estimating diabetes prevalence from different metrics of blood glucose or diabetes

The dependent variable in each of these regressions was the primary outcome for diabetes prevalence (prevalence of FPG ≥7.0 mmol/L, HbA1c ≥6.5%, or taking medication for diabetes), and the independent variable was a mean (e.g., mean FPG) or a prevalence with a definition of diabetes that differed from the primary outcome or a combination of both. All regressions included terms for age, sex, as well as “super-regional” random intercepts, study specific random intercepts and interactions between predictors and age and sex, based on the Bayesian Information Criterion (BIC).[2] Age was centred at 50 years to reduce multicollinearity. There were eight “super-regions” used for super-regional random intercepts, which are largely based on geography and national income.[3] The reciprocal of mean bio-marker level and probit-transformed prevalence were used as independent variables

(predictors) as the relationship between them and the probit-transformed prevalence of diabetes was closer to a linear relationship than other transformations of these predictors.

The coefficients of these regressions were estimated using data from studies that had information on FPG, HbA1c and medication, and hence allowed calculating both the primary outcome and those metrics that required conversion. When estimating the coefficients, we excluded data points with fewer than 25 participants. We also excluded data points in which the sample sizes of the dependent and independent variables differed by over 10%, because it suggested that there was a substantial non-overlap between the individuals contributing to the two variables. This potential difference in sample size might have arisen from different requirements for FPG and HbA1c measurement (e.g., fasting duration) and/or the difference in data availability for biomarker measurement conducted in a laboratory and medication use collected in a questionnaire. The regression coefficients and number of data points we use to estimate the coefficients are shown in Table 1.

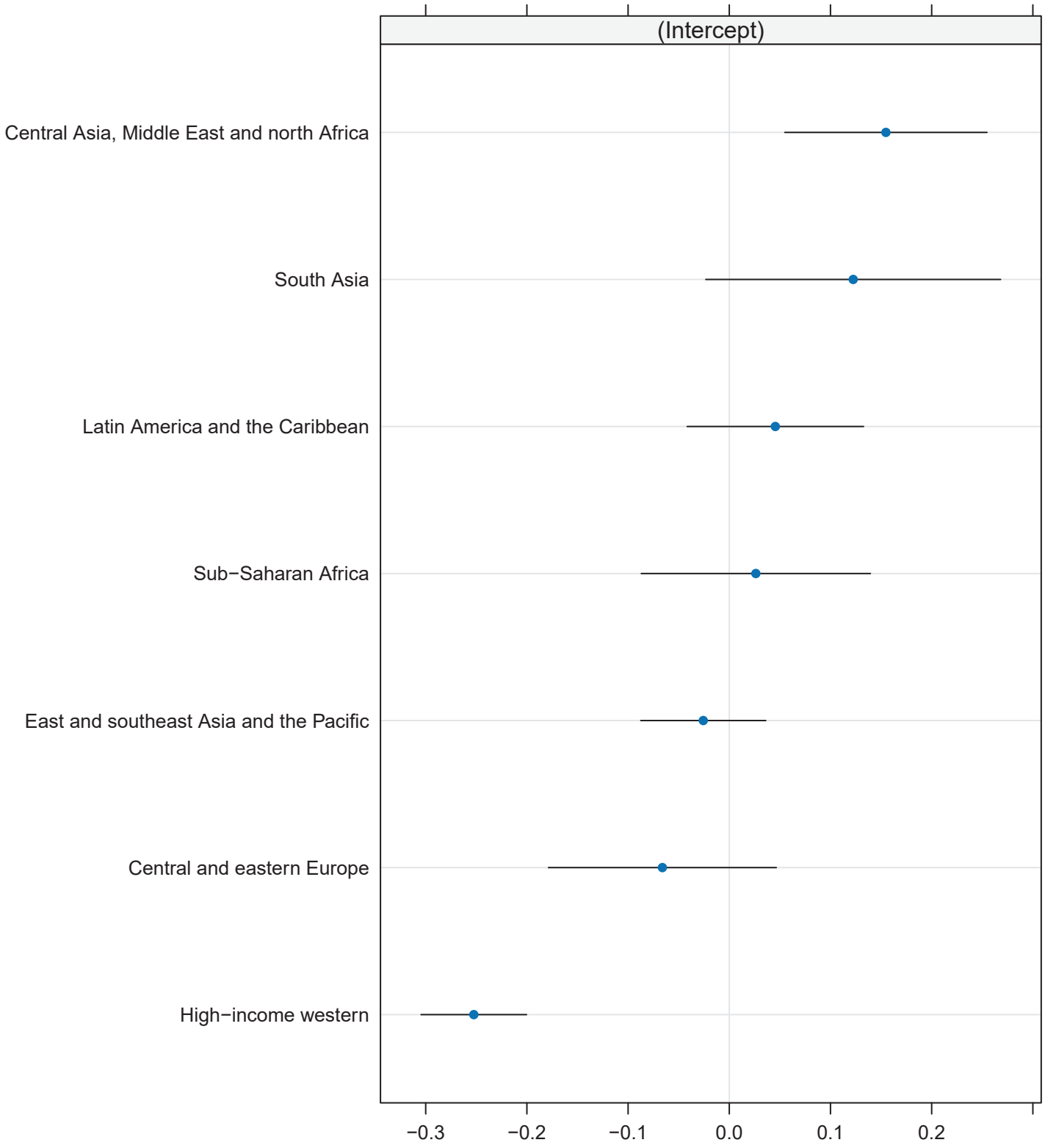
Table 1. Model specifications and regression coefficients to estimate prevalence of diabetes, defined as FPG ≥7.0 mmol/L, HbA1c ≥6.5%, or taking medication for diabetes, from other metrics.

The dependent variable in all regressions was the prevalence of diabetes based on the primary definition, fitted using a generalised linear mixed model with a probit link function. Random intercepts for super-regions in regression are presented after the table of coefficients.

* denotes statistical interaction. CI: confidence interval.

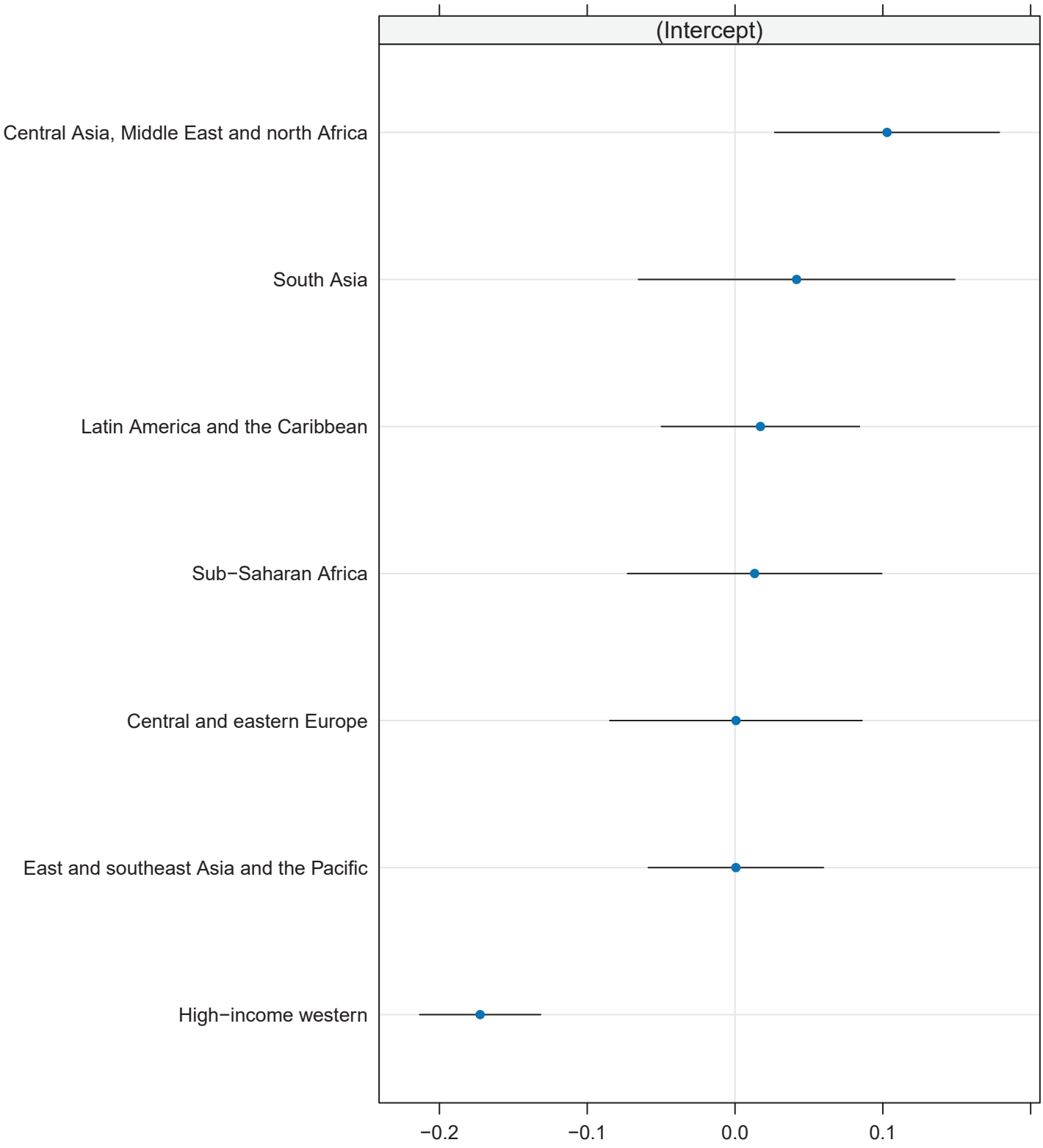
Independent variable(s): Inverse mean FPG	
Variables	**Coefficients (95% CI)**
Intercept	2.99 (2.83, 3.16)
Inverse mean FPG	-23.30 (-24.00, -22.60)
Mid-age of age group	1.44 (1.40, 1.49)
Male sex	-0.056 (-0.18, 0.071)
Inverse mean FPG * mid-age of age group	-0.30 (-0.58, -0.024)
Inverse mean FPG * male sex	0.20 (-0.54, 0.94)
Standard deviation of study-specific random effects	0.195
Number of data points used to fit the model = 1,531	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.811.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.3
−0.2
−0.1
0.0
0.1
0.2

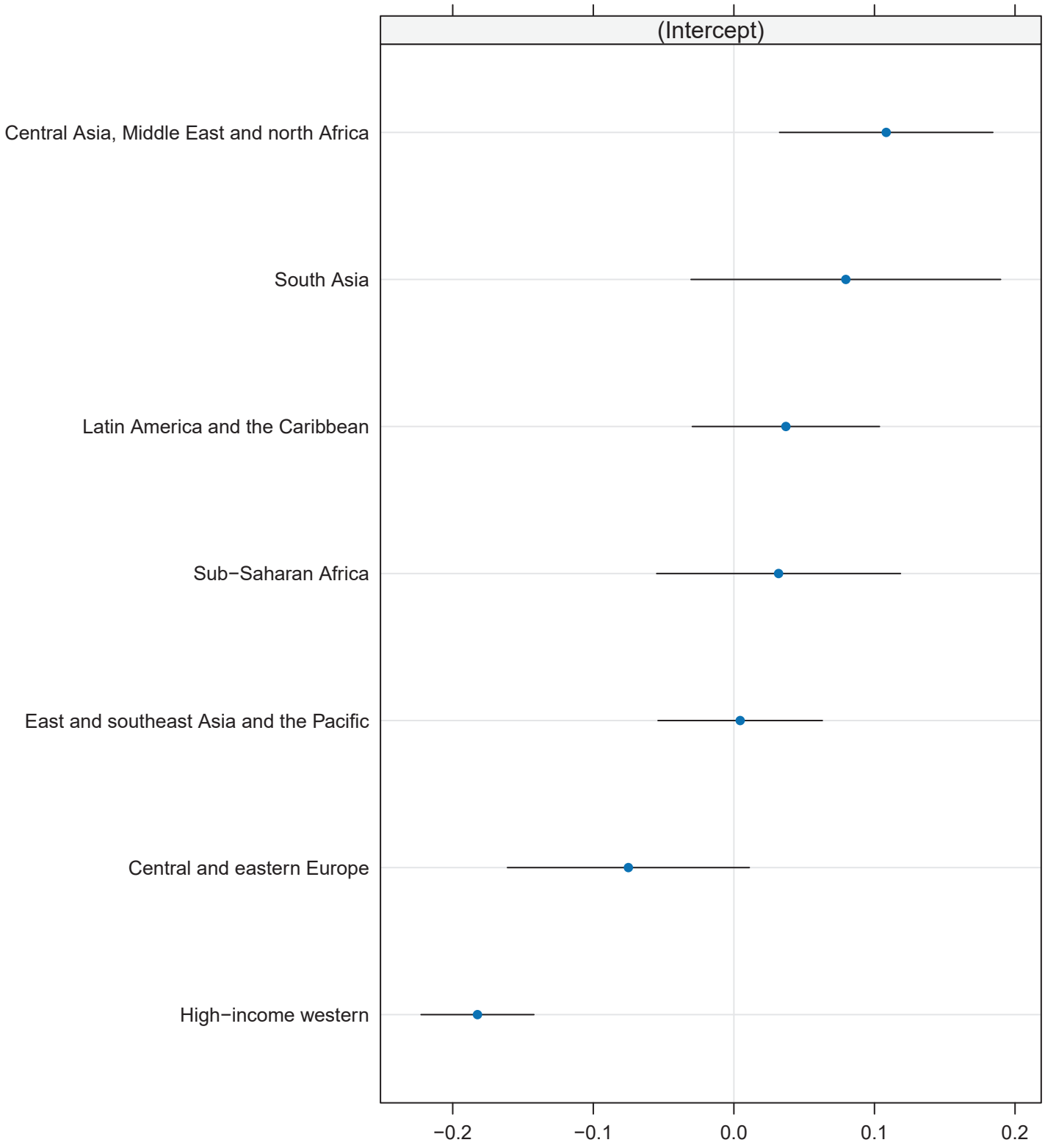
Independent variable(s): Inverse mean FPG, inverse mean HbA1c	
Variables	**Coefficients (95% CI)**
Intercept	4.11 (3.92, 4.30)
Inverse mean FPG	-13.80 (-15.10, -12.50)
Inverse mean HbA1c	-16.10 (-18.00, -14.20)
Mid-age of age group	1.80 (1.74, 1.86)
Male sex	-0.16 (-0.31, -0.012)
Inverse mean FPG * mid-age of age group	2.45 (2.10, 2.81)
Inverse mean HbA1c * mid-age of age group	-6.10 (-6.51, -5.69)
Inverse mean FPG * male sex	-1.84 (-2.82, -0.86)
Inverse mean HbA1c * male sex	2.82 (1.73, 3.90)
Standard deviation of study-specific random effects	0.152
Number of data points used to fit the model = 1,386	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.825.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
Sub−Saharan Africa
Central and eastern Europe
East and southeast Asia and the Pacific
High−income western
−0.2
−0.1
0.0
0.1

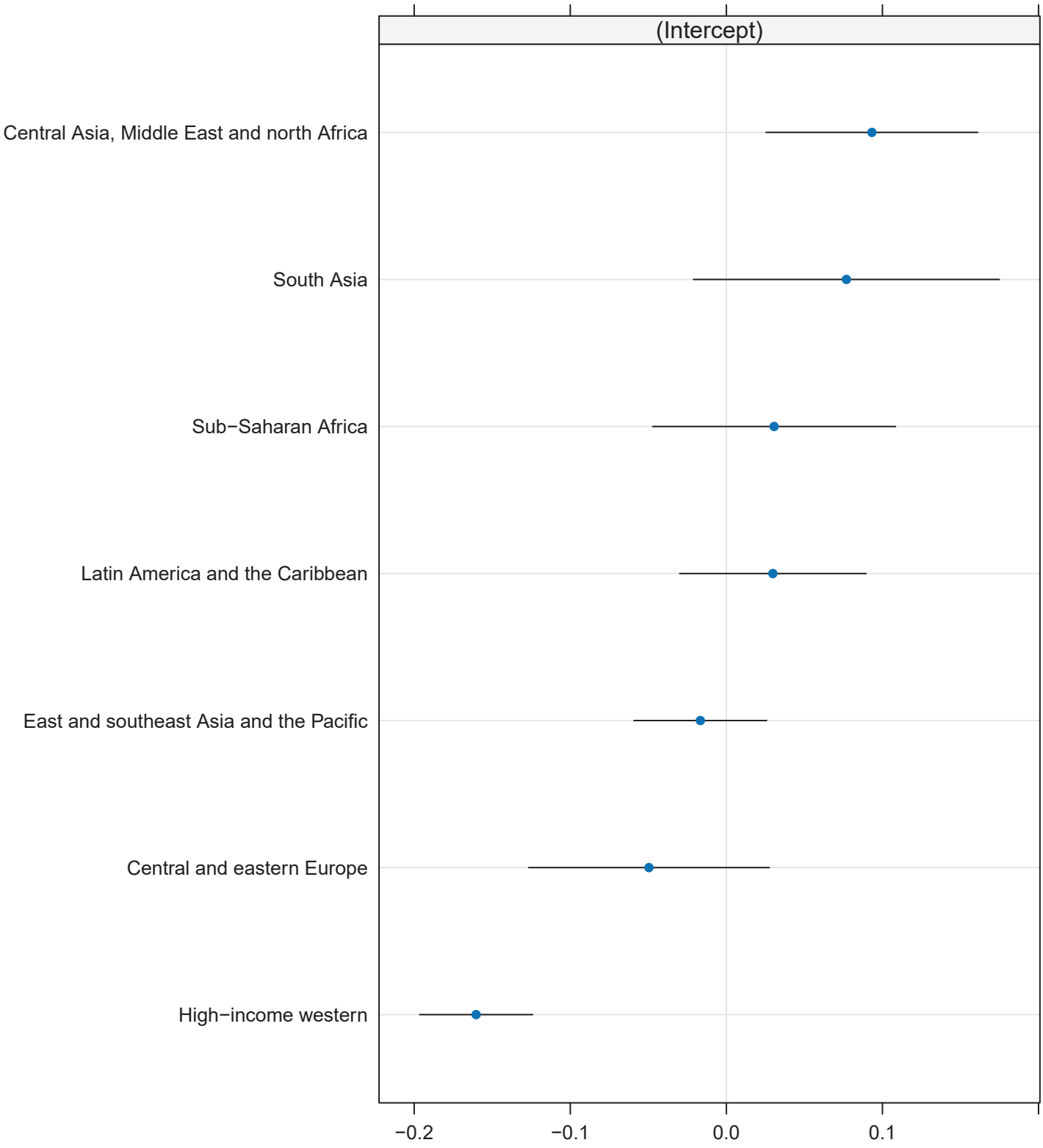
Independent variable(s): Inverse mean FPG, probit-transformed prevalence (FPG ≥6.7 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.84 (0.61, 1.06)
Inverse mean FPG	-5.79 (-7.32, -4.25)
Probit-transformed prevalence (FPG ≥6.7 mmol/L)	0.70 (0.64, 0.76)
Mid-age of age group	2.44 (2.35, 2.54)
Male sex	-0.081 (-0.32, 0.16)
Inverse mean FPG * mid-age of age group	-11.20 (-11.90, -10.60)
Probit-transformed prevalence (FPG ≥6.7 mmol/L) * mid-age of age group	-0.36 (-0.38, -0.34)
Inverse mean FPG * male sex	0.19 (-1.57, 1.95)
Probit-transformed prevalence (FPG ≥6.7 mmol/L) * male sex	-0.012 (-0.072, 0.048)
Standard deviation of study-specific random effects	0.147
Number of data points used to fit the model = 1,349	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.838.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1
0.2

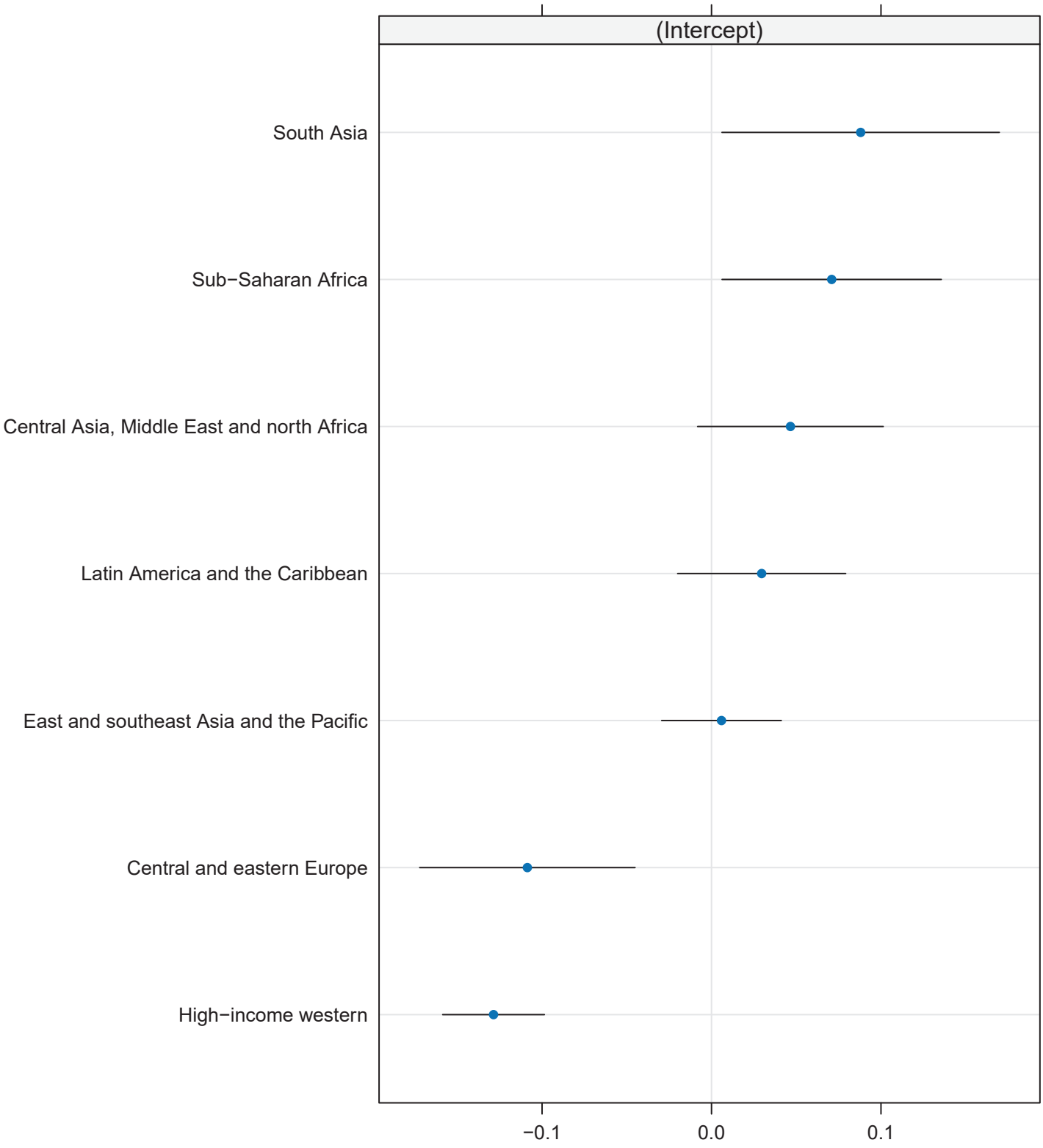
Independent variable(s): Inverse mean FPG, probit-transformed prevalence (FPG ≥7.0 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.76 (0.55, 0.97)
Inverse mean FPG	-4.59 (-6.07, -3.11)
Probit-transformed prevalence (FPG ≥7.0 mmol/L)	0.75 (0.70, 0.80)
Mid-age of age group	2.12 (2.04, 2.21)
Male sex	-0.083 (-0.31, 0.14)
Inverse mean FPG * mid-age of age group	-9.22 (-9.81, -8.64)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * mid-age of age group	-0.32 (-0.34, -0.30)
Inverse mean FPG * male sex	0.12 (-1.54, 1.78)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * male sex	-0.025 (-0.082, 0.033)
Standard deviation of study-specific random effects	0.131
Number of data points used to fit the model = 1,466	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.831.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1

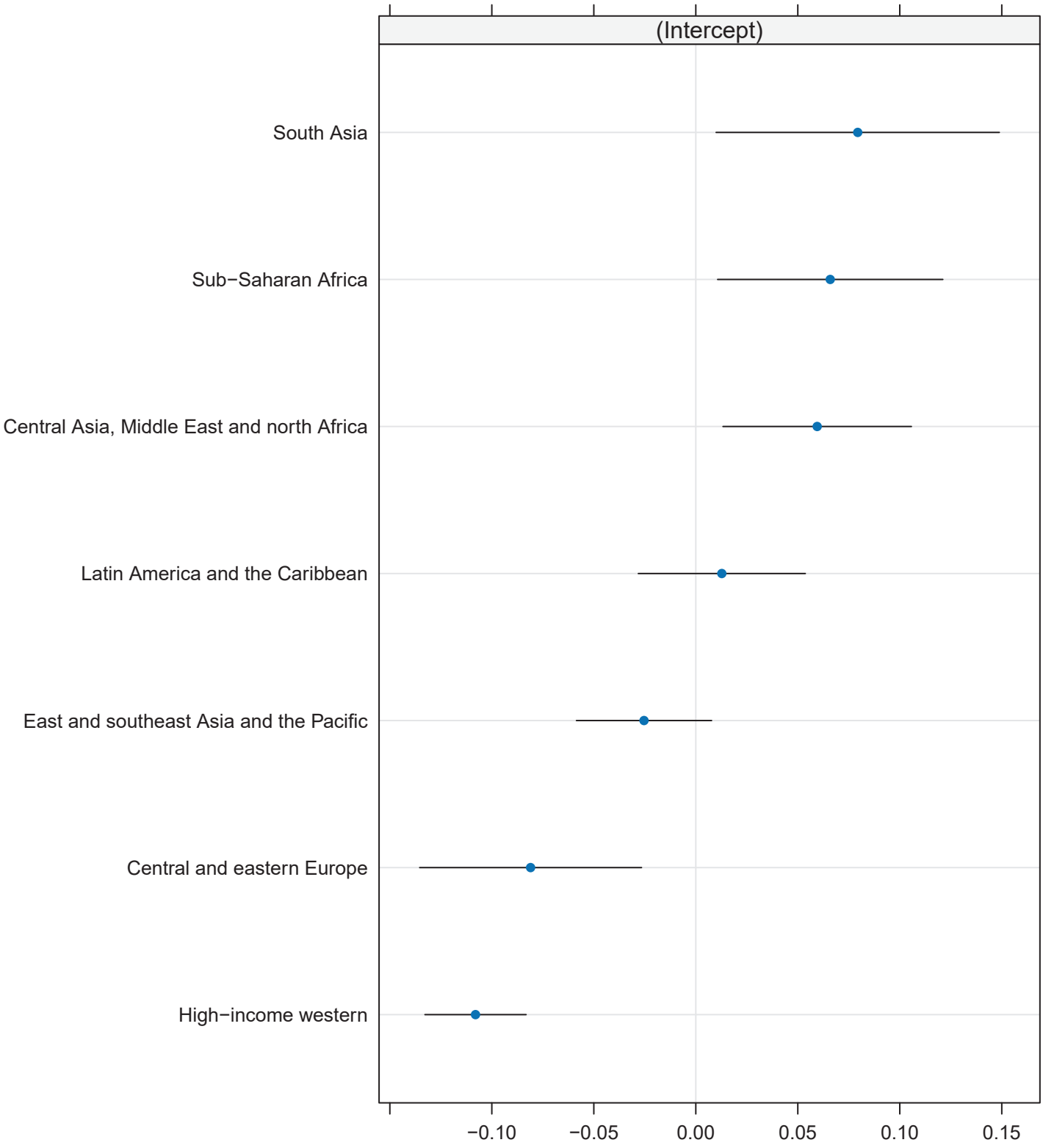
Independent variable(s): Inverse mean FPG, probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.67 (0.48, 0.86)
Inverse mean FPG	-4.44 (-5.68, -3.20)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	0.84 (0.80, 0.88)
Mid-age of age group	-0.014 (-0.088, 0.060)
Male sex	-0.13 (-0.32, 0.062)
Inverse mean FPG * mid-age of age group	2.02 (1.54, 2.50)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * mid-age of age group	0.0062 (-0.0085, 0.021)
Inverse mean FPG * male sex	0.68 (-0.63, 1.98)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * male sex	-0.0098 (-0.051, 0.032)
Standard deviation of study-specific random effects	0.101
Number of data points used to fit the model = 1,431	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.847.


(Intercept)
South Asia
Sub−Saharan Africa
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.1
0.0
0.1

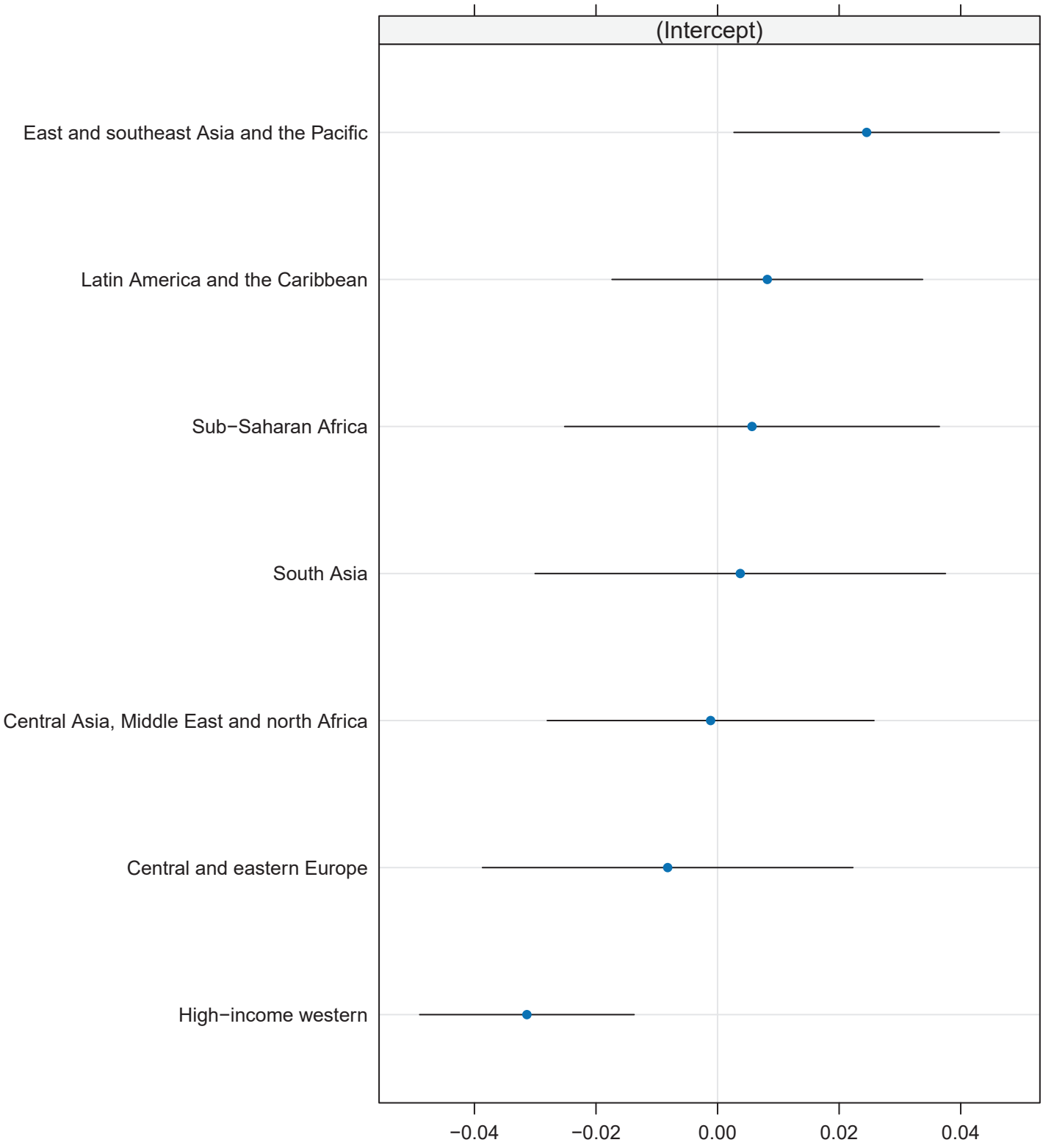
Independent variable(s): Inverse mean FPG, probit-transformed prevalence (FPG ≥7.0 mmol/L or treated)	
Variables	**Coefficients (95% CI)**
Intercept	0.21 (0.010, 0.40)
Inverse mean FPG	-0.79 (-2.10, 0.52)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated)	0.93 (0.88, 0.97)
Mid-age of age group	0.55 (0.48, 0.63)
Male sex	-0.040 (-0.24, 0.16)
Inverse mean FPG * mid-age of age group	-2.15 (-2.65, -1.66)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated) * mid-age of age group	-0.077 (-0.092, -0.062)
Inverse mean FPG * male sex	0.080 (-1.31, 1.47)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated) * male sex	-0.0074 (-0.050, 0.036)
Standard deviation of study-specific random effects	0.0827
Number of data points used to fit the model = 1,397	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.854.


(Intercept)
South Asia
Sub−Saharan Africa
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.10
−0.05
0.00
0.05
0.10
0.15

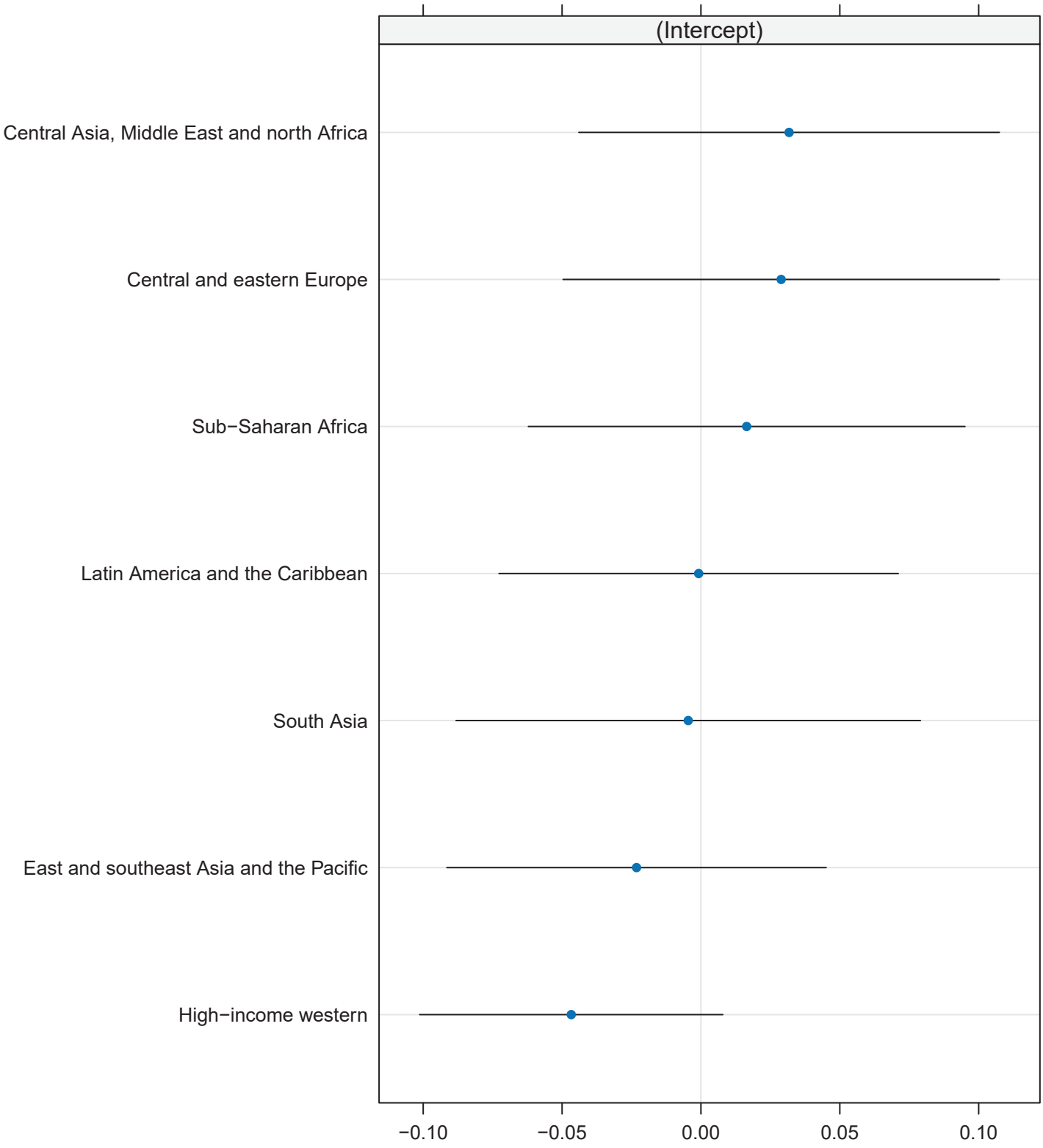
Independent variable(s): Inverse mean FPG, probit-transformed prevalence (HbA1c ≥6.5% or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.75 (0.59, 0.91)
Inverse mean FPG	-5.27 (-6.32, -4.23)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed)	0.83 (0.80, 0.87)
Mid-age of age group	0.42 (0.36, 0.48)
Male sex	0.087 (-0.087, 0.26)
Inverse mean FPG * mid-age of age group	-1.29 (-1.69, -0.88)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed) * mid-age of age group	-0.024 (-0.036, -0.012)
Inverse mean FPG * male sex	-0.72 (-1.86, 0.43)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed) * male sex	-0.064 (-0.098, -0.031)
Standard deviation of study-specific random effects	0.0559
Number of data points used to fit the model = 1,323	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.857.


(Intercept)
East and southeast Asia and the Pacific
Latin America and the Caribbean
Sub−Saharan Africa
South Asia
Central Asia, Middle East and north Africa
Central and eastern Europe
High−income western
−0.04
−0.02
0.00
0.02
0.04

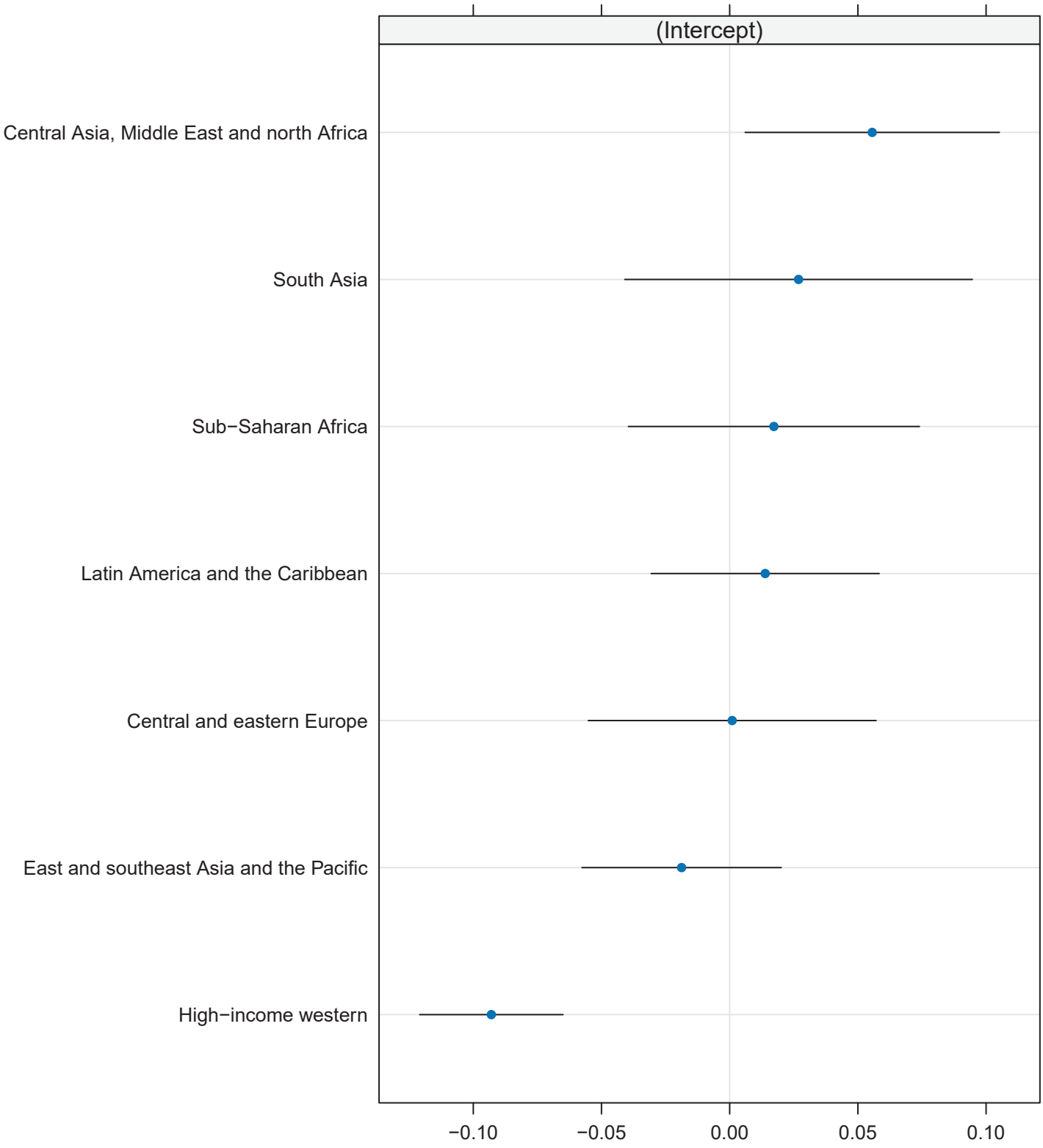
Independent variable(s): mean HbA1c	
Variables	**Coefficients (95% CI)**
Intercept	5.00 (4.81, 5.18)
Inverse mean HbA1c	-35.50 (-36.50, -34.40)
Mid-age of age group	1.06 (1.00, 1.12)
Male sex	-0.33 (-0.47, -0.19)
Inverse mean HbA1c * mid-age of age group	0.18 (-0.15, 0.52)
Inverse mean HbA1c * male sex	2.33 (1.50, 3.15)
Standard deviation of study-specific random effects	0.255
Number of data points used to fit the model = 1,386	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.815.


(Intercept)
Central Asia, Middle East and north Africa
Central and eastern Europe
Sub−Saharan Africa
Latin America and the Caribbean
South Asia
East and southeast Asia and the Pacific
High−income western
−0.10
−0.05
0.00
0.05
0.10

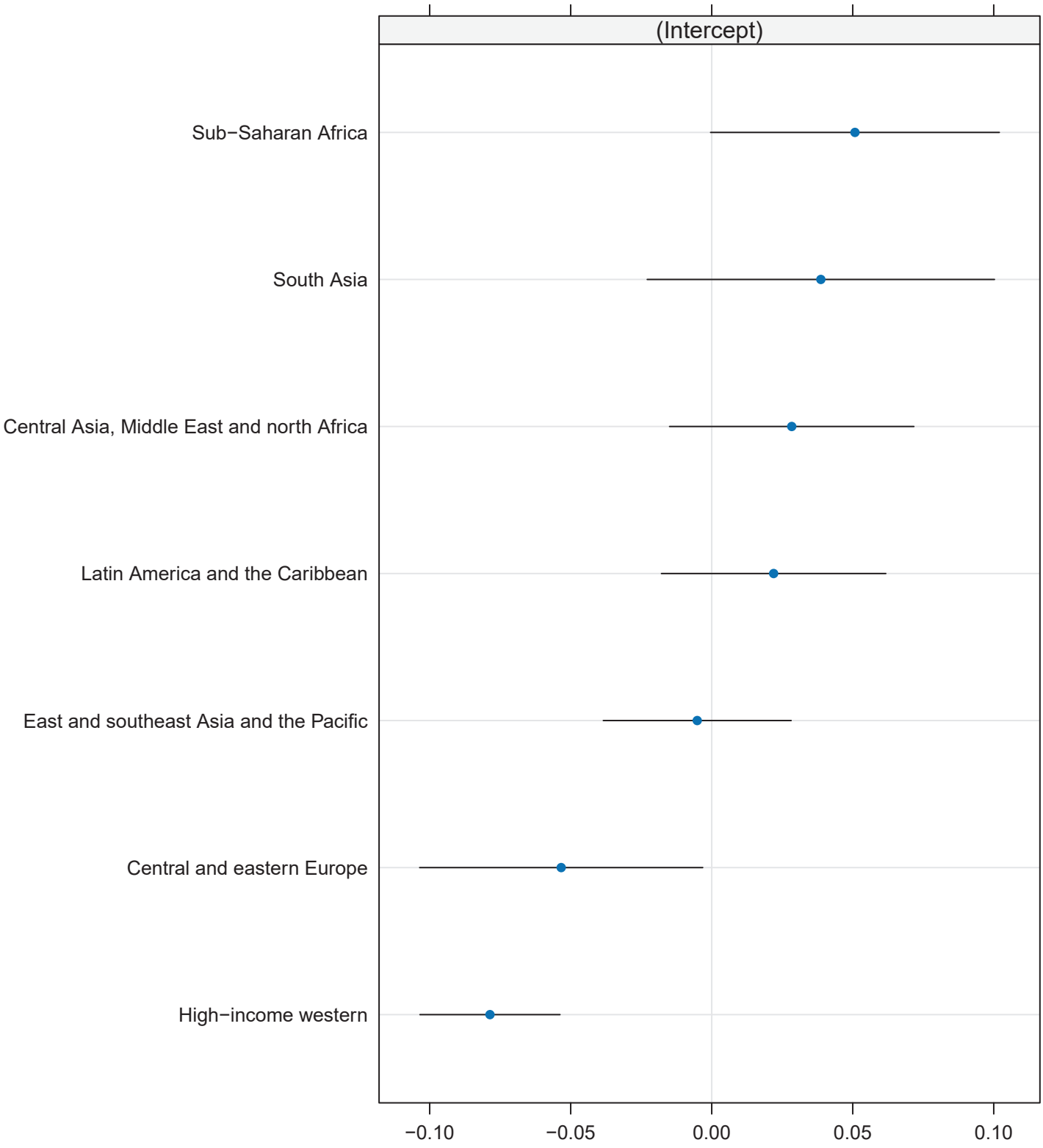
Independent variable(s): Inverse mean HbA1c, probit-transformed prevalence (FPG ≥7.0 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	1.83 (1.61, 2.05)
Inverse mean HbA1c	-11.40 (-12.90, -9.97)
Probit-transformed prevalence (FPG ≥7.0 mmol/L)	0.68 (0.64, 0.72)
Mid-age of age group	3.95 (3.89, 4.02)
Male sex	-0.47 (-0.64, -0.30)
Inverse mean HbA1c * mid-age of age group	-21.50 (-21.90, -21.10)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * mid-age of age group	-0.41 (-0.42, -0.40)
Inverse mean HbA1c * male sex	3.16 (2.00, 4.32)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * male sex	0.062 (0.025, 0.099)
Standard deviation of study-specific random effects	0.0991
Number of data points used to fit the model = 1,339	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.845.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
Latin America and the Caribbean
Central and eastern Europe
East and southeast Asia and the Pacific
High−income western
−0.10
−0.05
0.00
0.05
0.10

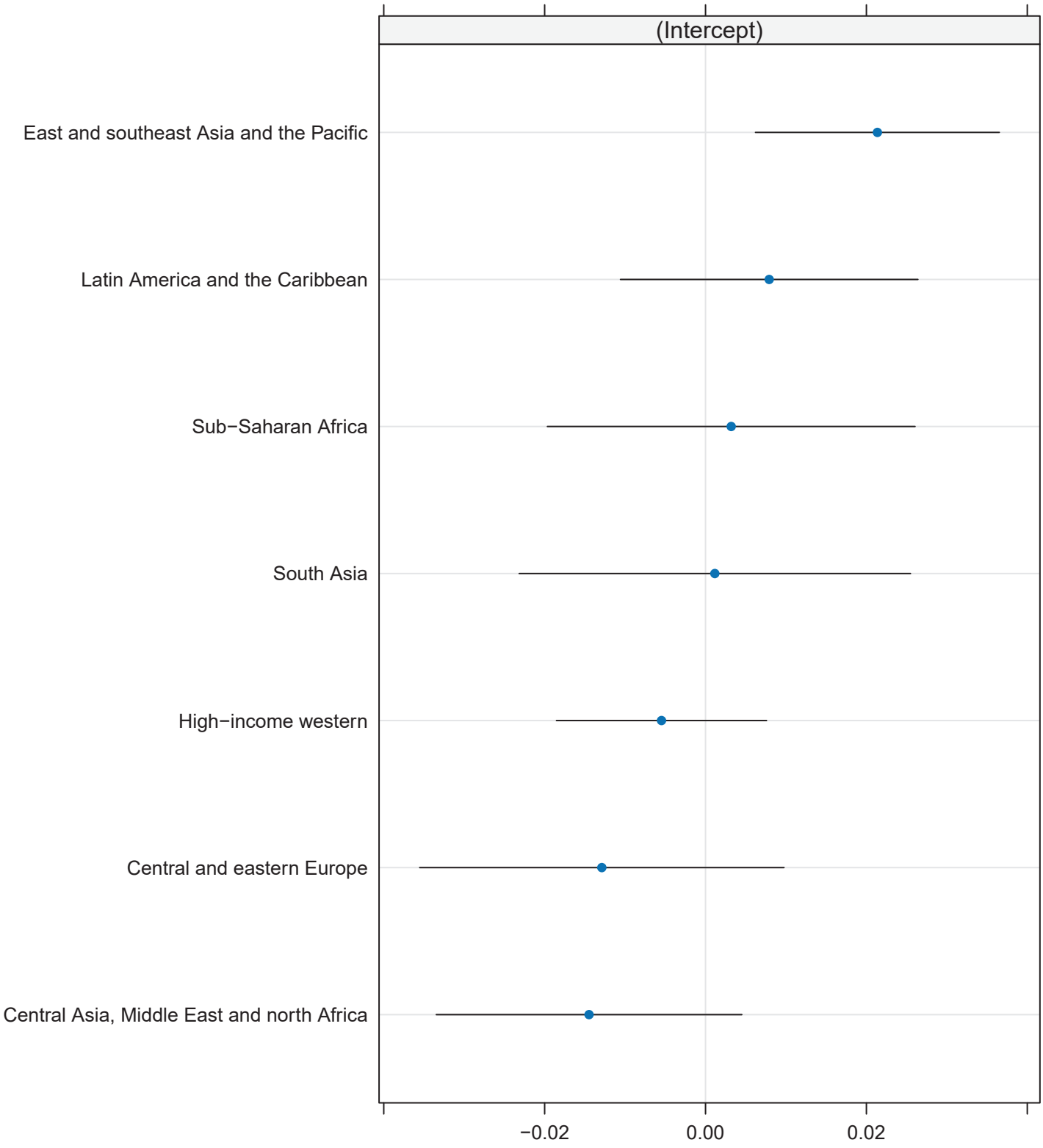
Independent variable(s): Inverse mean HbA1c, probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	1.61 (1.40, 1.82)
Inverse mean HbA1c	-10.40 (-11.80, -9.06)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	0.77 (0.73, 0.81)
Mid-age of age group	0.52 (0.45, 0.58)
Male sex	-0.49 (-0.66, -0.31)
Inverse mean HbA1c * mid-age of age group	-1.95 (-2.37, -1.53)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * mid-age of age group	-0.069 (-0.080, -0.058)
Inverse mean HbA1c * male sex	3.15 (2.00, 4.30)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * male sex	0.038 (0.0049, 0.071)
Standard deviation of study-specific random effects	0.0813
Number of data points used to fit the model = 1,324	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.855.


(Intercept)
Sub−Saharan Africa
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.10
−0.05
0.00
0.05
0.10

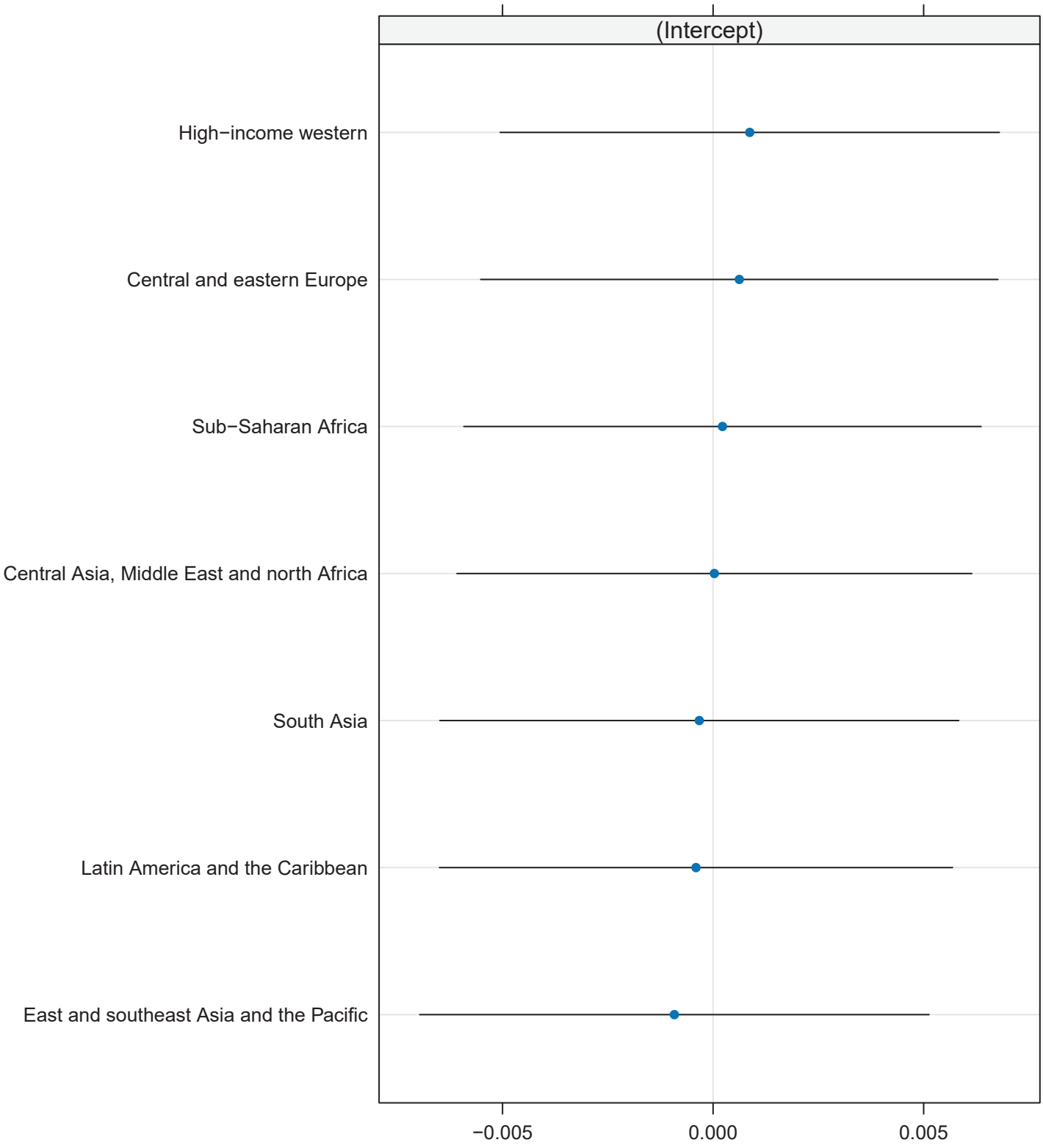
Independent variable(s): Inverse mean HbA1c, probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.64 (0.46, 0.82)
Inverse mean HbA1c	-4.34 (-5.52, -3.17)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed)	0.95 (0.92, 0.98)
Mid-age of age group	-1.08 (-1.15, -1.01)
Male sex	-0.25 (-0.45, -0.054)
Inverse mean HbA1c * mid-age of age group	6.66 (6.21, 7.11)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed) * mid-age of age group	0.079 (0.068, 0.091)
Inverse mean HbA1c * male sex	1.62 (0.33, 2.91)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed) * male sex	0.0075 (-0.028, 0.043)
Standard deviation of study-specific random effects	0.0331
Number of data points used to fit the model = 1,337	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.866.


(Intercept)
East and southeast Asia and the Pacific
Latin America and the Caribbean
Sub−Saharan Africa
South Asia
High−income western
Central and eastern Europe
Central Asia, Middle East and north Africa
−0.02
0.00
0.02

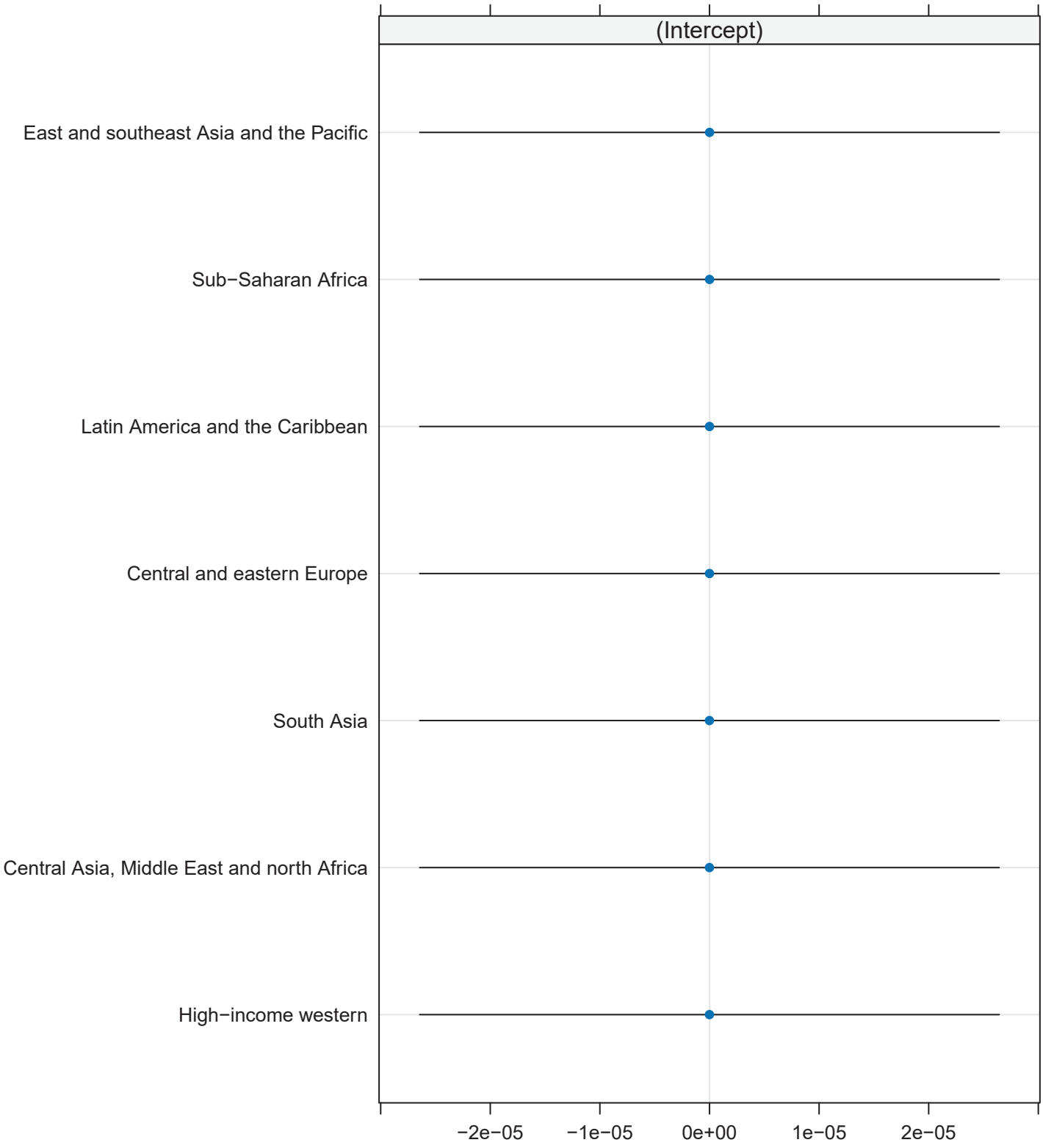
Independent variable(s): Inverse mean HbA1c, probit-transformed prevalence (HbA1c ≥6.5% or treated)	
Variables	**Coefficients (95% CI)**
Intercept	-0.058 (-0.30, 0.18)
Inverse mean HbA1c	0.49 (-1.12, 2.10)
Probit-transformed prevalence (HbA1c ≥6.5% or treated)	0.95 (0.91, 0.99)
Mid-age of age group	-0.21 (-0.30, -0.13)
Male sex	-0.10 (-0.34, 0.13)
Inverse mean HbA1c * mid-age of age group	2.00 (1.47, 2.54)
Probit-transformed prevalence (HbA1c ≥6.5% or treated) * mid-age of age group	-0.028 (-0.040, -0.015)
Inverse mean HbA1c * male sex	0.65 (-0.91, 2.21)
Probit-transformed prevalence (HbA1c ≥6.5% or treated) * male sex	-0.023 (-0.062, 0.016)
Standard deviation of study-specific random effects	0.0630
Number of data points used to fit the model = 1,367	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.858.


(Intercept)
High−income western
Central and eastern Europe
Sub−Saharan Africa
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
East and southeast Asia and the Pacific
−0.005
0.000
0.005

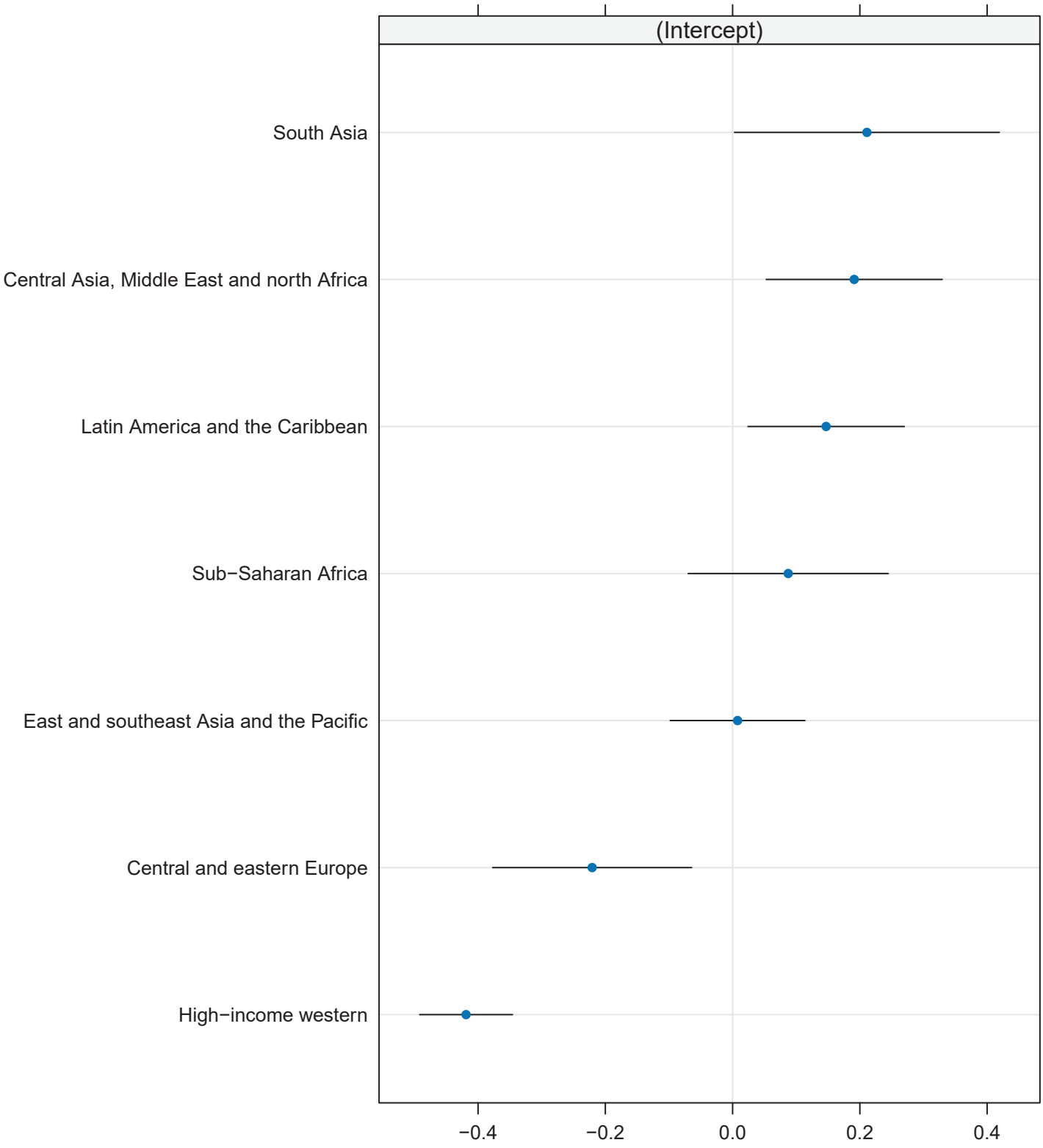
Independent variable(s): Inverse mean HbA1c, probit-transformed prevalence (HbA1c ≥6.5% or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.82 (0.58, 1.05)
Inverse mean HbA1c	-5.48 (-7.03, -3.94)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed)	0.88 (0.84, 0.92)
Mid-age of age group	-1.40 (-1.48, -1.32)
Male sex	-0.33 (-0.55, -0.12)
Inverse mean HbA1c * mid-age of age group	9.66 (9.15, 10.20)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed) * mid-age of age group	0.12 (0.11, 0.13)
Inverse mean HbA1c * male sex	2.16 (0.75, 3.57)
Probit-transformed prevalence (HbA1c ≥6.5% or diagnosed) * male sex	-0.011 (-0.049, 0.026)
Standard deviation of study-specific random effects	0.0784
Number of data points used to fit the model = 1,323	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.856.


(Intercept)
East and southeast Asia and the Pacific
Sub−Saharan Africa
Latin America and the Caribbean
Central and eastern Europe
South Asia
Central Asia, Middle East and north Africa
High−income western
−2e−05
−1e−05
0e+00
1e−05
2e−05

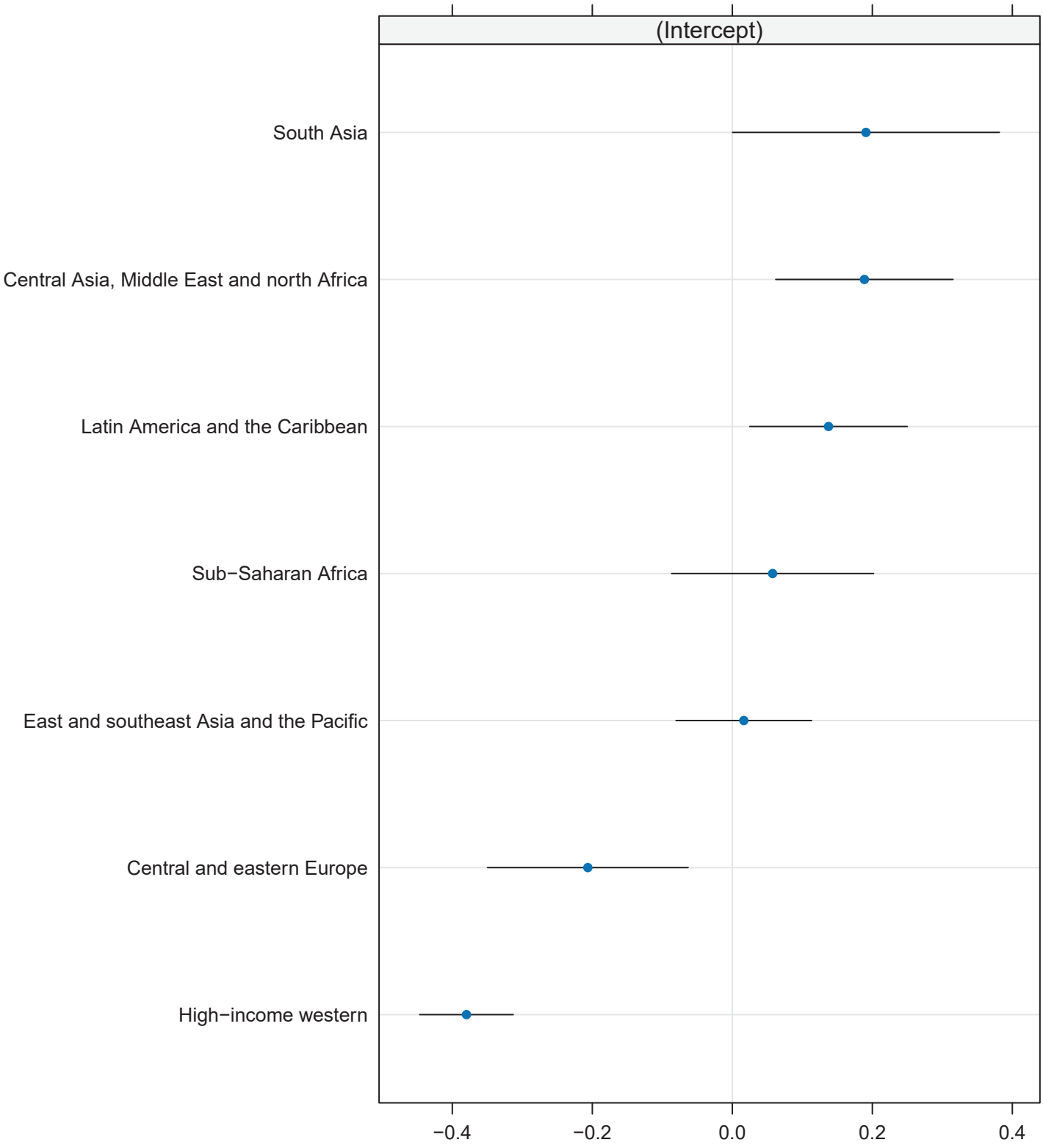
Independent variable(s): Probit-transformed prevalence (FPG ≥5.5 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	-0.82 (-1.00, -0.64)
Probit-transformed prevalence (FPG ≥5.5 mmol/L or diagnosed)	0.85 (0.82, 0.88)
Mid-age of age group	0.98 (0.97, 0.98)
Male sex	-0.082 (-0.093, -0.070)
Probit-transformed prevalence (FPG ≥5.5 mmol/L or diagnosed) * mid-age of age group	0.020 (0.012, 0.028)
Probit-transformed prevalence (FPG ≥5.5 mmol/L or diagnosed) * male sex	-0.0057 (-0.028, 0.017)
Standard deviation of study-specific random effects	0.265
Number of data points used to fit the model = 1,336	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.814.


(Intercept)
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.4
−0.2
0.0
0.2
0.4

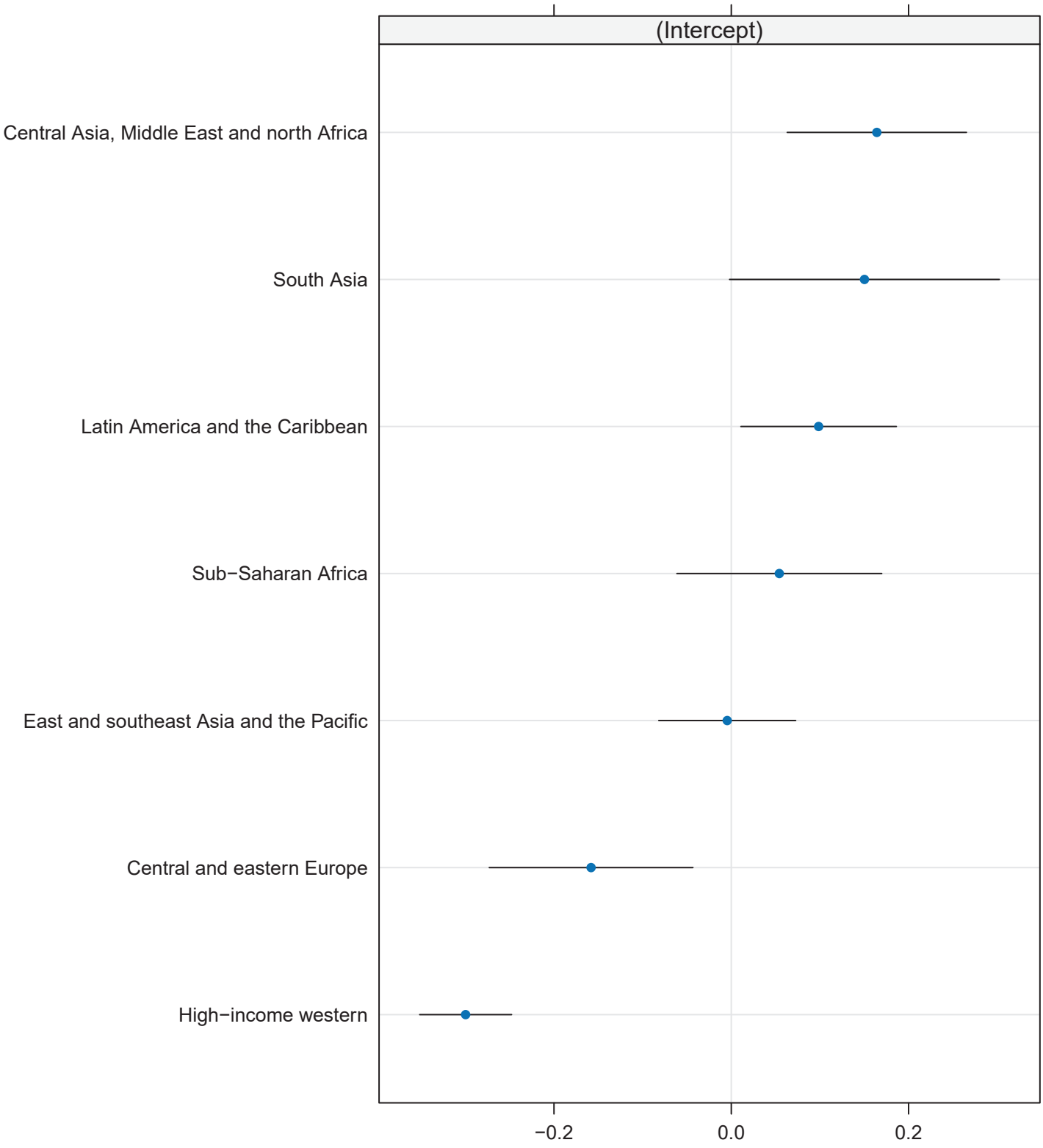
Independent variable(s): Probit-transformed prevalence (FPG ≥5.6 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	-0.71 (-0.87, -0.54)
Probit-transformed prevalence (FPG ≥5.6 mmol/L or diagnosed)	0.86 (0.84, 0.89)
Mid-age of age group	0.86 (0.86, 0.87)
Male sex	-0.076 (-0.089, -0.064)
Probit-transformed prevalence (FPG ≥5.6 mmol/L or diagnosed) * mid-age of age group	-0.0058 (-0.014, 0.0022)
Probit-transformed prevalence (FPG ≥5.6 mmol/L or diagnosed) * male sex	-0.0048 (-0.028, 0.018)
Standard deviation of study-specific random effects	0.242
Number of data points used to fit the model = 1,336	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.819.


(Intercept)
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.4
−0.2
0.0
0.2
0.4

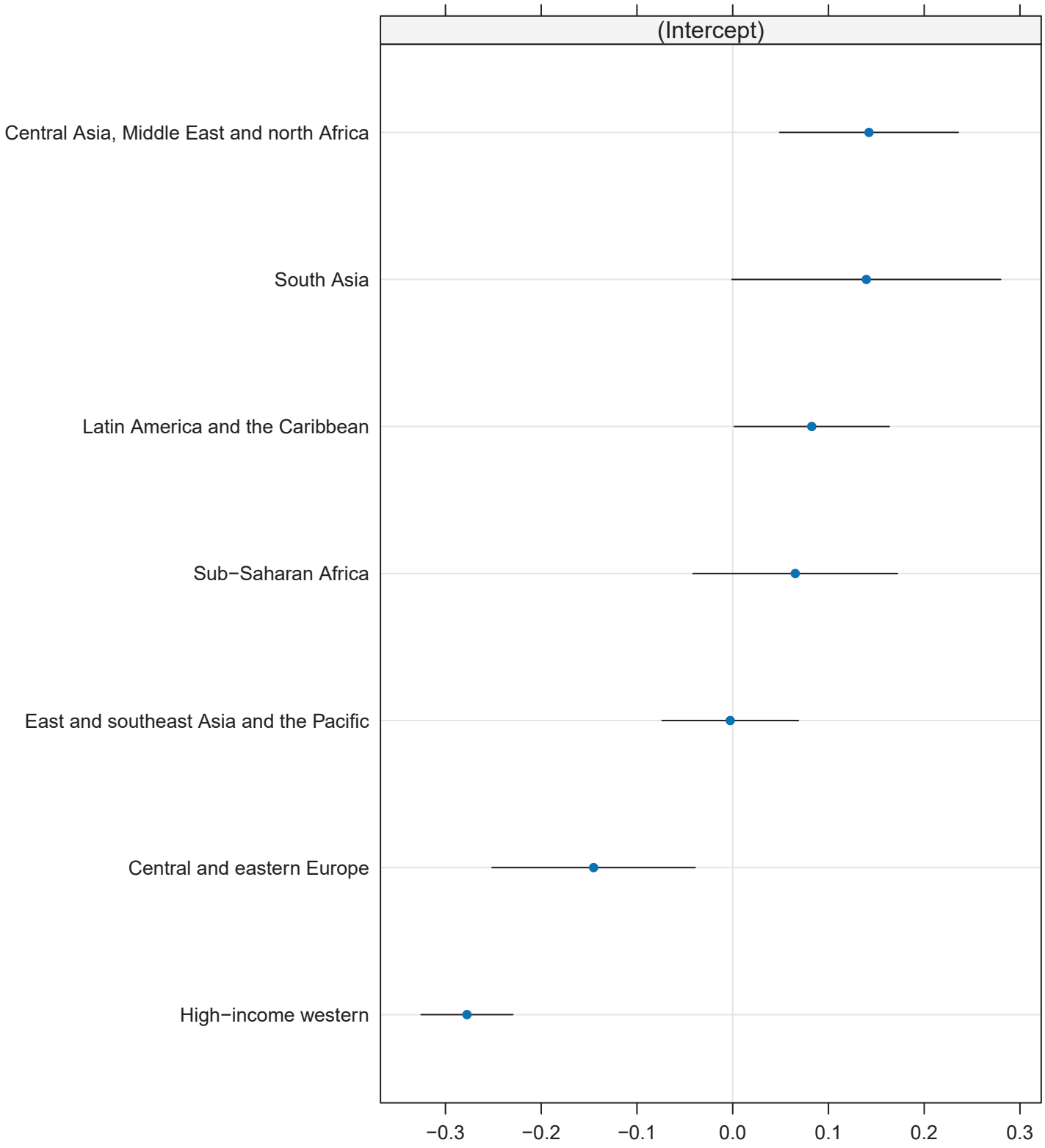
Independent variable(s): Probit-transformed prevalence (FPG ≥6.0 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	-0.32 (-0.45, -0.18)
Probit-transformed prevalence (FPG ≥6.0 mmol/L)	0.87 (0.85, 0.90)
Mid-age of age group	0.88 (0.87, 0.89)
Male sex	-0.060 (-0.080, -0.040)
Probit-transformed prevalence (FPG ≥6.0 mmol/L) * mid-age of age group	0.024 (0.015, 0.033)
Probit-transformed prevalence (FPG ≥6.0 mmol/L) * male sex	-0.0029 (-0.028, 0.022)
Standard deviation of study-specific random effects	0.192
Number of data points used to fit the model = 1,374	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.827.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
0.0
0.2

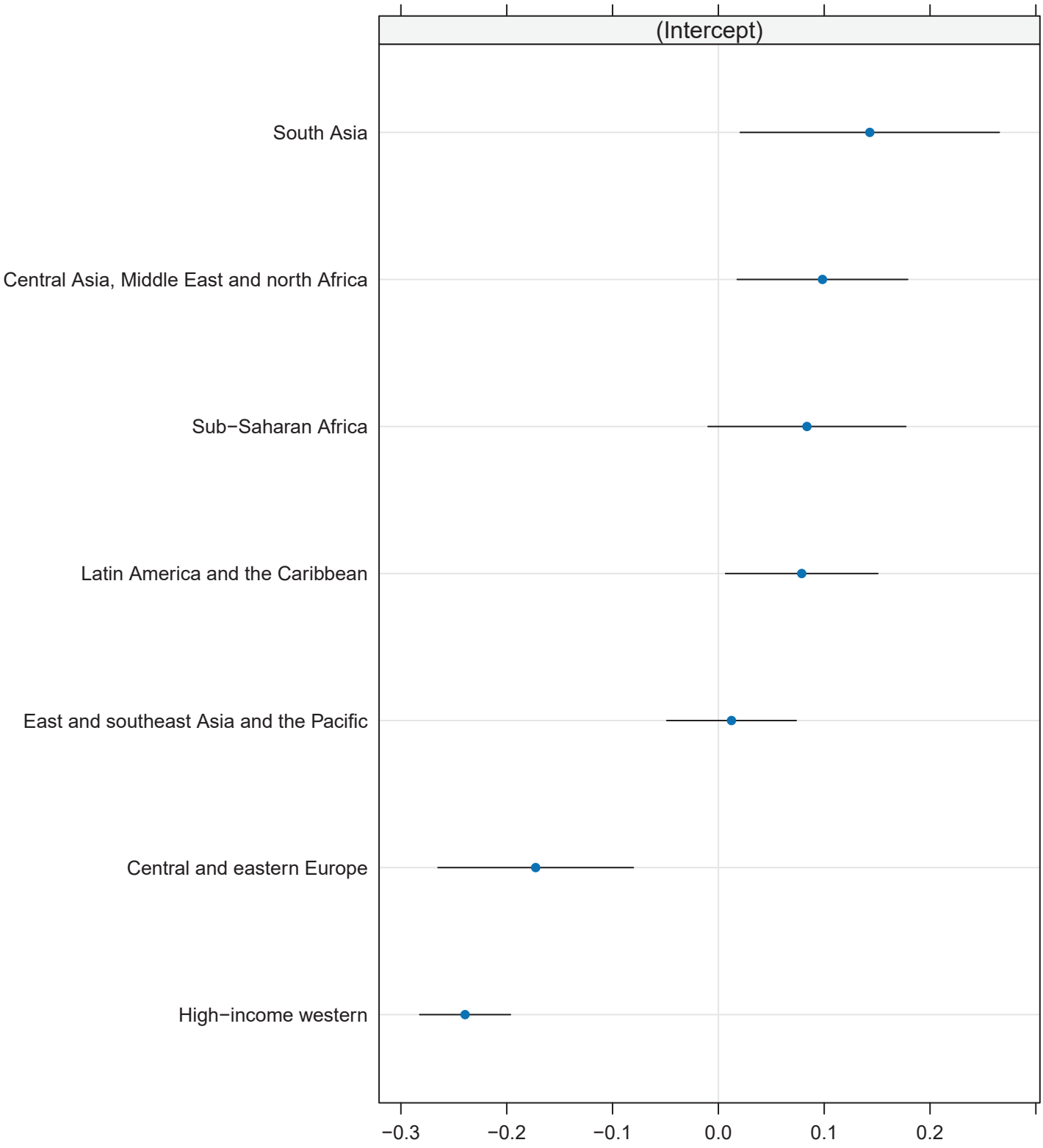
Independent variable(s): Probit-transformed prevalence (FPG ≥6.1 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	-0.24 (-0.36, -0.11)
Probit-transformed prevalence (FPG ≥6.1 mmol/L)	0.88 (0.85, 0.90)
Mid-age of age group	0.82 (0.81, 0.83)
Male sex	-0.056 (-0.079, -0.034)
Probit-transformed prevalence (FPG ≥6.1 mmol/L) * mid-age of age group	-0.0054 (-0.014, 0.0035)
Probit-transformed prevalence (FPG ≥6.1 mmol/L) * male sex	-0.0050 (-0.030, 0.020)
Standard deviation of study-specific random effects	0.177
Number of data points used to fit the model = 1,373	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.830.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Latin America and the Caribbean
Sub−Saharan Africa
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3

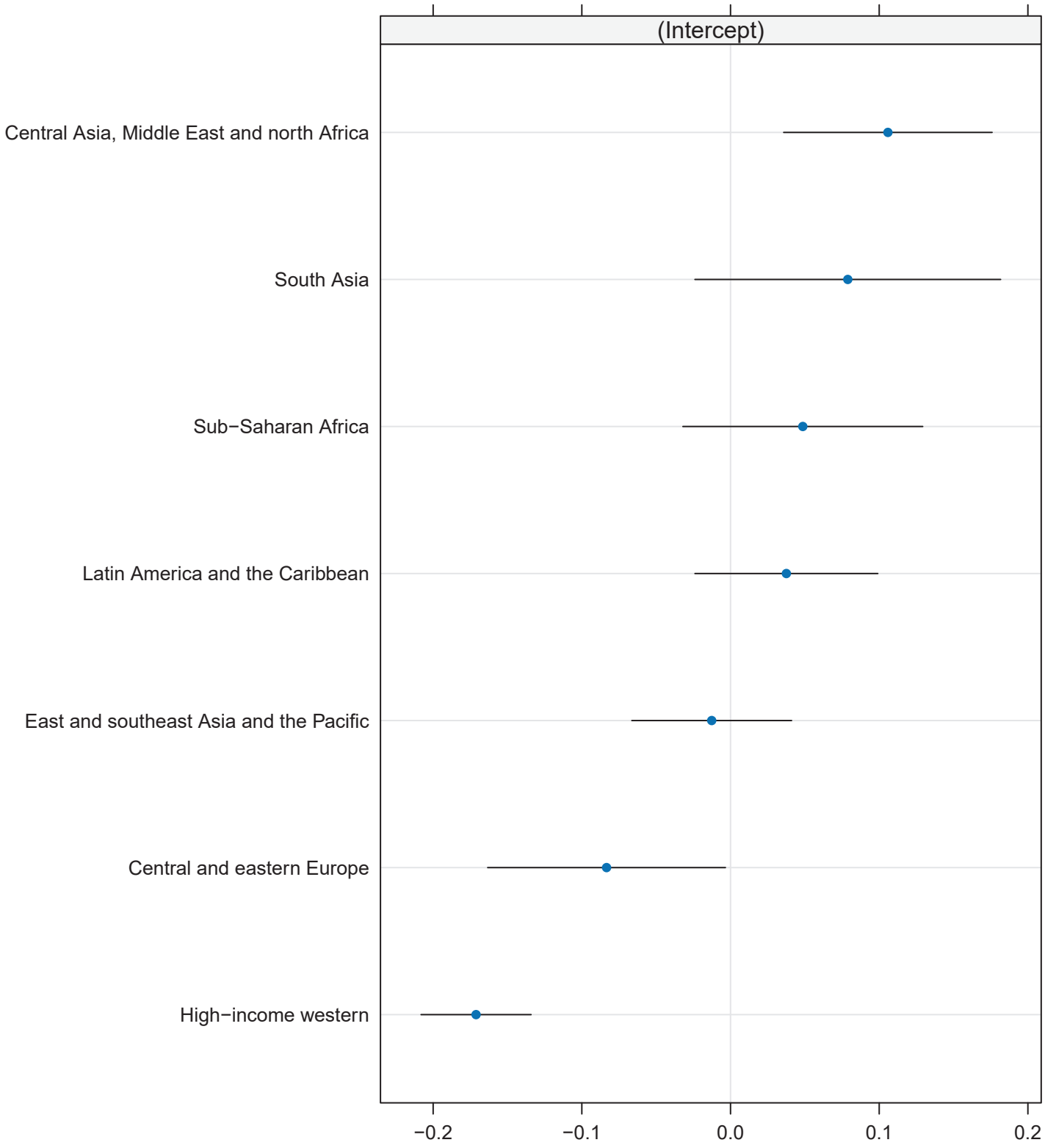
Independent variable(s): Probit-transformed prevalence (FPG ≥6.1 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	-0.28 (-0.39, -0.16)
Probit-transformed prevalence (FPG ≥6.1 mmol/L or diagnosed)	0.93 (0.91, 0.96)
Mid-age of age group	0.39 (0.38, 0.40)
Male sex	-0.046 (-0.065, -0.026)
Probit-transformed prevalence (FPG ≥6.1 mmol/L or diagnosed) * mid-age of age group	-0.078 (-0.087, -0.070)
Probit-transformed prevalence (FPG ≥6.1 mmol/L or diagnosed) * male sex	-0.0086 (-0.033, 0.016)
Standard deviation of study-specific random effects	0.151
Number of data points used to fit the model = 1,333	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.840.


(Intercept)
South Asia
Central Asia, Middle East and north Africa
Sub−Saharan Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.3
−0.2
−0.1
0.0
0.1
0.2

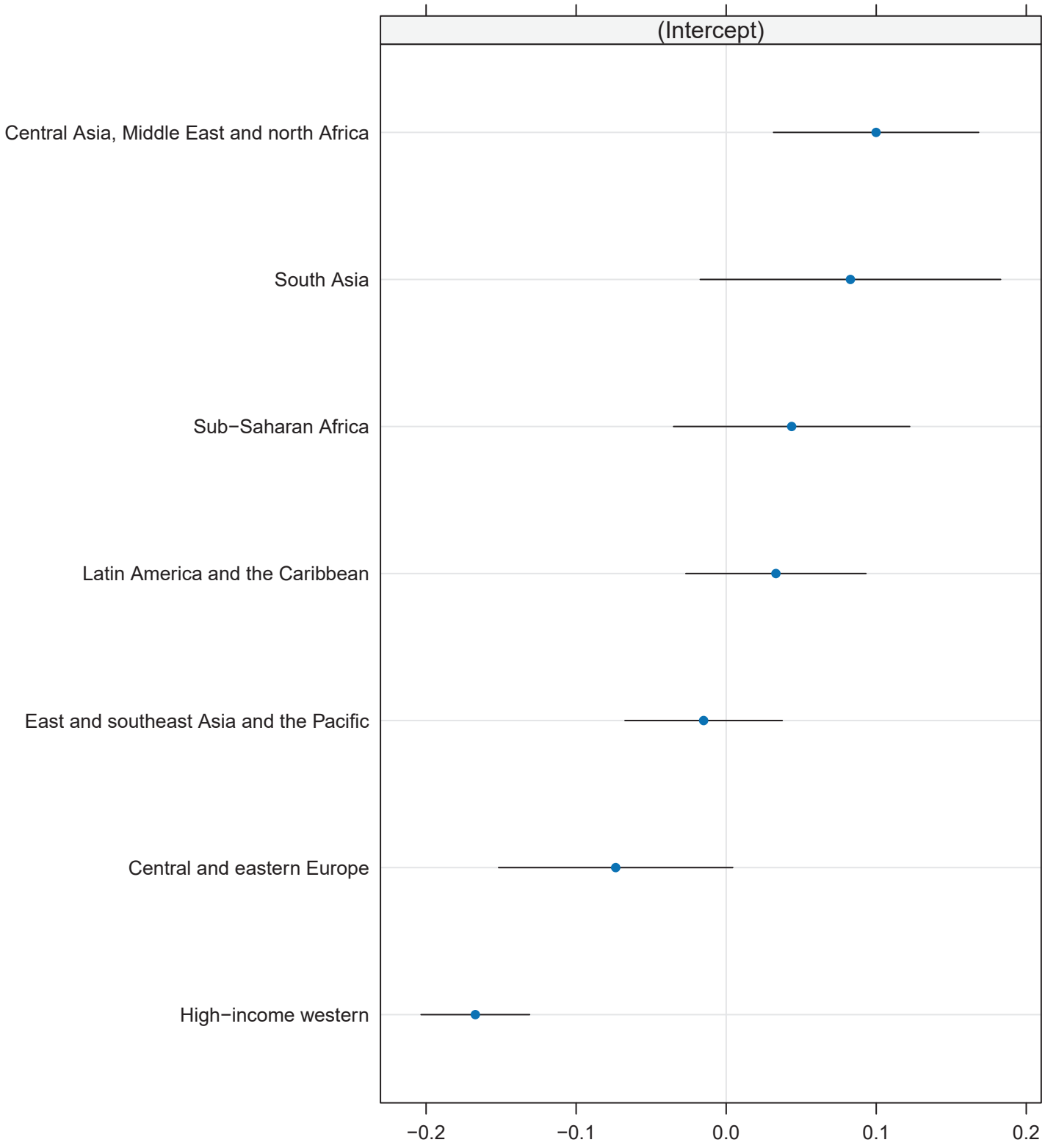
Independent variable(s): Probit-transformed prevalence (FPG ≥6.7 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.065 (-0.020, 0.15)
Probit-transformed prevalence (FPG ≥6.7 mmol/L)	0.89 (0.87, 0.92)
Mid-age of age group	0.81 (0.79, 0.82)
Male sex	-0.060 (-0.092, -0.030)
Probit-transformed prevalence (FPG ≥6.7 mmol/L) * mid-age of age group	-0.035 (-0.045, -0.026)
Probit-transformed prevalence (FPG ≥6.7 mmol/L) * male sex	-0.025 (-0.051, 0.0010)
Standard deviation of study-specific random effects	0.134
Number of data points used to fit the model = 1,349	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.836.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1
0.2

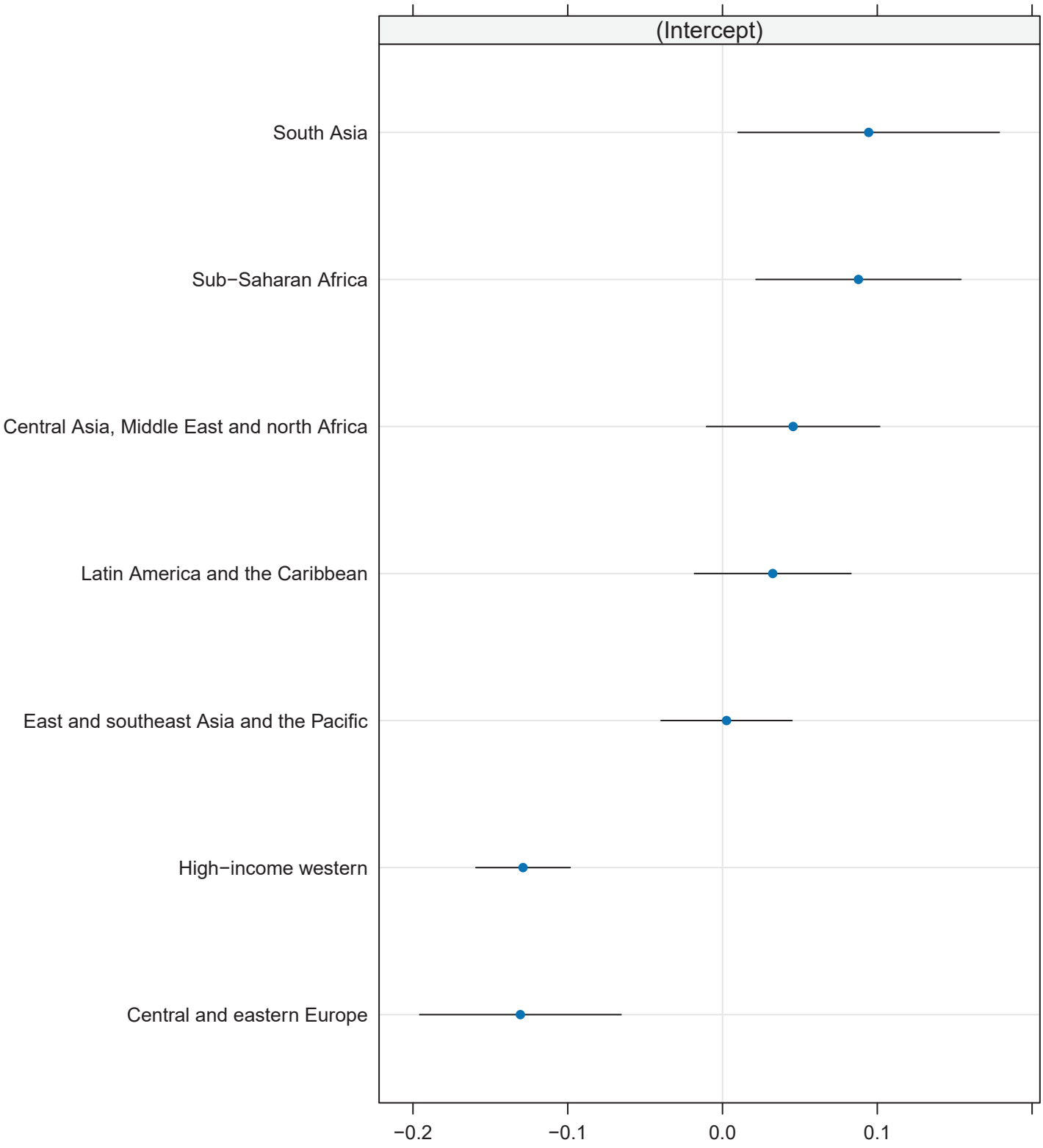
Independent variable(s): Probit-transformed prevalence (FPG ≥6.8 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.091 (0.0080, 0.17)
Probit-transformed prevalence (FPG ≥6.8 mmol/L)	0.88 (0.86, 0.91)
Mid-age of age group	0.83 (0.82, 0.84)
Male sex	-0.063 (-0.096, -0.031)
Probit-transformed prevalence (FPG ≥6.8 mmol/L) * mid-age of age group	-0.049 (-0.059, -0.040)
Probit-transformed prevalence (FPG ≥6.8 mmol/L) * male sex	-0.026 (-0.052, 0.00040)
Standard deviation of study-specific random effects	0.130
Number of data points used to fit the model = 1,347	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.836.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1
0.2

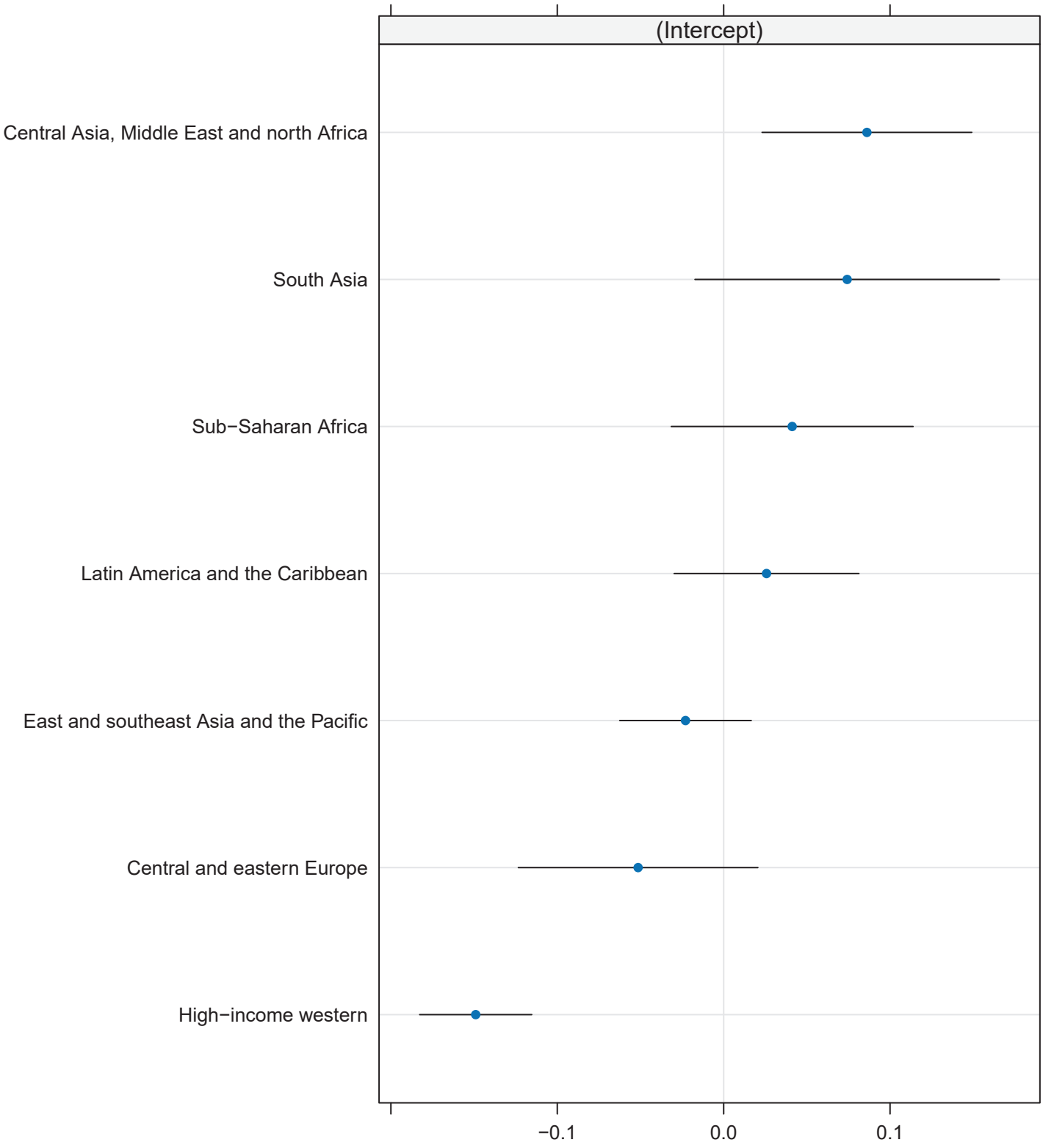
Independent variable(s): Probit-transformed prevalence (FPG ≥6.8 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.012 (-0.066, 0.090)
Probit-transformed prevalence (FPG ≥6.8 mmol/L or diagnosed)	0.98 (0.95, 1.00)
Mid-age of age group	0.18 (0.17, 0.19)
Male sex	-0.037 (-0.062, -0.012)
Probit-transformed prevalence (FPG ≥6.8 mmol/L or diagnosed) * mid-age of age group	-0.088 (-0.097, -0.080)
Probit-transformed prevalence (FPG ≥6.8 mmol/L or diagnosed) * male sex	-0.037 (-0.061, -0.014)
Standard deviation of study-specific random effects	0.102
Number of data points used to fit the model = 1,327	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.850.


(Intercept)
South Asia
Sub−Saharan Africa
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
High−income western
Central and eastern Europe
−0.2
−0.1
0.0
0.1

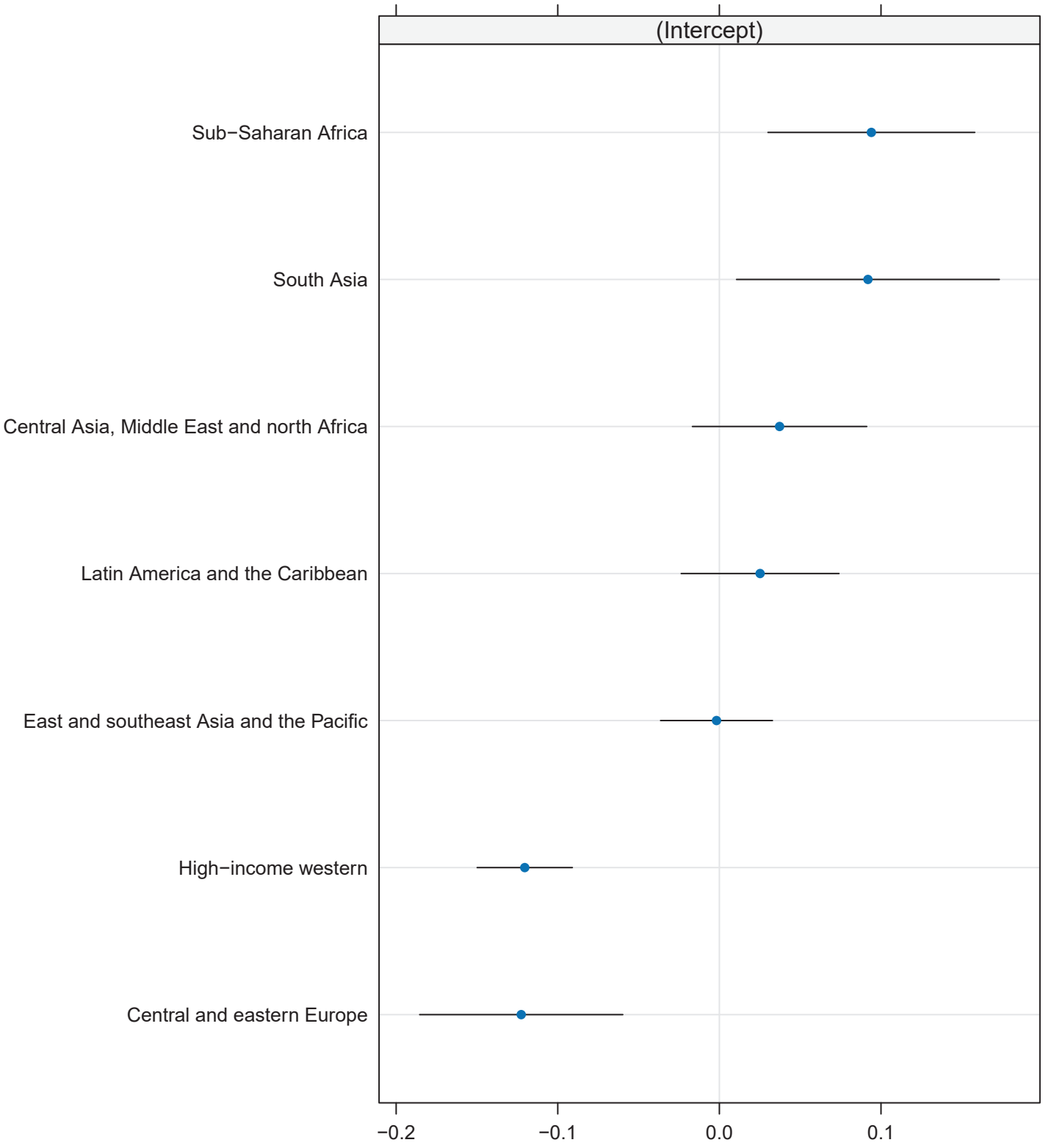
Independent variable(s): Probit-transformed prevalence (FPG ≥7.0 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.17 (0.091, 0.24)
Probit-transformed prevalence (FPG ≥7.0 mmol/L)	0.90 (0.88, 0.93)
Mid-age of age group	0.84 (0.82, 0.85)
Male sex	-0.070 (-0.10, -0.037)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * mid-age of age group	-0.049 (-0.058, -0.039)
Probit-transformed prevalence (FPG ≥7.0 mmol/L) * male sex	-0.033 (-0.059, -0.0071)
Standard deviation of study-specific random effects	0.121
Number of data points used to fit the model = 1,466	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4], was 0.830.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.1
0.0
0.1

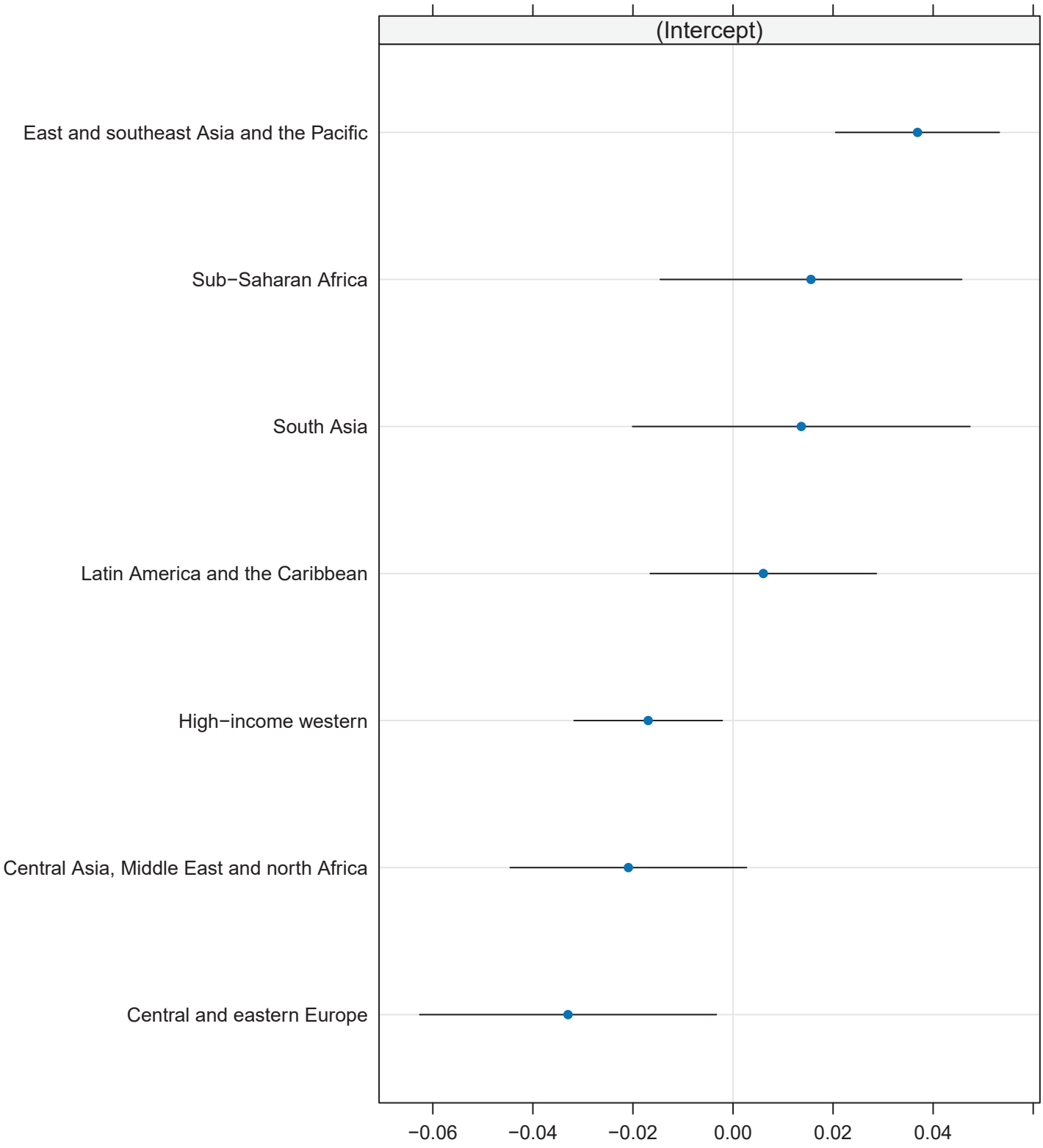
Independent variable(s): Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.044 (-0.031, 0.12)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed)	0.97 (0.95, 1.0)
Mid-age of age group	0.18 (0.16, 0.19)
Male sex	-0.034 (-0.060, -0.0082)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * mid-age of age group	-0.096 (-0.10, -0.087)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or diagnosed) * male sex	-0.039 (-0.063, -0.016)
Standard deviation of study-specific random effects	0.0983
Number of data points used to fit the model = 1,433	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.846.


(Intercept)
Sub−Saharan Africa
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
High−income western
Central and eastern Europe
−0.2
−0.1
0.0
0.1

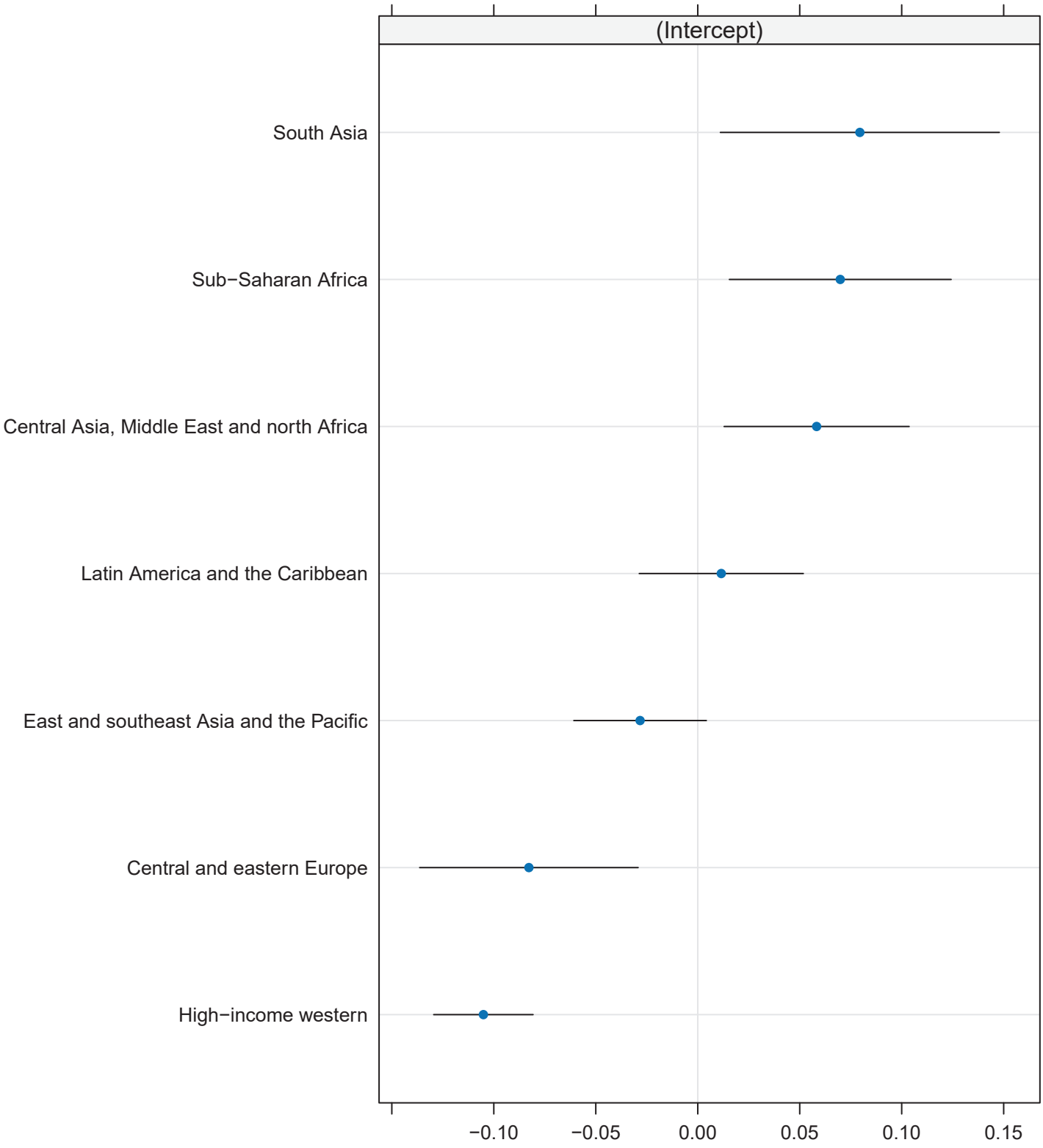
Independent variable(s): Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	-0.032 (-0.064, 0.00068)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed)	1.03 (1.01, 1.05)
Mid-age of age group	-0.052 (-0.062, -0.042)
Male sex	-0.010 (-0.033, 0.012)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed) * mid-age of age group	-0.075 (-0.083, -0.067)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or HbA1c ≥6.5% or diagnosed) * male sex	-0.030 (-0.053, -0.0080)
Standard deviation of study-specific random effects	0.0377
Number of data points used to fit the model = 1,447	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.860.


(Intercept)
East and southeast Asia and the Pacific
Sub−Saharan Africa
South Asia
Latin America and the Caribbean
High−income western
Central Asia, Middle East and north Africa
Central and eastern Europe
−0.06
−0.04
−0.02
0.00
0.02
0.04

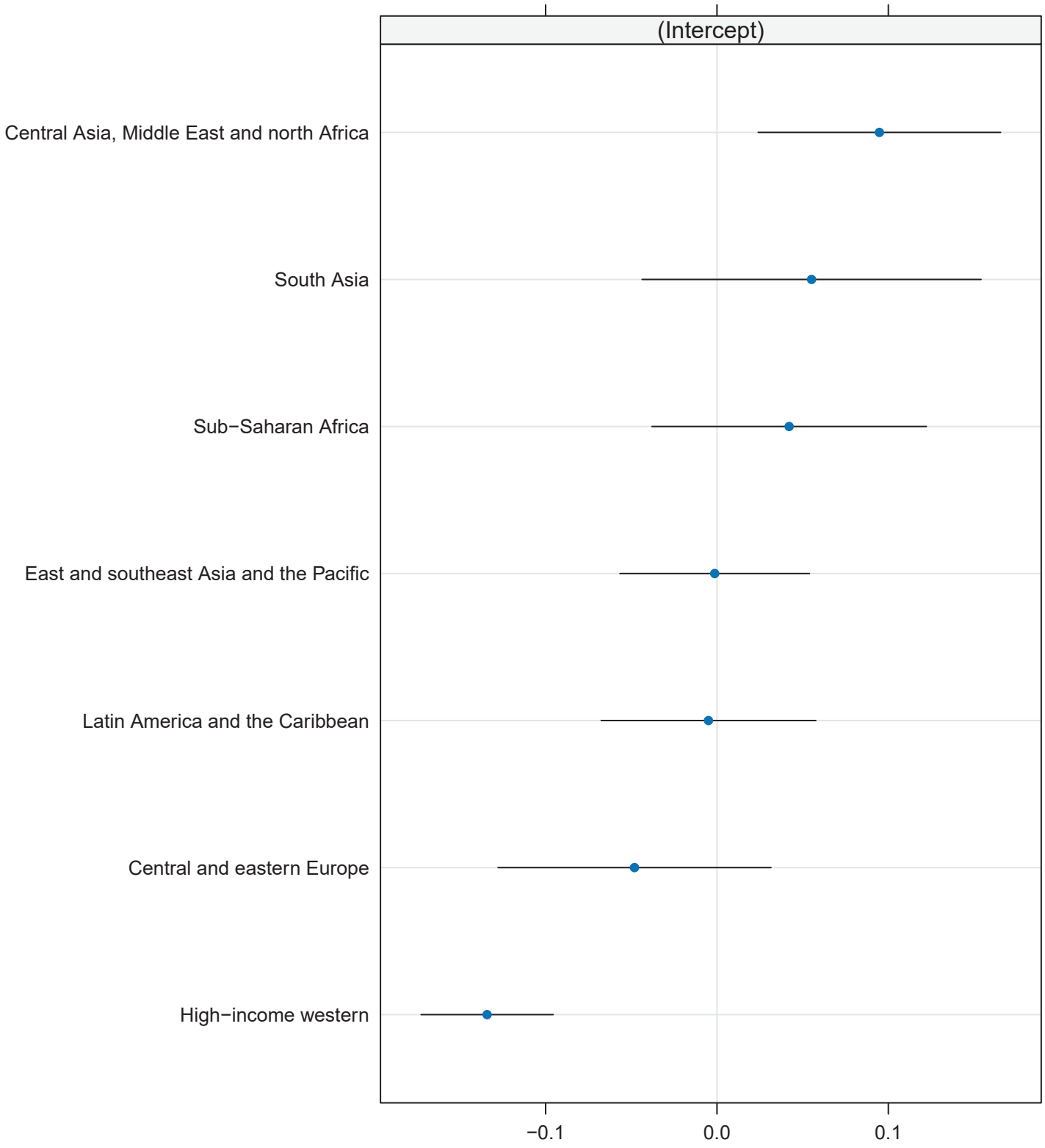
Independent variable(s): Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated)	
Variables	**Coefficients (95% CI)**
Intercept	0.099 (0.034, 0.16)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated)	0.95 (0.93, 0.98)
Mid-age of age group	0.20 (0.19, 0.22)
Male sex	-0.027 (-0.054, -0.00086)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated) * mid-age of age group	-0.033 (-0.041, -0.024)
Probit-transformed prevalence (FPG ≥7.0 mmol/L or treated) * male sex	-0.0092 (-0.032, 0.014)
Standard deviation of study-specific random effects	0.0808
Number of data points used to fit the model = 1,397	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.854.


(Intercept)
South Asia
Sub−Saharan Africa
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.10
−0.05
0.00
0.05
0.10
0.15

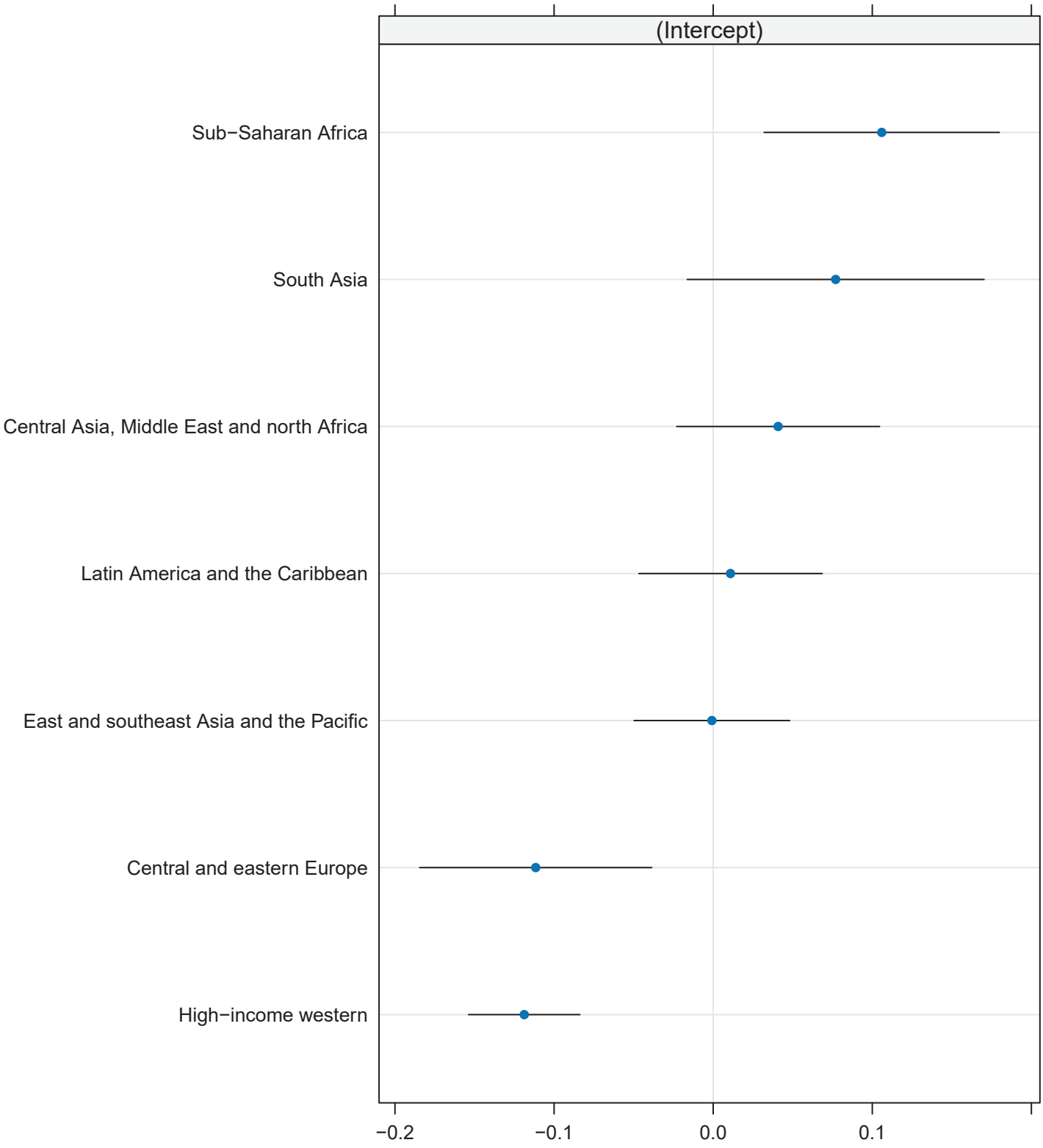
Independent variable(s): Probit-transformed prevalence (FPG ≥7.8 mmol/L)	
Variables	**Coefficients (95% CI)**
Intercept	0.22 (0.14, 0.30)
Probit-transformed prevalence (FPG ≥7.8 mmol/L)	0.83 (0.81, 0.86)
Mid-age of age group	1.10 (1.08, 1.11)
Male sex	-0.13 (-0.17, -0.092)
Probit-transformed prevalence (FPG ≥7.8 mmol/L) * mid-age of age group	-0.16 (-0.17, -0.15)
Probit-transformed prevalence (FPG ≥7.8 mmol/L) * male sex	-0.086 (-0.11, -0.059)
Standard deviation of study-specific random effects	0.142
Number of data points used to fit the model = 1,290	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.819.


(Intercept)
Central Asia, Middle East and north Africa
South Asia
Sub−Saharan Africa
East and southeast Asia and the Pacific
Latin America and the Caribbean
Central and eastern Europe
High−income western
−0.1
0.0
0.1

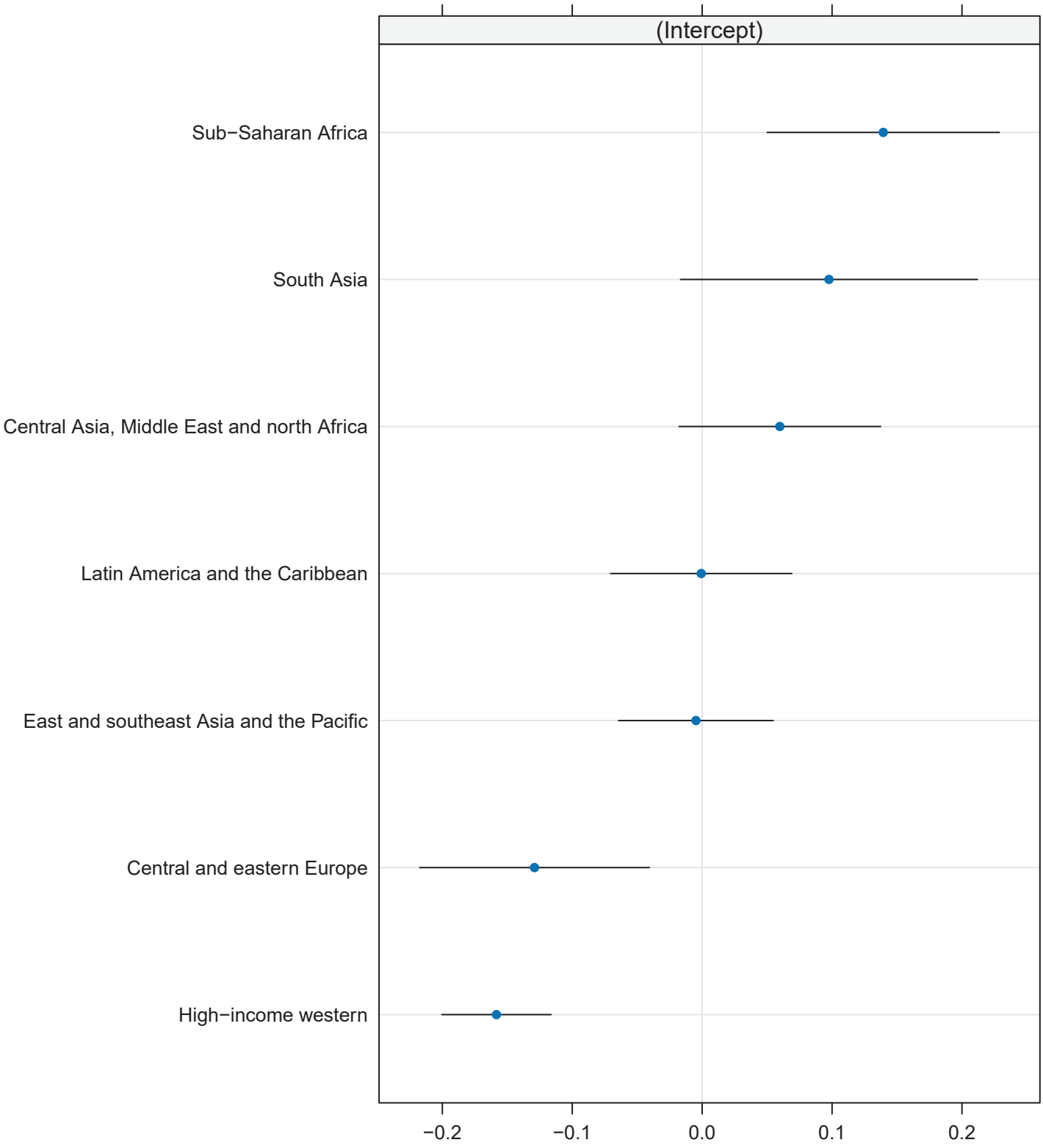
Independent variable(s): Probit-transformed prevalence (FPG ≥7.8 mmol/L or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.067 (-0.010, 0.14)
Probit-transformed prevalence (FPG ≥7.8 mmol/L or diagnosed)	0.93 (0.90, 0.95)
Mid-age of age group	0.27 (0.26, 0.29)
Male sex	-0.037 (-0.065, -0.0096)
Probit-transformed prevalence (FPG ≥7.8 mmol/L or diagnosed) * mid-age of age group	-0.11 (-0.12, -0.10)
Probit-transformed prevalence (FPG ≥7.8 mmol/L or diagnosed) * male sex	-0.059 (-0.083, -0.036)
Standard deviation of study-specific random effects	0.121
Number of data points used to fit the model = 1,310	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.841.


(Intercept)
Sub−Saharan Africa
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1

Independent variable(s): Probit-transformed prevalence (HbA1c ≥10% or diagnosed)	
Variables	**Coefficients (95% CI)**
Intercept	0.066 (-0.028, 0.16)
Probit-transformed prevalence (HbA1c ≥10% or diagnosed)	0.86 (0.84, 0.89)
Mid-age of age group	0.35 (0.34, 0.36)
Male sex	-0.025 (-0.054, 0.0030)
Probit-transformed prevalence (HbA1c ≥10% or diagnosed) * mid-age of age group	-0.11 (-0.12, -0.099)
Probit-transformed prevalence (HbA1c ≥10% or diagnosed) * male sex	-0.066 (-0.088, -0.044)
Standard deviation of study-specific random effects	0.148
Number of data points used to fit the model = 1,281	

Traditional R^2 is not clearly defined for mixed-effect models. The pseudo R^2 for the model, which describes the proportion of variance explained by both fixed and random factors,[4] was 0.829.


(Intercept)
Sub−Saharan Africa
South Asia
Central Asia, Middle East and north Africa
Latin America and the Caribbean
East and southeast Asia and the Pacific
Central and eastern Europe
High−income western
−0.2
−0.1
0.0
0.1
0.2

References

1. Danaei G, Finucane MM, Lu Y, et al. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants. *Lancet* 2011; **378**(9785): 31-40.
2. Schwarz G. Estimating the dimension of a model. *Ann Stat* 1978; **6**(2): 461-4.
3. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. *Lancet* 2024; **403**(10431): 1027-50.
4. McFadden D. Conditional Logit Analysis of Qualitative Choice Behavior. In: Zarembka P, ed. *Frontiers in econometrics: Academic Press*; 1974: 105-42.