ExPoSE

Explaining Population trends in cardiovascular risk: A comparative analysis of health transitions in South Africa and England

Collaborating institutions:

University of Greenwich, Institute for Lifecourse Development

Stellenbosch University / Iyunivesithi / Universiteit

UCL

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UKRI Economic and Social Research Council

CVD risk trends in England and South Africa: Findings from the ExPoSE project

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London, UK

1. **Methods**
   - Data sources, cleaning and consolidation
   - Risk scores
   - Statistics
2. **CVD risk trends in England (1998-2017)**
   - Trends in major bio-behavioural risk factors, variance explained and adjusted CVD trends
   - Socio-economic patterns
3. **Comparison with South Africa & Next steps for England analyses**

1. Methods

Health Survey England Dataset v0.3

- **Individuals:** 168,415, age 16+
- **Variables:** ~150
- Socio-demographics & administrative
- Height, weight, blood pressure, cholesterol, waist & hip circumference, BMI, smoking, reported long-standing illnesses & diagnoses, general health, antihypertensives, etc…

	Year	Sample
1	1998	15,908
2	2001	15,647
3	2002	7,393
4	2003	14,836
5	2005	7,630
6	2006	14,142
7	2007	6,882
8	2008	15,098
9	2009	4,645
10	2010	8,420
11	2011	8,610
12	2012	8,290
13	2013	8,795
14	2014	8,077
15	2015	8,034
16	2016	8,011
17	2017	7,997

Methodology: Data cleaning & preprocessing

- Individuals with no Government Office Region (stratification variable) were excluded (n=119)
- Recoding to correspond to variable definitions and names used for the South Africa analysis where possible.
- Recoding to account for restricted data (e.g. age estimates, household size, etc.)
- Implausible values applied to measurements
- England sample aged 40-74 years with non-lab risk score: approximately 60K
- All analyses accounted for survey design and applied appropriate weights (non-lab/nurse, lab/blood with 2006 CVD)

Implausible values applied to measurements

Variable	Implausible values applied
Height	Height<120 cm or height > 220 cm
Weight	Females: Weight<25 Kg or weight > 250 Kg; Males: Weight <35 Kg; Weight > 250 Kg
Body mass index (BMI)	BMI < 10 kg/m^2 or BMI>131 kg/m^2
Waist circumference	Waist < 30 cm or waist > 220 cm
Hip circumference	Hip circumference < 40 cm or hip circumference > 230
Systolic blood pressure (SBP)	SBP < 60 mmHg or SBP > 270 mmHg SBP readings were set to missing if less than 15 mmHg greater than the corresponding DBP reading.
Diastolic blood pressure (DBP)	DBP < 30 mmHg; DBP > 150 mmHg. DBP readings were set to missing if they were less than 15 mmHg lower than the corresponding SBP reading.
Resting heart rate (RHR)	RHR < 20 bpm; RHR > 250 bpm
Total cholesterol	<1.75 mmol/L or >20 mmol/L or total cholesterol < HDL cholesterol
HDL cholesterol	<0.40 mmol/L or >5.00 mmol/L or total cholesterol < HDL cholesterol
HbA1c	HbA1c< 2.5% or > 25%

Main outcome

10-year risk of fatal and non-fatal cardiovascular disease (myocardial infarction and stroke)

Model

ARTICLES | VOLUME 7, ISSUE 10, E1332-E1345, OCTOBER 2019 | Download Full Issue

World Health Organization cardiovascular disease risk charts: revised models to estimate risk in 21 global regions

The WHO CVD Risk Chart Working Group † • Show footnotes

Cox hazard model fitted on a pooled cohort from 85 prospective studies (10+ years follow-up, CVD free participants at baseline, followed until the first myocardial infarction, fatal coronary heart disease, or stroke event

ARTICLES | VOLUME 5, ISSUE 3, P196-213, MARCH 2017 | Download Full Issue

Laboratory-based and office-based risk scores and charts to predict 10-year risk of cardiovascular disease in 182 countries: a pooled analysis of prospective cohorts and health surveys

Peter Ueda, PhD • Prof Mark Woodward, PhD • Yuan Lu, ScD • Kaveh Hajifathalian, MD • Rihab Al-Wotayan, MD † • Carlos A Aguilar-Salinas, PhD † • et al. Show all authors • Show footnotes

Calibration using age-specific and sex-specific incidences and risk factor values available from 21 global regions.

Calibration using age-specific and sex-specific incidences and risk factor values available for individual countries

Predictors

blood pressure, history of diabetes, and total cholesterol.

Non-laboratory model

age, smoking status, systolic blood pressure, body mass index.

Cardiovascular Risk

World Health Organisation (WHO) CVD Risk Score (2019)

- Predicts 10-yr risk of fatal and nonfatal CVD (CHD or stroke) in 40-74 year olds
- Calibrated to 21 WHO regions (e.g. Western Europe, Southern Africa)
- **Non-laboratory risk score: Age, sex, systolic blood pressure (SBP), smoking, body mass index (BMI)**
- Laboratory risk score: Age, sex, smoking, SBP, total cholesterol (TC), diabetes mellitus (DM)

GAM

Age and sex-specific trends in CVD risk and risk factors between 1998 and 2017

Adjusted CVD risk trends

Censored GAMLSS

Observed and counterfactual BP & cholesterol distributions over time

MLM

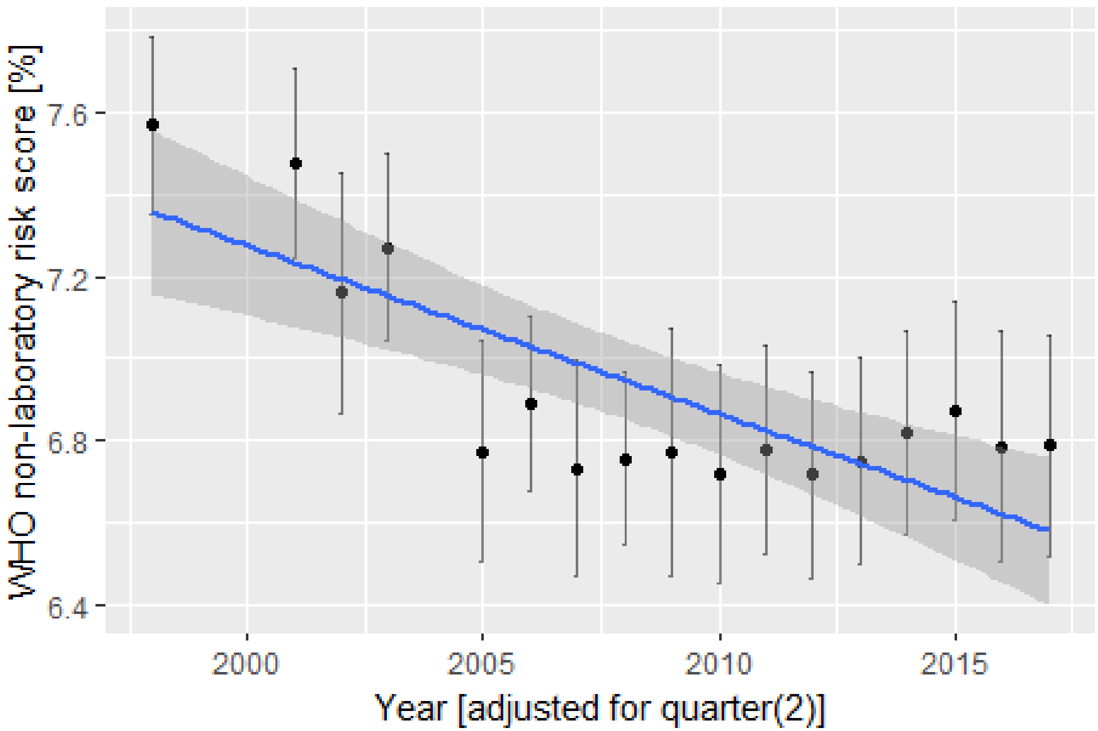
Variance Decomposition

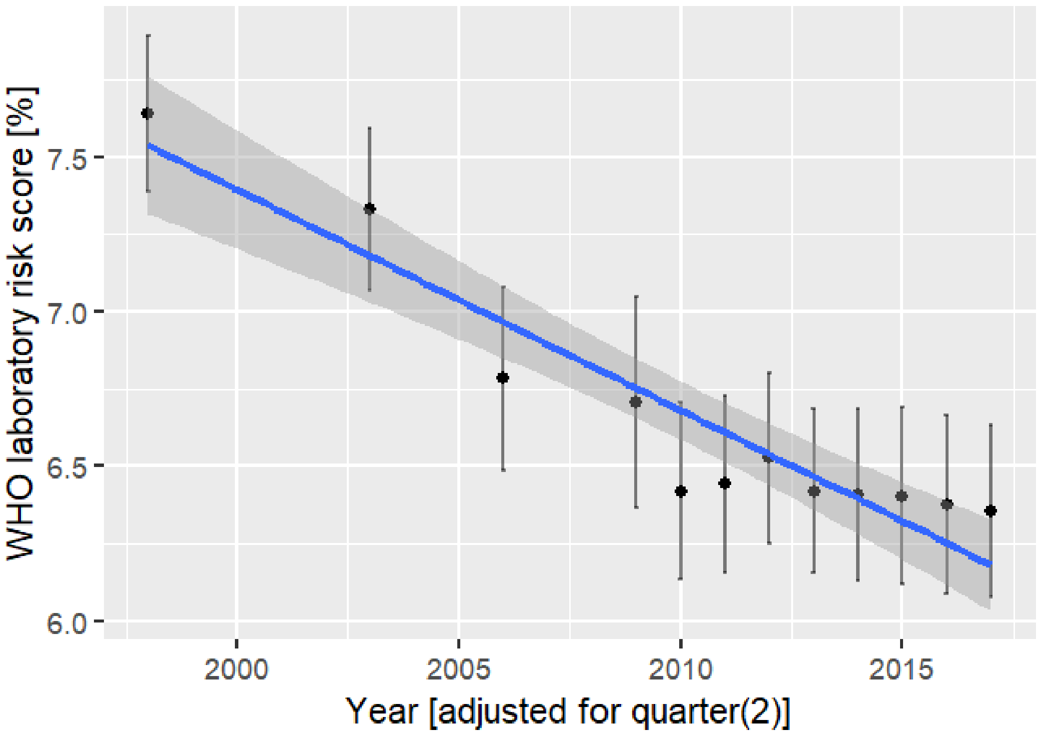
Linear models used for simplicity

Adjustment for seasonality

Adjustment of standard errors for survey design

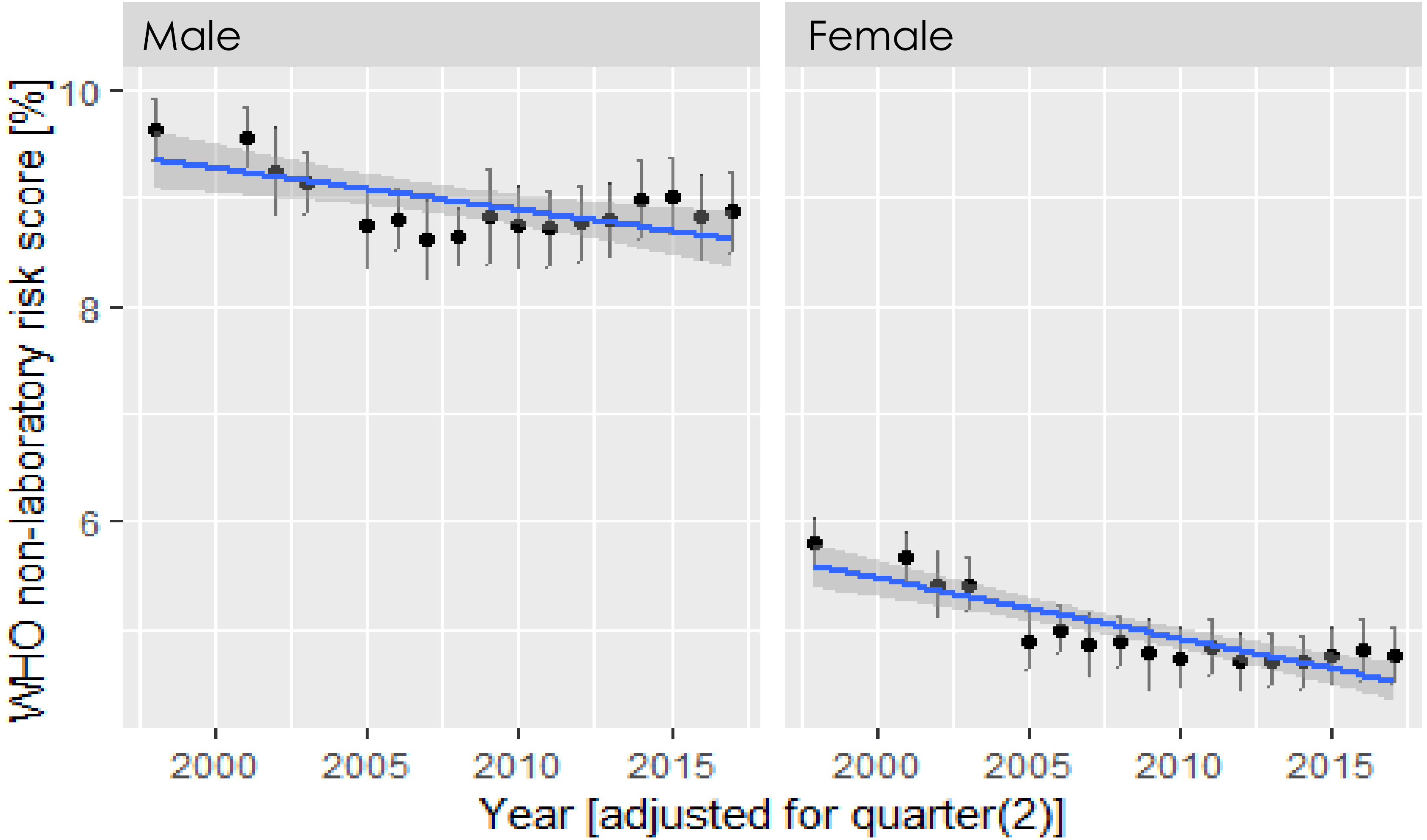
2. CVD risk score trends in England

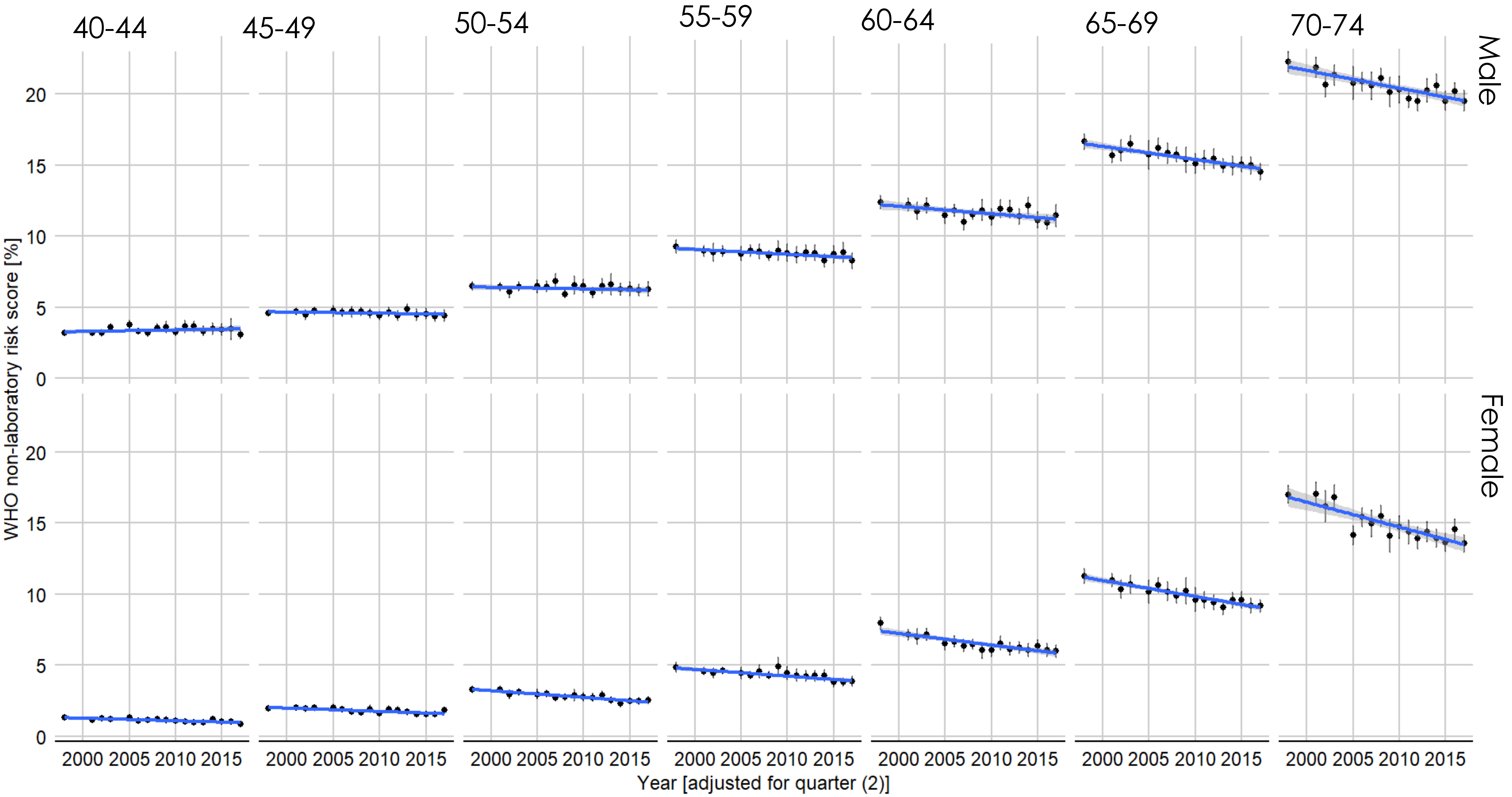




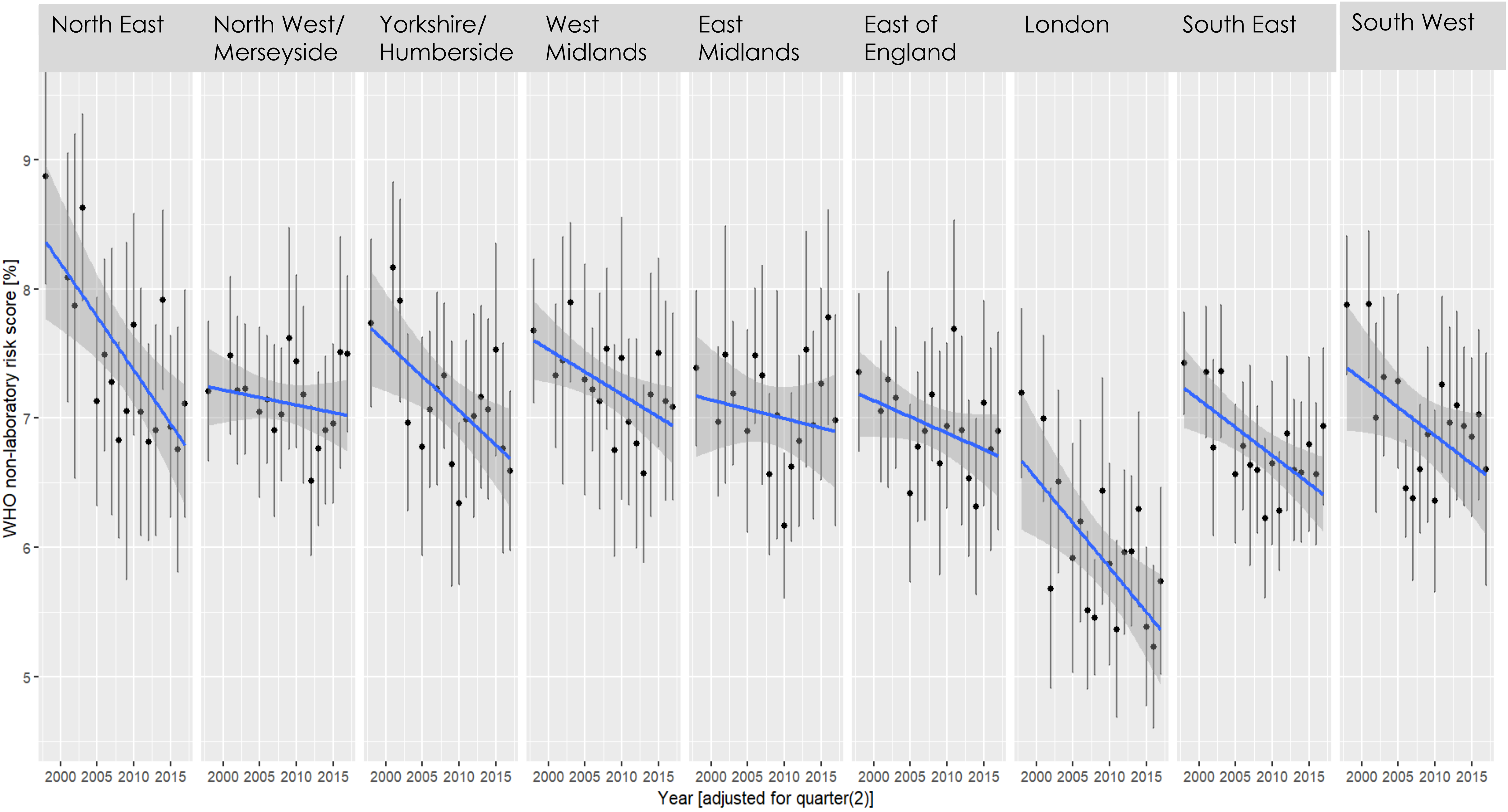
England total population age 40-74

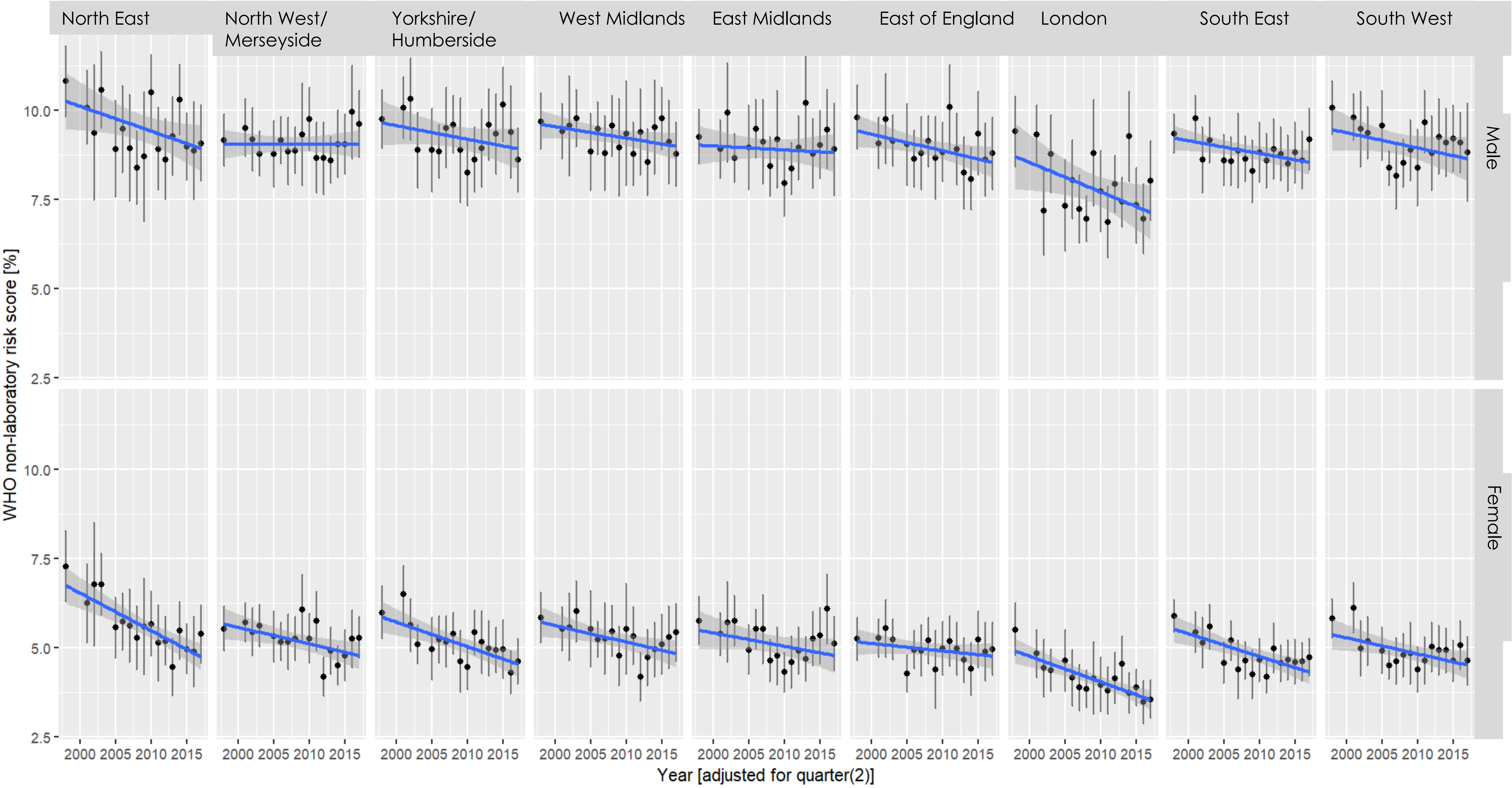
Trends in CVD risk, total population aged 40-74 years by sex



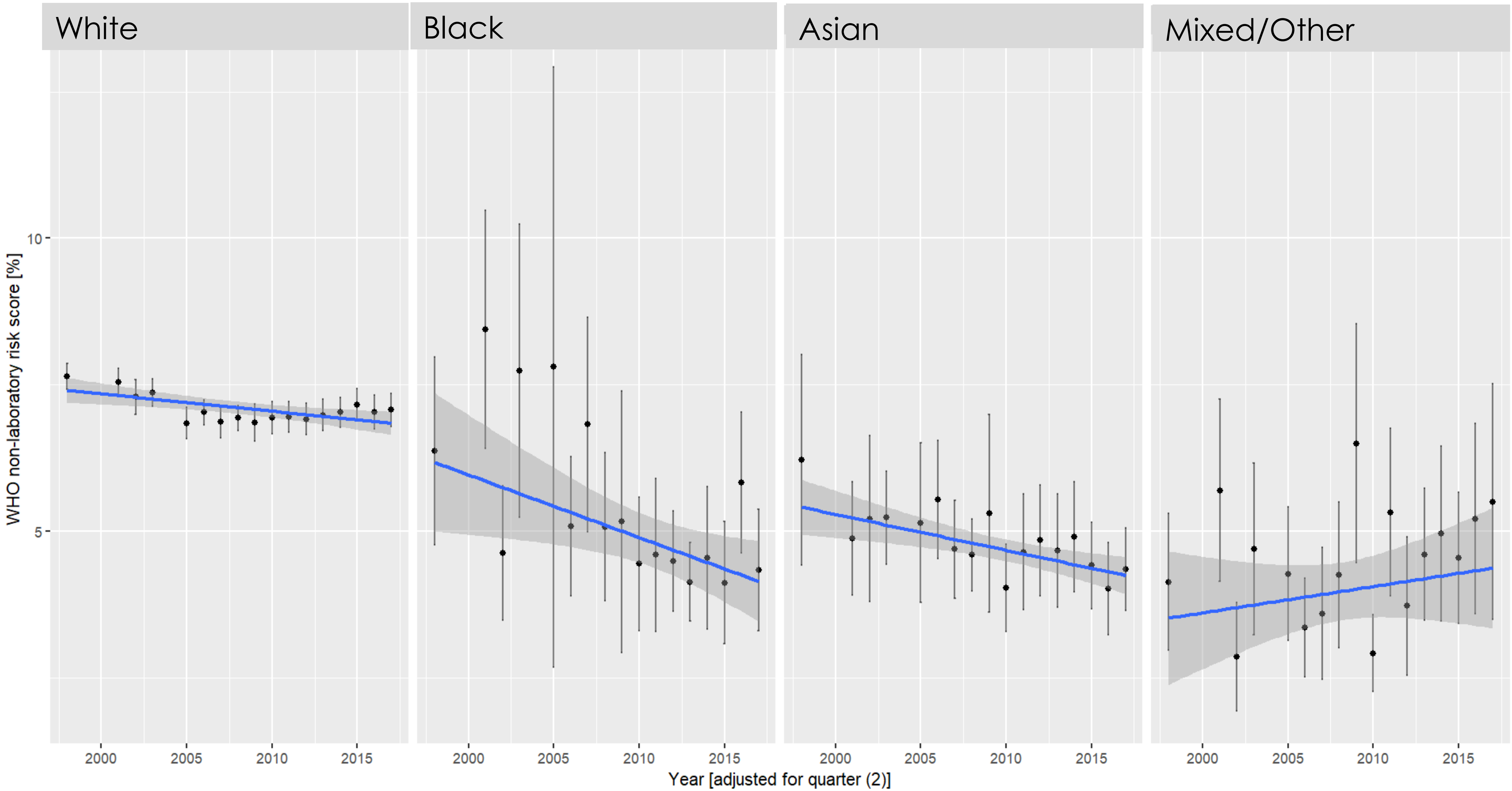

40-44
45-49
50-54
55-59
60-64
65-69
70-74
Male
Female
WHO non-laboratory risk score [%]
0
5
10
15
20
2000 2005 2010 2015
Year [adjusted for quarter (2)]

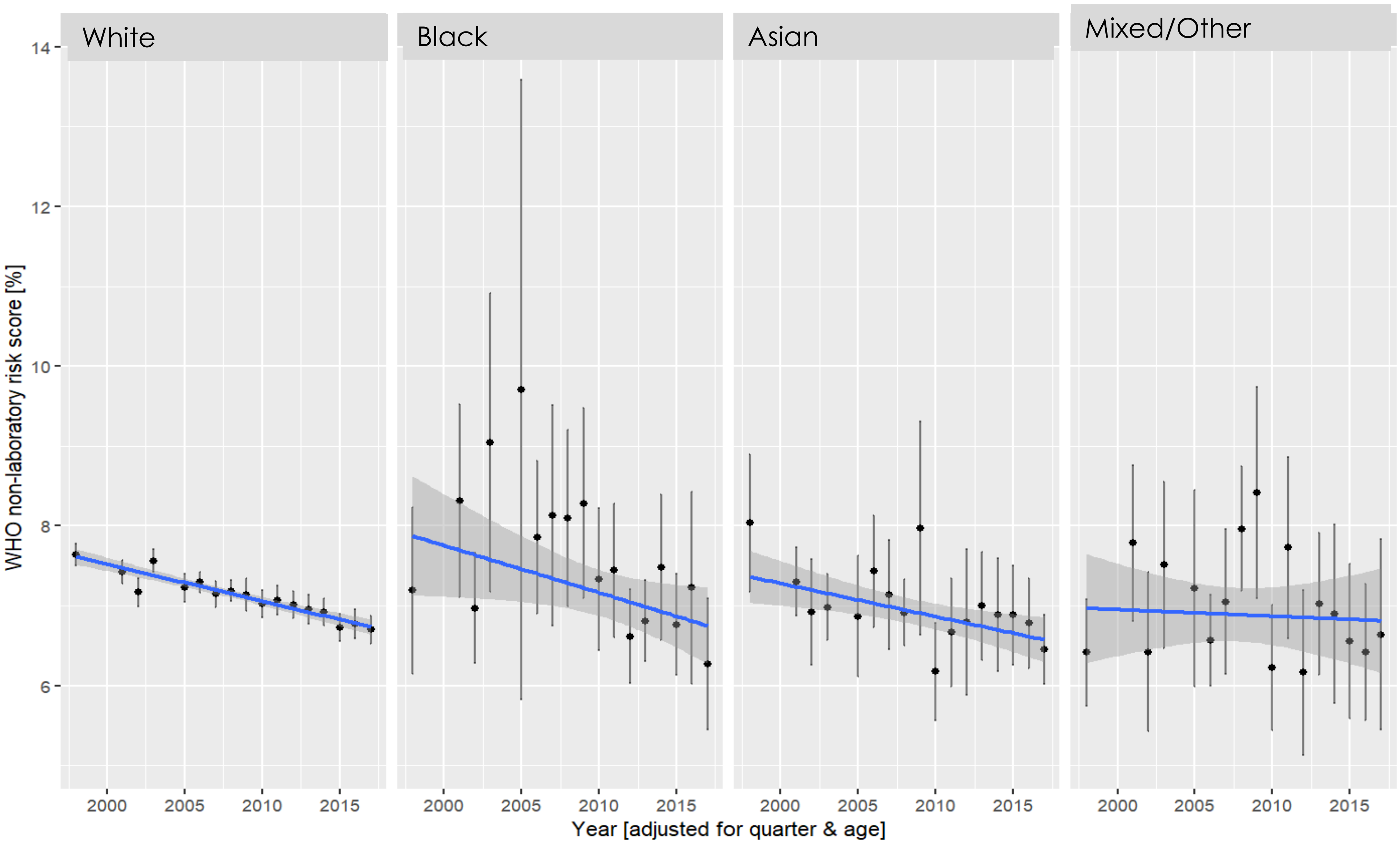
Inequalities


North East
North West/ Merseyside
Yorkshire/ Humberside
West Midlands
East Midlands
East of England
London
South East
South West
WHO non-laboratory risk score [%]
9
8
7
6
5
2000 2005 2010 2015
Year [adjusted for quarter(2)]


North East
North West/ Merseyside
Yorkshire/ Humberside
West Midlands
East Midlands
East of England
London
South East
South West
Male
Female
WHO non-laboratory risk score [%]
2.5
5.0
7.5
10.0
2000 2005 2010 2015
Year [adjusted for quarter(2)]

Ethnicity

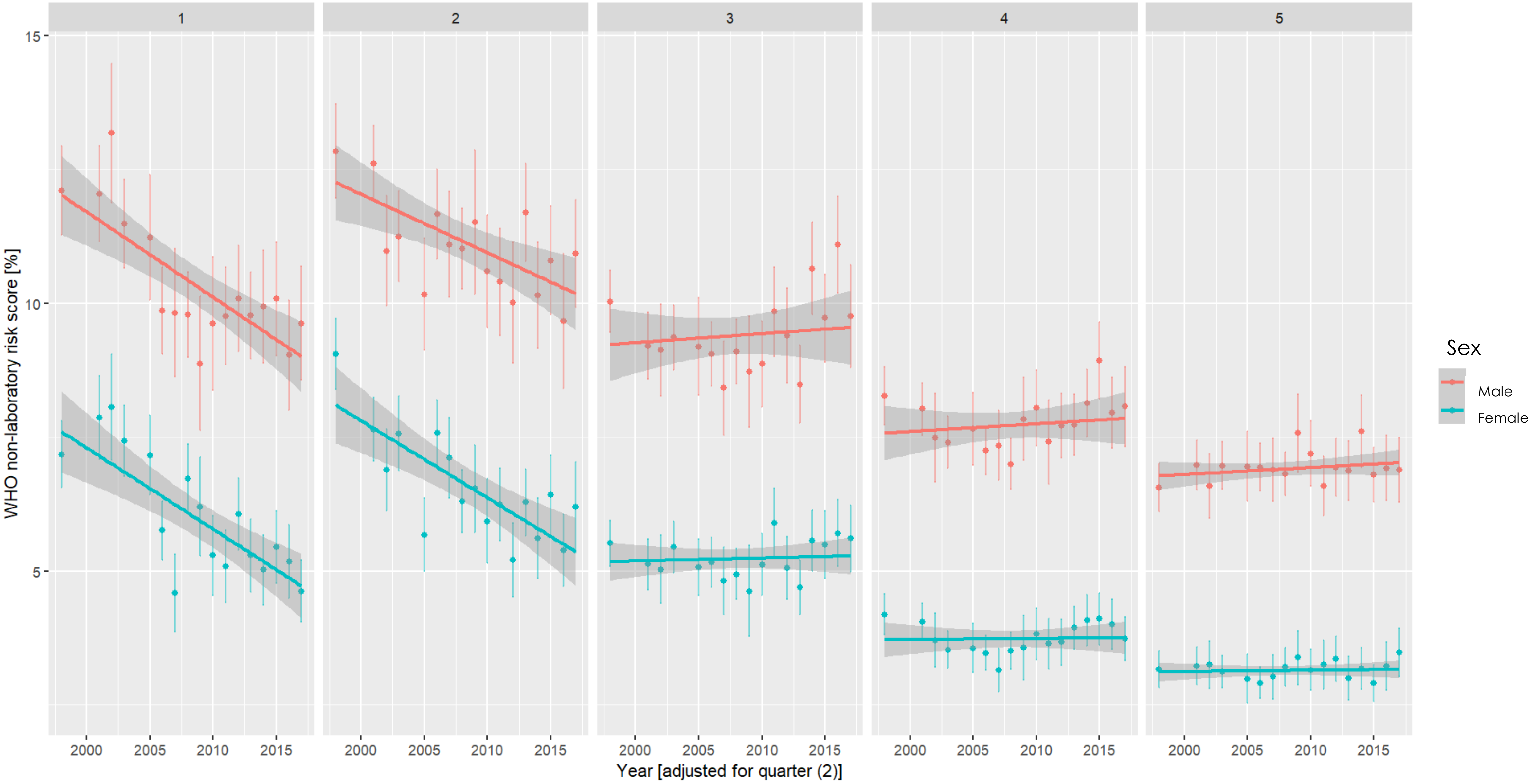

White
Black
Asian
Mixed/Other
WHO non-laboratory risk score [%]
10
5
2000
2005
2010
2015
Year [adjusted for quarter (2)]



Trends estimated at mean 1998 age of 55.

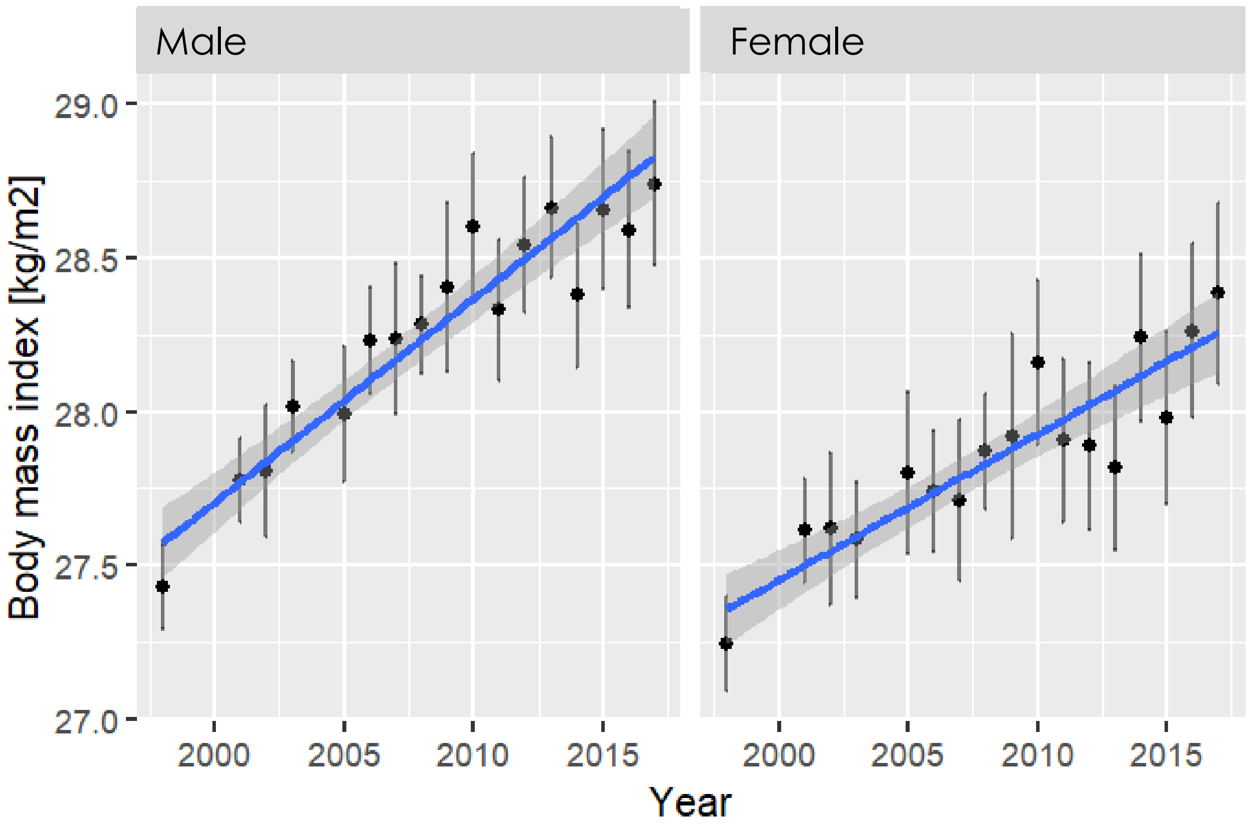
Adjusting for age, non-white groups have higher risk.

Household income quintile, sex stratified

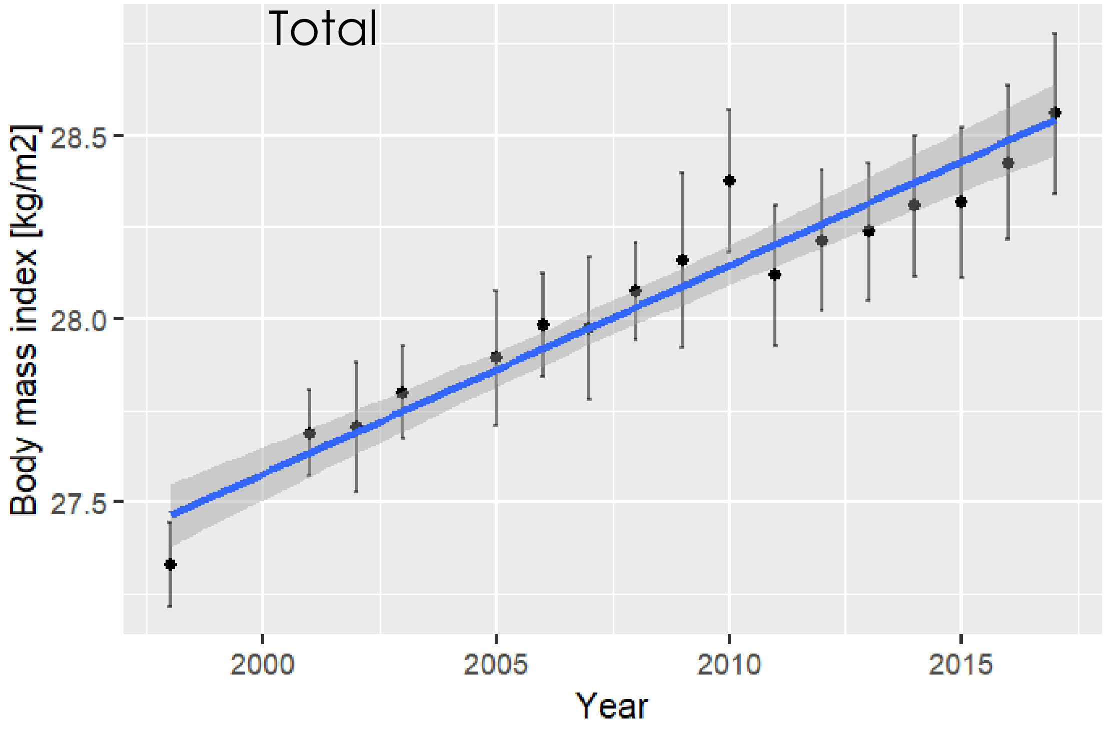


Trends in risk score components

BMI Trends

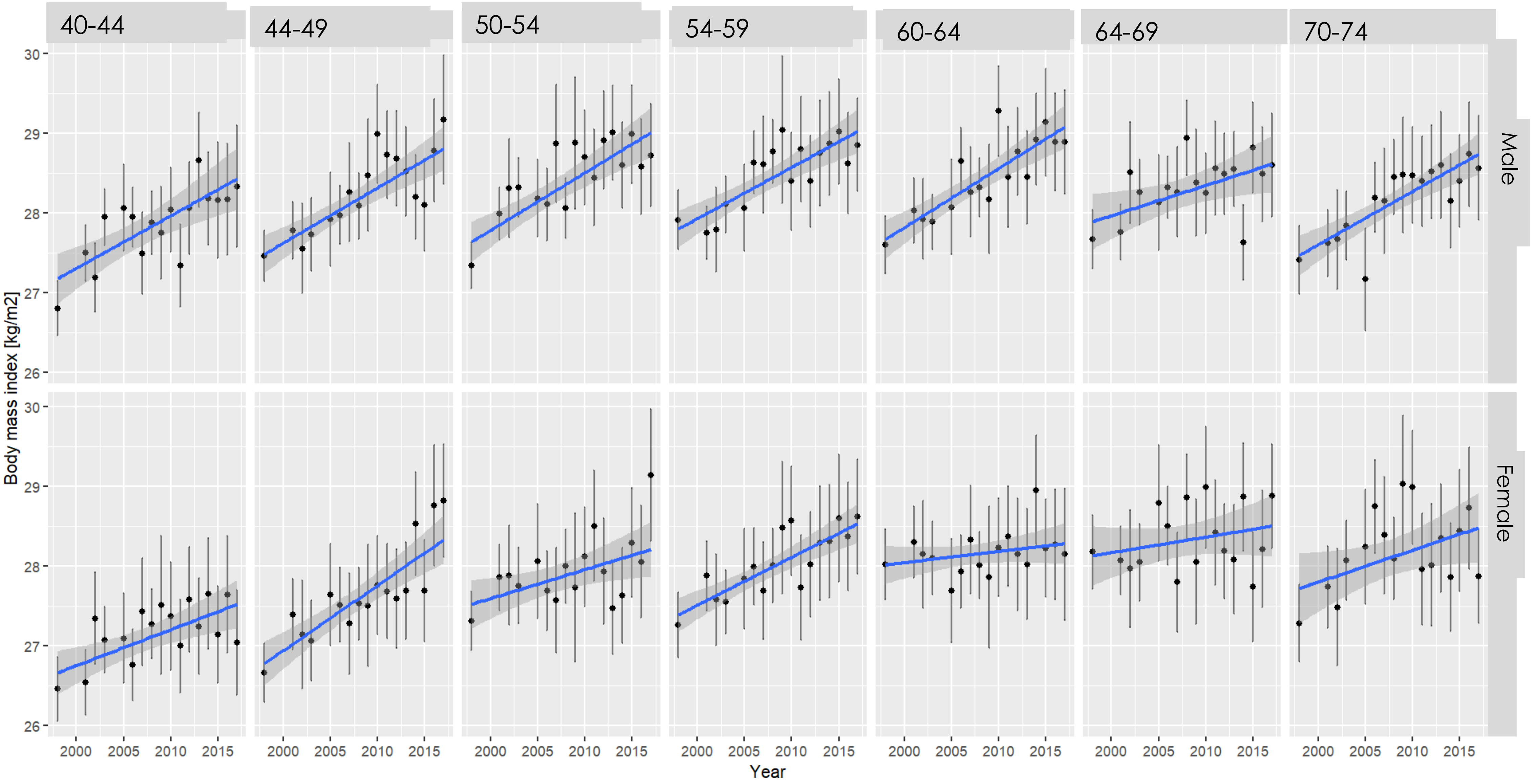


Male
Female
Body mass index [kg/m2]
29.0
28.5
28.0
27.5
27.0
2000
2005
2010
2015
Year

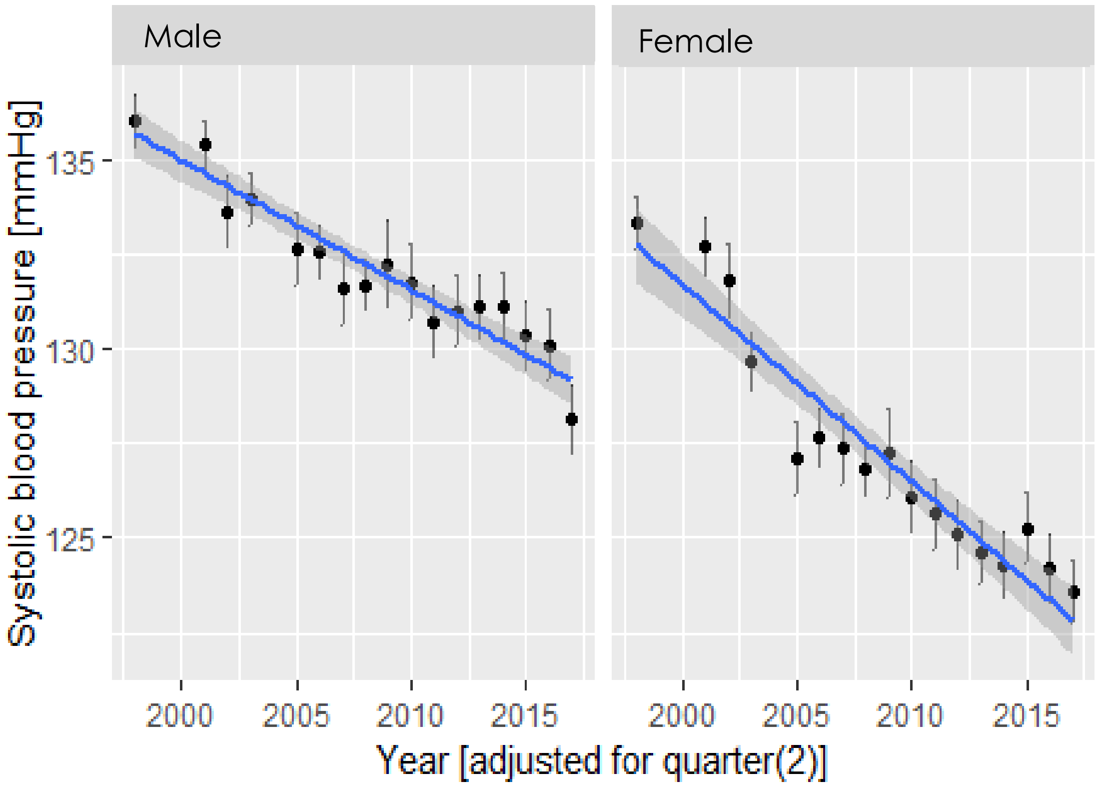


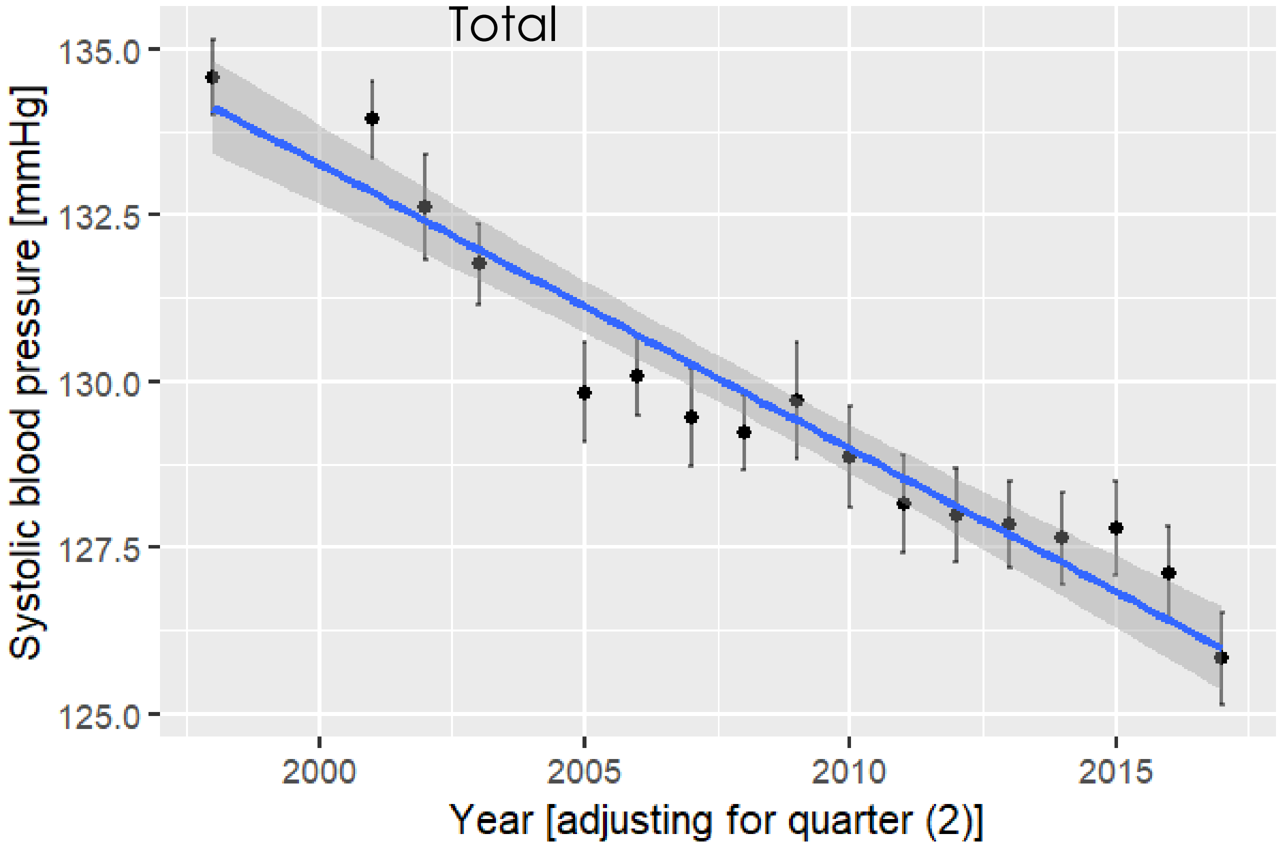
Total
Body mass index [kg/m2]
28.5
28.0
27.5
2000
2005
2010
2015
Year

BMI by age category and sex



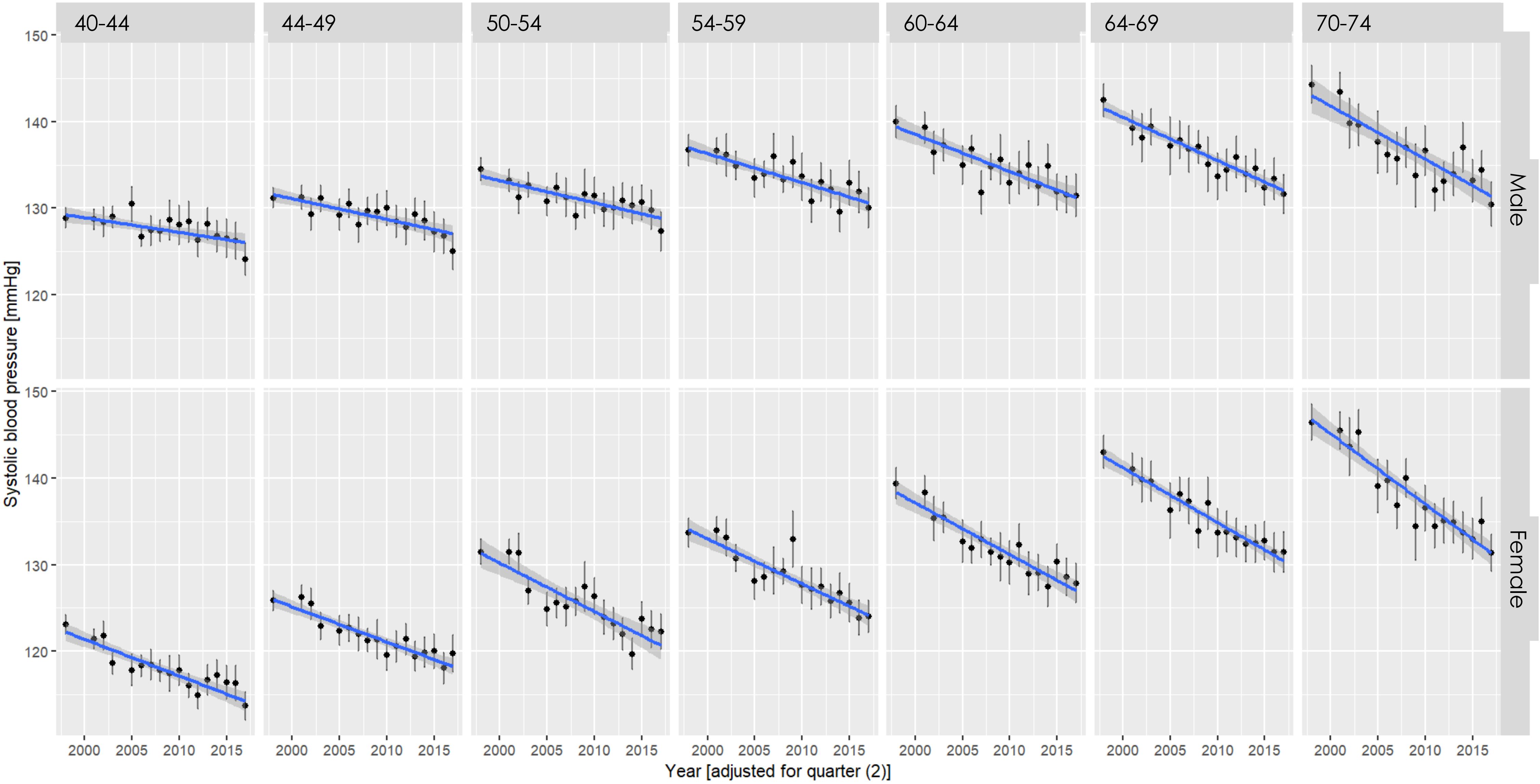
SBP Trends

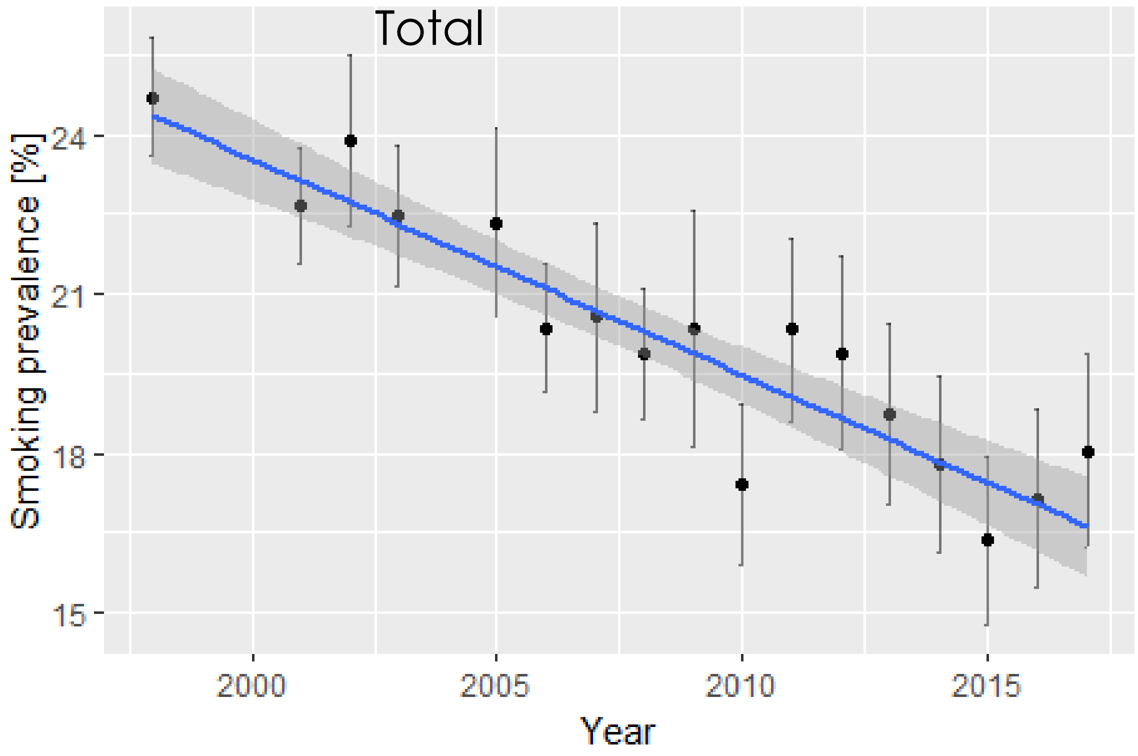


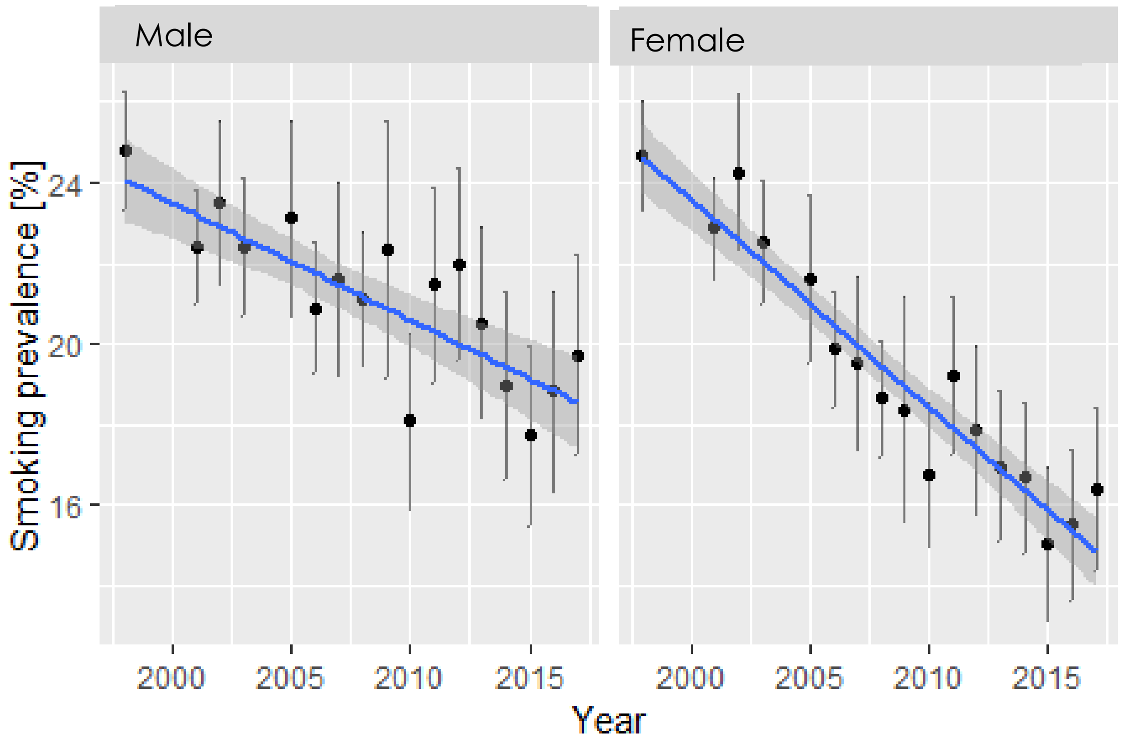


Population aged 40-74 years

SBP by age category and sex

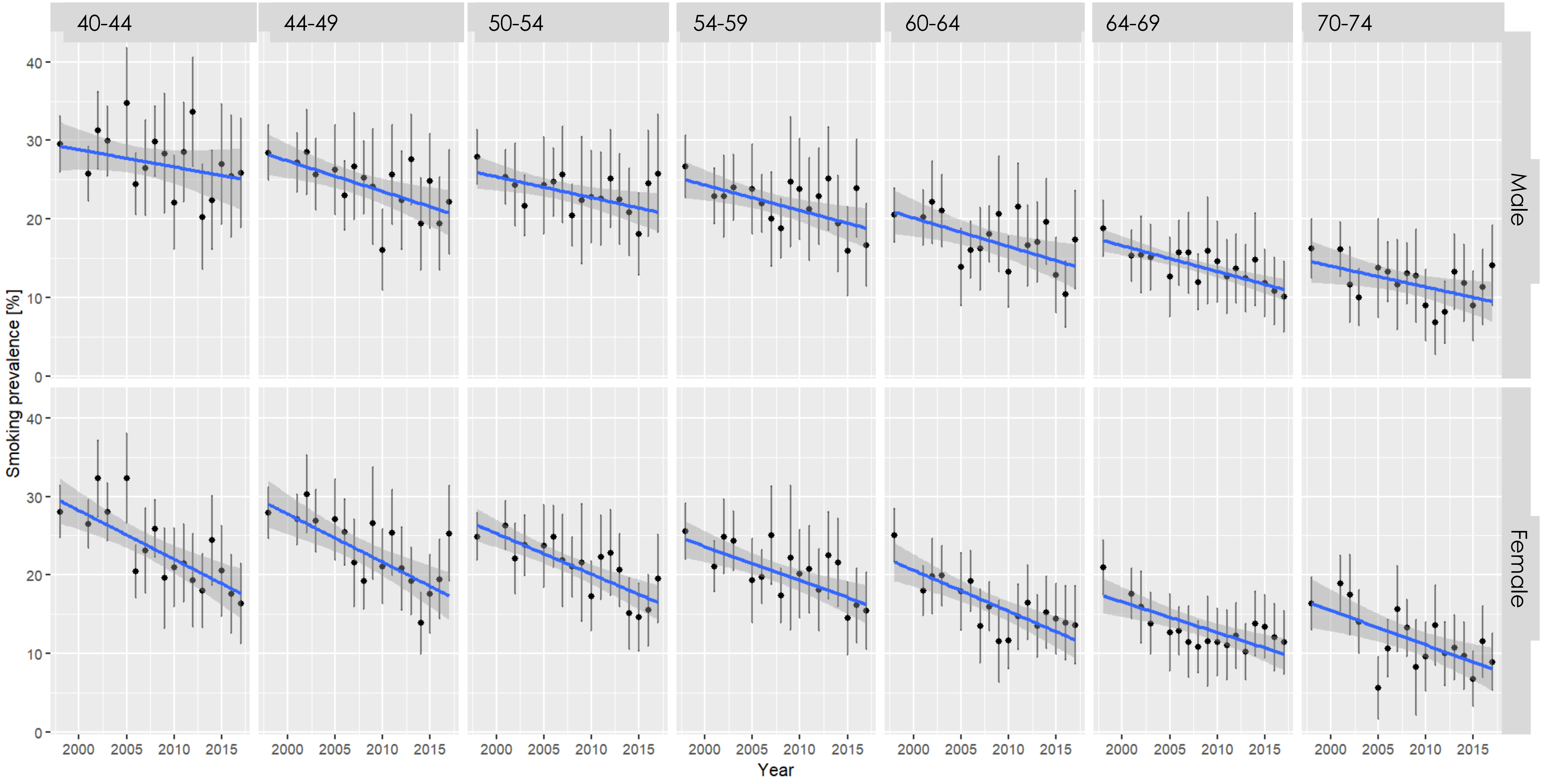


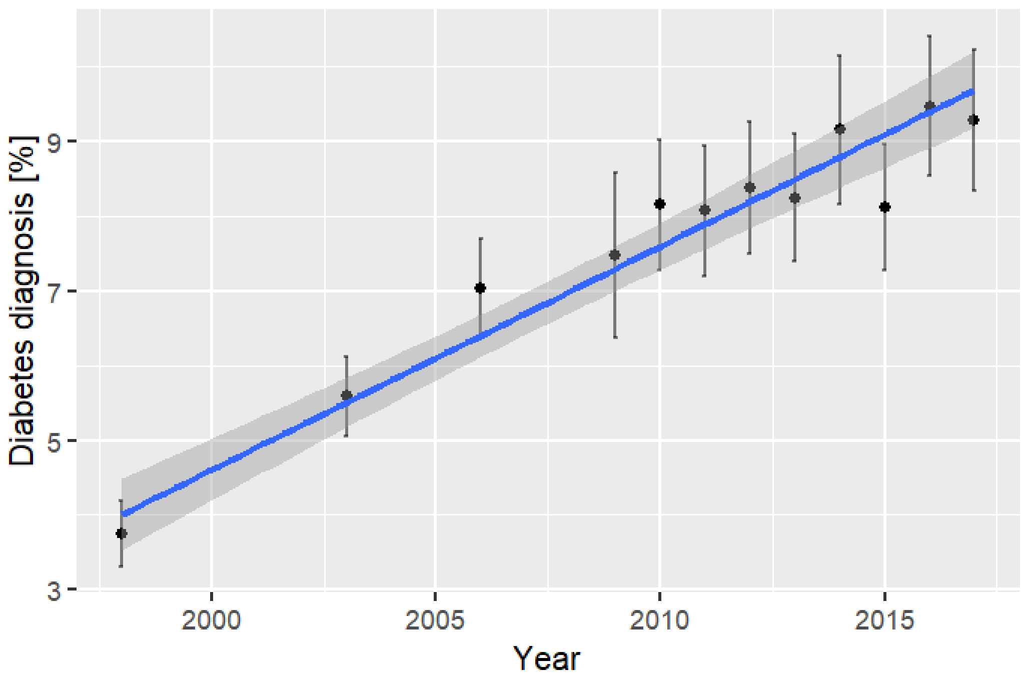

Total
Smoking prevalence [%]
24
21
18
15
2000
2005
2010
2015
Year

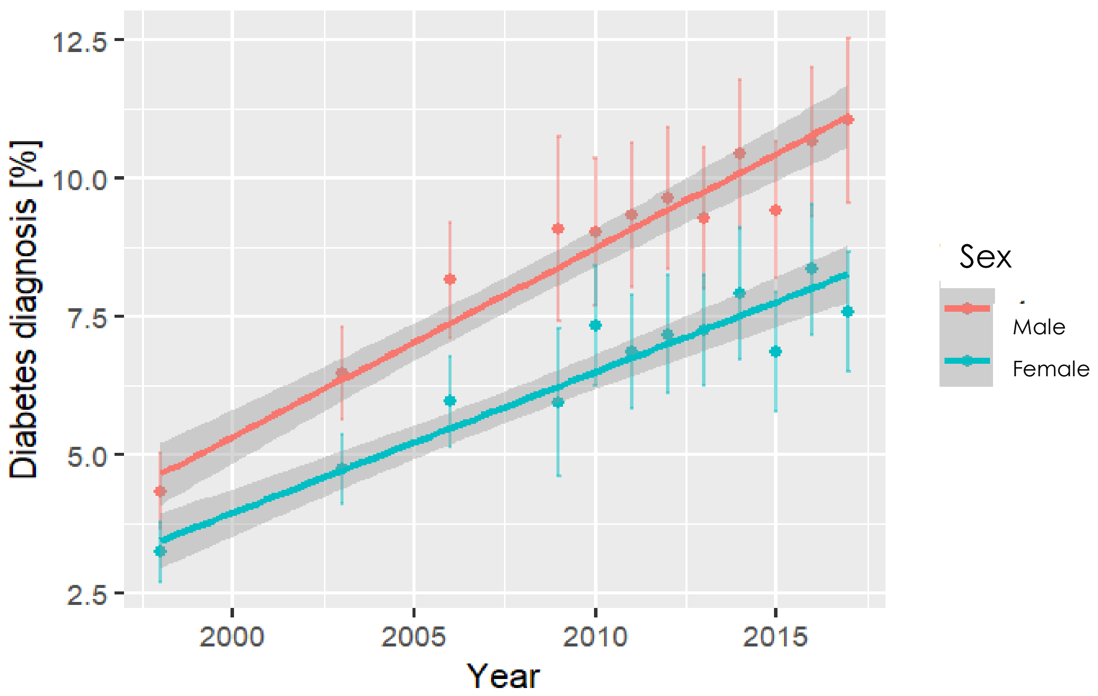

Male
Female
Smoking prevalence [%]
24
20
16
2000
2005
2010
2015
Year

Smoking

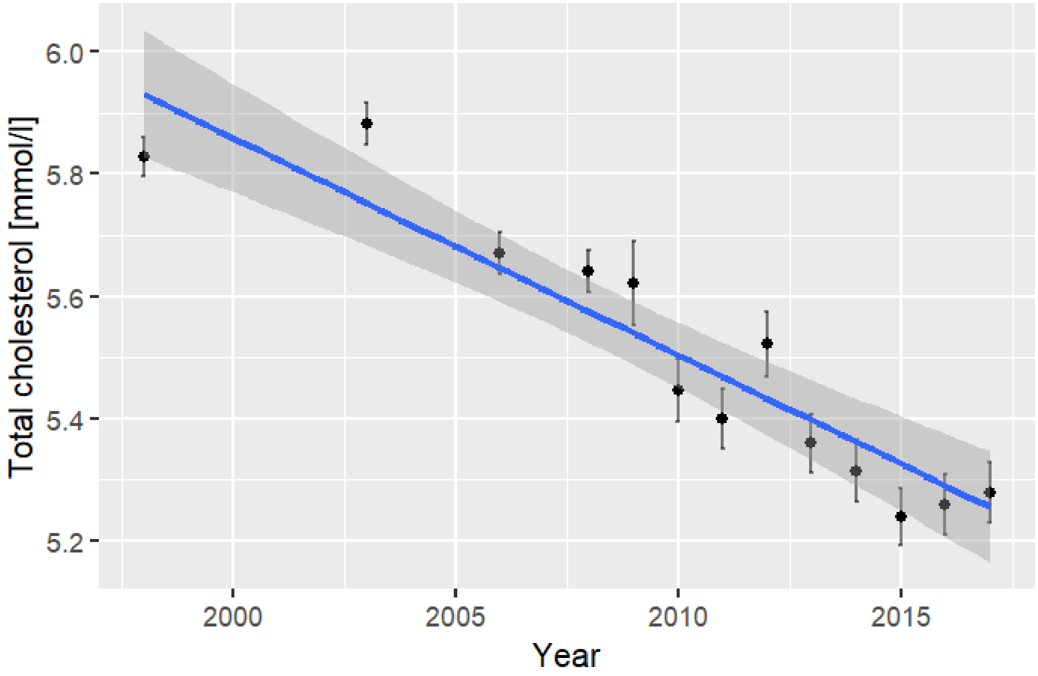
Smoking by age category and sex

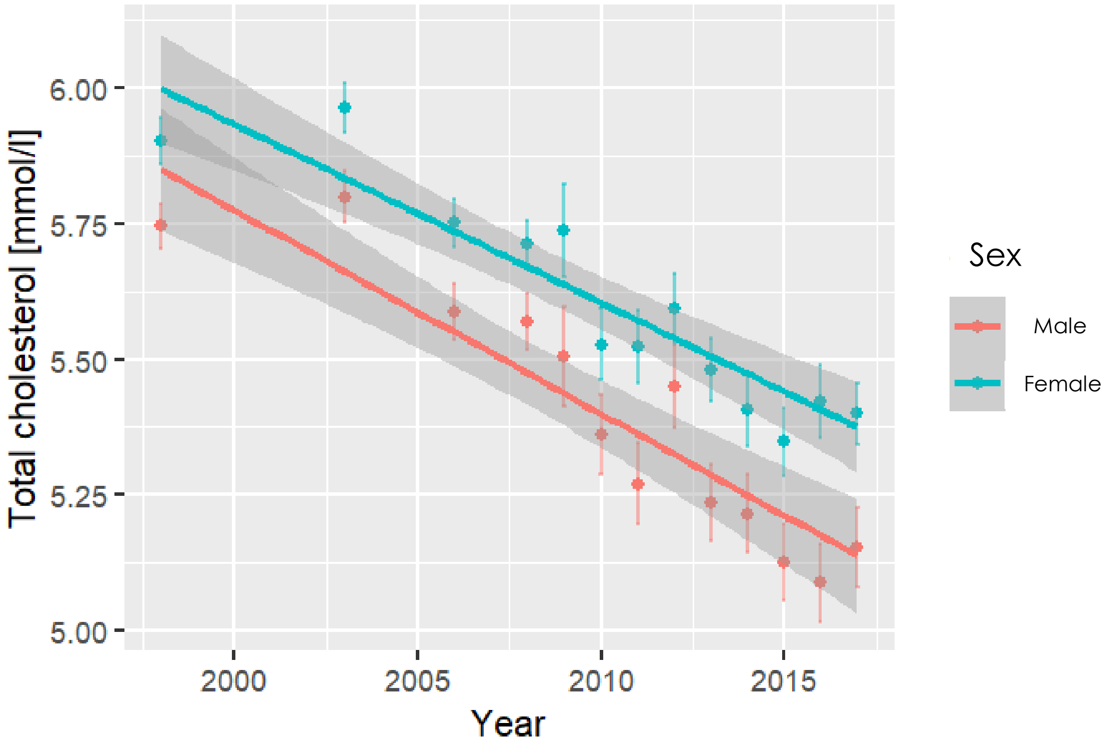






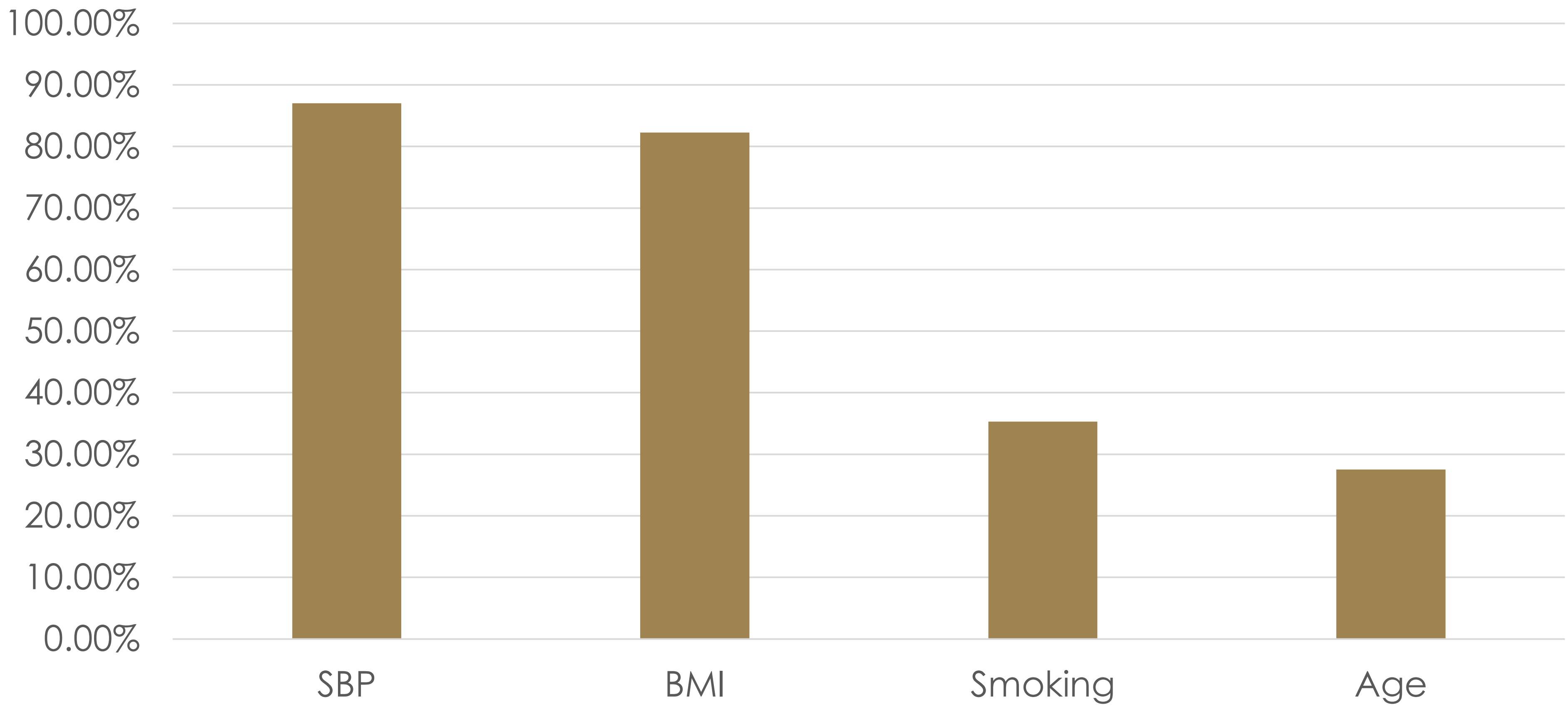
Diabetes diagnosis



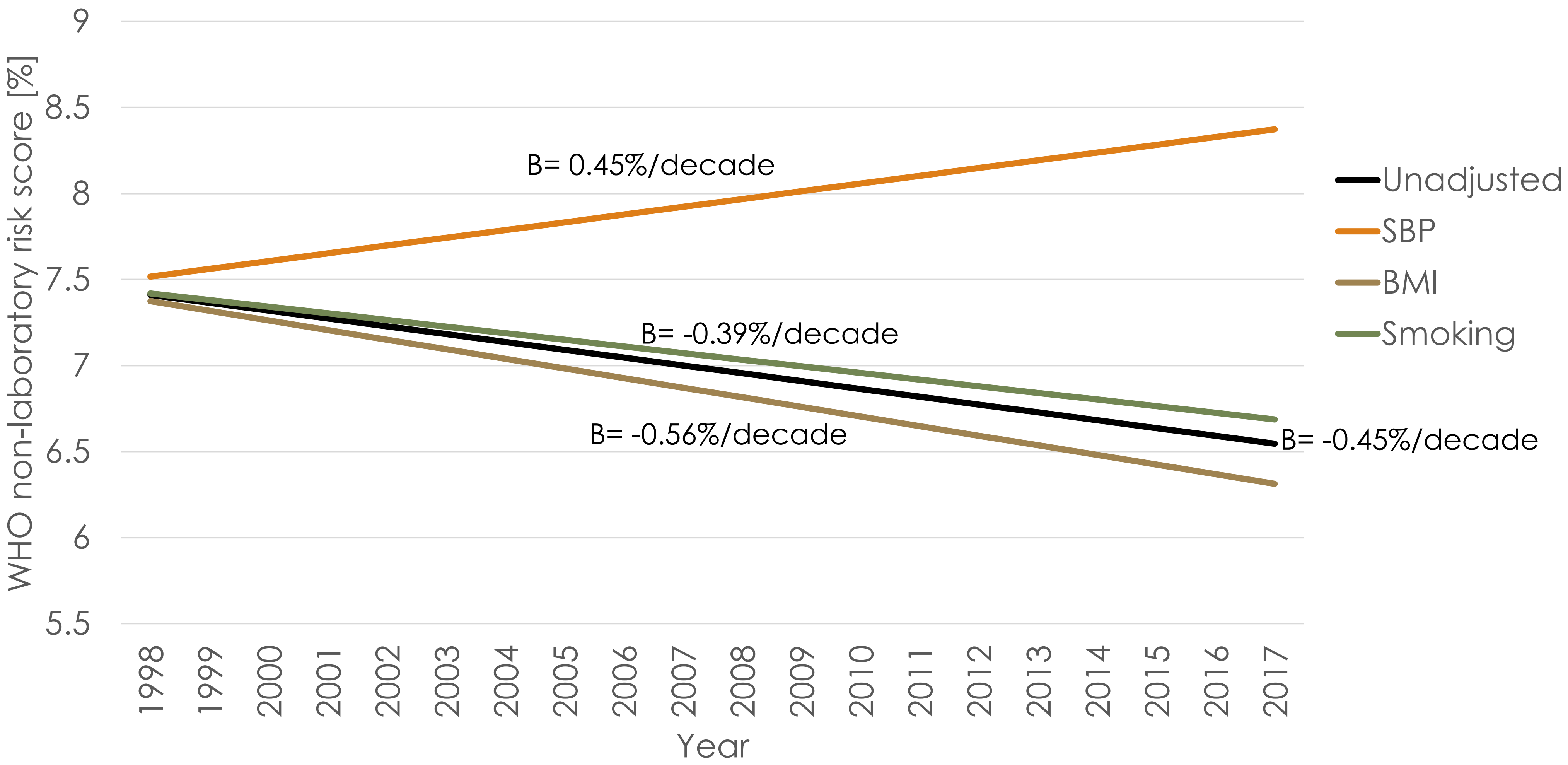


Total cholesterol

Explaining variation in risk over time

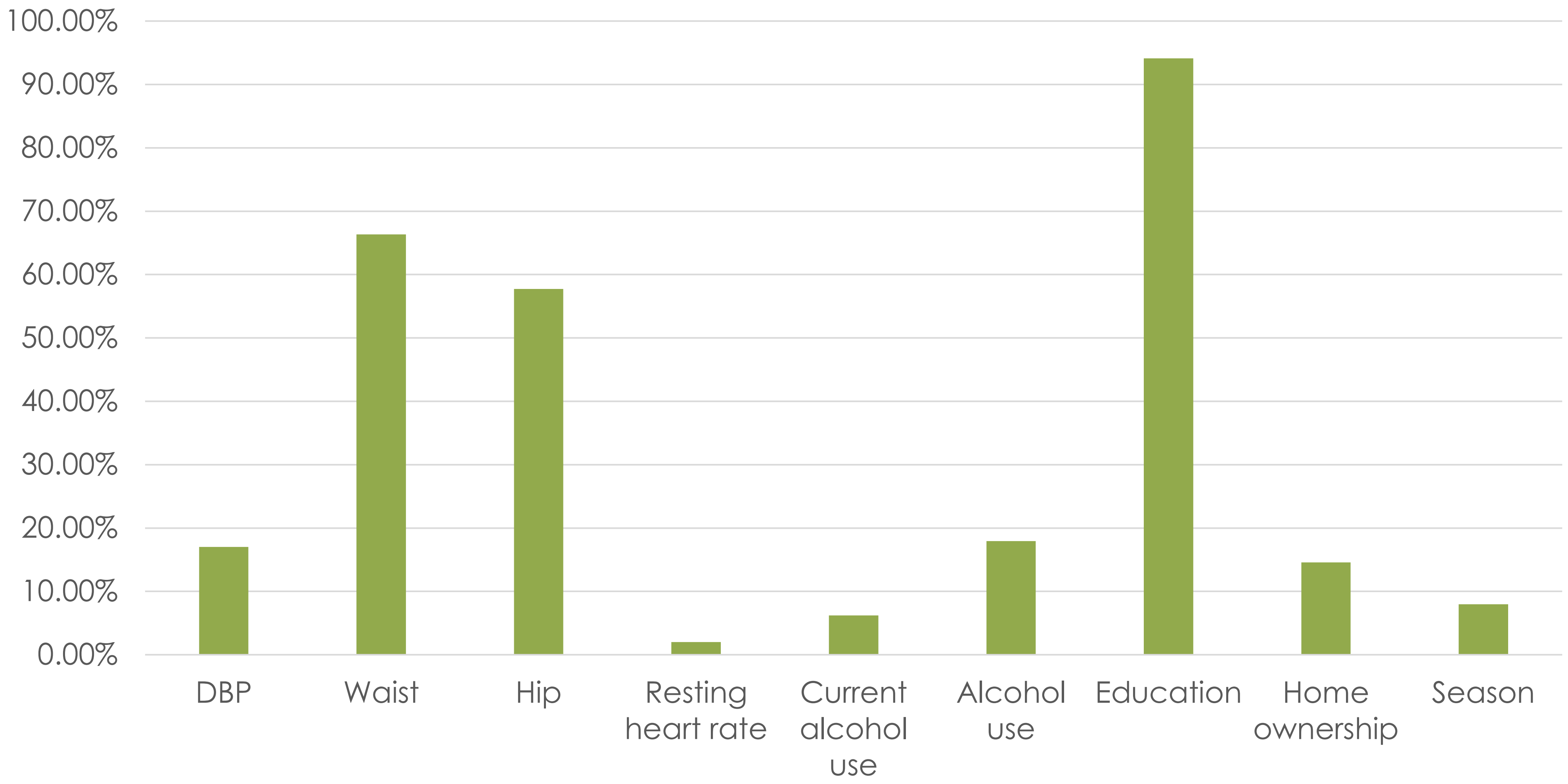


Exploratory analysis of year variation in WHO non-laboratory CVD risk score explained by risk score components, England population aged 40-74 years

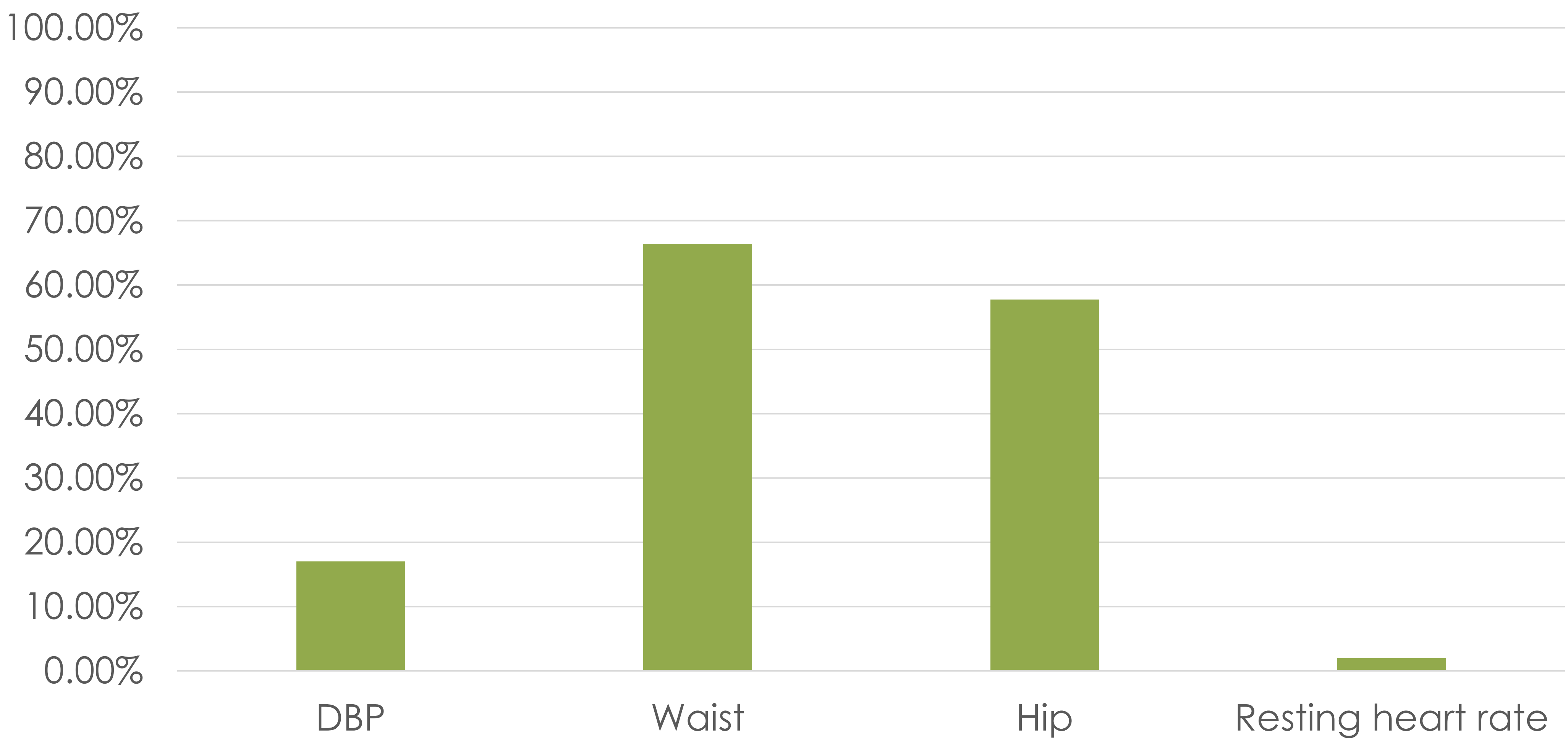


Estimated trends in CVD Risk. England population 40-74 years, 1998-2017. Adjusted for risk score components.

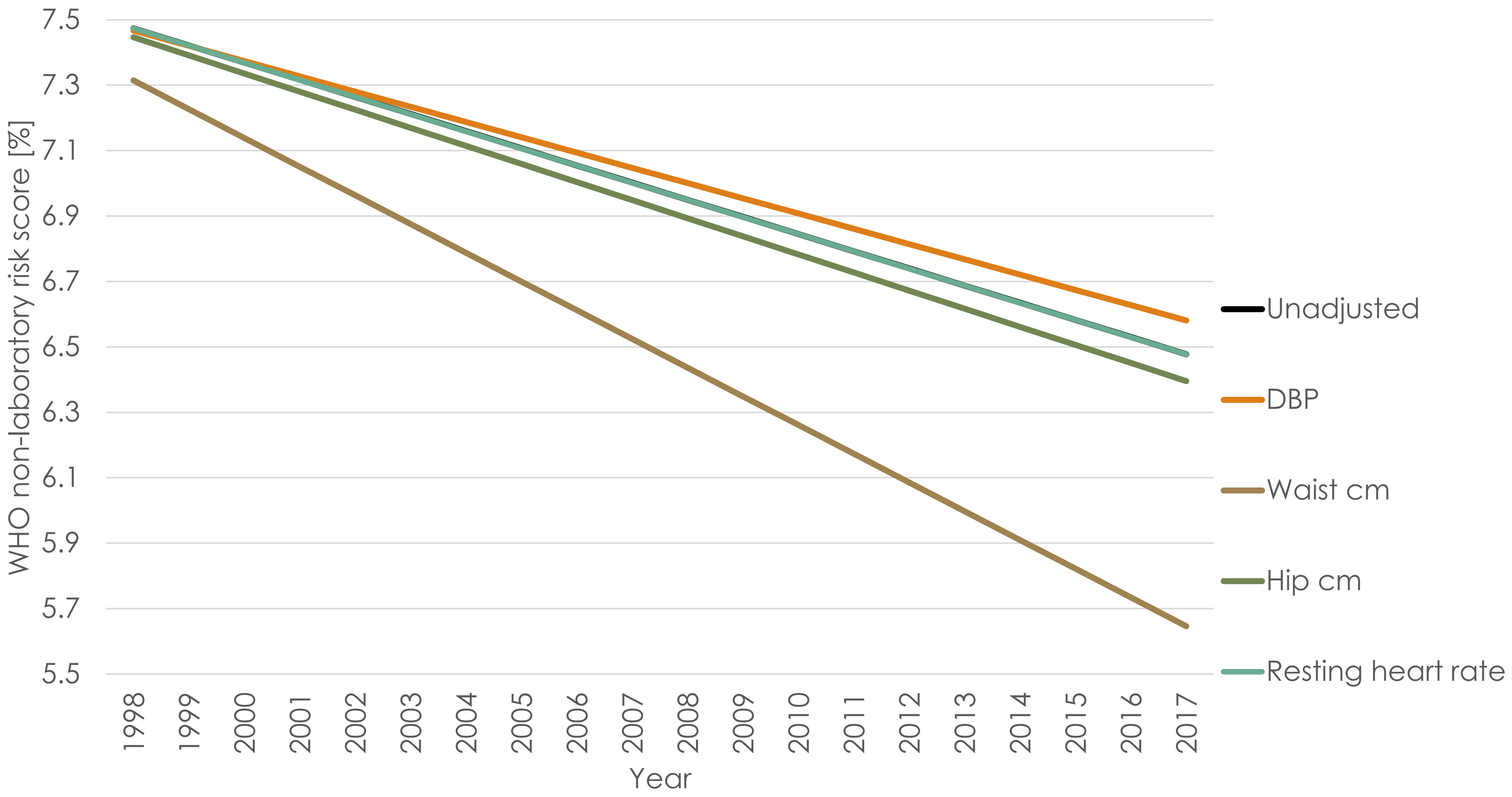
All slopes were statistically different from zero at the p<0.001 level.



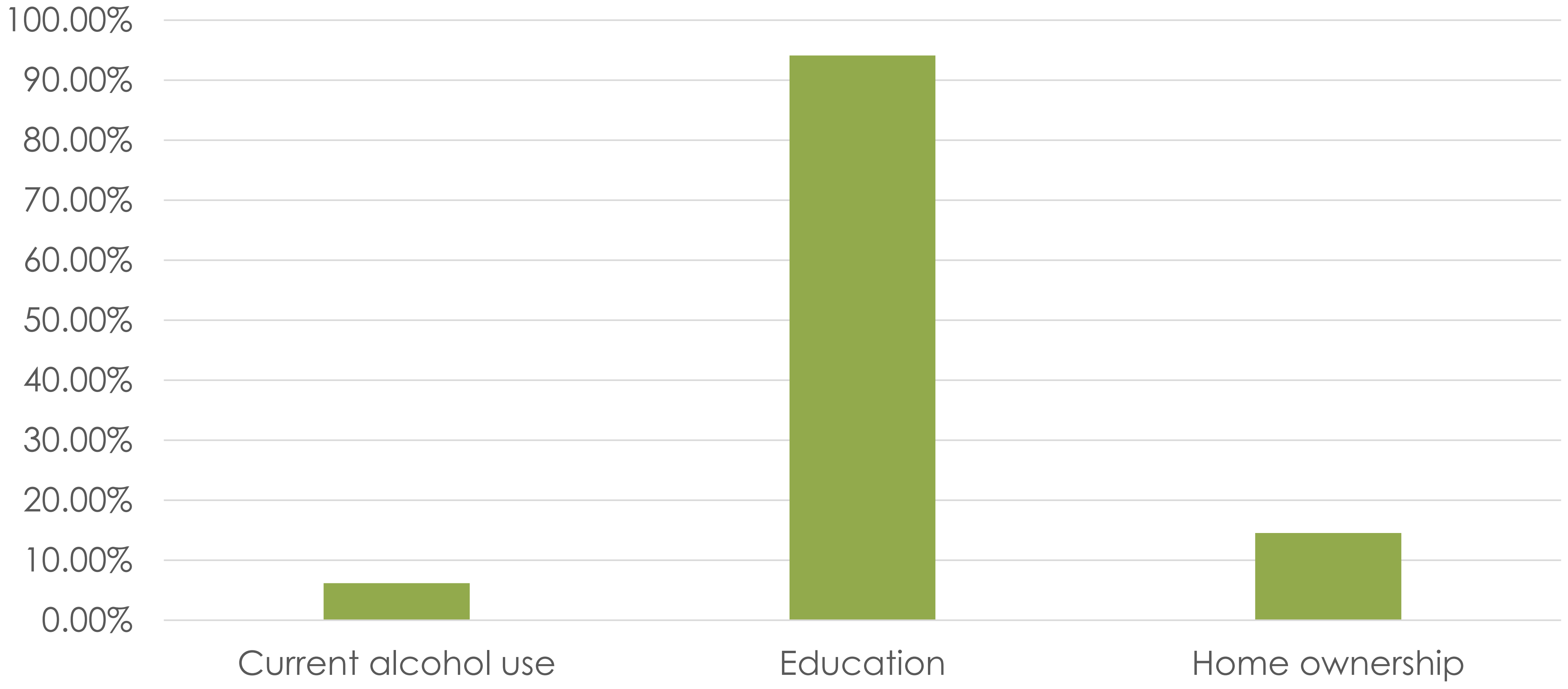
Exploratory analysis of year variation in WHO non-laboratory CVD risk score explained by other risk factors and explanatory variables, England population aged 40-74 years



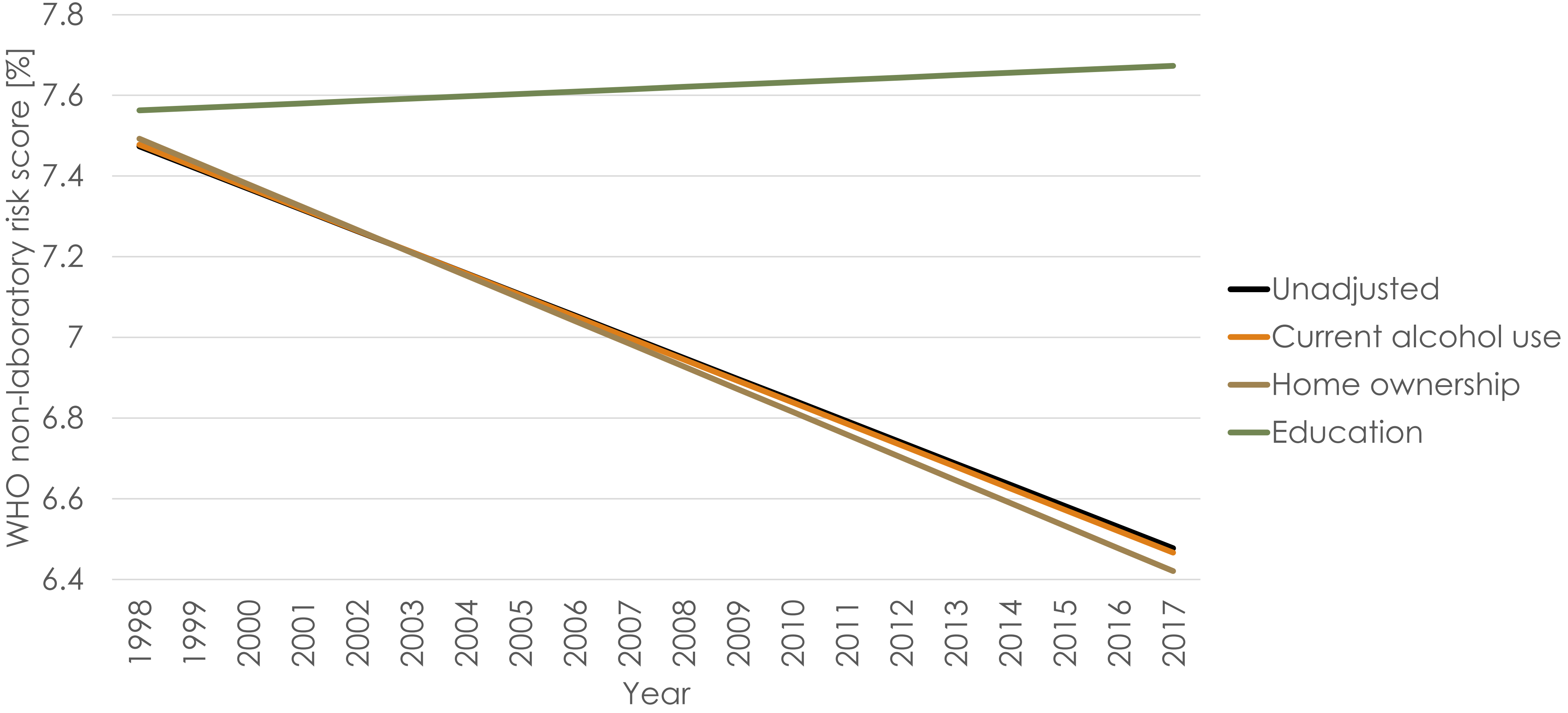
Exploratory analysis of year variation in WHO non-laboratory CVD risk score explained by biological and metabolic factors, England population aged 40-74 years



Estimated trends in CVD Risk. England population 40-74 years, 1998-2017. Adjusted for selected biological and metabolic factors.



Exploratory analysis of year variation in WHO non-laboratory CVD risk score explained by select behavioural and socioeconomic factors, England population aged 40-74 years



Estimated trends in CVD Risk. England population 40-74 years, 1998-2017.
Adjusted for selected behavioural and socioeconomic factors.

3. Comparison with South Africa & next steps

Methods

Cleaning

Uniform recording

Calibration

Geography

Wealth Index

Excluded records with missing data on basic demographic and location

Age Range: 25+

Multiple imputation

Age groups

Categorical variables

Unit of measurement

Calibration to consistent demographic series

mdb municipal demarcation board

IPUMS DHS

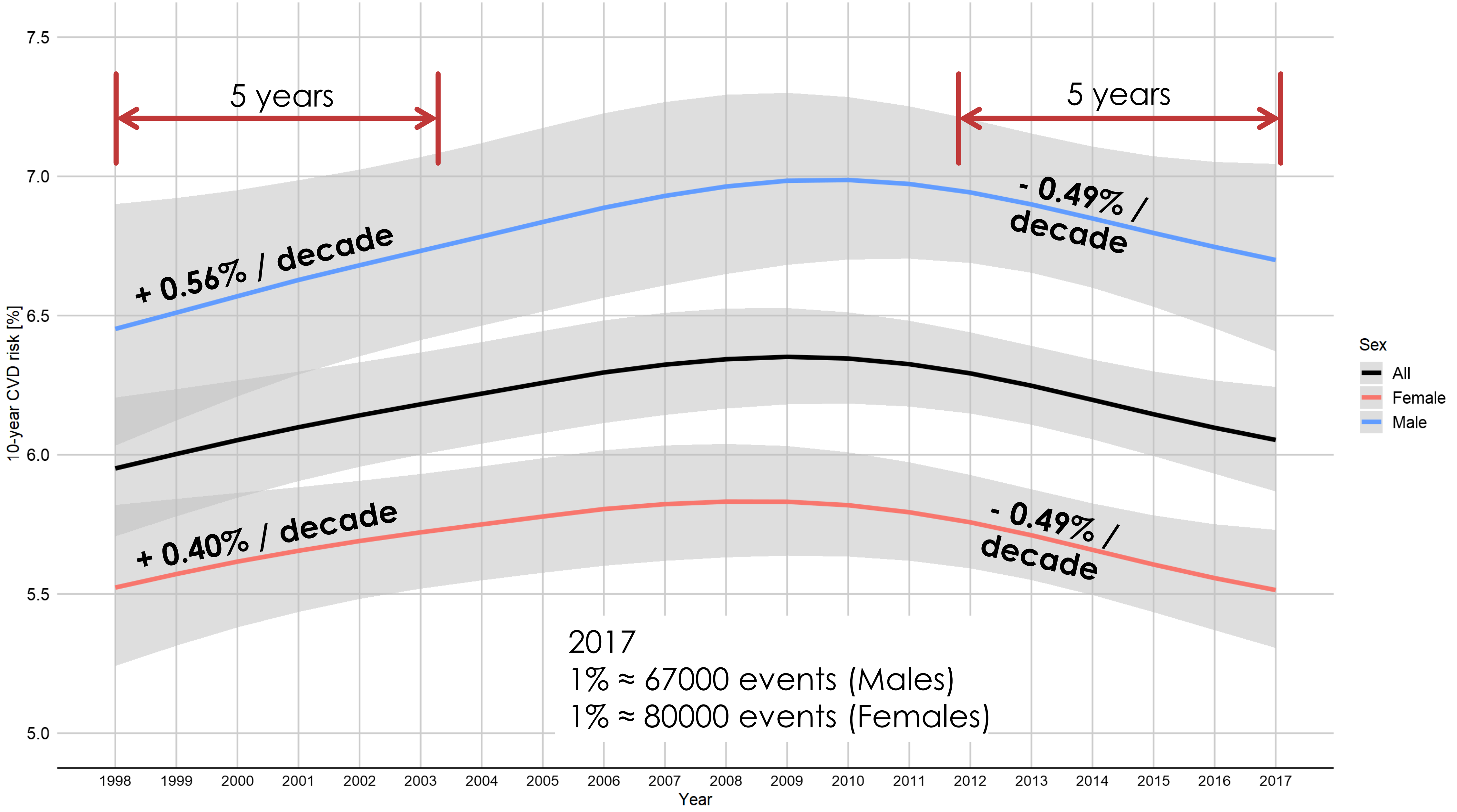
Statistics South Africa
Preferred supplier of quality statistics

USAID

MAKING THE DEMOGRAPHIC AND HEALTH SURVEYS WEALTH INDEX COMPARABLE

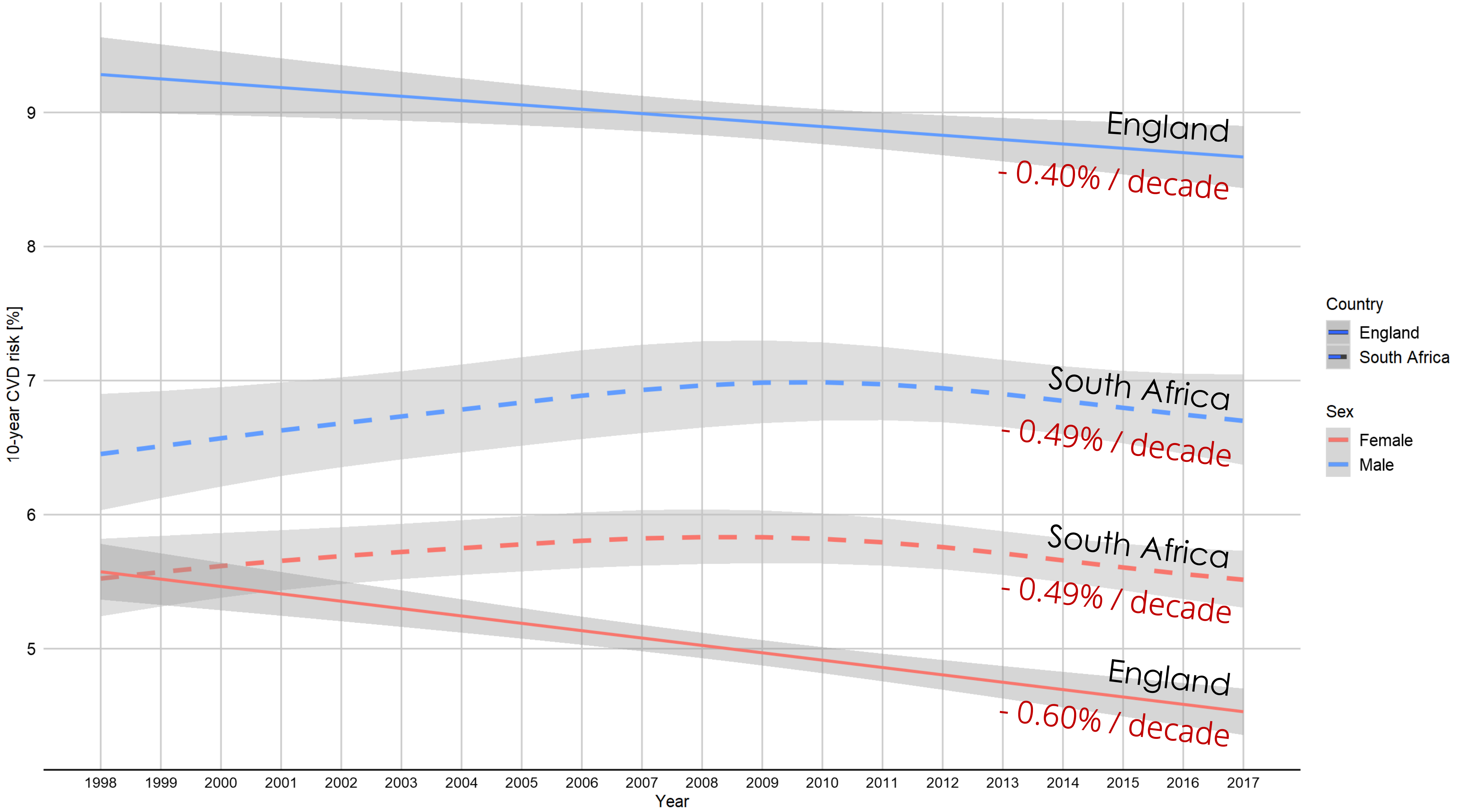
DHS METHODOLOGICAL REPORTS 9

Risk score trends



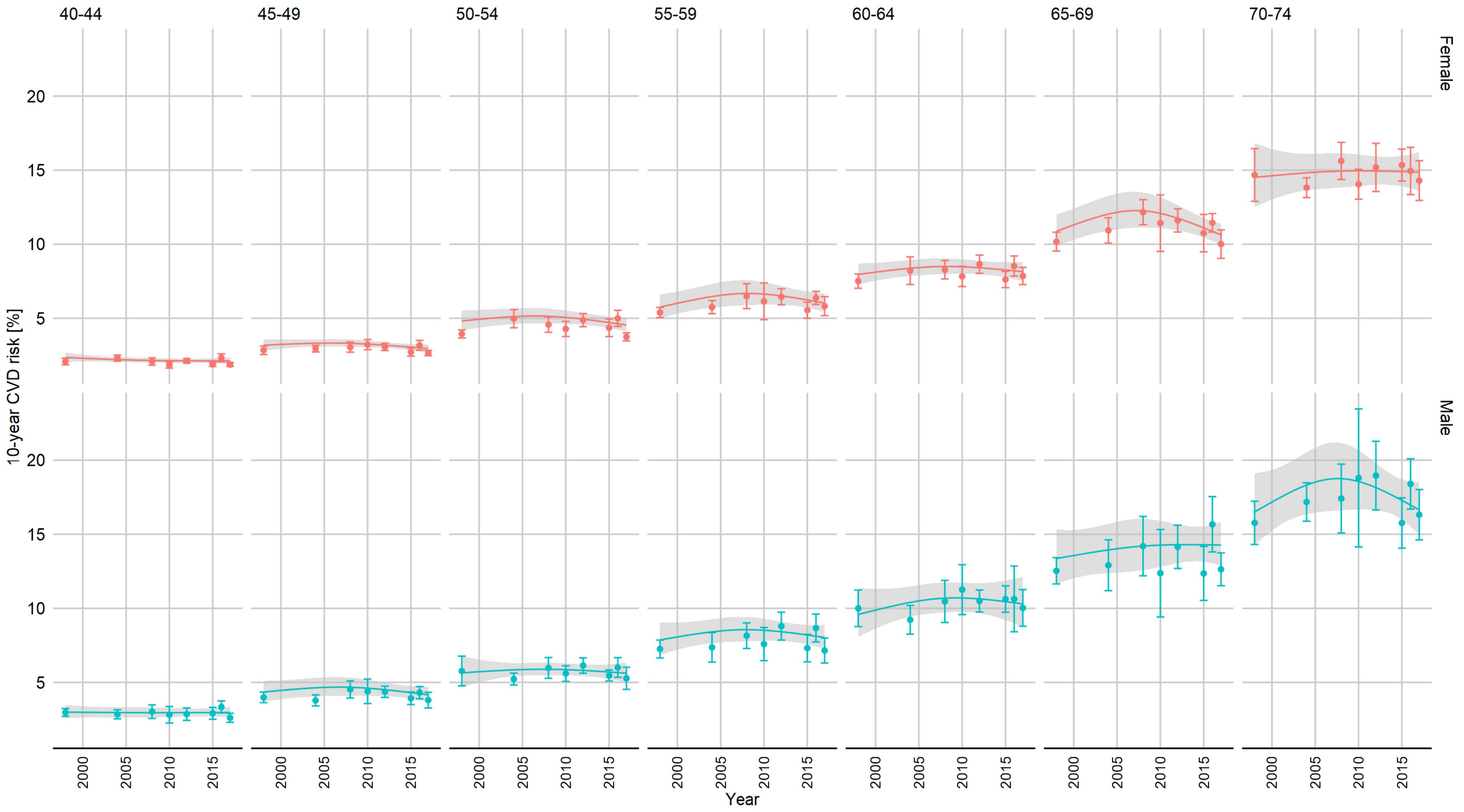
Estimated trend in CVD Risk. South African population 40-74 years. By sex.

WHO non-laboratory risk score. Estimates and 95% confidence intervals/bands.



Estimated trend in CVD Risk. England and South African populations 40-74 years. By sex

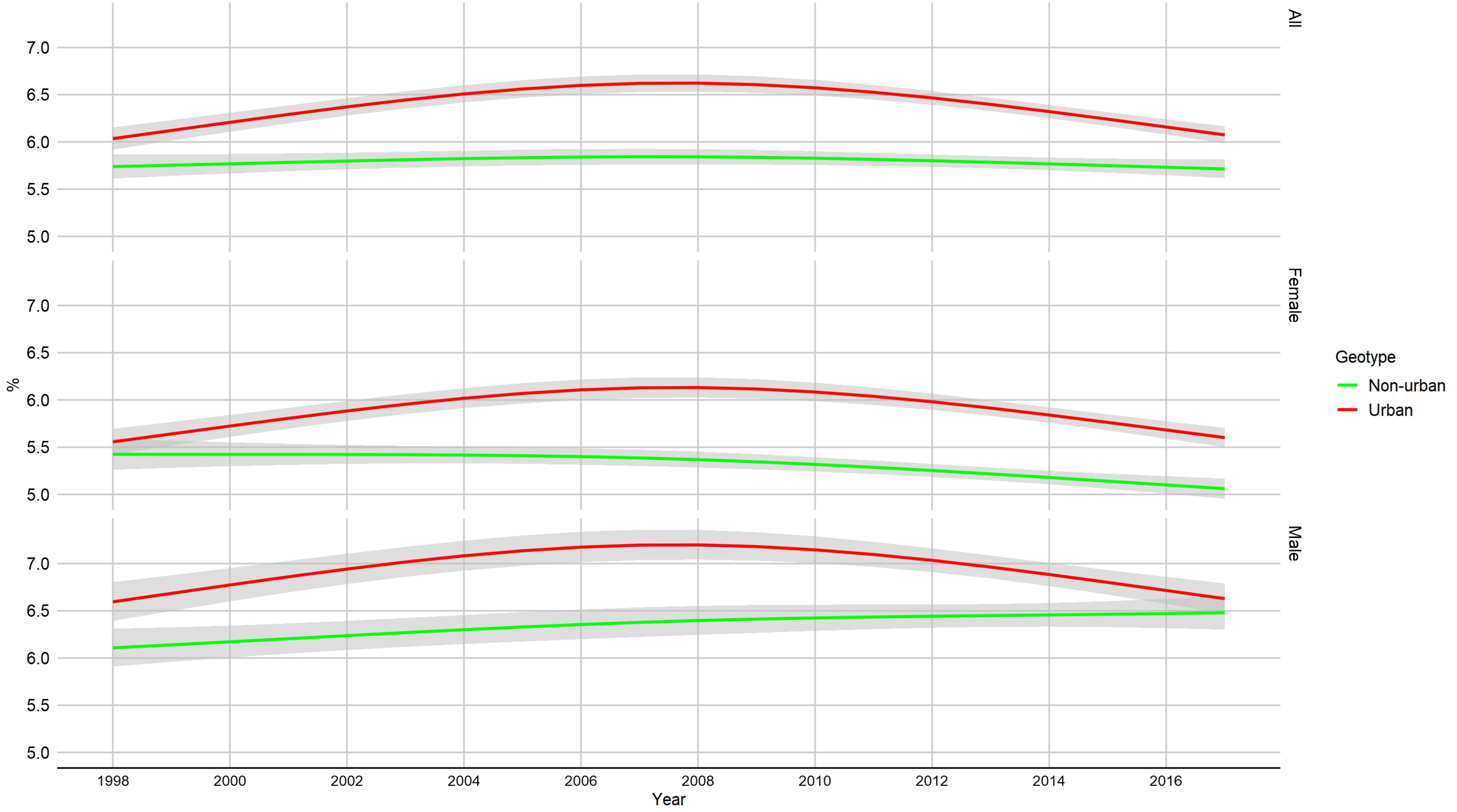
WHO non-laboratory and WHO laboratory risk score. Estimates and 95% confidence intervals/bands.



Estimated trend in CVD Risk. South African population 40-74 years. By sex and age group.

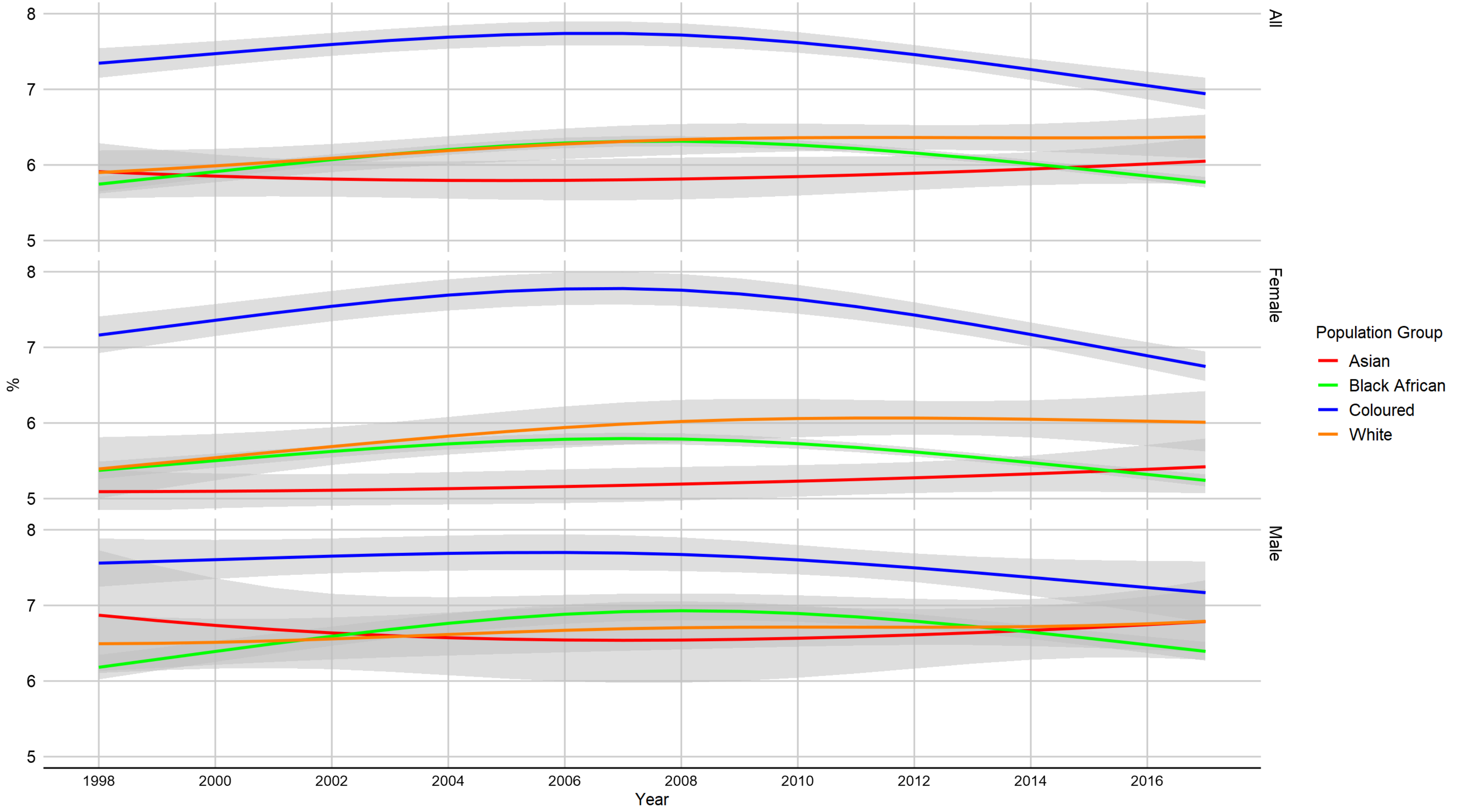
WHO non-laboratory risk score. Estimates and 95% confidence intervals/bands.

Inequalities



Estimated trend in CVD Risk. South African population 40-74 Age standardised. By geographic type.

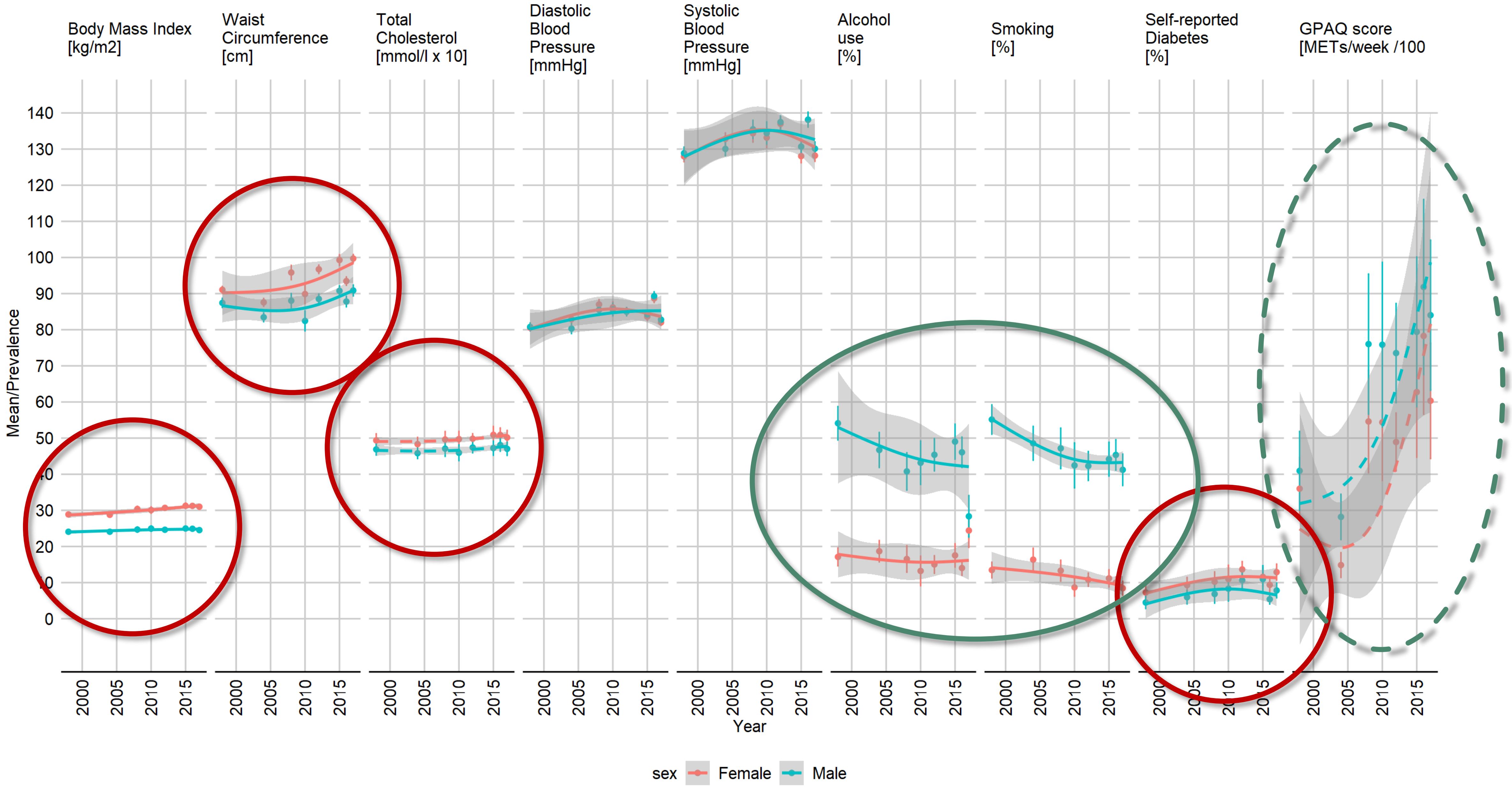
WHO non-laboratory risk score.



Estimated trend in CVD Risk. South African population 40-74 Age standardised. By population group.

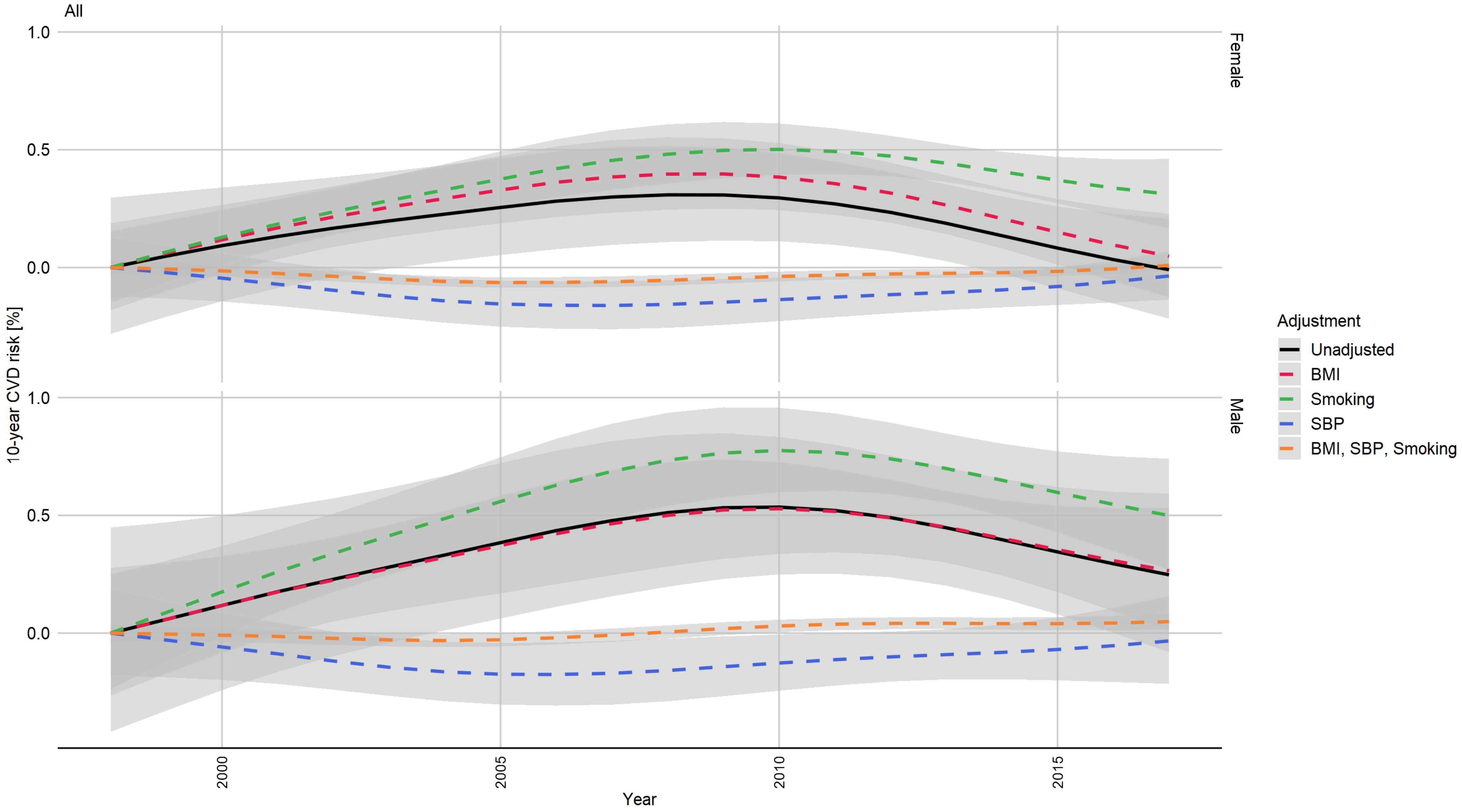
WHO non-laboratory risk score.

Risk factors and explaining changes



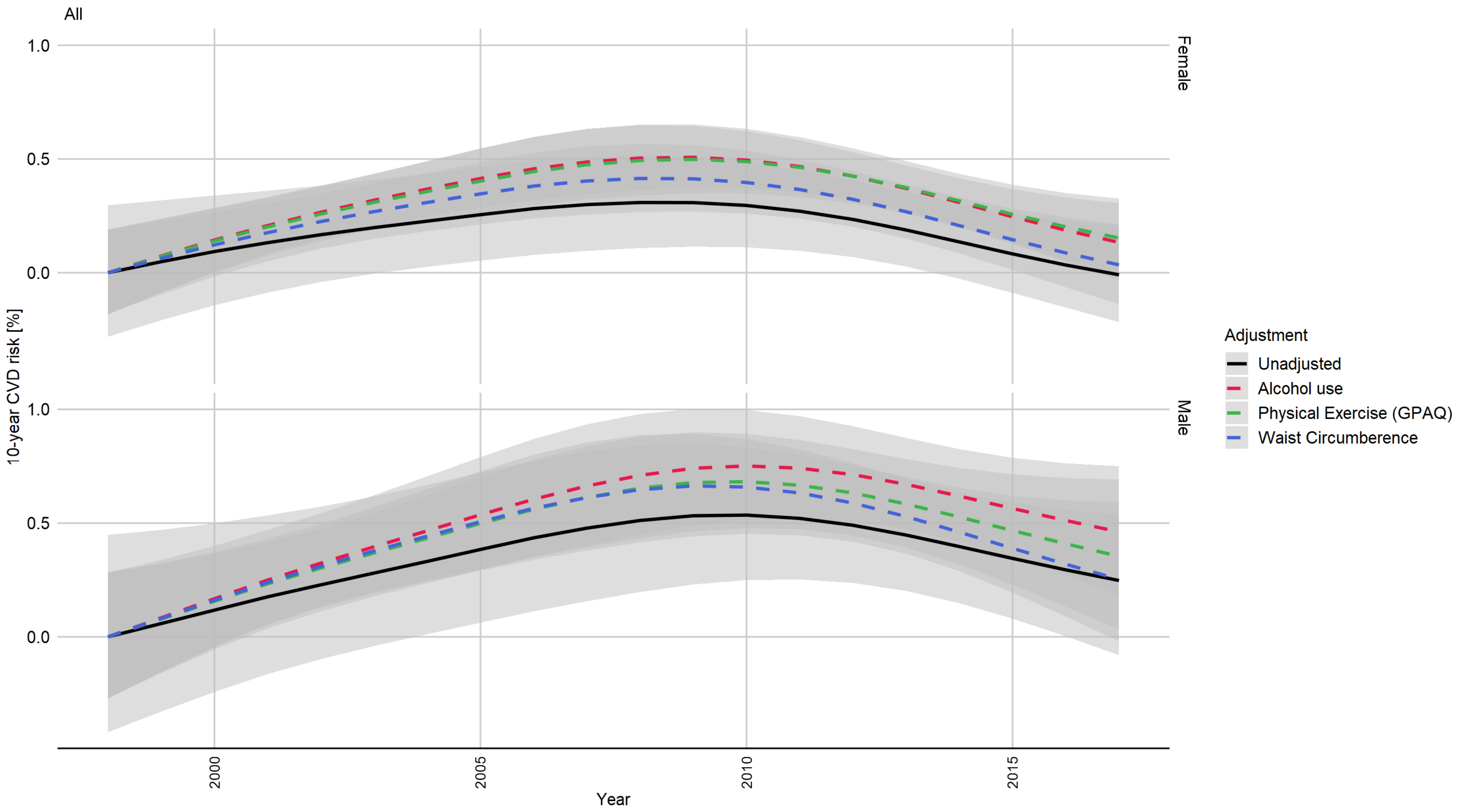
Trends in major CVD risk factors. South African population 40-74 years. By sex.

Estimates with 95% confidence intervals and smoothed trends..



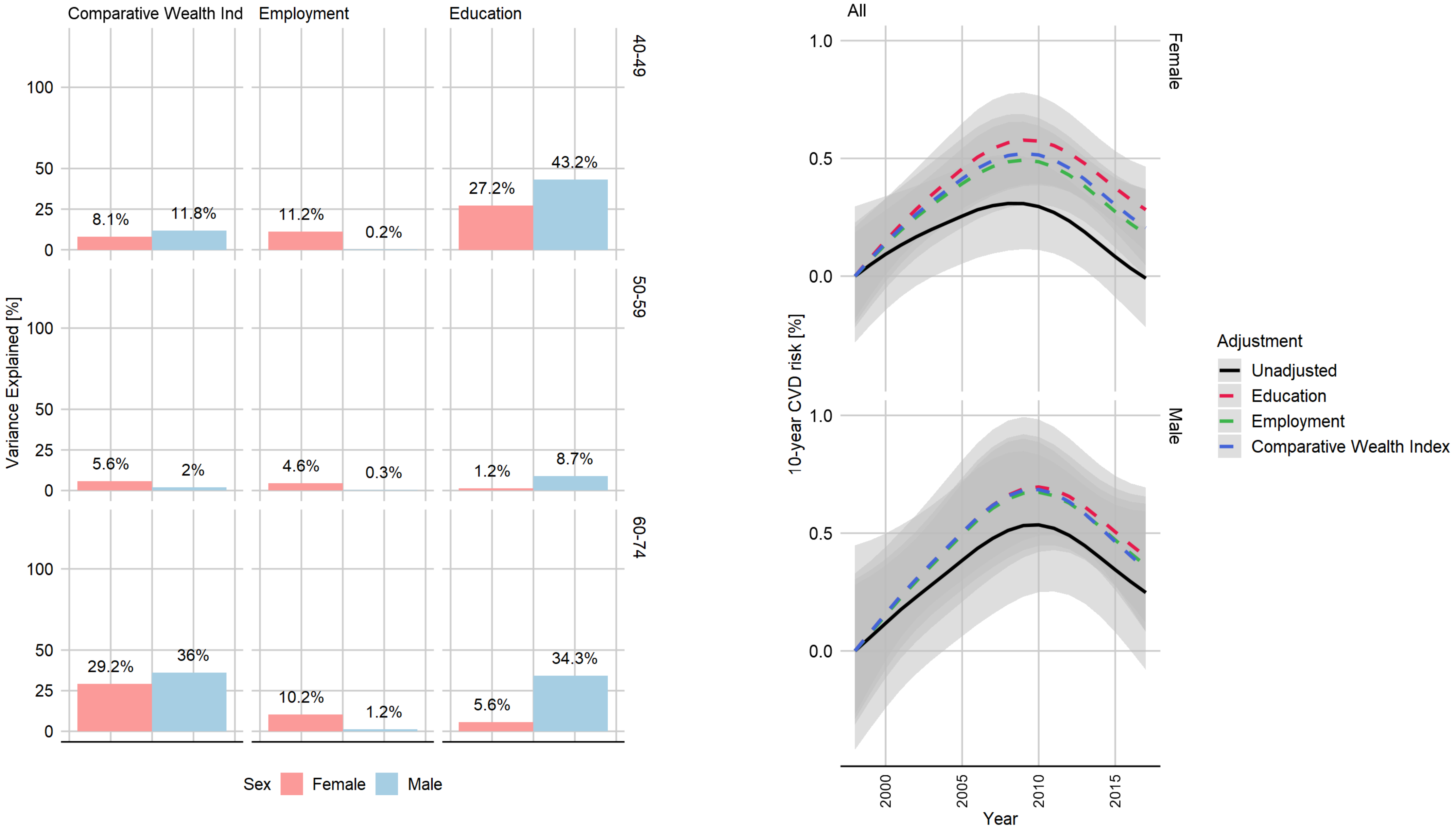
Estimated trends in CVD Risk. South African population 40-74 years 2012-2017. Adjusted for selected risk factors. By sex.

WHO non-laboratory risk score. Centred at year = 1998.



Estimated trends in CVD Risk. South African population 40-74 years 2012-2017. Adjusted for selected risk factors. By sex.

WHO non-laboratory risk score. Centred at year = 1998.

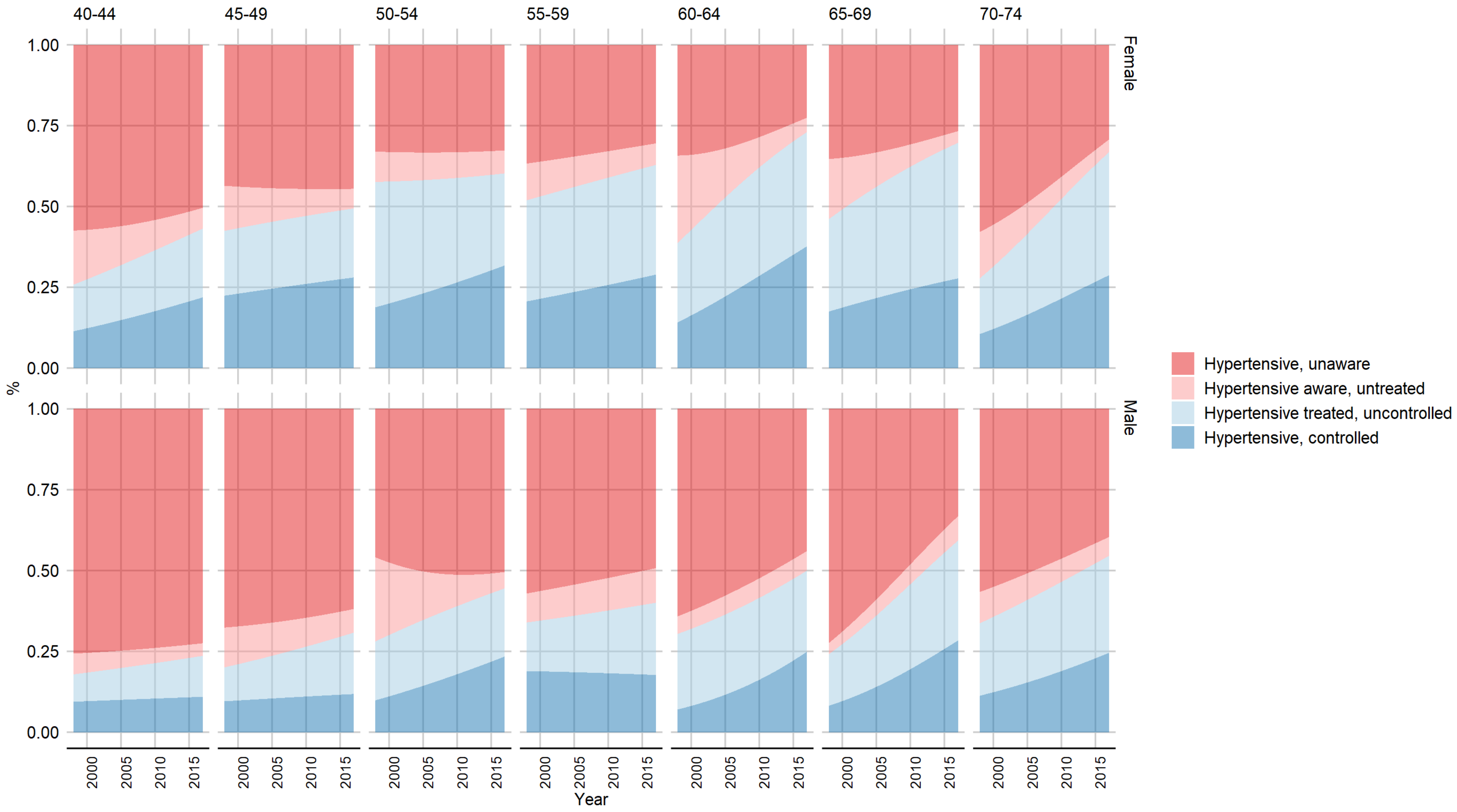


Proportion of variance explained and adjusted trends for selected socioeconomic factors. South African population 40-74 years. By sex.

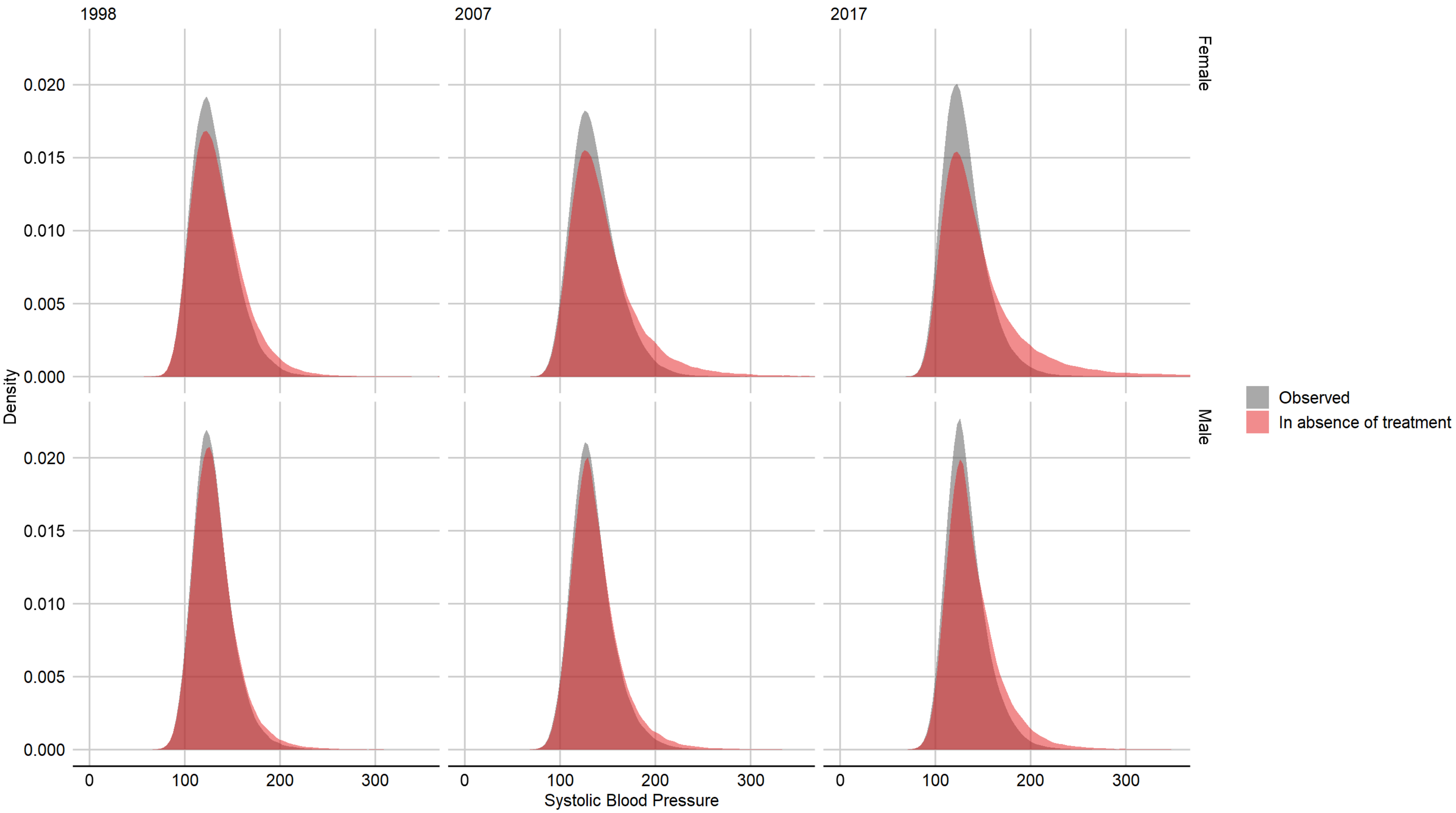
Who non-laboratory risk score.


Why is
BP
decreasing?

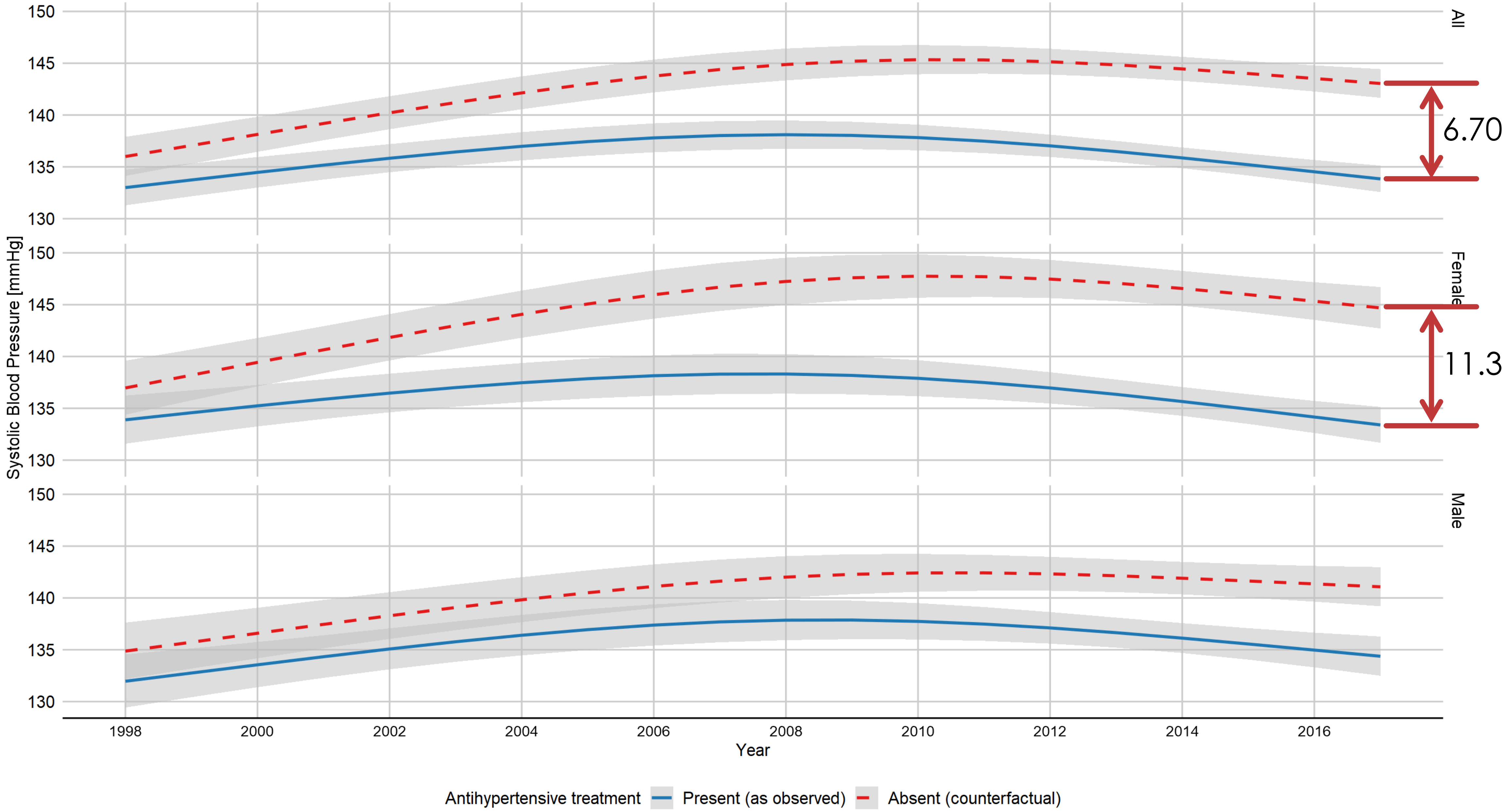
Treatment?



Hypertension cascade. South African population 40-74 years. By age and sex..

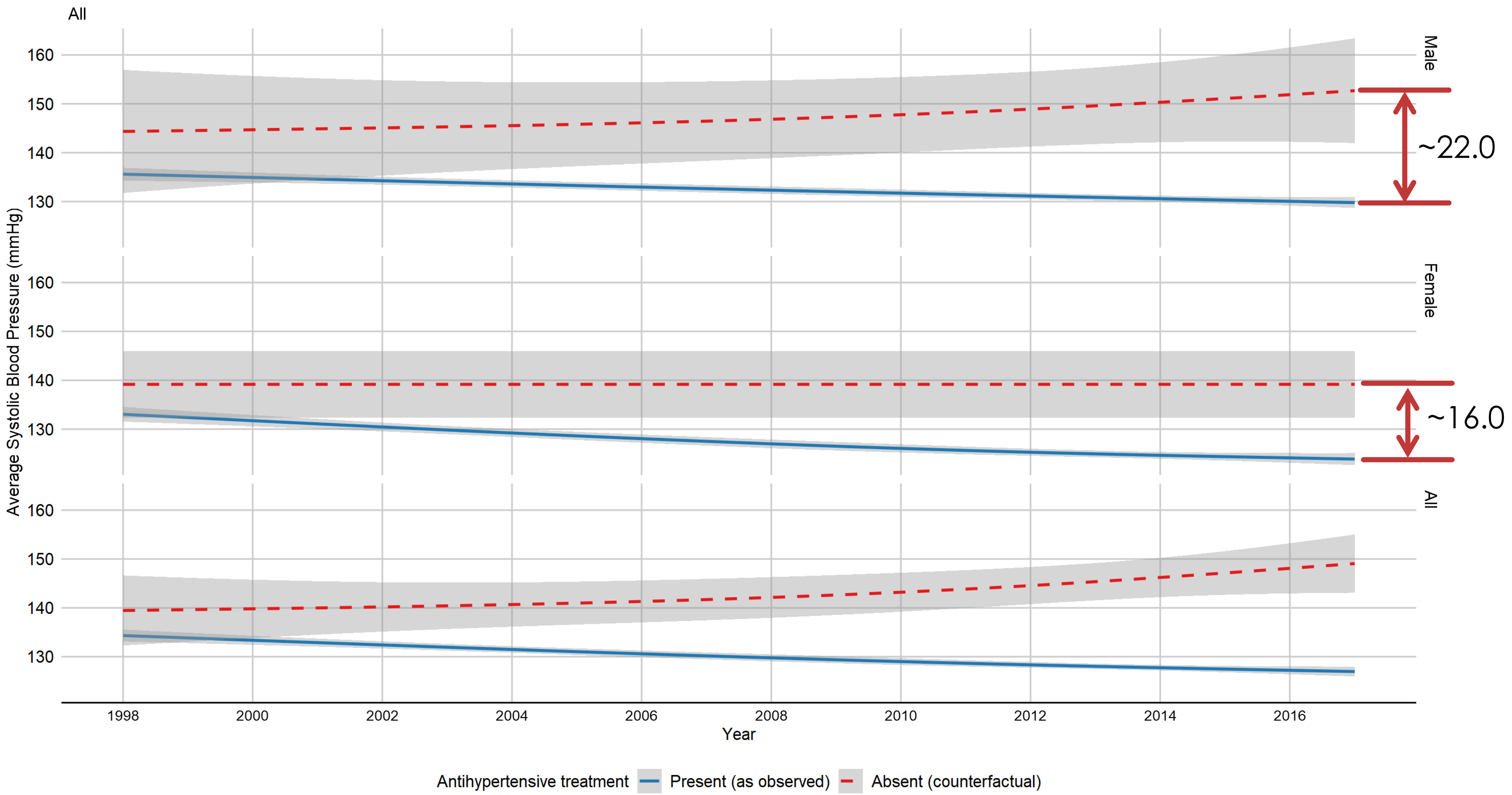


Observed vs counterfactual distribution of systolic blood pressure. South African population 40-74 years. by year and sex

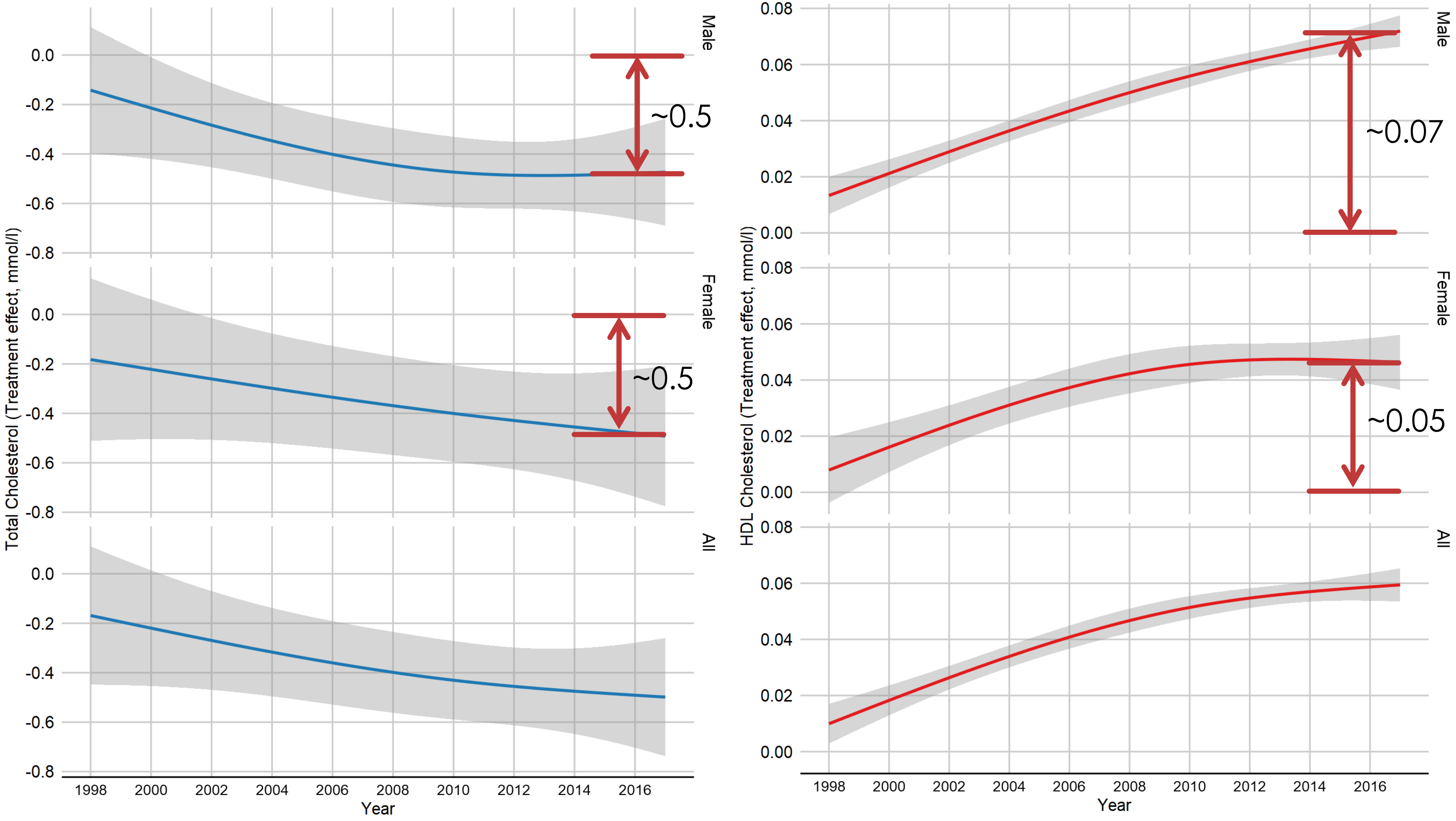


Estimated trend in systolic blood pressure. South African population 40-74 years. Observed and in absence of treatment. By sex.

WHO non-laboratory risk score. Estimates and 95% confidence intervals/bands.



Estimated trend in systolic blood pressure. England population 40-74 years. Observed and in absence of treatment. By sex.



Trends in treatment effects on cholesterol. England population 40-74 years. by year and sex

Conclusions & Discussion Points

- CVD risk scores declined in England from 1998-2017 (potentially flattening in recent years). This contrasts with South Africa which showed an increasing and then decreasing pattern.
- Decreases are present, with different magnitude across age groups and sexes. Absolute risk is consistently higher among males.
- Trends in CVD risk scores seemed to be influenced most strongly by variations in SBP. Variation in BMI/waist circumference and smoking also contribute, to a lesser extent.
- Trends in average blood pressure seem to be significantly affected by increasing diffusion (and, possibly, improved effectiveness) of antihypertensive treatment. Increasing treatment penetration/quality may contribute the risk reduction.
- Enhancing awareness and treatment among males may help to reduce sex inequalities in CVD risk.
- CVD risk scores (and major risk factors) show gender, ethnic, geographic and socioeconomic patterns, with some potential signs of convergence over time.
- Improving socioeconomic circumstances, especially education, may also lead to population improvements in CVD risk.

References

Bradshaw, D., Pillay van-Wyk, V., Neethling, I., Roomaney, R. A., Cois, A., Joubert, J. D., Nannan, N., Abdelatief, N., Awotiwon, O. F., Turawa, E. B., Nojilana, B., Groenewald, P., Matzopoulos, R., Prinsloo, M., Cairncross, E., Wright, C. Y., Peer, N., & Pacella, R. (2022). Overview: Second Comparative Risk Assessment for South Africa (SACRA2) highlights need for health promotion and strengthened surveillance. South African Medical Journal, 556–570. https://doi.org/10.7196/SAMJ.2022.v112i8b.16648

Iyen, B., Weng, S., Vinogradova, Y. et al. Long-term body mass index changes in overweight and obese adults and the risk of heart failure, cardiovascular disease and mortality: a cohort study of over 260,000 adults in the UK. BMC Public Health 21, 576 (2021). https://doi.org/10.1186/s12889-021-10606-1

Machemedze T, Kerr A, Dorrington R. *South African Population Projection and Household Survey Sample Weight Recalibration. WIDER Working Paper 2020/67*. Vol 67.; 2020. https://www.wider.unu.edu/sites/default/files/Publications/Working-paper/PDF/wp2020-67.pdf

NCD Risk Factor Collaboration (NCD-RisC). (2020). Repositioning of the global epicentre of non-optimal cholesterol. *Nature*, 582(7810), 73–77. https://doi.org/10.1038/s41586-020-2338-1

Ueda P, Woodward M, Lu Y, et al. Laboratory-based and office-based risk scores and charts to predict 10-year risk of cardiovascular disease in 182 countries: a pooled analysis of prospective cohorts and health surveys. *The Lancet Diabetes & Endocrinology*. 2017;5(3):196-213. doi:10.1016/S2213-8587(17)30015-3

Kaptoge S, Pennells L, De Bacquer D, et al. World Health Organization cardiovascular disease risk charts: revised models to estimate risk in 21 global regions. *The Lancet Global Health*. 2019;7(10):e1332-e1345.

Boyer C, Danaei G, Hajifathalian K, Ueda P, M. Carrillo Larco R. *Globorisk: Globorisk: Global CVD Risk Calculator*.; 2022. https://github.com/boyercb/globorisk

Kaptoge S, Pennelles L. whocvdrisk. Published online 2019. Accessed August 6, 2023. https://www.phpc.cam.ac.uk/ceu/erfc/programs/.

Ezzati M, Obermeyer Z, Tzoulaki I, Mayosi BM, Elliott P, Leon DA. Contributions of risk factors and medical care to cardiovascular mortality trends. *Nat Rev Cardiol*. 2015;12(9):508-530. doi:10.1038/nrcardio.2015.82