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ABSTRACT

Background: Hypertension is a key modifiable risk factor for cardiovascular disease –the leading cause of death in the UK. Good blood pressure (BP) control reduces mortality. However, health inequities may lead to variability in hypertension monitoring and control.

Aim: To investigate health inequities related to ethnicity, sex, age, and socio-economic status in the monitoring, treatment and control of BP in a large cohort of adult patients with hypertension.

Design and Setting: A cross-sectional cohort study of adults with hypertension registered with general practices in North East London on 1st April 2019.

Method: Multivariable logistic regression was used to estimate associations of demographics and treatment intensity on the following hypertension management indicators: 1) BP recording in last 12 months, 2) BP on age-adjusted target, 3) BP on age-adjusted target and BP recorded in last 12 months.

Results: In total, 156,296 adults were included. The Black ethnicity group was less likely to have controlled BP than the White ethnicity group (OR 0.89, 95% CI = 0.86-0.92). The Asian ethnicity group was more likely to have controlled blood pressure (OR 1.29, 95% CI = 1.25-1.34). Ethnicity differences in control could not be explained by the likelihood of having a recent blood pressure recording, nor by treatment intensity differences. Older adults were more likely to have controlled hypertension than younger patients.

Conclusion: Black ethnicity individuals and younger people are less likely to have controlled hypertension and may warrant targeted interventions. Possible explanations for these findings are presented but further research is needed on reasons for ethnic differences.

Keywords: Hypertension, Health Inequities, Blood pressure, Antihypertensives, Cardiovascular Diseases, General Practice

HOW THIS FITS IN

Health inequities in the management of long-term conditions are widely recognised. This study identifies ethnic, age, gender and deprivation inequities in the monitoring, treatment and control of blood pressure in a large unselected cohort of adults with hypertension in an ethnically diverse and nationally disadvantaged area of London. It confirms previous findings that blood pressure control in Black ethnic groups with hypertension is worse than in White or Asian ethnic groups. These differences were not related to access to blood pressure recording or treatment intensity. Younger adults were less likely to have controlled hypertension than older adults.

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of death in the UK. In the last decade, the reduction in CVD mortality has stalled and, for some disadvantaged groups, mortality rates have actually increased.[1–3] The importance of effective control of blood pressure in people with hypertension is recognised at local, national and international level as a major contributor to reduction in CVD-related morbidity and mortality.[4–7]

Health inequities in the management of hypertension have been investigated in several regional and national patient cohorts in the United Kingdom: the Black ethnicity group is significantly less likely to have controlled blood pressure than White ethnicity group and, in some studies, the Asian ethnicity group had better control.[8–10] Similar inequities have been described in Europe and the USA.[11,12]

The North East London locations investigated in this study are among the most ethnically diverse and deprived in the United Kingdom.[13] However, supported by local quality improvement programmes, the control of blood pressure was among the best in England in the national NHS Quality and Outcomes Framework (QOF) reward and incentive programme up until the pandemic.[14]

Regular monitoring of blood pressure and appropriate treatment initiation and escalation are fundamental in effective management of hypertension.[5] Therefore, our study included adults with hypertension and aimed to analyse socio-demographic inequities in recording and control of blood pressure, and inequities in treatment intensity.

METHODS

A cross-sectional study was carried out in five contiguous North-East London Clinical Commissioning Groups (CCGs): City and Hackney (CH), Newham (NH), Redbridge (RB), Tower Hamlets (TH) and Waltham Forest (WF). The study cohort was derived from currently registered patients in general practices which used the EMISWeb electronic health record system (EMIS Health, Leeds). Pseudonymised coded demographic and clinical data were extracted by our data analyst from CCG-level GP electronic health records using the EMISWeb “Population Reporting” tool.

The study cohort comprised adults aged 18 years and older, with diagnosed hypertension on the index date: 1st April 2019. The QOF “HYP_COD” reference codeset identified hypertension, excluding individuals with a subsequent “hypertension resolved” code (Supplementary Table 1 and https://clinicalcodes.rss.mhs.man.ac.uk/medcodes/article/200/).[15]

For each cohort individual, the following demographic data were extracted (Supplementary Table 2): Age in years on index date; Sex; home Lower Layer Super Output Areas (LSOA); Ethnic group code.

The most recent systolic and diastolic blood pressure values (mmHg) and their entry dates were extracted. Blood pressure recordings made more than 12 months prior to the index date were omitted. Blood pressure recordings were also omitted for individuals with unreliable or unfeasible blood pressures, namely: incomplete recording (systolic blood pressure (SBP) but no diastolic blood pressure (DBP) or vice-versa), separately recorded blood pressures elements (SBP date different from DBP date), and SBP <70mmHg or SBP >=270mmHg or DBP <40mmHg or DBP >=150mmHg (Figure 1).

Medicines prescribed in the 6 months up to and including the index date were considered for eight classes of antihypertensive medication (Supplementary Table 2): i) ACE inhibitors/Angiotensin Receptor Blockers, ii) Beta-blockers, iii) Potassium-sparing diuretics, iv) Calcium channel blockers, v) Thiazide-type and thiazide-like diuretics, vi) Centrally-acting anti-hypertensives, vii) Alpha-blockers and viii) Loop diuretics. Only the most recently prescribed antihypertensive in each medication class was considered. Most individuals with hypertension require two or more antihypertensive drugs to maintain their blood pressures within acceptable range.[6,16,17] The number of different classes prescribed were therefore grouped into categoric treatment intensity: 0 (untreated), 1 (possibly undertreated), or 2 or more medications.

Ethnic groups were categorised according to top-level Office of National Statistics 2001 census categories and comprised: White (including British, Irish, or White other); Black and Black British (including Caribbean, African, and other Black background); Asian and Asian British (including Bangladeshi, Pakistani, Indian and any other Asian background); Mixed ethnicity (including White and Black Caribbean, White and Black African, White and Asian); and Chinese or other (herein White, Black, Asian, Mixed, and Other ethnicity groups respectively).[18] The Unknown ethnicity group comprised individuals with no ethnicity code recorded, unclassified codes and the “not stated” codes.

An individual’s Index of Multiple Deprivation (IMD) was based on their small area indicators (LSOA) and used the 2019 national quintiles from quintile 1 (most deprived areas) to quintile 5 (least deprived areas).[19]

Blood pressure was deemed controlled as per NHS QOF indicators HYP003 and HYP007: individuals under 80 years of age: systolic blood pressure less than or equal to 140mmHg and diastolic blood pressure less than or equal to 90mmHg (HYP003); individuals 80 years of age and older, systolic blood pressure less than or equal to 150mmHg and diastolic blood pressure less than or equal to 90mmHg (HYP007).[15]

Outcomes

Three binary outcome variables of blood pressure management were considered.

1. BLOOD_PRESSURE_RECORDED was true of Individuals with a valid blood pressure recorded within 12 months of the index date.
2. HYPERTENSION_CONTROLLED considered the entire cohort (i.e. individuals with HYPERTENSION) and was true for patients with a blood pressure within the QOF age-adjusted target. Individuals without a blood pressure within 12 months of the index date were considered to be above target blood pressure.

3. BLOOD_PRESSURE_CONTROLLED considered only Individuals with a BLOOD_PRESSURE recorded within 12 months of the index date and was true for patients with a blood pressure within the QOF age-adjusted target.

The difference between HYPERTENSION_CONTROLLED and BLOOD_PRESSURE_CONTROLLED is worth clarifying. The former aligns with the NHS' QOF management of hypertension indicators. QOF takes a "worst-case scenario" approach: individuals on the hypertension register who do not have a blood pressure recorded in the last 12 months are deemed to have uncontrolled hypertension.[15] However, it is unlikely that all individual with no blood pressure recorded in the last year actually have uncontrolled blood pressure. By considering only individuals with a blood pressure recorded in the last 12 months, as is the case with our BLOOD_PRESSURE_CONTROLLED indicator, a more reliable estimate of overall management of blood pressure can be obtained. We use HYPERTENSION_CONTROLLED to simplify comparison of our findings with other audits which treat "out of date" blood pressure recordings as QOF does, and BLOOD_PRESSURE_CONTROLLED as our preferred indicator of BP control (see Discussion).

Statistics

Data were processed, aggregated and validated and descriptive statistics derived using Python (version 3.9.1). Univariate and multiple logistic regression analyses (adjusted for Sex, Age, Ethnicity, IMD quintile and treatment intensity) were performed using R (version 4.0.5) with sub-analyses performed by treatment intensity. Forest plots were generated using the forestplot python package (version 0.2.0).[20]

RESULTS

The study cohort was derived from 190 out of 199 practices in the participating five North-East London CCGs with a population of approximately 1.23 million adults of whom 156,296 (12.7%) had hypertension. The nine excluded practices used a different electronic health record system.

The summary characteristics of the study cohort are described in Table 1. 14,077 individuals did not have a blood pressure recorded in the 12 months up to and including the index date and a further 93 blood pressure recordings were excluded as unreliable or unfeasible (Figure 1). Therefore, among the whole cohort, 90.0% (142,126/156,296) had a valid blood pressure recorded in the 12 months prior to and including the index date (BLOOD_PRESSURE_RECORDED).

Using the entire cohort (all missing BP values deemed uncontrolled), HYPERTENSION_CONTROLLED was 73.4% (114,653/156,296) controlled to age-adjusted targets. Of those with recorded BPs, 80.7% (114,653/142,126) had controlled BP as per age-adjusted targets (BLOOD_PRESSURE_CONTROLLED).

96% (149,974/156,296) of the cohort individuals had an ethnicity code assignable to one of the five known-ethnicity groups considered in this study, and only 2.7% (4,279/156,296) of cohort individuals had no ethnicity code recorded (Table 1).

Blood pressure recording and ethnicity

BLOOD_PRESSURE_RECORDED and ethnicity were modelled using unadjusted and adjusted logistic regression in relation to the White ethnicity group (Table 2A). In the univariate model, the Asian ethnicity group was 60% more likely to have a recent blood pressure recorded than the White ethnicity group (Odds Ratio (OR) 1.60, 95% CI = 1.53-1.68, p-value <0.001), all other ethnicity groups (except for the Unknown ethnicity group) were all within 10% of the reference White ethnic group (Table 2A and Supplementary Figure 1A).

In the multivariate model, the odds ratios for blood pressure recording were essentially unchanged. For the Asian ethnicity group, the OR was 1.62 (95% CI = 1.55 to 1.71, p-value <0.001), and for the Black ethnicity group, the OR was 1.09, 95% CI = 1.03-1.14, p-value <0.001) as shown in Figure 2A.

Control of hypertension and ethnicity

HYPERTENSION_CONTROLLED (where individuals with no blood pressure recorded in the 12 months up to and including the index date were categorised as having uncontrolled blood pressure) and ethnicity were likewise modelled using univariate and multivariate models (Table 2B).

In the univariate model, the Asian ethnicity group was 26% more likely to have controlled hypertension than the White ethnicity group (OR 1.26, 95% CI = 1.22 to 1.30, p-value <0.001) and the Black ethnicity group was 10% less likely (OR 0.90, 95%CI = 0.87 to 0.93, p-value <0.001) to have controlled hypertension than the White ethnicity group (Table 2B and Supplementary Figure 1B).

In the multivariate model (Table 2B and Figure 2B), the Asian ethnicity group was 39% more likely to have controlled hypertension than the White ethnicity group (OR 1.39, 95% = CI 1.35-1.43, p-value <0.001) whilst the Black ethnicity group was 8% less likely (OR 0.92, 95% CI 0.89-0.95, p-value <0.001).

Control of blood pressure and ethnicity

The relationship between BLOOD_PRESSURE_CONTROLLED (where only individuals with a blood pressure recorded in the 12 months up to and including the index date were considered) and ethnicity was modelled as for the two previous indicators (Table 2C).

In the univariate model, the Asian ethnic group was 24% more likely to have controlled blood pressure than the White ethnic group (OR 1.24, 95% CI = 1.20 to 1.27, p-value <0.001) whereas the Black ethnicity group was 8% less likely (OR 0.92, 95% CI = 0.89 to 0.95, p-value <0.001) as shown in Table 2C and Supplementary Figure 1C.

These differences were accentuated in the multivariate model (Table 2C and Figure 2C). The Asian ethnicity group was 28% more likely to have controlled blood pressure than the White ethnicity group (OR 1.28, 95% CI = 1.23 to 1.32, p-value <0.001); the Black ethnicity group was 13% less likely to have a controlled blood pressure (OR 0.87, 95% CI = 0.84 to 0.91, p-value <0.001).

Age, IMD, Sex and treatment intensity

Data from the multivariate analysis of the BLOOD_PRESSURE_CONTROLLED indicator (our favoured indicator of control as explained in the Discussion section) were considered to understand the impact of age, deprivation, sex and treatment intensity on effective management of hypertension (Figure 2C).

Compared to individuals in the (most populated) 60-70 years age-bracket (25.5% [39,854/156,296]), individuals in the 30-40 years age bracket (3.9% [6,063/156,296]) were 39% less likely to have a controlled blood pressure (OR 0.61, 95% CI = 1.57 to 1.65, p-value <0.001). Conversely, individuals in the 80-90 years bracket (11.7% [18,264/156,296]) were 175% more likely to have controlled blood pressure (OR 2.75, 95%CI = 2.58 to 2.94, p-value <0.001). When re-grouping the data, individuals under 50 years of age were 40% less likely to have controlled blood pressure than those 50 years and older (OR 0.60, 95% CI =0.60-0.61, p-value = <0.001).

The likelihood of blood pressure control decreased with decreasing deprivation (Figure 2C). Patients in the least deprived Index of Multiple Deprivation quintiles (Q4 and Q5) were 28% less likely than patients in the most deprived quintile (Q1) to have controlled blood pressure (ORs 0.72, CI = 0.68 to 0.76 and 0.72, 95% CI = 0.66 to 0.78 respectively, both p-values <0.001). Women were 14% more likely to have controlled blood pressure than men (Figure 2C; OR 1.14. 95% CI = 1.11 to 1.17, p-value <0.001).

Relative to untreated individuals, the likelihood of blood pressure control increased with treatment intensity by approximately 38% regardless of treatment intensity (Figure 2C; ORs: 1 antihypertensive 1.39, 95% CI = 1.33 to 1.46; 2+ antihypertensives 1.37, 95% CI = 1.31 to 1.44, both p-values <0.001).

Ethnicity and treatment intensity

The distribution of treatment intensities by ethnicity group in those with controlled versus uncontrolled blood pressures (i.e. above target, unrecorded or invalid blood pressure recordings) is shown in Supplementary Figure 2.

Individuals in the Asian ethnicity group were the least likely to be untreated in both the uncontrolled and controlled blood pressure groups: 10.6% (908/7,639) and 7.3% (2,627/36,169) respectively.

Individuals in the Black ethnicity group were similarly or less likely to be untreated or be on a single anti-hypertensive medication than the White ethnicity group. In the controlled blood pressure group, 8.5% (2,016/23,850) of the Black ethnicity group were untreated and 32.9% (7,851/23,850) on a single agent (cf. 9.4% (4,084/43,659) and 34.4% (15,033/43,659) for the White ethnicity group). In the uncontrolled blood pressure group, 13.6% (918/6,731) of the Black ethnicity group were untreated and 31.7% (2,133/6,731) on a single agent as compared to 13.0% (1,329/10,233) and 36.0% (3,685/10,233) for the White ethnicity group.

A multivariate analysis was conducted for the BLOOD_PRESSURE_CONTROLLED indicator on: i) untreated individuals, ii) individuals on one class of antihypertensive, and iii) individuals on two or more classes of antihypertensives. The ORs by ethnicity group for this treatment intensity sub-analysis are shown in Figure 3. Relative to the White ethnicity group, and regardless of the number of medications they were on, individuals in the Asian ethnicity group were more 12-26% more likely to have controlled blood pressure: 0 medications: OR 1.26, 95% CI = 1.13 to 1.40, p-value <0.001; 1 medication: OR 1.18, 95% CI = 1.12 to 1.25, p-value <0.001; 2+ medications: OR 1.22, 95% CI = 1.16 to 1.28, p-value <0.001. The Black ethnicity group was always less likely (10-23%) to have controlled blood pressure (0 medications: OR 0.77, 95% CI = 0.69 to 0.85, p-value <0.001; 1 medication: OR 0.90, 95% CI = 0.85 to 0.96, p-value <0.001; 2+ medications: OR 0.85, 95% CI = 0.81 to 0.90, p-value <0.001).

DISCUSSION

Summary

This cross-sectional study of an unselected, large cohort of 156,296 adult patients with hypertension from 190 GP practices in North-East London, identified inequities in the monitoring and control of hypertension by ethnicity, age, sex and deprivation.

The Black ethnicity group was more likely to have uncontrolled hypertension than White or Asian ethnicity groups. This was not due to less frequent recording of blood pressure in the Black ethnicity group, whose individuals were in fact more likely to have a blood pressure recorded within 1 year than members of the White ethnicity group –nor was this finding due to associations with age, sex or deprivation. Regardless of treatment intensity, control of blood pressure in the Black ethnicity group was worse, and in the Asian ethnicity group better, than in the White ethnicity group. It is of note that despite better control of hypertension in the Asian ethnicity group, CVD mortality is higher in this group than in both the White and Black ethnicity groups [21].

These data suggest that lower levels of blood pressure control in the Black ethnicity group cannot be directly attributed to relative under-recording of blood pressure or less intensive treatment. Possible other possible factors include unidentified confounding factors, differences in age at diagnosis, initial treatment choice and dosage, treatment escalation, adherence and physiological treatment resistance. [10,22–24] Medication costs on working age adults and adherence may also be contributory factors in particularly in younger people.[10,25,26]

Patients with hypertension under 50 years were 40% less likely than those older, to have controlled hypertension. Given that 17% of the cohort was under the age of 50 (with more potential years at risk), this represents a notable treatment inequity.[25] Similar concerns have been expressed about statin under-treatment in younger patients.[27]

Lastly, this study highlights the importance of indicator choice in assessing cohort-level management of hypertension. The difference between BLOOD_PRESSURE_CONTROLLED and the QOF derived HYPERTENSION_CONTROLLED indicators has been previously noted as reflecting missing recordings rather than reduction in control.[7] The QOF HYP003 and HYP007 indicators may be suitable for performance assessment in incentive programmes, but do not provide reliable indicators of the management of hypertension –considering both BLOOD_PRESSURE_RECORDED (an indicator of monitoring) and BLOOD_PRESSURE_CONTROLLED (an assumption-free indicator of control) is preferable.

Strengths and limitations

The study cohort was unselected, included almost all (95%) general practices in the region, and had a high level (96%) of recorded ethnicity in an ethnically diverse population with broad representation of the three principal ethnic groups discussed. However, it is important to be mindful that high-level ethnicity groupings can conceal underlying heterogeneity between constituent ethnicity groups.[28]

The study was cross-sectional and trajectories of the patient groups through time were not addressed. Treatment changes within 6 months would not be captured accurately, possibly overestimating treatment intensity in a small number of patients. In North East London 72.6% of the population were in the two most deprived quintiles and only 10% in the two most affluent. The urban density and the fact that the rich and poor often live in close proximity means that area level measures such as IMD quintile reduce gradients between extremes of deprivation. In addition, the most affluent may be away from their London residences for prolonged periods or access alternative health services which may further influence blood pressure recording and control and contribute to apparent poor management in this group.

Comparison with existing literature

Our study confirms previous findings of inequities in the control of blood pressure in patients with hypertension, with poorer control in the Black ethnicity group, and better control in the Asian ethnicity group in comparison to the White ethnicity group, as well as better control in women compared to men.[8–12] We found younger individuals had poorer control than older individuals, a finding not replicated in a cross-sectional population-based study of almost 100,000 individuals with hypertension enrolled in the UK Biobank database (though that study did not consider individuals under 40 years of age).[9] In our study, the Black ethnicity group had similar access to primary-care based blood pressure recording as other ethnicity groups, a finding similar to that in a South East London based study.[8]

In a UK-wide study by Eastwood *et al.* comparing management of newly diagnosed hypertension in European, South Asian and African/African Caribbean ethnicities, the findings of poorer control in the Black ethnicity group was similar to our own study but the South Asian group was found to have similar levels of BP monitoring and control in comparison to other ethnic groups.[10] We found higher levels of BP monitoring and of BP control in the Asian ethnicity group than in the White ethnicity group. However, the UK-wide study considered only recently diagnosed patients which may account for differences in findings in the South Asian ethnicity group.

Our study showed that, regardless of treatment intensity, the Black ethnicity group was less likely to have controlled hypertension. When considering only antihypertensive-adherent individuals, Eastwood *et al.* did not find differences between BP control in the African/African Caribbean and

European groups, with cost of prescriptions as a possible contributing factor in working adults.[26] Two UK-based studies investigated the impact of ethnicity on medication adherence, although neither considered antihypertensive medication. The first considered diabetes, dyslipidaemia or hypothyroidism medication within an ethnically diverse inner-city cohort and found lower adherence in Asian or Black patients.[29] The second considered persistence with oral medication for type-2 diabetes. Relative to the White ethnicity group, non-persistence was more likely in the Black and the Asian ethnic groups (hazard ratios 1.83 and 1.53 respectively).[30] Such findings do not explain the higher likelihood of controlled blood pressure in our study's Asian ethnicity group. Furthermore, we found no evidence that Black ethnicity group was undertreated.

The age-standardised mortality rates (ASMR) from ischaemic heart disease (IHD) for the Bangladeshi, Pakistani, and Indian ethnicity groups are significantly higher than in the White ethnicity group - who in turn have a higher ASMR than the Black ethnicity group.[21] Given the higher risk of cardiac death, there should be no complacency in the need to improve blood pressure control in Asian ethnicity group and higher levels of stroke in Black ethnicity group raise similar concerns.

Implications for research and practice

Further research is needed to understand ethnic differences in IHD and stroke mortality, and the relevance of thresholds for blood control or ethnicity-specific treatment pathways.[23,28,31]

In North-East London and the UK more generally, a focus on the optimisation of blood pressure control in the Black ethnicity group and in younger people could be an important step in addressing monitor and control of hypertension inequities.

The impact of medication costs in younger working age-groups deserves further attention and in particular the role of single pill combination therapies that reduce patient costs and improve adherence. Easier access to monitoring of blood pressure is relevant to all people with hypertension particularly those of working age.[4,32,33]

ETHICS APPPOVAL

This study is based on de-identified information obtained from routinely compiled general practitioner electronic health records and did not require ethics committee approval.

COMPETING INTERESTS

The authors have declared no competing interests.

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REFERENCES

1 World Health Organisation. The top 10 causes of death. 2018. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death (accessed 26 Nov 2019).

2 Office for National Statistics. ONS Statistical Bulletin: Deaths registered in England and Wales: 2019. 2020. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregistrationsummarytables/2019 (accessed 15 Sep 2020).

3 Marmot M, Allen J, Boyce T, *et al.* Health Equity in England: The Marmot Review 10 Years On. 2020. https://www.health.org.uk/sites/default/files/upload/publications/2020/Health Equity in England_The Marmot Review 10 Years On_full report.pdf (accessed 24 July 2023).

4 Robson J, Rison S. *Triple Aim: Optimising CVD medicines -- Summary Guidelines*. London, England. Clinical Effectiveness Group (CEG) 2020. ISBN 978-1-910195-33-8 https://www.qmul.ac.uk/blizard/ceg/media/blizard/real-health/files/RH-CVD---Summary-Guidelines---Triple-Aim-v7.0.pdf (accessed 12 Dec 2020).

5 National Institute for Health and Care Excellence. Hypertension in adults: diagnosis and management (NICE guideline NG136). 2019. https://www.nice.org.uk/guidance/ng136 (accessed 9 Sep 2019).

6 Williams B, Mancia G, Spiering W, *et al.* 2018 ESC/ESH Guidelines for themanagement of arterial hypertension. Eur. Heart J. 2018;**39**(33):3021–104. doi:10.1093/eurheartj/ehy339

7 Office for Health Improvement & Disparities (OHID) and NHS Benchmarking Network. CVDPREVENT Second Annual Audit Report. 2022. https://www.nhsbenchmarking.nhs.uk/cvdprevent-outputs (accessed 24 July 2023)

8 Schofield P, Saka O, Ashworth M. Ethnic differences in blood pressure monitoring and control in south east London. *Br J Gen Pract* 2011;**61**(585):190–6. doi:10.3399/bjgp11X567126

9 Tapela N, Collister J, Clifton L, *et al.* Prevalence and determinants of hypertension control among almost 100 000 treated adults in the UK. *Open Hear* 2021;**8**(1). doi:10.1136/openhrt-2020-001461

10 Eastwood S V., Hughes AD, Tomlinson L, *et al.* Ethnic differences in hypertension management, medication use and blood pressure control in UK primary care, 2006–2019: A retrospective cohort study. *Lancet Reg Heal - Eur* 2023;**25**:100557. doi:10.1016/j.lanepe.2022.100557

11 van der Linden EL, Couwenhoven BN, Beune EJAJ, *et al.* Hypertension awareness, treatment and control among ethnic minority populations in Europe: a systematic review and meta-analysis. *J Hypertens* 2021;**39**(2):202–13. doi:10.1097/HJH.0000000000002651

12 Fontil V, Pacca L, Bellows BK, *et al.* Association of Differences in Treatment Intensification, Missed Visits, and Scheduled Follow-up Interval With Racial or Ethnic Disparities in Blood Pressure Control. *JAMA Cardiol* 2022;**7**(2):204–12. doi:10.1001/jamacardio.2021.4996

13 Office for National Statistics. 2011 Census: key statistics for local authorities in England and Wales. 2012. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/2011censuskeystatisticsforlocalauthoritiesinenglandandwales

(accessed 24 Oct 2022).

14 NHS Digital. Quality and Outcomes Framework, 2019-20. 2020. https://digital.nhs.uk/data-and-information/publications/statistical/quality-and-outcomes-framework-achievement-prevalence-and-exceptions-data/2019-20 (accessed 24 Oct 2022).

15 NHS Digital. Quality and Outcomes Framework (QOF) business rules v42 2019-2020 baseline release. 2019. https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-collections/quality-and-outcomes-framework-qof/quality-and-outcome-framework-qof-business-rules/quality-and-outcomes-framework-qof-business-rules-v42-2019-2020-baseline-releas (accessed 1 Jul 2020).

16 Gu Q, Burt VL, Dillon CF, *et al.* Trends in antihypertensive medication use and blood pressure control among United States adults with hypertension: the National Health And Nutrition Examination Survey, 2001 to 2010. *Circulation* 2012;**126**(17):2105–14. doi:10.1161/CIRCULATIONAHA.112.096156

17 Guerrero-García C, Rubio-Guerra AF. Combination therapy in the treatment of hypertension. *Drugs Context* 2018;**7**:212531. doi:10.7573/dic.212531

18 HM Government. 2021. List of Ethnic Groups. Ethnicity Facts and Figures - Style Guide. 2021. https://www.ethnicity-facts-figures.service.gov.uk/style-guide/ethnic-groups (accessed 24 July 2023).

20 Shen L, Shapiro A. LSYS/forestplot: v0.2.0. 2022. doi:10.5281/zenodo.7270258

21 Cooke A, Butt A, Nasir R, *et al.* Mortality from leading causes of death by ethnic group, England and Wales: 2012 to 2019. Census 2021. 2021. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/mortalityfromleadingcausesofdeathbyethnicgroupenglandandwales/2012to2019 (accessed 11 May 2023).

22 Redmond N, Baer HJ, Hicks LS. Health behaviors and racial disparity in blood pressure control in the national health and nutrition examination survey. *Hypertens (Dallas, Tex 1979)* 2011;**57**(3):383–9. doi:10.1161/HYPERTENSIONAHA.110.161950

23 Lackland DT. Racial differences in hypertension: implications for high blood pressure management. *Am J Med Sci* 2014;**348**(2):135–8. doi:10.1097/MAJ.0000000000000308

24 Aggarwal R, Chiu N, Wadhera RK, *et al.* Racial/Ethnic Disparities in Hypertension Prevalence, Awareness, Treatment, and Control in the United States, 2013 to 2018. *Hypertens (Dallas, Tex 1979)* 2021;**78**(6):1719–26. doi:10.1161/HYPERTENSIONAHA.121.17570

25 Johnson HM, Warner RC, Bartels CM, *et al.* 'They're younger… it's harder.' Primary providers' perspectives on hypertension management in young adults: a multicenter qualitative study. *BMC Res Notes* 2017;**10**(1):9. doi:10.1186/s13104-016-2332-8

26 Callum M. Revealed: 800,000 could have saved with a prescription 'season ticket' last year. MSE news. 2018.https://www.moneysavingexpert.com/news/2018/01/revealed-800000-could-have-saved-with-a-prescription-season-ticket-last-year/ (accessed 11 Jan 2023).

27 Hayek A, Marquis-Gravel G. Lipid lowering in primary prevention: time to focus on young patients. *Heart* 2023;**109(7)**:500–1. doi:10.1136/heartjnl-2022-321972

28 Mathur R, Rentsch CT, Venkataraman K, *et al.* How do we collect good-quality data on race and ethnicity and address the trust gap? *Lancet (London, England)* 2022;**400**(10368):2028–30. doi:10.1016/S0140-6736(22)02490-4

29 Langley CA, Bush J. The Aston Medication Adherence Study: mapping the adherence patterns of an inner-city population. *Int J Clin Pharm* 2014;**36**(1):202–11. doi:10.1007/s11096-013-9896-3

30 McGovern A, Hinton W, Calderara S, *et al.* A Class Comparison of Medication Persistence in People with Type 2 Diabetes: A Retrospective Observational Study. *Diabetes Ther* 2018;**9**(1):229–42. doi:10.1007/s13300-017-0361-5

31 Gopal DP, Francis R. Does race belong in the hypertension guidelines? *J Hum Hypertens* 2021;**35**(10):940–1. doi:10.1038/s41371-020-00414-2

32 Vrijens B, Antoniou S, Burnier M, *et al.* Current Situation of Medication Adherence in Hypertension. *Front Pharmacol* 2017;**8**:100. doi:10.3389/fphar.2017.00100

33 Van Emmenis M, Jamison J, Kassavou A, *et al.* Patient and practitioner views on a combined face-to-face and digital intervention to support medication adherence in hypertension: a qualitative study within primary care. *BMJ Open* 2022;**12**:e053183. doi:10.1136/bmjopen-2021-053183

Tables and figures

Tables

Individual patients [n]	156,296	
Age (years): mean [STD]	61.2 [13.9]	
Systolic BP (mmHg): mean [STD]	133.4 [14.0]	
Diastolic BP (mmHg): mean [STD]	78.4 [10.1]	
Sex: num [%]		
Female	**79,940 [51.1%]**	
Male	76,356 [48.9%]	
Ethnicity: num [%]		
White	**59,897 [38.3%]**	
Asian or Asian British	46,856 [30.0%]	
Black or Black British	33,731 [21.6%]	
Unknown *No ethnicity code recorded* *Unclassified code* *"Not stated" code*	6,322 [4.0%] *4,279 [2.7%]* *1,089 [0.7%]* *954 [0.6%]*	
Other Ethnic Groups	6,256 [4.0%]	
Mixed	3,234 [2.1%]	
Age distribution: num [%]		
(18-30]	894 [0.6%]	
(30-40]	6,063 [3.9%]	
(40-50]	19,325 [12.4%]	
(50-60]	37,970 [24.3%]	
(60-70]	**39,854 [25.5%]**	
(70-80]	30,195 [19.3%]	
(80-90]	18,264 [11.7%]	
(90-120]	3,731 [2.4%]	
Index of Multiple Deprivation (IMD) Quintile: num [%]		
Q1 (most deprived)	41,364 [26.5%]	
Q2	**72,009 [46.1%]**	
Q3	26,242 [16.8%]	
Q4	11,801 [7.6%]	
Q5 (least deprived)	4820 [3.1%]	
Q0 (unknown)	60 [<0.1%]	
Number of antihypertensive medications: num [%]		
0	20,365 [13%]	
1	**53,492 [34.2%]**	
2	48,635 [31.1%]	82,439 [52.8%]
3	23,373 [15%]	
4	8,120 [5.2%]	
5+	2,311 [1.5%]	

Table 1: *Characteristics of patients included in the study cohort (N= 156,296 adult patients with hypertension). In variables with multiple categories, the largest top-level category is shown in bold type.*

	Logistic regression model			
	Unadjusted [INDICATOR ~ ETHNICITY]		**Adjusted** [INDICATOR ~ ETHNICITY + SEX + AGE GROUP + IMD QUINTILE + TREATMENT INTENSITY]	
Ethnicity	**Odds Ratio [95% CI]**	**p-value**	**Odds Ratio [95% CI]**	**p-value**
A. BLOOD_PRESSURE_RECORDED [Likelihood of having BP recorded up to 1 year prior to the index date]				
Asian or Asian British	1.60 [1.53-1.68]	<0.001***	1.62 [1.55-1.71]	<0.001***
Other ethnic group	1.10 [1.01-1.20]	0.04*	1.14 [1.03-1.25]	0.008**
Black or Black British	1.08 [1.03-1.13]	<0.001***	1.09 [1.03-1.14]	0.001**
White	1 [N/A]	N/A	1 [N/A]	N/A
Mixed	0.96 [0.85-1.07]	0.43	0.99 [0.87-1.12]	0.85
Unknown	0.56 [0.52-0.60]	<0.001***	0.69 [0.64-0.74]	<0.001***
B. HYPERTENSION_CONTROLLED [Likelihood of BP meeting age-adjusted BP target, whole cohort]				
Asian or Asian British	1.26 [1.22-1.30]	<0.001***	1.39 [1.35-1.43]	<0.001***
Other ethnic group	1.17 [1.10-1.24]	<0.001***	1.26 [1.18-1.34]	<0.001***
White	1 [N/A]	N/A	1 [N/A]	N/A
Black or Black British	0.90 [0.87-0.93]	<0.001***	0.92 [0.89-0.95]	<0.001***
Mixed	0.85 [0.79-0.92]	<0.001***	0.90 [0.83-0.98]	0.011*
Unknown	0.63 [0.60-0.67]	<0.001***	0.75 [0.71-0.79]	<0.001***
C. BLOOD_PRESSURE_CONTROLLED [Likelihood of BP meeting age-adjusted BP target in patients with a BP recorded up to 1 year prior to the index date]				
Other ethnic group	1.34 [1.25-1.44]	<0.001***	1.29 [1.20-1.39]	<0.001***
Asian or Asian British	1.23 [1.20-1.27]	<0.001***	1.28 [1.23-1.32]	<0.001***
White	1 [N/A]	N/A	1 [N/A]	N/A
Black or Black British	0.92 [0.89-0.95]	<0.001***	0.87 [0.84-0.91]	<0.001***
Mixed	0.90 [0.83-0.99]	0.023*	0.87 [0.80-0.96]	0.003**
Unknown	0.78 [0.73-0.83]	<0.001***	0.82 [0.76-0.87]	<0.001***

Table 2: *Binomial logistic regression modelling of the impact of ethnicity on blood pressure control as assessed by the A. BLOOD_PRESSURE_RECORDED, B. HYPERTENSION_CONTROLLED, and C. BLOOD_PRESSURE_CONTROLLED indicators. (* p-val <0.05, ** p-val <0.01, *** p-val <0.001).*

Figures

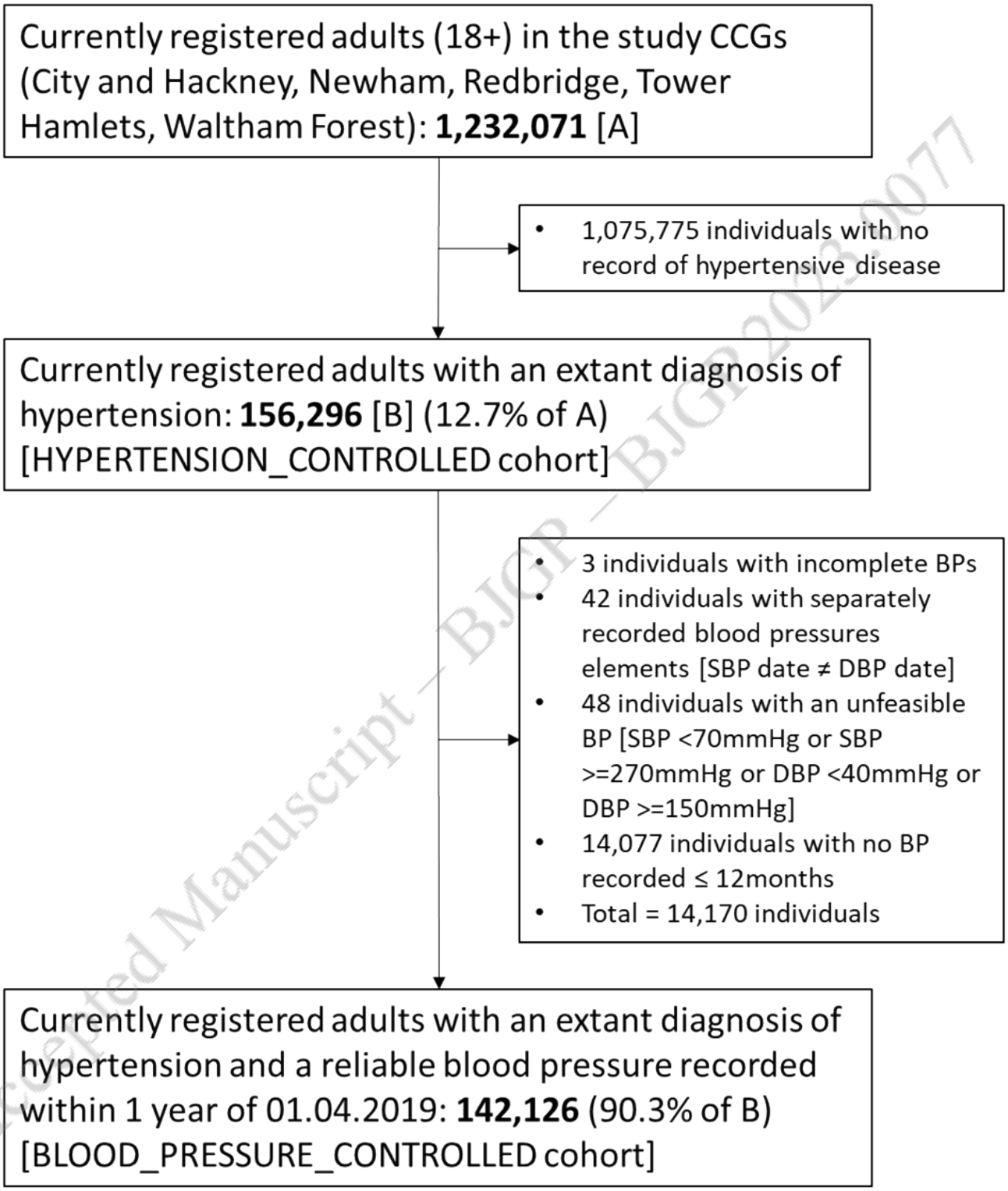
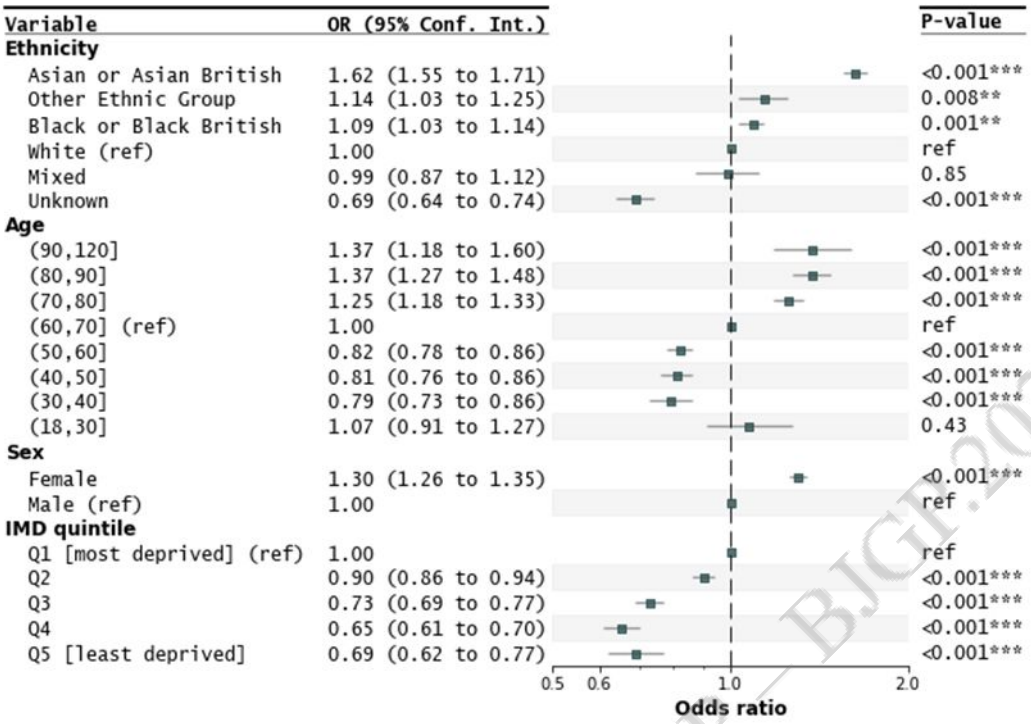
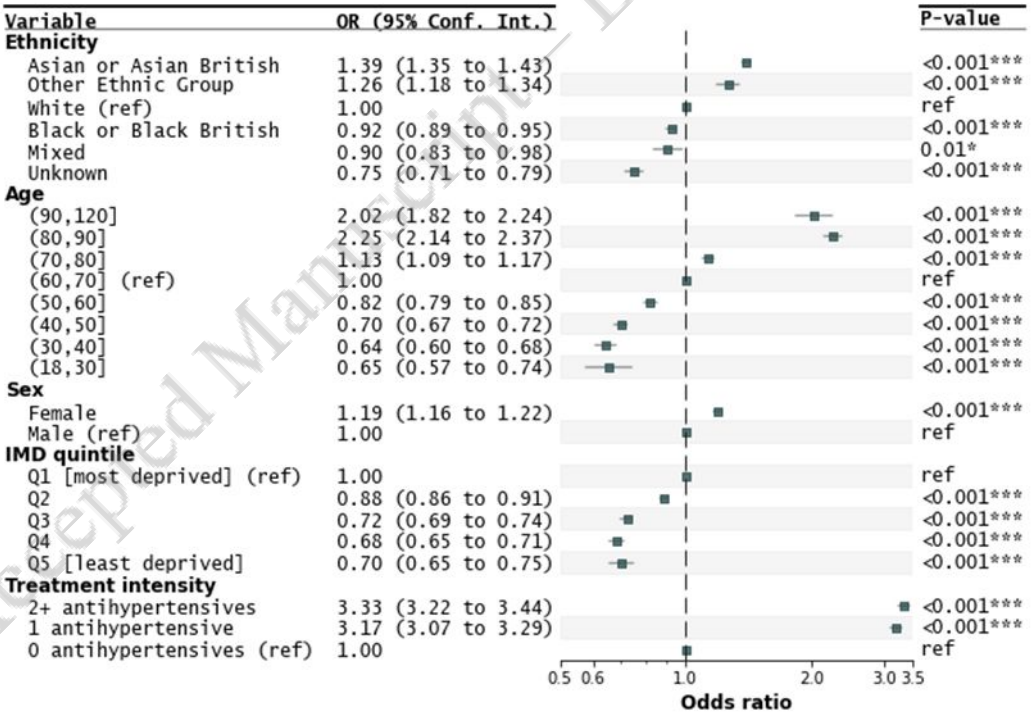


Figure 1: *Study population flowchart.*

A. BLOOD_PRESSURE_RECORDED



B. HYPERTENSION_CONTROLLED



C. BLOOD_PRESSURE_CONTROLLED

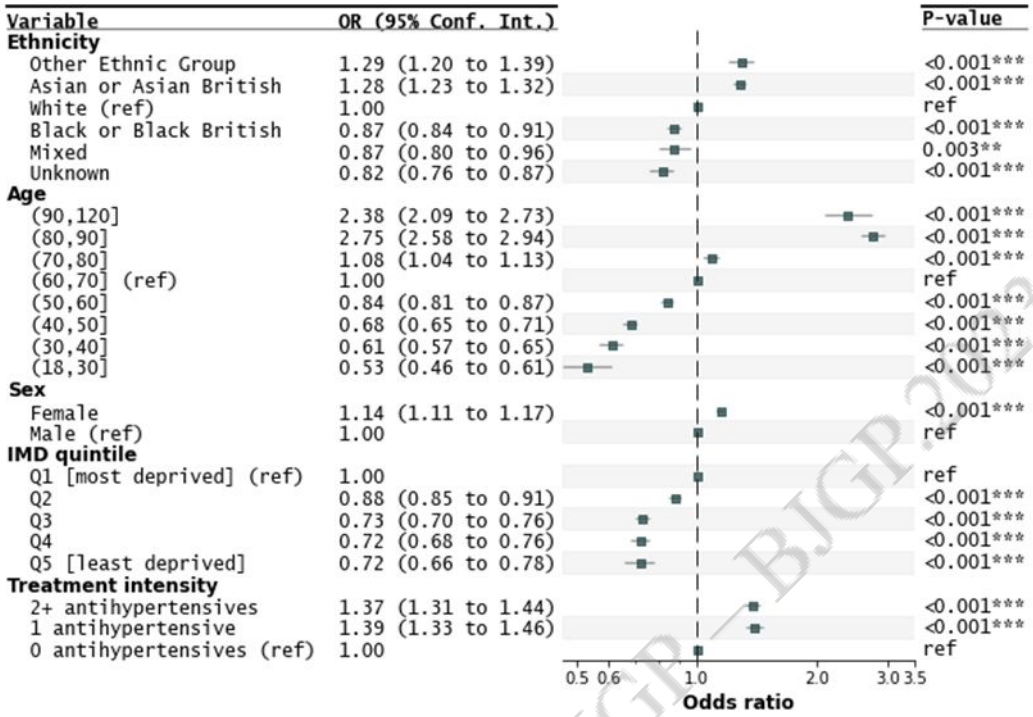


Figure 2: *Forest plots of Odds Ratios (ORs) for A. BLOOD_PRESSURE_RECORDED, B. HYPERTENSION_CONTROLLED and C. BLOOD_PRESSURE_CONTROLLED. The squares plot the OR relative to the reference (ref) category and the whisker bars are the 95% confidence interval for the OR. Squares to the left of the vertical line (OR = 1.0) indicate categories in which individuals are less likely to have a blood pressure recorded in the 12 months up to and including the index date (A), or controlled blood pressure (B and C). Squares on the right indicate individuals more likely to have a recorded blood pressure (A), or a controlled blood pressure (B and C). HYPERTENSION_CONTROLLED (B) considers the whole cohort whilst BLOOD_PRESSURE_CONTROLLED (C) considers only cohort members with a valid blood pressure recorded in the 12 months up to and including the index date. The ORs for treatment intensity for BLOOD_PRESSURE_RECORDED are not plotted as they are significantly larger than the other ORs and affect graph clarity (1 medication: 7.83 [95%CI = 7.48 – 8.21]; 2+ medications: 9.99 [95% CI = 9.55 – 10.45]; both p-values <0.001).*

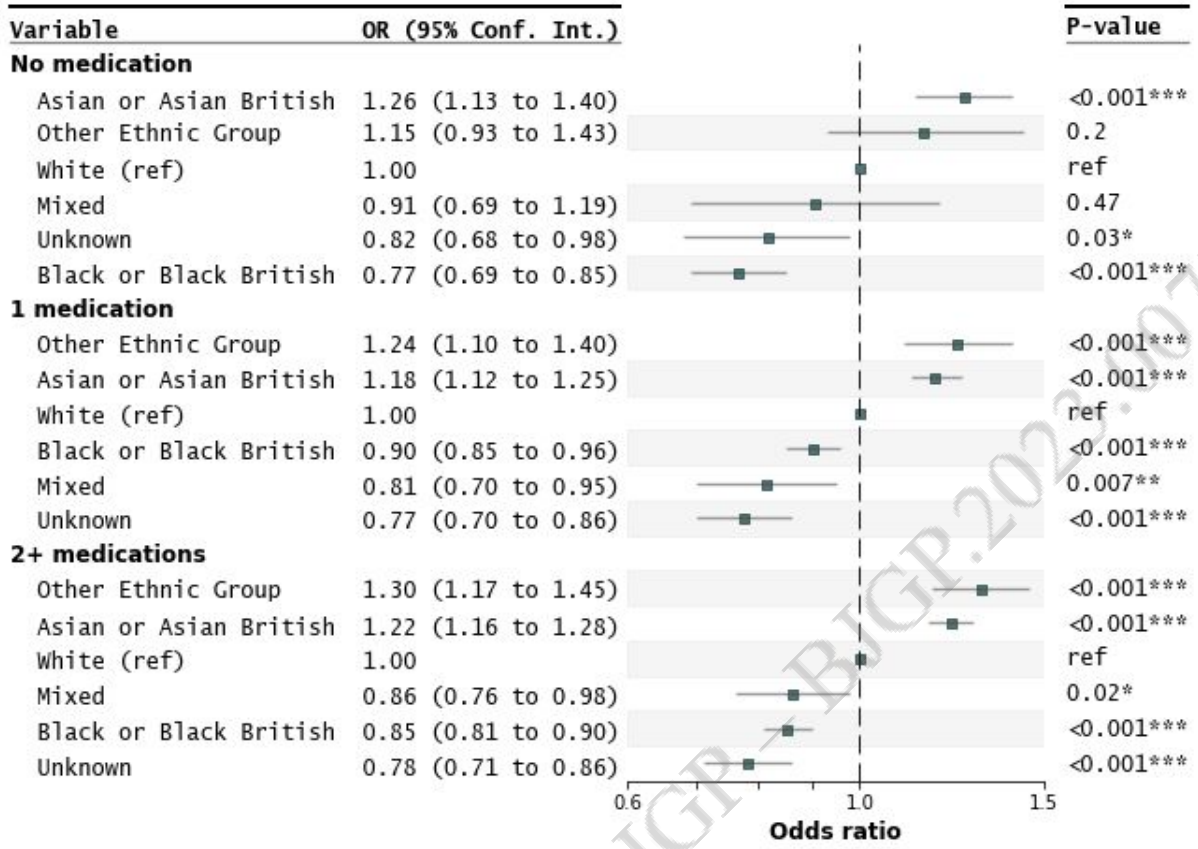


Figure 3: *Odds ratios (BLOOD_PRESSURE_CONTROLLED) by ethnicity for patients on 0, 1, and 2 or more (2+) antihypertensive medications.*