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ORIGINAL RESEARCH

Detection and Management of Diabetes in England: Results from the Health Survey for England

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ABSTRACT

Introduction: As part of a control strategy current guidance in the UK recommends more intense surveillance of HbA1C levels among those of South-east Asian or Chinese ethnicity above specified BMI thresholds. The objective of this study was to determine whether disparities in the identification and control of diabetes in England persisted despite these guidelines and assess current strategies in light of these findings.

Methods: Data were extracted from the 2013 Health Survey for England that included ethnicity, BMI status and HbA1C levels. Descriptive statistics and logistic regression analyses were used to examine relationships among undetected diabetes, poorly controlled diabetes and a range of covariates including ethnicity and BMI. Concentration indices were used to examine the socio-economic gradient in disease detection and control among and between ethnic groups.

Results: In regression models that controlled for a range of covariates Asians were found to have a 5% point higher risk of undetected diabetes than Whites. With respect to disease management, Bangladeshis and Pakistanis were found to be at a 28% point and 21% point higher risk of poor disease control respectively than Whites. Concentration indices revealed better disease control among more affluent Whites than poor Whites, no significant pattern between income and disease management was found among Pakistanis and poorer disease control was more evident among more affluent than poorer Bangladeshis.

Conclusion: In the UK current guidance recommends practitioners consider testing for diabetes among South-east Asians and Chinese where BMI exceeds 23. Our findings suggest that the risk experienced by Asians in disease detection is independent of BMI and may warrant a more active screening policy than currently recommended. With respect to disease management, our findings suggest that Indians and Pakistanis experience particularly high levels of poor disease control that may also be usefully reflected in guidance.

Keywords: Diabetes; Disparities; Ethnicity; Quality of care; UK

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INTRODUCTION

Diabetes is characterised by an impaired ability to produce or respond to the hormone insulin. Between 90% and 95% of diabetics suffer from type 2 diabetes [29]. The disease is associated with a significant economic burden [1, 11, 12, 31, 38] that based on current trends seems set to increase in many countries [7, 39, 41]. That it can remain asymptomatic for several years contributes to this burden by allowing complications associated with it to accumulate that could be avoided were it detected and managed earlier [8, 10, 34]. While prompt identification and effective management are clearly important to avoiding such costs, several studies highlight not only the existence of a substantial prevalence of undiagnosed disease [4, 14, 17, 20, 28, 32] but also the existence of distinct patterns of undiagnosed disease. In the UK, Moody et al. [20], for example, found that males, those who are older (greater than 34 years) and those who are ethnic Asians were more likely to have undiagnosed diabetes. In the US, Menke et al (2015) [17] similarly found that rates of undiagnosed diabetes were higher among those who were older (45 years plus) and among Asians compared with Whites or younger persons.

Other studies point to similar patterns regarding glycaemic control among those with diagnosed diabetes. In Scotland, for example, Negandhi et al. [21] highlight higher levels of HbA1C (a measure of glycated haemoglobin used to define diabetes status) among those of Pakistani and Indian ethnicity compared to White Scottish, findings echoed elsewhere in the UK by James et al. [13]. Similar findings were evident in Sweden, where native Swedes exhibited better glycaemic control relative to those of South-east Asian ethnicity [26] and in the US where Non-hispanic Blacks [5, 9] and Mexican-American men [9] exhibited poorer glycaemic control relative to Whites.

Beyond ethnicity, studies provide mixed evidence regarding the role of socio-economic status (SES) in undiagnosed and poorly controlled diabetes. Some such as Lee et al (2015) [15] report a higher prevalence of undiagnosed diabetes among the less well off compared to the better off in Korea, as do Moody et al. [20] in the UK and Zhang et al. [40] in China. By contrast, others such as [33, 41] found no role for income in the US with similar findings by Rathmann et al. [25] in Germany. Similarly, concerning education, the evidence is mixed. Zhang et al. [41], Lee et al. [15] and Wilder et al. [33] found no role for education in undiagnosed diabetes while Moody et al. [20] found that those who were better educated were less likely to be undiagnosed. A similar pattern is found regarding glycaemic control among those diagnosed with diabetes. While Zhang et al. [40] and Moody et al. [20] found those who were better educated exhibited better glycaemic control than those who were not, Lee et al. [15] found no role for education in glycaemic control and Marden et al. [16] found numeracy but not literacy skills were important in glycaemic control.

Relationships reported in the literature can be seen to have informed screening guidelines for diabetes. In the UK, for example, the National Institute for Health and Clinical Excellence recommend that general practitioners should consider blood tests for those aged 25 and over of South Asian or Chinese descent whose body mass index (BMI) is greater than 23 kg/m^2 [22]. While a little different in terms of specifics, similar risk profiling related to age, obesity and ethnicity features in guidance offered by the US Preventive Services Task Force [30] though others have mooted the use of different thresholds for assessing diabetes risk related to ethnicity given different relationships between HbA1C and other measures of blood glucose across ethnic groups [2, 36].

The objective of this study is to ascertain whether current guidance related to diabetes screening in the UK appropriately reflects the differential risks of diabetes. We extend the analysis to examine whether distinct patterns in glycaemic control related to ethnicity are sufficient to warrant a reconsideration of disease management strategies in the UK. The article adds to current knowledge by extending the

disaggregation of ethnicity to examine groups that have not yet been separately studied, specifically those of Bangladeshi ethnicity. We also compare socio-economic gradients in undiagnosed and poorly managed disease across ethnic groups to shed light on the factors that might explain their heterogeneous experience in diagnosis and disease control.

METHODS

Data were extracted from the 2013 Health Survey for England (HSE). The HSE is an annual cross-sectional survey of a representative sample of community-dwelling individuals in England. Data are collected in two stages. In the first, respondents complete a health interview that includes details of self-reported conditions as well as the respondent's socio-demographic characteristics (age, gender, employment status, income, education, ethnicity, etc.). In the second stage the respondent is visited by a nurse who takes various physical measurements, records prescribed medication and takes biological samples. In most years approximately 8000 adults complete the first stage of the survey and around 6000 the second stage. The disease focus of the nurse visit varies from year to year. In 2013 a focus was placed on diabetes. Further details on the survey are available in [18]. All analyses reported here are based on this previously conducted study and do not involve any new studies of human or animal subjects performed by any of the authors.

Ethnicity was examined regarding Whites, Blacks and Asians and, when sample size permitted, within Asians with respect to Bangladeshi, Pakistani, Indian and other Asians based on self-reported status. Undiagnosed diabetes was a constructed variable based on the respondent having an HbA1C level over 6.5% while self-reporting s/he was not diabetic. Poorly controlled diabetes was a constructed variable based on the respondent reporting diabetes as a condition s/he experienced and having an HbA1C above 6.5%. Other variables used in the analysis and their precise definition are presented in Table 4 of "Appendix 1".

The distribution of HbA1C was graphed and compared visually by ethnic group. Descriptive statistics (mean and 95% confidence interval) were estimated and compared by ethnic group regarding the proportion of respondents who had undiagnosed and poorly controlled diabetes. Erryeger's (2009) corrected concentration indices were estimated using the conindex commands [23] by ethnic group regarding undiagnosed and poorly controlled disease. The concentration index measures the distribution of undiagnosed (and poorly controlled) diabetes in the sample relative to the distribution of income. The index is bounded by values of 1 and −1. An over-representation of undiagnosed diabetes among those with low income would be reflected in a negative index and an over-representation among those with high income by a positive index. Logistic regression analyses were undertaken in which undiagnosed and poorly controlled diabetes respectively were regressed on functions that controlled for age, BMI, ethnicity, income, education and smoking status. To allow for the impact of differential access/use of GP services in diabetes detection and control, whether the respondent had visited the GP in the last 12 months was included as a covariate in the regression analyses. This allowed us to provide a sharper focus on the success or otherwise of current primary care screening practices in the detection and management of diabetes across ethnic and socio-economic groups. Confirmatory analyses were undertaken in which BMI was included as a series of categorical variables in the regression analyses with separate thresholds used to define groups at risk based on their relative risks of complications related to obesity. Among Chinese, thresholds were based on a WHO consensus statement [37]; among Indians, Pakistanis and Bangladeshis they were based on a consensus statement from a group of Indian clinicians [19] and for other ethnicities on existing BMI classifications [37].

RESULTS

Figure 1 displays the distribution of HbA1C by ethnic groups. As can be seen not only is mean
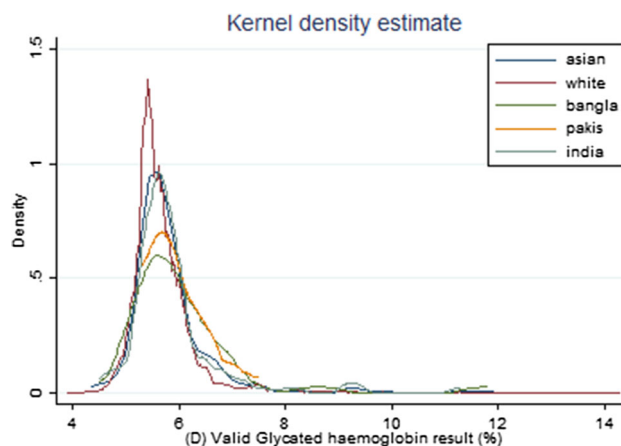
Fig. 1 Kernel density estimate. kernel = epanechnikov, bandwidth = 0.1362

HbA1C higher among those of Asian ethnicity relative to Whites but the distributions are also quite different among specific ethnic Asian groups. The distribution of Asian's HbA1C is typically centred to the right of those for Whites, for example, while the distribution for Bangladeshis exhibits a heavier tail than that for Pakistanis. In Table 1 descriptive statistics reveal that incomes among Pakistanis and Bangladeshis is significantly lower than those of Indians and Whites, the latter also tending to have higher levels of education.

In Table 2 the concentration indices in which equivalised household income is used as a ranking variable and undiagnosed and poorly controlled diabetes are used as health outcomes are presented. Small sample sizes precluded the estimation of indices for each specific ethnic group regarding undiagnosed disease. As the table shows, however, distinct patterns between Whites and Asians exist and regarding poorly controlled diabetes distinct patterns are evident among different ethnic groups of South-east Asians. While a pro-poor gradient is exhibited regarding poor control for Whites and Indians for example (that is, more poor Whites and Indians relative to their representation in the sample have poorly controlled disease), there is no significant gradient regarding Pakistanis and a pro-rich gradient is evident regarding Bangladeshis.

In Table 3 the results of a series of logistic regression analyses are presented. Regarding undiagnosed disease and controlling for having seen a GP in the past 12 months, those of Asian ethnicity, those who are older, who are male and who have a higher BMI are seen to be more likely to have undiagnosed disease compared to the relevant comparator groups. Those who have higher incomes are less likely to be undiagnosed compared to those with lower incomes. Regarding poorly controlled disease and again controlling for having seen a GP in the past 12 months, those who are Indian, Pakistani and Bangladeshi are seen to be more likely to have poorly controlled disease compared to Whites. While Blacks are also more likely to have poorly controlled disease this only attains borderline significance. Those who are better educated and those with higher incomes are seen to be less likely to have poorly controlled disease compared to those less well educated and those with lower incomes. As with undiagnosed, those who are older and with higher BMI are more likely to have poorly controlled diabetes. Confirmatory analysis of undiagnosed and poorly controlled disease are reported in Table 5 of Appendix 1. As can be seen Asians remain more likely to experience undiagnosed disease relative to Whites adjusting for Chinese and Indian specific BMI thresholds. For glycaemic control, Pakistanis and Indians with diabetes remain significantly less likely to exhibit glycaemic control than Whites. While Bangladeshis appeared more likely to exhibit poor glycaemic control this failed to attain statistical significance.

Table 1 Sample descriptive statistics

Income	Median	Mean	Confidence interval	
Whites	24,718.31	33,612.67	32,979.14	34,246.20
Asians	17,769.78	27,664.03	25,249.65	30,078.41
Bangladesh	9919.68	12,023.68	9684.823	14,362.54
Pakistani	13,307.09	20,095.06	15,542.9	24,647.22
Indians	25,514.02	34,608.66	30,471.51	38,745.81

Variable	Obs	Mean	SD	Min	Max
Having visited GP	8696	0.7832	0.4121	0	1
Age group					
25–34	8795	0.1806	0.3847	0	1
35–44	8795	0.1532	0.3602	0	1
45–54	8795	0.2543	0.4355	0	1
Education	8764	0.2708	0.4444	0	1
BMI	8798	25.9056	6.1745	12.4421	63.0914
Smoke					
Ex-occasional smoker	8725	0.3221	0.4673	0	1
Never smoker	8725	0.4834	0.4998	0	1
Ethnic					
Black	10,946	0.0293	0.1687	0	1
Asian	10,946	0.0732	0.2604	0	1
Mixed	10,946	0.0200	0.1400	0	1
Any other	10,946	0.0092	0.0956	0	1
Male	10,980	0.4577	0.4982	0	1
Tertile of income					
Second tertile	8790	0.3226	0.4675	0	1
Highest tertile	8790	0.3373	0.4728	0	1

DISCUSSION

Previous work has shown that in the UK, Asians are at greater risk of their diabetes going undiagnosed and when diagnosed of it being poorly controlled [13, 20, 21]. This is reflected to an extent in current guidance on screening where NICE [22] suggest that GPs and practice nurses "…should…consider a blood test for those aged 25 and over of South Asian or Chinese descent whose body mass index (BMI) is greater than 23 kg/m" [22]. Our analyses reveal that despite this guidance in 2013 Asians remained more likely to have undiagnosed diabetes than Whites and among those with diagnosed diabetes there is evidence that Indians, Pakistanis and Bangladeshis in particular were more likely to exhibit poor glycaemic control. That in both

Table 2 Concentration indices regarding diabetes control and diagnosis by ethnic group

Poorly controlled group	Concentration index	Confidence interval		N
Poorly controlled (Bangladesh)	0.09375	0.0406	0.1470	32
Poorly controlled (Pakistani)	−0.1600	−0.3455	0.0255	10
Poorly controlled (Indians)	−0.0400	−0.0615	−0.0215	68
Poorly controlled (Asians)	−0.01951	−0.0273	−0.0117	167
Poorly controlled (Whites)	−0.0528	−0.5283	−0.0525	3447
Undiagnosed (all)	−0.0543	−0.0547	−0.0540	3747
Undiagnosed (White)	−0.0429	−0.0433	−0.0426	3447
Undiagnosed (Black)	−0.0048	−0.0099	0.0195	65
Undiagnosed (Asian)	−0.0719	−0.0780	−0.0658	167

instances elevated risks existed in regressions where contact with doctor services was controlled for indicates that this is not simply an issue of potentially lower service uptake by these groups but also of the manner in which these groups are served.

Regarding undiagnosed disease, as seen in Table 3, the magnitude of the penalty experienced by Asians is significant and independent of age and BMI. (These results are supported by confirmatory analysis reported in Table 5 "Appendix 1".) The marginal effect of Asian ethnicity on risk of undiagnosed disease is equivalent to approximately 14 BMI points. That is, it is equivalent to moving someone from underweight to obese. Given the effects of ethnicity are independent of age and BMI, it is debatable whether the ethnicity risk premium is appropriately reflected in current guidance, which refers to *consideration* being given to testing *conditional* on age and BMI. In short, it could be argued that advice might usefully be rephrased as "GPs and practice nurses should offer a blood test to persons of South Asian or Chinese descent regardless of age and BMI status". While such a change would require an assessment of its cost effectiveness and budgetary impact, it seems reasonable that it should at a minimum be investigated.

Regarding the management of diabetes, as seen in Table 3, currently those of Indian, Pakistani and Bangladeshi descent exhibit poorer glycaemic control relative to Whites controlling for age, BMI and socio-economic status. (These results are largely supported by confirmatory analyses in Table 5 of the "Appendix 1". While the result regarding Bangladeshis failed to attain statistical significance this may indicate a poorer correlation in risk between Indian-specific BMI thresholds and disease risk among Bangladeshis.) Again the extent of elevated risk can be assessed by comparison with the change in BMI that would be required to raise risk by an equivalent amount. In Table 3 with respect to diabetic Pakistanis, the marginal effect of their ethnicity on having an HbA1C measure that exceeds 6.5% is equivalent to a change in BMI of approximately 46 BMI points (moving from underweight to extreme obesity).

Given this, it is questionable whether current incentives contained within the UK's Quality Outcomes Framework are sufficient or are sufficiently targeted to address poor glycaemic control among several Asian groups.

As with the failure to detect diabetes, failure to control blood sugar among diabetics will impact directly on the economic burden of the disease and on the distribution of that burden. In the UK, the estimated cost of diabetes in 2010/11 was £23.7 billion of which £9 billion was estimated to be born directly by patients and their families in the form of higher absenteeism, presenteeism, informal care and mortality [11]. It seems reasonable to conclude that

Table 3 Logistic regression analyses

Variables	Undiagnosed diabetes margins	Poorly controlled diabetes margins
visit_GP	0.0114 (0.00789)	0.0273** (0.0107)
Age group (ref.: 16–44)		
45–54	0.0132** (0.00621)	0.0215*** (0.00762)
55–64	0.0327*** (0.00872)	0.0379*** (0.00922)
65+	0.0416*** (0.00878)	0.0709*** (0.00977)
Education (age person finished continuous full-time education ≥19)	−3.72e−05 (0.00751)	−0.0217** (0.00986)
BMI	0.00327*** (0.000546)	0.00461*** (0.000620)
Ex-occasional/regular smoker	−0.0147 (0.00988)	0.00557 (0.0103)
Current smoker	−0.0143 (0.00981)	−0.00210 (0.0100)
Ethnicity (ref.: whites)		
Black		0.0777* (0.0434)
Indian		0.142*** (0.0522)
Pakistani		0.212*** (0.0735)
Bangladeshi		0.284** (0.129)
Chinese and other Asian		0.0194 (0.0453)
Chinese		
Other asian		
Mixed		−0.00998 (0.0255)
Any other		0.0451 (0.0715)
Male	0.0154*** (0.00580)	0.0210*** (0.00698)
17,402–34,788	0.00254 (0.00752)	−0.00294 (0.00860)
>34,788	−0.0162** (0.00686)	−0.0178** (0.00866)
Black	0.0188 (0.0199)	
Asian	0.0467*** (0.0121)	
Observations	3205	3408

Note: margins report average partial effects. Figures in parentheses report standard errors
*** Significant at $p < 0.01$; ** significance at $p < 0.05$; * significance at $p < 0.1$

a substantial proportion of this burden might be avoided if the disease is detected earlier and effective management adopted before complications associated with it can accumulate [8, 10, 34]. This has the potential to reduce both the burden of disease and disparities in the distribution of that burden. As with diagnosis, using ethnicity to help target disease management efforts would have to be assessed in terms of its cost effectiveness and budgetary impact. As with diagnosis, however, that such a policy should be investigated seems reasonable.

Consideration of our results regarding concentration indices alongside regression analyses provides potentially valuable insights into the source of difference between ethnic groups. Both Asians and Whites exhibit a pro-poor pattern of undiagnosed disease, that is, one in which those who are less well off are over-represented among undetected diabetics relative to their representation in the population. This indicates a role for poverty in the failure to detect diabetes, an inference supported by the statistical significance of income in the regression analysis. The picture may be somewhat more complex than this though. Thus while the concentration index among Asians is significantly higher in absolute terms than that for Whites—suggesting poverty among Asians may have a particularly deleterious effect—the heterogeneous experience of Asians regarding glycaemic control may well be mirrored in respect to undiagnosed disease. Sample size meant it was not possible for us to pursue this line of enquiry but it is one that warrants further research.

As noted by Rhodes et al. [27], with specific reference to Bangladeshi diabetics, language, culture and poverty may combine to present particular barriers in terms of both access to care and the quality of care received when accessed. The ability to afford transport, prolonged visits to Bangladesh during which access to ongoing care may not be possible as well as cultural issues around women attending clinics were cited as issues in access and quality of care. Such issues may present differential barriers to those who are relatively more recent migrants to England than those who have a more established history in the country. It is notable, for example, that among South-east Asians, in terms of waves of migrants Indians preceded Pakistanis who in turn preceded Bangladeshis to the UK [24]. This sequence mirrors the rank order of marginal effects in diabetes control suggesting not just language but assimilation more generally may contribute to differences between ethnicities in observed glycaemic control. Unfortunately, it was not possible to explore the relationship among migration history, diagnosis and glycaemic control with the data available in the Health Survey for England

as information on how recently families migrated was not recorded. This area though does offer a potentially fruitful line of future investigation.

Beyond ethnicity the negative association among disease control, income and education after controlling for use of GP services are consistent with the predictions of the Grossman health investment model [6]. This model predicts that as income increases and/or as education increases so too will investments in health. The relative magnitude of the two marginal effects in this case is instructive. Finishing education after 19 years of full-time education compared to earlier was more than equivalent to a move from the lowest to the highest income tertile (a change that would involve approximately £17,386 per annum in this sample). This suggests that in terms of its impact on health, education has a larger effect than income. These findings regarding the relative magnitude of education and income are consistent with those of other authors who show education to have a higher impact on health [3, 35] and health-improving behaviours [3]. They also underscore the limitations of healthcare as a means of addressing broader socio-economic disparities though. Whether more forceful screening strategies, health promotion and aggressive disease management framed around personalised medicine can address some of the disparities noted in this study warrants further investigation.

CONCLUSIONS

This article has demonstrated that after controlling for use of GP services Asians are at higher risk of undetected diabetes than are Whites in England. It has shown that among Asians distinct patterns in glycaemic control are evident with those of Pakistani and Indian descent experiencing particular disadvantage and evidence indicating this may also extend to Bangladeshis. Our analysis suggests that current guidance on screening for diabetes may not adequately reflect the relative risks experienced by ethnic minorities and barriers may exist that limit the effectiveness of current practice

regarding glycaemic control. Our findings on socio-economic status, however, also underscore the limitations of healthcare to address inequalities whose origins reflect broader inequalities in society related to education and incomes.

ACKNOWLEDGEMENTS

Disclosures. Mimi Xiao and Ciaran O'Neill have nothing to disclose.

Compliance with Ethics Guidelines. This article is based on previously conducted studies and does not involve any new studies of human or animal subjects performed by any of the authors.

Data Availability. The data sets generated during and/or analysed during the current study are available in the UK Data Archive repository http://www.data-archive.ac.uk.

APPENDIX 1

See Tables 4 and 5.

Table 4 Definition of variables used in regression analyses

Variable	Definition
Visited GP	Having visited GP in the past 12 months
Age group	16–24
	25–34
	35–44
	45–54
Education	Age person finished continuous full-time education. =1 if ≥19
BMI	Body mass index
Smoking status	Never smoker
	Ex-occasional smoker
	Never smoker
Ethnic	Black
	Asian
	Mixed
	Any other
Gender	Male = 1
Tertile of income	Lowest tertile (≤17,402)
	Second tertile (17,402–34,788)
	Highest tertile (>34,788)
BMI categories	
Others[1]	
Underweight	Below 18.5
Normal weight	18.5–24.9
At risk (overweight)	25–29.9
At higher risk (obese)	30+
Chinese[1]	
Underweight	Below 18.5
Normal weight	18.5–22.9
At risk (overweight)	23–27.49

Table 4 continued

Variable	Definition
At higher risk (obese)	27.5+
Indian, Pakistani, Bangladeshi[2]	
Underweight	<18
Normal weight	18–22.9
At risk (overweight)	23–24.9
At higher risk (obese)	25+

[1] [37]
[2] [19]

Table 5 Logistic regression analyses

Variables	Undiagnosed margins	Poor margins
Visit_GP	0.0174** (0.00800)	0.0353*** (0.0112)
Age group (ref.: 16–44)		
45–54	0.0132** (0.00579)	0.0266*** (0.00775)
55–64	0.0359*** (0.00898)	0.0426*** (0.00945)
65+	0.0409*** (0.00848)	0.0752*** (0.00935)
edu	−0.00628 (0.00743)	−0.0254** (0.0101)
Obesity status (ref.: underweight/normal weight)		
Over	0.00300 (0.00511)	0.00638 (0.00650)
Obese	0.0396*** (0.00742)	0.0654*** (0.00876)
Smoking status (ref.: non-smoker)		
Ex-occasional/ regular smoker	−0.00944 (0.00909)	0.00687 (0.0102)
Current smoker	−0.00836 (0.00886)	−0.000764 (0.00989)

Table 5 continued

Variables	Undiagnosed margins	Poor margins
Ethnicity (ref.: Whites)		
Black		0.0798* (0.0450)
Indian		0.0789** (0.0395)
Pakistani		0.150** (0.0639)
Bangladeshi		0.118 (0.0878)
Chinese and other Asian		−0.00110 (0.0351)
Mixed		−0.00943 (0.0333)
Any other		0.0652 (0.0663)
Male	0.0163*** (0.00569)	0.0175** (0.00700)
Tertile of income (ref.: <17,402)		
17,402–34,788	0.00156 (0.00744)	−0.00576 (0.00856)
>34,788	−0.0153** (0.00670)	−0.0218** (0.00861)
Black	0.0313* (0.0171)	
Asian	0.0351*** (0.0124)	
Observations	3397	3651

Standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

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