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Socio-Economic Determinants of Abdominal Aortic Aneurysm Rupture Incidence: A Nationwide Geospatial Study

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WHAT THIS PAPER ADDS

This 20 year nationwide analysis demonstrates that abdominal aortic aneurysm (AAA) rupture is clustered into geographically defined high risk communities in Aotearoa New Zealand that are identifiable and largely stable over extended time periods, providing opportunities for targeted preventative interventions. The Māori population and communities affected by socio-economic deprivation (SED) bear an excess burden of AAA rupture. This should be considered in the management and implementation of AAA screening and treatment. Most of the national variability observed in AAA rupture incidence can be explained by SED and smoking prevalence. Removing SED was modelled to lower AAA rupture risk by 26%.

Objective: The impact of socio-economic factors on abdominal aortic aneurysm (AAA) rupture are poorly understood at a geospatial level, but they are important considerations in the targeted distribution of preventive resources such as screening and treatment. This study aimed to map the nationwide geospatial distribution of AAA ruptures in Aotearoa New Zealand and to analyse associations with socio-economic factors.
Methods: A nationwide, retrospective, geospatial analysis of all AAA ruptures between January 2000 and December 2019 in Aotearoa New Zealand was performed using national registry mortality and hospitalisation data within a Bayesian framework. Standardised incidence ratios (SIRs) of AAA rupture were calculated for populations grouped by socio-economic factors (deprivation, ethnicity, and urban accessibility). Geospatial analysis was performed using Bayesian Poisson regression modelling to provide smoothed estimates of AAA rupture incidence at the small community level. The association between rupture incidence and small area level smoking rates, Māori population proportion, urban accessibility, and socio-economic deprivation (SED) was examined through geospatially linked data.
Results: Over the 20 year study period, 5 942 fatal and non-fatal AAA ruptures were identified. High AAA rupture incidence was geospatially clustered into persistent hotspots. SED (coefficient 3.39, 95% credible interval [CrI] 2.38 – 4.49) and smoking prevalence (coefficient 1.14, 95% CrI −0.03 – 2.27) were associated with increased AAA rupture incidence and this was persistent over the study, despite the AAA rupture incidence falling from 1.05/1 000 person years (95% CrI 0.60 – 1.85) in 2000 – 2006, to 0.65/1 000 person years (95% CrI 0.38 – 1.13) in 2013 – 2019. SIRs were elevated in socio-economically deprived, Māori, and rural communities.
Conclusion: AAA rupture is clustered into geographically defined and persistent high risk communities in Aotearoa New Zealand. High deprivation communities bear an excess burden of AAA rupture, as do the indigenous Māori population, consistent with entrenched health inequities following colonisation. This should inform the management and implementation of AAA screening and treatment.

Keywords: Abdominal aortic aneurysm, Māori health, Rural health, Screening, Socio-economic deprivation, Spatial epidemiology
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INTRODUCTION

In Aotearoa New Zealand (NZ), abdominal aortic aneurysm (AAA) rupture causes 200 − 400 deaths and over 1 000 hospitalisations annually, with the highest dollar cost per admission of any cardiovascular condition, leading to service costs of NZD$25 million annually.[1]

The indigenous Māori population of NZ have higher AAA prevalence than NZ Europeans (3.6% *vs.* estimated 1.4%), with rupture occurring 8.3 years earlier.[2,3] In response, NZ surgeons use a lower repair threshold (50 mm *vs.* 55 mm) for Māori men.[4]

The mechanisms driving AAA related inequity are unclear; however, they are not believed to be due to any underlying biological difference, but rather differential exposure to risk factors owing to the ongoing effects of colonisation and systemic racism.[2,3,5−7] NZ Māori experience greater socio-economic deprivation (SED), higher smoking rates, poorer health service accessibility, lower rates of referral to specialist health services, and poorer quality of care.[5,8−10] Residing rurally, which is more common among Māori, further limits access to vascular and radiology services.[11,12]

SED and healthcare access are recognised determinants of cardiovascular disease outcomes.[13−16] These factors are known to be geospatially clustered, leading to geographical hotspots of elevated risk of diseases such as diabetes, cardiovascular disease, and cancers.[13,17−23] It follows that deprived and low health service access communities might experience elevated AAA rupture risk, but this is poorly understood.

The 2024 European Society for Vascular Surgery (ESVS) guidelines state that a poor understanding of the role of SED on AAA incidence as a limitation requiring further study.[24] They cite a single study from England that found no difference in the incidence of *all* AAA presentations between deprivation groups.[25] However, this analysis probably obscured socio-economically driven variations in AAA rupture risk by grouping stable low risk and clinically important AAA incidence. In an unscreened population such as NZ, where only 30% of ruptures are in patients with an existing AAA diagnosis, inequities in AAA rupture rates may identify communities that stand to derive the greatest benefit from national screening.[26] Contemporary studies from the UK, USA, and Sweden have shown that men from more socio-economically deprived areas are more likely to present with a ruptured than an intact AAA. This requires confirmation through more sophisticated analysis accounting for multiple confounding socio-economic factors such as smoking rates and ethnicity.[27−30]

A UK style screening programme would be cost effective in NZ and was approved in principle in 2016 but remains unimplemented.[31,32] Male AAA screening programmes remain cost effective internationally.[30,33−37] While screening in women has been viewed as not cost effective in Europe and elsewhere, a population study of 1 526 Māori women found an AAA prevalence similar to European men, and a prevalence of 9% in currently smoking $>$ 65 year olds.[3]

Improving understanding of the geospatial distribution of AAA rupture risk and the association with socio-economic factors across a country could facilitate a more informed approach to AAA screening design, ensuring fair access for high risk communities to achieve equitable disease outcomes. Within NZ, this may improve understanding of the increased AAA risk seen in Māori. It is hypothesised that elevated AAA rupture rates are associated with geospatial patterning of higher SED and poorer healthcare service accessibility.

METHODS

Study design and setting

This was a retrospective, nationwide, cross sectional analysis of all AAA documented ruptures occurring between January 2000 and December 2019 in NZ. It was reported using the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE)[38] and REporting of studies Conducted using Observational Routinely collected health Data (RECORD) guidelines. The study used secondary registry data that contain non-identifiable patient data. The Health and Disability Ethics Committee deemed the study low risk. Data were collected between November 2021 and February 2022 and analysis was completed in January 2024. AAA rupture rates were initially analysed non-spatially, followed by a geospatial analysis of their national distribution.

Participants

Documented fatal and non-fatal AAA ruptures were extracted from the NZ National Minimum Dataset of Hospitalisations (NMDS) and the National Mortality Collection using International Classification of Diseases, Tenth Revision (ICD-10) codes (I71.3, abdominal aortic aneurysm, ruptured; I71.52, paravisceral aneurysm of the thoraco-abdominal aorta, ruptured). These national datasets include all public and private hospital discharges and deaths, including primary diagnosis, secondary diagnoses, comorbidities, Census Area Unit (CAU) of residence, and interventions.[39,40] Data were cleaned and formatted for analysis using Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

Population at risk

The sex specific population at risk was expressed as the mean 1 000 person years of the $\geq$ 55 year old population from the 2001, 2006, 2013, and 2018 censuses multiplied by the 20 years in the study period.

Study area

For non-spatial analysis, the study area was the whole of NZ. For spatial analysis, the population was divided into CAUs based on the 2013 boundaries produced by Statistics NZ.[41] These represent communities that interact together socially and economically; each area has an average population of 600.[41]

Variables and data sources

Outcomes. The primary outcome was the mean posterior estimated incidence of AAA rupture. For non-spatial analysis, rates were calculated for the whole NZ population grouped by independent variables (see below) and compared through indirectly standardised incidence ratios (SIRs). For geospatial analysis, incidence was calculated for each CAU and analysed against CAU level independent variables.

Independent variables. The independent variables were area level SED, smoking prevalence, Māori population proportion, and urban accessibility (UA). SED was obtained from the NZ Deprivation Index 2013,[42] which gives a numerical score of SED based on nine validated census derived variables, including income, employment status, academic qualifications, home ownership, living space, and living conditions. Higher scores indicate higher SED.[42] The SED score was used for spatial analysis. For non-spatial analysis, CAUs were grouped by SED deciles, with decile ten representing the most deprived areas. The highest three deciles were compared with the lowest three deciles. Smoking prevalence was calculated as the mean percentage of current and past smokers within the population at risk in each CAU from the 2006, 2013, and 2018 national censuses (2001 data were unavailable). The Māori population proportion was given as the mean percentage of the population at risk self identifying as Māori through prioritised ethnicity classification from the 2001, 2006, 2013, and 2018 censuses. UA refers to the geographical accessibility of CAUs to urban areas based on driving time from the population weighted centre of each CAU to the outskirts of the nearest major urban centre; the 2018 classification was used.[43] UA is provided as eight groups numerically coded 1 – 8 (inland water, very remote, remote, low urban accessibility, medium urban accessibility, high urban accessibility, medium urban area, and large urban area), with 1 being the most remote. For non-spatial analysis, UA was grouped into low (UA 1 – 3) and high (UA 5 – 8) accessibility. UA was used as a proxy for specialist health service accessibility because in NZ all specialist vascular and AAA surveillance services are centralised to major urban areas (UA group 8).

Data linkage. Data, including patient residential location, were linked by CAU identification numbers.

Data validation. The NMDS AAA hospital procedure data from 2013 – 2019 used in this study have previously been found to have excellent agreement with the Australasian Vascular Audit of vascular procedures regarding patient age (97.5%) and sex (98.9%).[44] The NZ Deprivation index has undergone extensive validation and is used extensively in population research and policy development.[42,45]

Statistical analysis

All modelling was conducted within a Bayesian framework, which is optimal for applying multiparameter models to complex multifaceted phenomena.[46] All analyses were performed in R statistical software v4.1.2 (R Core Team 2021, Vienna, Austria)[47] using the SpatialEpi, R2WinBUGS, and Leaflet packages.[48–50]

Non-spatial nationwide analysis. Nationwide AAA rupture rates were calculated and compared between Māori and non-Māori, low and high SED, and low and high UA groups using SIRs.[51] Posterior means for standardised rupture incidence for each group were estimated from 1 000 simulations using a gamma posterior distribution. Bayesian *P* values are reported, where, contrary to classical *P* values, values closer to 1 indicate a true difference.

Spatiotemporal statistical analysis. The NZ population was disaggregated into CAUs, and the study period was divided into three time intervals: January 2000 – December 2006, January 2007 – December 2012, and January 2013 – December 2019.

Conditional autoregressive modelling. To estimate AAA rupture rates across CAUs, a Bayesian Poisson regression model with spatial smoothing, also known as a conditional autoregressive model, was used.[46] This approach is commonly used in public health to analyse rare outcomes such as AAA rupture in small populations.[52] In these cases, incidence rates can appear artificially high or low in some areas just by chance. The conditional autoregressive model reduces this random noise by smoothing estimated rates based on rates in neighbouring areas. The resultant smoothed estimates are more stable and reflect the probable underlying geographical patterns in rupture risk, rather than random variation.

Model performance was assessed using the deviance information criterion (DIC), with smaller values corresponding to the better models, and a difference of at least three considered substantial.[53]

The model was fitted using the WinBUGS software and the R2WinBUGS package.[54] A total of 5 000 iterations were run, with the first 1 000 discarded as a burn in, and then every fourth kept for posterior inference. All the variables were centred and scaled to facilitate convergence. Convergence was visually assessed via the trace and posterior density plots.

RESULTS

Overall, 5 942 fatal ($n = 4\,468$) and non-fatal ($n = 1\,474$) AAA ruptures were identified over the 20 year study period occurring within an at risk population of 1.73 million person years. There were 4 097 male (68.9%) and 1 845 female (31.1%) ruptures. CAU Māori population proportion ranged 0 – 88%, CAU smoking prevalence ranged 0 – 100%, and CAU SED scores ranged 850 – 1 356.

Nationwide non-spatial analysis

Among the at risk population, 6.4% were Māori (1 112 thousand person years) and 7.8% of ruptures occurred in Māori ($n = 463$). The estimated standardised incidence of AAA rupture was 1.35 times higher in Māori than non-Māori

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Table 1. Estimated standardised incidence ratios (SIRs) of abdominal aortic aneurysm (AAA) ruptures per 1 000 person years grouped by independent variables.

Group	Rupture − *n*	Population in 1 000 person years	SIR of AAA rupture (95%CrI)	*P* value*
Ethnicity				
Māori	463	1 112	1.30 (1.18–1.43)	>.999
Non-Māori	5 479	16 170	–	
Social deprivation				
High deprivation†	2 352	5 586	1.64 (1.53–1.76)	>.999
Low deprivation†	1 131	4 408	–	
Urban accessibility				
Low urban accessibility‡	809	2 342	1.03 (0.95–1.10)	.741
High urban accessibility‡	4 674	13 875	–	

SIR = standardised incidence ratio; AAA = abdominal aortic aneurysm; CrI = credible interval; SED = socio-economic deprivation. Estimated age and sex SIRs calculated using the indirect method in a nationwide analysis of 5 942 AAA ruptures in Aotearoa New Zealand. The SIR is given as a ratio of mean posterior estimations of AAA rupture rates between the following groups: Māori *vs.* non-Māori; high deprivation *vs.* low deprivation; and low urban accessibility *vs.* high urban accessibility. The comparative group is shown as –.

* *P* value indicates the probability that the SIR is higher than the comparative group; values close to 1 indicate a high probability of a difference.

† High deprivation = SED deciles 8 − 10; low deprivation = SED deciles 1 − 3.

‡ Low urban accessibility = groups 1 − 3 (inland water, very remote, remote); high urban accessibility = groups 5 − 8 (medium urban area, high urban accessibility, large urban area, major urban area).

(SIR 1.30, 95% Credible Interval [CrI] 1.18 − 1.43; *P* >.999). When examined by SED, 32% of the at risk population (5 586 thousand person years) resided in the highest three deciles of SED and 39.6% of ruptures occurred in this group (*n* = 2 352). The estimated standardised incidence of AAA rupture was 1.64 times higher in the highest three deciles of SED *vs.* the lowest three deciles (SIR 1.64, 95% CrI 1.53 − 1.76; *P* >.999). Moreover, 13.5% of the at risk population (2 342 thousand person years) were in the low urban accessibility group and 13.6% of ruptures occurred in this group (*n* = 809). The estimated standardised incidence of AAA rupture was 1.03 times higher in low urban accessibility CAUs *vs.* high urban accessibility CAUs; however, a lower probability of a true difference was noted (SIR 1.03, 95% CrI 0.95 − 1.10; *P* = .741) (Table 1).

Spatiotemporal analysis

Spatiotemporal trends in incidence. The overall incidence of AAA rupture was estimated to decrease from 1.05/1 000 person years (95% CrI 0.60 − 1.85) in 2000 − 2006 to 0.92/1 000 person years (95% CrI 0.55 − 1.51) in 2007 − 2012, and further to 0.65/1 000 person years (95% CI 0.38 − 1.13) in 2013 − 2019. Mapping exceedance probabilities (Fig. 1) show the probabilities that the estimated incidence for each CAU is above the period specific global average incidence. CAUs close to 100% have almost certainly higher AAA rupture incidence, and CAUs close to 0% have almost certainly lower AAA rupture incidence compared with the national mean. Persistent hotspots of almost certainly elevated AAA rupture incidence across a 20 year period were demonstrated in the northeast and northern tip of North Island, western coast of South Island, southern suburbs of Auckland City, the Wellington region urban centres of Porirua and Lower Hutt, and the eastern suburbs of Christchurch (Fig. 2 − 4). This is not an exhaustive list of all persistent hotspots nationally, rather examples to demonstrate the tendency for geospatial clustering of AAA rupture incidence. An interactive map where specific locations can be viewed in more detail can be found here: https://ajk-87.github.io/AAA-Map/interactive_map.html.

Individual covariable effects. To identify the single best predictor of AAA rupture incidence, models with only one explanatory variable at a time were fitted and compared with a null model including no covariables through comparison of DIC (Table 2, column 3). The single best predictor of AAA rupture incidence was SED score (176.38 reduction in DIC), followed by smoking prevalence (131.15 reduction in DIC), Māori population proportion (63.94 reduction in DIC), and UA (3.84 reduction in DIC).

Multivariable spatial modelling. There was no evidence that covariable effects on rupture incidence changed over time, as a model with time specific coefficients showed no improvement on a model with a single whole study period coefficient (10.71 increase in DIC). There was evidence of interactions between covariables, as a model with interactions showed improved fit compared with a model without (1.46 decrease in DIC). Based on this, for each covariable the final model estimates a single coefficient for the whole study period and includes interactions between covariables.

There was strong evidence of a positive association between SED and AAA rupture incidence with a CrI not containing zero. There was also strong evidence of covariable interaction between SED score and UA and between SED and smoking, indicating a moderating effect (Table 2, column 2).

Removing SED score or smoking prevalence deteriorated the model, as indicated by an increase in DIC of 45.74 and 13.77, respectively (Table 2, column 4). This indicates that

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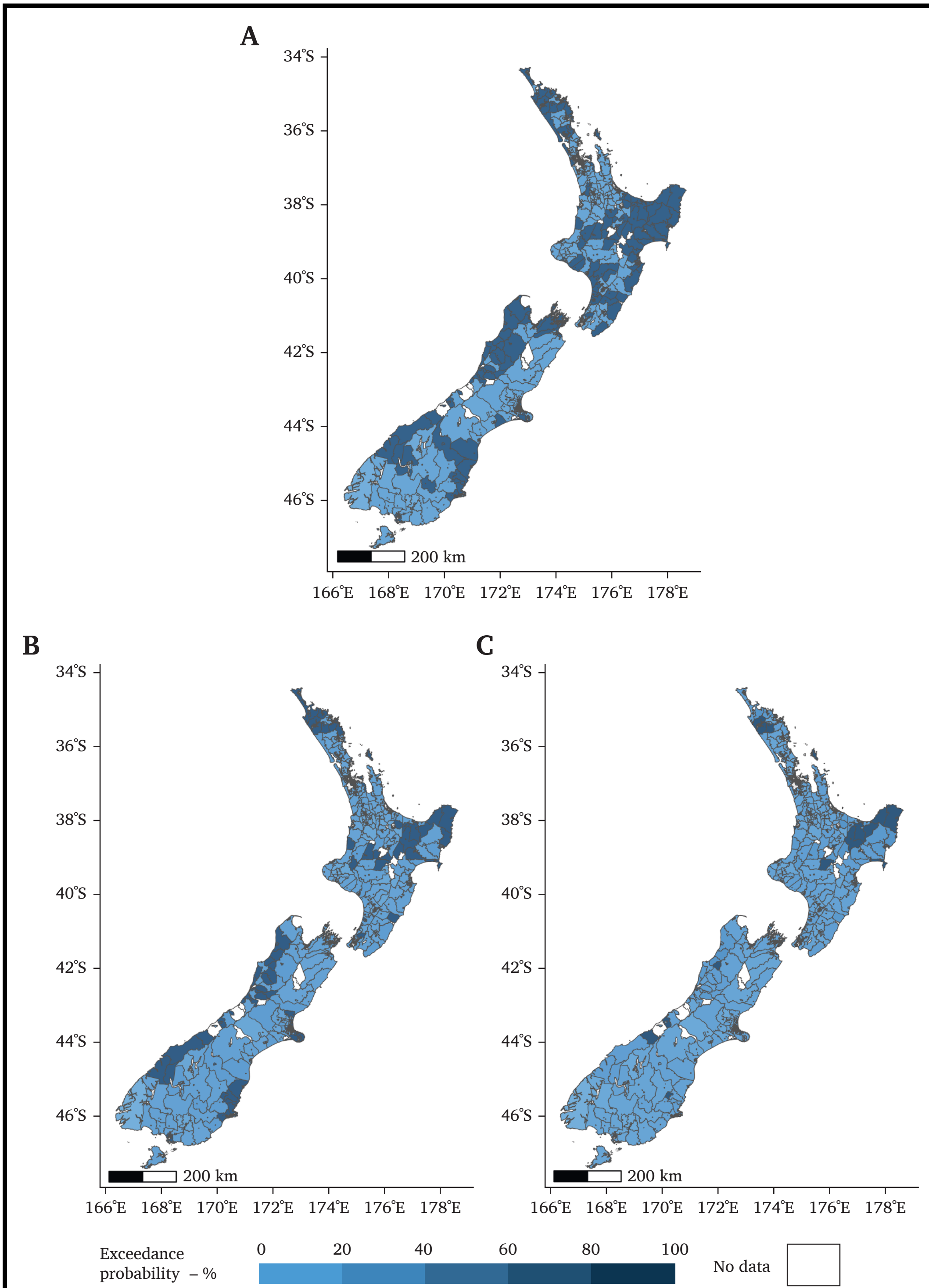

Figure 1. Choropleth maps of exceedance probabilities based on 5 942 abdominal aortic aneurysm (AAA) ruptures nationwide over the 20 year study period. Area disaggregated to census area unit (CAU) level for the three study time periods: (A) 2000 – 2006; (B) 2007 – 2012; and (C) 2013 – 2019. Exceedance probabilities give the probability that AAA rupture incidence estimated from a Bayesian Poisson regression model (see Methods) for each CAU is above the period specific global average incidence. CAUs close to 1 have almost certainly elevated AAA rupture incidence, and CAUs close to zero have almost certainly decreased AAA rupture incidence compared with the national mean. Low to high estimated rates are represented by light to dark hues, respectively. White areas indicate areas with zero population. Evidence of geospatial clustering of high rupture rates can be appreciated at a national level for all time periods and there are hotspots persistent across the entire 20 year study period in the northeast and northern tip of North Island and the western coast of South Island. Geospatial clustering at a community level is better represented in Figures 2 – 4.

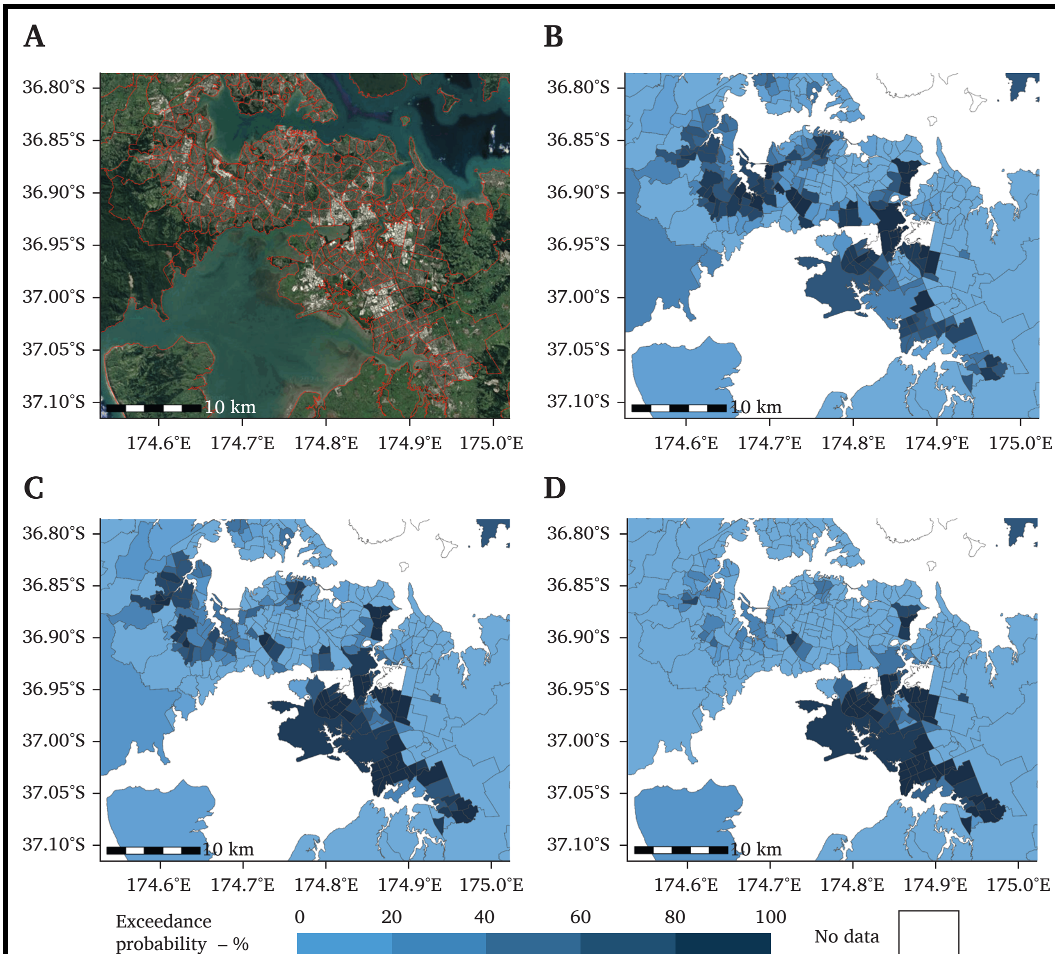

Figure 2. (A) Census area units (CAUs) for Auckland City and the surrounding areas outlined in red. Choropleth maps of exceedance probabilities giving the probability that abdominal aortic aneurysm (AAA) rupture incidence estimated from a Bayesian Poisson regression model (see Methods) for each CAU is above the period specific global average for the three study time periods: (B) 2000 – 2006; (C) 2007 – 2012; and (D) 2013 – 2019. Low to high estimated rates are represented by light to dark hues, respectively. White areas indicate areas with zero population. Evidence of geospatial clustering of high AAA rupture rates can be appreciated with persistent hotspots in the south of the city, while the north city hotspots evident in 2000 – 2006 appear to diminish.

most of the national variability observed in AAA rupture incidence can be explained by SED score and smoking prevalence.

Partial dependence plot. The presence of interactions makes interpretation of the effect coefficients complex. To offer a more readily interpretable analysis of the effects of covariables, a partial dependence plot was produced (Fig. 5). The plot shows how the estimated average country wide AAA rupture incidence would change if area specific SED improved while holding other covariables constant. The starting point corresponds to the actual situation observed during the final 7 year study period (2013 – 2019), and the 100% reduction corresponds to a deprivation score of 850 (lowest possible score) everywhere.

There was an estimated AAA rupture incidence of 0.65/1 000 person years at the end of the study period. Partial dependence plots estimate that with a 25%, 50%, 75%, and 100% reduction in SED score nationwide, rupture incidence would reduce by 9.2% (to 0.59/1 000 person years), 15.4% (to 0.55/1 000 person years), 21.5% (to 0.51/1 000 person years), and 26.2% (to 0.48/1 000 person years), respectively.

DISCUSSION

This nationwide study provides detailed geospatial mapping and analysis of AAA rupture rates and the association with socio-economic determinants of health, specifically SED, smoking prevalence, ethnicity primarily as a surrogate for the ongoing effects of colonisation and racism, and accessibility of urban centred specialist health facilities. Key findings include: (1) a decline in AAA rupture incidence over 20 years; (2) a persistent link between increased SED and higher AAA rupture rates; (3) geospatial clustering of AAA ruptures, with persistent

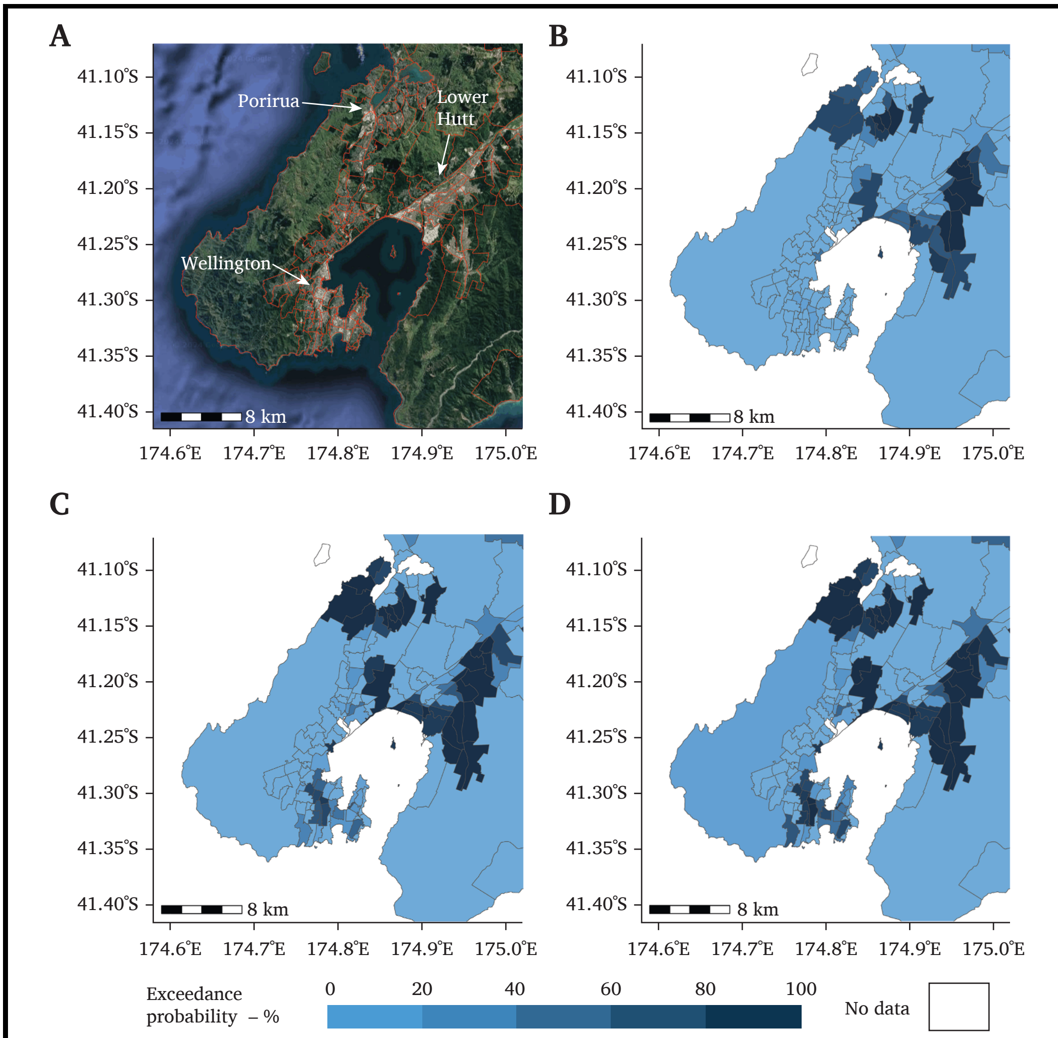

Figure 3. (A) Census area units (CAUs) for the Wellington region including the urban areas of Wellington, Lower Hutt, and Porirua outlined in red. Choropleth maps of exceedance probabilities giving the probability that abdominal aortic aneurysm (AAA) rupture incidence estimated from a Bayesian Poisson regression model (see Methods) for each CAU is above the period specific global average for the three study time periods: (B) 2000 – 2006; (C) 2007 – 2012; and (D) 2013 – 2019. Low to high estimated rates are represented by light to dark hues, respectively. White areas indicate areas with zero population. Evidence of geospatial clustering of high AAA rupture rates can be appreciated with persistent hotspots in the Porirua and eastern Lower Hutt. There are emergency hotspots evident in the central suburbs of Wellington from 2007 – 2019.

hotspots over 20 years; and (4) in univariable analysis, elevated rupture rates in Māori and high SED areas.

The study highlights a socio-economic inequity in AAA rupture risk. It adds to existing literature by controlling for smoking prevalence and the ethnicity, sex, and age structure of the population at risk. Furthermore, it was possible to demonstrate that these trends were consistent over a 20 year period. These strengths greatly enhance the generalisability of the study and support previous evidence of entrenched community level inequities.[5] Recent ESVS guidelines state that AAA "incidence does not increase with increasing socio-economic deprivation";[24] however, they offer no guidance on the influence of SED on AAA rupture incidence specifically, citing significant limitations in the generalisability of the current literature.[25] The findings presented here offer more generalisable data that should be considered in further guidelines to prompt enhanced focus on socio-economic risk factors in primary prevention and screening approaches to address inequitable rupture rates. These findings also raise the question of whether elevated rupture rates are reflective of elevated prevalence, or other factors influencing rupture risk in these communities. This requires further investigation at the patient level into the mechanisms linking AAA rupture risk with SED,[13] answering calls for an increased focus on the influence of wider determinants of health on cardiovascular disease outcomes and AAA epidemiology.[14,15,24]

The study corroborates strong existing evidence of elevated AAA rupture risk in Māori,[2–5] although no association was found when controlling for SED and smoking. While the association with smoking is unsurprising, the

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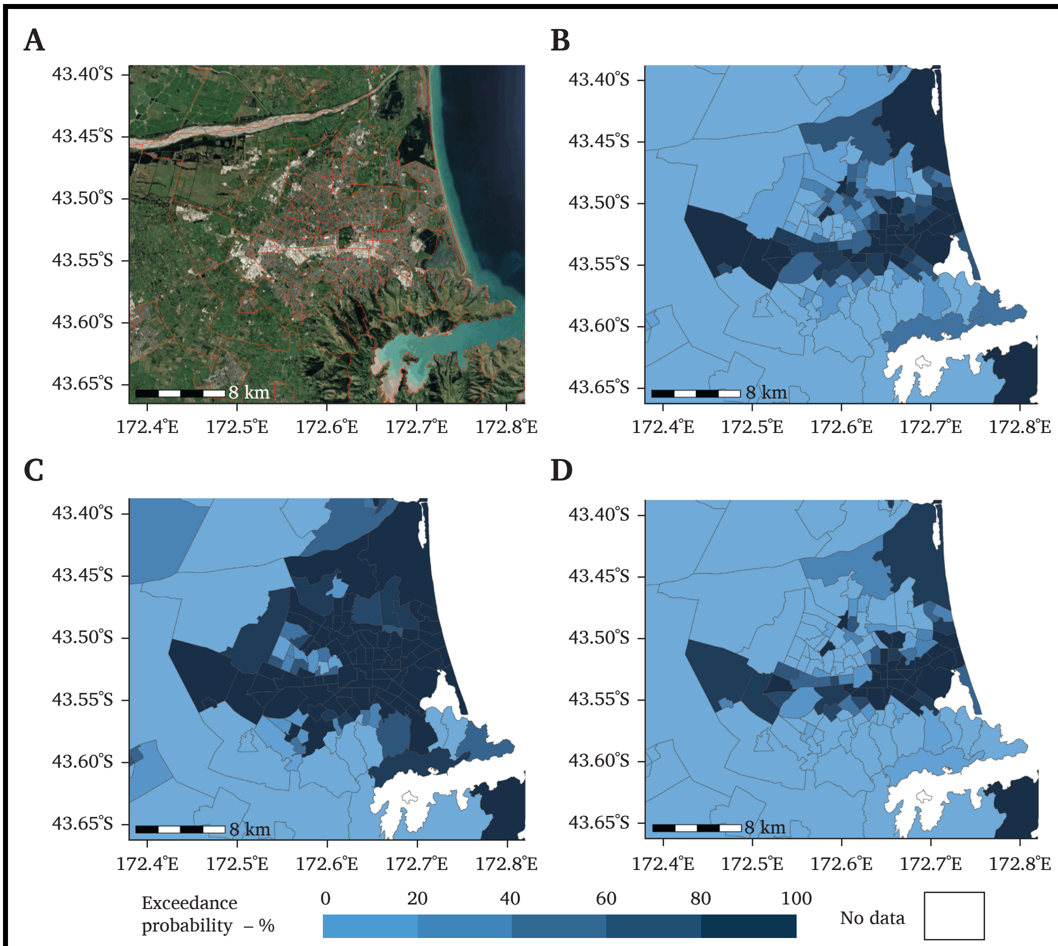

Figure 4. (A) Census area units (CAUs) for Christchurch city and the surrounding area outlined in red. Choropleth maps of exceedance probabilities giving the probability that abdominal aortic aneurysm (AAA) rupture incidence estimated from a Bayesian Poisson regression model (see Methods) for each CAU is above the period specific global average for the three study time periods: (B) 2000 – 2006; (C) 2007 – 2012; and (D) 2013 – 2019. Low to high estimated rates are represented by light to dark hues, respectively. White areas indicate areas with zero population. Evidence of geospatial clustering of high AAA rupture rates can be appreciated with persistent hotspots in the southeast–central and eastern suburbs of the city. There are transient hotspots evident in the central and northeastern suburbs of the city in 2007 – 2012 only.

moderating influence of SED generates the hypothesis of SED having a role in driving the elevated AAA rupture risk in Māori at the ecological level.[4] This relationship requires confirmation at the individual level (e.g., through case control studies). SED driven elevated AAA risk in Māori would be in line with widely reported poorer health outcomes due to ongoing effects of colonisation and racism in the absence of any genetic predisposition to elevated AAA risk.[5,55] Māori supported the enactment of world leading tobacco control measures, which were expected to disproportionately benefit Māori health but were reversed by the current government.[5,56,57]

The study improves on weak existing evidence of broad geospatial segregation of AAA rupture risk in Germany and Sweden[58,59] by demonstrating persistent hotspots in much smaller communities of approximately 600 people (CAUs) that are stable over decades. The use of fine level geospatial modelling is a novel approach in AAA epidemiology. This approach may facilitate more targeted policy response such as distribution of AAA screening resources with emphasis on ensuring fair access for high SED and Māori communities that have historically suffered poorer access to specialist preventative health measures.[9,11,20,23]

This study had several limitations, including the retrospective use of registry datasets. Underdiagnosis of AAA deaths is a potential cause of bias.[60] NZ has comparatively low post mortem rates,[61] and internationally there is evidence of lower post mortem rates in rural populations.[62] However, the rate of misclassification of AAA deaths is unknown, which is an intrinsic limitation of research using registry data. Validation of these data against the NZ Vascular Audit suggests that the risk of misclassification is very low.[44]

SED was taken from a single timepoint (2013) as a midpoint measure, so variations in SED during the study period are not accounted for. Ethnicity data were analysed as prioritised single ethnicity, which has limitations because

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Table 2. Mean estimated Bayesian Poisson regression coefficients for covariable effects on abdominal aortic aneurysm (AAA) rupture incidence and interactions between covariables. Model comparisons using deviance information criterion (DIC) to identify best predictors of AAA rupture incidence.

	Mean estimated posterior coefficient (95% CrI)	Change in DIC when included as the single predictor*	Change in DIC when removed from model†
Covariable effects			
Deprivation score	3.39 (2.38–4.49)	−176.38	45.74
Māori prevalence	−0.35 (−1.41 – 0.61)	−63.94	−9.58
Urban accessibility	0.07 (−0.18–0.32)	−3.84	−3.58
Smoking prevalence	1.14 (−0.03–2.27)	−131.15	13.77
Interactions			
SED:UA	−4.57 (−7.79 - −1.48)	–	–
SED:M	−1.82 (−7.16–3.31)	–	–
SED:S	−12.26 (−19.41 - −5.30)	–	–
M:UA	1.99 (−0.35–4.49)	–	–
M:S	7.36 (−0.24–14.82)	–	–
UA:S	−0.73 (−4.06–2.61)	–	–

CrI = credible interval; DIC = deviance information criterion; SED = socio-economic deprivation; M = Māori prevalence; UA = urban accessibility; S = smoking prevalence.

Column 2: mean posterior coefficients for effect of covariables on area level abdominal aortic aneurysm (AAA) rupture incidence and interactions between covariables in a national analysis of 5 942 AAA ruptures in Aotearoa New Zealand using a Bayesian Poisson regression model with spatially autocorrelated residuals. Columns 2 and 3: analysis of covariable effects through comparison of DIC. A reduction in DIC implies improvement.

* Change in model fit when added to the intercept only model as a single predictor.

† Change in model fit when removed from the final model with all the relevant interactions. An increase in DIC implies deterioration of the model when removed, and *vice versa*. Changes of at least three are considered substantial.

11% of the NZ population identify with multiple ethnic groups. There were no data on the intensity or duration of smoking.

Conclusion

This nationwide analysis showed that AAA rupture rates are geospatially clustered and linked to SED. The influence of SED on AAA rupture risk at the individual level is an important area for future research. The geospatial and demographic distribution of AAA ruptures should be considered in efficacy modelling and outreach strategies of AAA screening design to reduce inequities. Tobacco control should be enacted to reduce AAA risk.

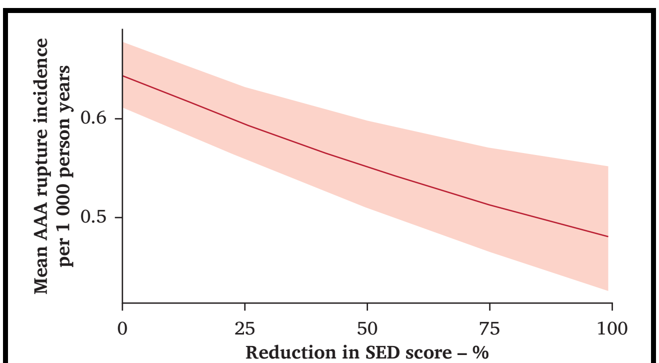

Figure 5. Partial dependence plot showing the estimated average nationwide incidence of abdominal aortic aneurysm (AAA) rupture and 95% credible interval (shaded area) if area specific socio-economic deprivation (SED) improved while holding other factors constant. The starting point corresponds to the situation observed during the final seven year study period, and the 100% reduction corresponds to a SED score of 850 (lowest score) everywhere.

CONFLICTS OF INTEREST

None.

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