Is ethnicity an independent predictor of health need? Linked cohort logistic regression analysis to predict amenable mortality

Andrea Teng, Melissa McLeod, Sue Crengle

ABSTRACT

AIM: This study examines whether ethnicity is an independent marker of health or if ethnic disparities are fully explained by age, sex, rurality, socio-economic position and morbidity.

METHOD: Using the Stats NZ Tatauranga Aotearoa Integrated Data Infrastructure, we identified the resident population of Aotearoa New Zealand each year from 2009 to 2018, establishing 10 cohorts that were followed up with at 12 months for amenable mortality, i.e., deaths from conditions responsive to healthcare in under-75-year-olds. Age, sex, ethnicity, rurality, small area deprivation, personal income and morbidity of cohort members were described. Logistic regression analyses and likelihood ratio tests were used to assess the independent association of these variables with amenable mortality.

RESULTS: Ethnicity, socio-economic position and morbidity, along with age, sex and rurality, made significant independent contributions to predicting amenable mortality. Ethnicity predicted amenable mortality after adjusting for other variables. Compared with Europeans, the odds of amenable mortality were 1.46 (95% confidence interval [CI] 1.43–1.50) times greater in Māori and 1.18 (95% CI 1.14–1.23) times greater in Pacific and half as likely in Asian (0.54, 95% CI 0.52–0.57).

CONCLUSION: Māori and Pacific ethnicity, and also socio-economic position and morbidity, are independent markers of health need relevant to the distribution of health resources and targeting of health services.

The inclusion of ethnicity alongside deprivation, morbidity and rurality in the design and delivery of health services and programmes, health resourcing and targeting has been politically contested. The Aotearoa New Zealand Cabinet issued a directive in 2024 restricting the use of ethnicity as a measure of need for targeting services, requiring strong rationale, efficacy, consideration of other markers of need and evaluation.[1] Public health experts, however, have cited extensive evidence for ethnicity as a marker of health need and its importance for targeting services.[2]

Current and intergenerational racism has been cited as the “basic” cause of ethnic inequities in health.[3] Ethnic inequities are created and maintained through the differential distribution of the determinants of health (such as socio-economic position, education), and differential access to and the quality of healthcare.[4] Including ethnicity in analyses of health is important to capture differential heath need as well as the wide-ranging effects of racism on health[5] that may be otherwise poorly measured within administrative datasets—for example, differential access and quality of care,[6] and differential exposure to risk factors[7] (air pollution, housing quality, occupational exposures, tobacco). For Māori, the ongoing existence of inequities in health and government inaction to address these are a breach of Te Tiriti o Waitangi/the Treaty of Waitangi[8] and Indigenous rights.[9]

Controversy around use of ethnicity as a marker of health need has implications for resourcing and targeting of health services. For example, primary care and community care has been under review. The WAI 2575 Waitangi Tribunal claim[10] found that the current approach to the funding of primary care embeds historical inequity and systematically underfunds services for Māori by not recognising higher needs and historical under-utilisation. The formula to determine how money is distributed among primary care services has been based on population age and sex distributions and on historical fees for service subsidies, and thus embeds and perpetuates historical patterns of differential access and entirely ignores those with past (and future) unmet need for healthcare.[11] A report was commissioned in

2026 Jan 30; 139(1628). ISSN 1175-8716
https://www.nzmj.org.nz/ ©PMA

2022 by the Health Transition Unit within the Department of Prime Minister and Cabinet.[11] It advises on the development of a new capitation funding formula for general practice services, highlighting that the major problem with the current formula is that it does not appropriately capture health need, e.g., as the population ages and patient complexity increases. The report recommends funding be based upon a combination of age, sex, ethnicity, deprivation and morbidity. In 2025, the minister of health announced that deprivation and multimorbidity will be added to a revised primary care funding formula from July 2026. However, this revision has failed to include ethnicity, as recommended.[11] The weighting on each factor remains unknown.

In another example, the use of universal age criteria to start screening programmes ignores the epidemiological evidence that the incidence of long-term conditions and most cancers increase at earlier ages for Māori. The bowel screening age was introduced at 60–74 years. However, there is a higher proportion of bowel cancer in Māori before they reach 60 years (58% Māori females vs 27% non-Māori females, and 52% Māori males vs 29% non-Māori males).[12] As a result of the universal starting age (60 years), Māori have less opportunity to benefit from bowel cancer screening than non-Māori.

There is plenty of evidence quantifying the strong relationship between comorbidities and health outcomes such as mortality and cancer (e.g., using the M3 index[13]). However, it is more rare for health research to investigate the independent predictive effect of all three—ethnicity, deprivation and comorbidities—simultaneously. This paper will address that gap. Similar papers investigating emergency department (ED) attendances, ED outcomes and ambulatory-sensitive hospitalisations have been identified.[14,15] Our approach will use national datasets and focus on amenable mortality, which is unlikely to be susceptible to biases from different levels of healthcare access. Amenable deaths are from conditions responsive to healthcare that occur in individuals under the age of 75 years.

The aim of this study was to quantify to what extent ethnicity can predict health need over and above age, sex, rurality, deprivation, income and morbidity. The goal of this study was to inform approaches to distributing health resources and targeting of health services that address differential health needs and support health equity by ethnicity. We were interested in contributing to what could be improved to ensure people get the right level of services, rather than maintaining current approaches that are not working.

Methods

This retrospective cohort study uses the Stats NZ Tatauranga Aotearoa (Stats NZ) Integrated Data Infrastructure (IDI), a research database of whole-population administrative data, census and sub-population survey datasets. In the IDI, datasets (nodes) such as health and census are probabilistically linked to a central spine dataset. The spine aims to include anyone who has been a resident in New Zealand, identified from linked birth, tax and migration records.

Population and demographic data

The IDI-estimated residential population (IDI-ERP) of New Zealand[16] was identified on 30 June (reference date) in each year from 2009 to 2018, thus allowing for population mobility during the 10-year study period and avoiding COVID-19 effects. The IDI-ERP includes individuals in the IDI spine (ever residents) who had activity in accident or injury insurance, tax, health or education datasets in the 12 months prior, and excludes those who have died or spent several months overseas (in the 6 months either side of the reference date). This gave us 10 national resident cohorts over a 10-year period. On each reference date, the cohort was characterised by age, sex, ethnicity, deprivation quintile, rurality and morbidity; and then they were followed-up over the subsequent 12 months to assess mortality outcome. Individuals 75 years old or more were excluded because no deaths in this age group are classified as amenable.

The IDI personal details table was used to identify age (0–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74 years old on the reference date), sex and total response ethnicity. Māori, Pacific, Asian, Middle Eastern/Latin American/African (MELAA), Other and European ethnic groups were identified, based on data availability in the highest-ranked source for ethnicity data quality, i.e., from a census, the Department of Internal Affairs or the Ministry of Health – Manatū Hauora, etc. Total response ethnicity was used for descriptive results (allowing individuals to identify with more than one ethnicity), and prioritised ethnicity was used for regression analyses (with ethnicity assigned as the first one identified in the order of the groups listed above).

The IDI address notification table was used to identify the most recent address, reported to contributing agencies before the study reference date. The meshblock of this address was used to assign the corresponding New Zealand Index of Deprivation 2013 or 2018 quintile and the Geographic Classification for Health.[17] Inland revenue data were used to sum income from the previous 5 years for everyone in the cohort who was 25 years old or more. Quintiles were produced after stratification by year and age group.

Multimorbidity

Multimorbidity is commonly defined as the presence of multiple diseases or conditions, often with the cutoff of two or more conditions.[18] As has been recommended,[18] we selected a multimorbidity index that has been locally validated using mortality outcomes. The M3 index has been developed in New Zealand to predict hospitalisation events and death using a 5-year look-back period of diagnoses during hospitalisation. M3 has outperformed both the Charlson and Elixhauser indices in predicting hospitalisation events and death in New Zealand,[13] and was selected as the primary multimorbidity measure for this analysis.

We collated public and private hospital discharge datasets in the IDI using a look-back period of 5 years for everyone in each cohort. All hospitalisation events and their corresponding unique primary and secondary diagnoses (International Classification of Diseases 10th revision [ICD-10]) were selected. We applied the X3 index macro[13] to give each individual an M3 weighting. If no weighting was available for an individual (e.g., they had no hospital admissions) then they received an M3 index of 0. The M3 index was categorised into 0, >0 to 1, >1 to 2, and >2 for ease of interpretation.

Amenable mortality

Measuring health need is fraught because service utilisation is a poor measure of the true health need, i.e., healthcare services may be needed but are not sought due to cost and other barriers. Administrative data rely on health service use, and therefore we focussed on amenable mortality as a measure of health need. Amenable deaths are from conditions responsive to healthcare that occur in individuals under the age of 75 years old,[19,20] and can be considered to include an element of unmet health need. Amenable mortality does not rely on health service use for its measurement (i.e., mortality datasets include deaths irrespective of where they occurred), and has been used previously as a measure of health need in New Zealand.[20,21] The greatest health needs and costs to the health system are in the last year of life,[22] supporting the use of a mortality measure.

We followed-up each cohort for 1 year (1 July to 30 June) from the index date to identify cases of amenable mortality. Mortality registrations (with month and year) were identified from the Ministry of Health – Manatū Hauora Mortality Collection in the IDI. We collated the underlying causes of death using the World Health Organization definitions (ICD-10, Australian modification). Deaths were categorised as amenable or non-amenable based on 2016 Ministry of Health – Manatū Hauora definitions.[20]

Analysis

The analysis investigated the predictive effects of variables on study outcomes and did not seek to report on the causal pathways. Amenable mortality rates were reported for each New Zealand residential population cohort, comprising 10 years of follow-up from July 2009 to June 2019 (Table 1). Rates were reported overall and by sex, age, ethnicity, deprivation, income, morbidity index and rurality.

Logistic regression analysis was used to assess the independent explanatory power of ethnicity, deprivation, morbidity, rurality, age and sex for predicting amenable mortality, reported with odds ratios (OR) and their 95% confidence intervals (CI) in Table 2. Logistic regression was appropriate for a binary outcome and preferred over time-to event analyses given the limited added value of the latter for 12-months of follow-up. Univariate and multivariate results were reported and used to assess whether there are significant independent predictive effects of ethnicity, deprivation, morbidity and rurality, after adjusting for age and sex. Likelihood ratio tests were used to assess whether each variable in the full model contributed to a significantly better model fit compared with a model without that variable. Table 3 reports the OR of amenable mortality rates in each ethnic group compared with the European group, and how this association changes with stepwise addition of each new variable to the model.

All analyses were carried out in a secure IDI environment (Datalab), using SAS Enterprise Guide V.8.3. Confidentiality rules in the IDI required suppression of small numbers (<6

Table 1: Crude amenable mortality rates in New Zealand residential population younger than 75 years old, New Zealand, July 2009 to June 2019.

		Person years[c]	Amenable deaths[c]	Rate
		%	n	per 100,000
Total	All	42,223,521	52,371	124
Sex	Male	21,140,766	31,482	149
	Female	21,081,780	20,889	99
	Other	975	S	S
Age (years)	0–14	9,072,957	495	5
	15–24	6,373,227	2,307	36
	25–34	5,937,483	2,073	35
	35–44	5,985,627	3,588	60
	45–54	6,202,086	7,938	128
	55–64	5,051,727	13,467	267
	65–74	3,600,420	22,506	625
Total response ethnicity	Māori	7,738,731	12,471	161
	Pacific	3,737,439	4,266	114
	Asian	5,618,157	2,325	41
	MELAA	821,577	618	75
	Other	913,161	738	81
	European	30,463,104	36,354	119
	Missing[a]	144,087	S	S
Area-level deprivation index	Lowest	8,559,297	6,636	78
	Low–middle	8,299,827	7,878	95
	Middle	8,163,987	9,330	114
	High–middle	8,167,776	11,742	144
	Highest	8,697,423	16,359	188
	Missing	335,214	432	129
Income from last 5 years (25+ years old)	Lowest	5,481,678	10,896	199
	Low–middle	5,491,296	15,153	276
	Middle	5,474,013	11,514	210
	High–middle	5,486,571	7,233	132
	Highest	5,483,376	5,010	91
	Missing	14,806,593	2,565	17
Morbidity index (M3)	0[b]	38,360,733	20,085	52
	>0–1	3,270,708	12,276	375
	>1–2	415,527	8,043	1,936
	>2	176,556	11,967	6,778

Table 1 (continued): Crude amenable mortality rates in New Zealand residential population younger than 75 years old, New Zealand, July 2009 to June 2019.

		Person years[c]	Amenable deaths[c]	Rate
		%	n	per 100,000
Geographic Classification for Health	Urban 1	26,655,423	28,113	105
	Urban 2	7,560,306	11,424	151
	Rural 1	4,947,597	7,725	156
	Rural 2	2,317,179	4,017	173
	Rural 3	484,377	936	193
	Missing	258,642	162	63

[a] Missing only refers to prioritised ethnicity.
[b] Includes people with no hospitalisation in the last 5 years.
[c] Random rounded to base three.
S = suppressed due to small numbers fewer than six.
MELAA = Middle Eastern/Latin American/African.

Table 2: Relative odds of amenable morality, July 2009 to June 2019, New Zealand.

		Unadjusted	Adjusted for age and sex	Adjusted for all other variables in the table	Likelihood ratio test (evidence variable improves model fit)
		OR (95% CI)	OR (95% CI)	OR (95% CI)	
Sex	Male	1	1	1	<0.001
	Female	0.66 (0.64–0.67)	0.65 (0.64–0.66)	0.62 (0.61–0.63)	
Age (years)	25–34	0.06 (0.05–0.06)	0.06 (0.05–0.06)	0.12 (0.12–0.13)	<0.001
	35–44	0.10 (0.09–0.10)	0.10 (0.09–0.10)	0.19 (0.18–0.20)	
	45–54	0.21 (0.20–0.21)	0.20 (0.20–0.21)	0.34 (0.33–0.35)	
	55–64	0.43 (0.42–0.44)	0.43 (0.42–0.43)	0.57 (0.55–0.58)	
	65–74	1	1	1	

Table 2 (continued): Relative odds of amenable morality, July 2009 to June 2019, New Zealand.

		Unadjusted	Adjusted for age and sex	Adjusted for all other variables in the table	Likelihood ratio test (evidence variable improves model fit)
		OR (95% CI)	OR (95% CI)	OR (95% CI)	
Prioritised ethnicity	Māori	1.66 (1.62–1.69)	2.49 (2.44–2.54)	1.46 (1.43–1.50)	<0.001
	Pacific	1.32 (1.27–1.36)	2.03 (1.96–2.10)	1.18 (1.14–1.23)	
	Asian	0.33 (0.31–0.34)	0.56 (0.53–0.58)	0.54 (0.52–0.57)	
	MELAA	0.48 (0.43–0.53)	0.84 (0.76–0.93)	0.72 (0.65–0.80)	
	Other	0.62 (0.58–0.67)	0.68 (0.63–0.74)	0.73 (0.67–0.79)	
	European	1	1	1	
Area-level deprivation index	Lowest	1	1	1	<0.001
	Low–middle	1.21 (1.17–1.25)	1.27 (1.23–1.31)	1.13 (1.10–1.17)	
	Middle	1.48 (1.44–1.53)	1.60 (1.55–1.65)	1.27 (1.23–1.31)	
	High–middle	1.93 (1.87–1.99)	2.13 (2.07–2.20)	1.44 (1.40–1.49)	
	Highest	2.79 (2.71–2.87)	3.27 (3.18–3.37)	1.67 (1.62–1.73)	
Income from last 5 years	Lowest	2.31 (2.23–2.39)	2.57 (2.48–2.66)	1.86 (1.80–1.93)	<0.001
	Low–middle	4.89 (4.74–5.05)	3.57 (3.45–3.68)	1.92 (1.86–1.99)	
	Middle	2.21 (2.14–2.29)	2.68 (2.59–2.77)	1.68 (1.62–1.74)	
	High–middle	1.25 (1.21–1.30)	1.56 (1.50–1.62)	1.24 (1.20–1.29)	
	Highest	1	1	1	
Morbidity index (M3)	0	1	1	1	<0.001
	>0-1	5.92 (5.78–6.06)	4.22 (4.12–4.32)	3.72 (3.63–3.81)	
	>1-2	28.27 (27.53–29.04)	17.82 (17.34–18.32)	13.74 (13.36–14.14)	
	>2	99.36 (97.02–101.75)	60.27 (58.79–61.79)	48.64 (47.42–49.89)	
Geographic Classification for Health	Urban 1	1	1	1	<0.001
	Urban 2	1.42 (1.39–1.45)	1.22 (1.19–1.25)	1.10 (1.07–1.12)	
	Rural 1	1.42 (1.38–1.45)	1.14 (1.11–1.17)	1.08 (1.05–1.11)	
	Rural 2	1.58 (1.53–1.64)	1.25 (1.21–1.29)	1.08 (1.04–1.12)	
	Rural 3	1.71 (1.60–1.83)	1.34 (1.25–1.43)	1.05 (0.98–1.13)	

Logistic regression analysis reporting ORs. Geographic Classification for Health urban/rural definitions are available from Whitehead et al.[23] Person-years (N) for all regression models was 26,511,750.
OR = odds ratio comparing likelihood of amenable mortality in this group compared with the reference group; 95% CI = confidence interval; MELAA = Middle Eastern/Latin American/African.

deaths), and random rounding of all raw counts to base 3. Also, rates that were based on small numbers had to be suppressed. Missing data were presented in tables wherever possible.

Ethics

Research was performed in accordance with the Declaration of Helsinki. The University of Otago Minimal Risk Health Research Committee gave ethics approval on 20 May 2024 (H24/0108). All administrative data used in this study on individuals were deidentified; thus, individualised consent for participation was not required.

Results

The New Zealand residential population, less than 75 years old, across 10 cohorts (2009 to 2018), was followed-up for 42-million person-years. There were 52,371 amenable deaths, with a crude rate of 124 per 100,000 person-years.

The descriptive table (Table 1) reports amenable mortality rates. There were higher crude amenable mortality rates in older age groups (55–74-year-olds), males, Māori, people living in more rural and higher deprivation areas, individuals with the lowest two quintiles of income and, particularly, individuals with an M3 index score greater than 0. The group with a >1 to 2 score had a 2% risk of amenable mortality in the next year, and the group with a >2 score had nearly a 7% risk (Table 1).

Key study results provide evidence demonstrating that ethnicity was a significant independent marker of health need, over and above the effects of age, sex, rurality, socio-economic position and morbidity (Table 2). In the fully adjusted model, Māori (OR 1.46, 95% CI 1.43–1.50) and Pacific (OR 1.18, 95% CI 1.14–1.23) had significantly higher odds of amenable mortality than European. Asian had the lowest odds of amenable mortality compared with European (OR 0.54, 95% CI 0.52–0.57). The inclusion of ethnicity to the fully adjusted model significantly improved the model fit (likelihood ratio tests all p<0.001).

At the same time, age, sex, rurality, area-level deprivation, income and morbidity also each significantly improved the fit of the model (likelihood ratio tests all p<0.001). Like for ethnicity, the independent effects of rurality, deprivation, income and morbidity remained statistically significant after adjustment for all other study variables. Morbidity had a very large effect on amenable mortality. Amenable mortality was 48.6 (95% CI 47.4–49.9) times as likely for people with a morbidity index score of >2 compared with 0. Socio-economic position was also an important predictor. The odds of amenable mortality were 1.67 (95% CI 1.62–1.73) times greater for people living in the highest vs lowest deprivation areas, and 1.86 (95% CI 1.80–1.93) times greater for people on the lowest vs highest incomes.

Stepwise regression (Table 3) was used to investigate the impact of each additional variable on the magnitude of the association between ethnicity and amenable mortality. Deprivation and morbidity index were associated with the greatest attenuation in ethnicity effects, e.g., the Māori compared with the European OR decreased from 2.46 to 1.91 with deprivation added to the model, and decreased from 1.84 to 1.46 with morbidity added.

Discussion

Summary of results considering the literature

Ethnicity remained a significant predictor of health need after accounting for the effects of age, sex, deprivation, income, morbidity and rurality. Māori and Pacific peoples had 1.46 and 1.18 greater odds of amenable mortality than European peoples after adjusting for other factors. These findings are consistent with research in New Zealand and internationally.[24,25] Ethnicity has been found to be an independent predictor of ED attendances and ambulatory-sensitive hospitalisation after adjusting for deprivation (Index of Multiple Deprivation), morbidity (M3) and multiple other factors.[14] Our analysis shows that this is also the case for amenable mortality.

Including ethnicity as an independent marker of health need in health funding and prioritisation is important to address known differences in health need, but also to capture the wide-ranging effects of racism on health[5] that may be otherwise poorly measured within administrative datasets.[6,7] For Māori, the ongoing existence of ethnic inequities in health and government inaction to address these are a breach of Te Tiriti o Waitangi[8] and Indigenous rights.[9]

Additionally, higher M3 morbidity index, greater deprivation and lower income were important predictors of greater amenable mortality (health need), over and above age and sex and ethnicity. High levels of the M3 index (>2) were (predictably) strongly associated with amenable mortality, experiencing 48 times the odds of amenable mortality in the subsequent year. This level of morbidity affected approximately one in 150 people in the

Table 3: How the relative odds of amenable morality by ethnicity varies with addition of rurality, deprivation and comorbidity variables in a stepwise logistic regression model, July 2009 to June 2019, New Zealand.

	Population	Unadjusted	Adjusted for age and sex	+ Adjusted for rurality, GCH	+ Adjusted for deprivation quintile	+ Adjusted for income quintile	+ Adjusted for morbidity, M3
	Person-years	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Māori	2,676,225	1.66 (1.62–1.69)	2.49 (2.44–2.54)	2.46 (2.40–2.51)	1.91 (1.87–1.95)	1.84 (1.80–1.89)	1.46 (1.43–1.50)
Pacific	1,081,869	1.32 (1.27–1.36)	2.03 (1.96–2.10)	2.11 (2.04–2.19)	1.45 (1.40–1.51)	1.35 (1.30–1.40)	1.18 (1.14–1.23)
Asian	2,481,327	0.33 (0.31–0.34)	0.56 (0.53–0.58)	0.58 (0.56–0.61)	0.53 (0.50–0.55)	0.46 (0.44–0.48)	0.54 (0.52–0.57)
MELAA	301,026	0.48 (0.43–0.53)	0.84 (0.76–0.93)	0.87 (0.78–0.96)	0.78 (0.70–0.87)	0.69 (0.62–0.76)	0.72 (0.65–0.80)
Other	392,817	0.62 (0.58–0.67)	0.68 (0.63–0.74)	0.68 (0.63–0.73)	0.67 (0.62–0.73)	0.69 (0.63–0.74)	0.73 (0.67–0.79)
European[a]	12,045,102	1	1	1	1	1	1

[a] European, sometimes referred to as Sole-European, is the reference ethnicity group.
OR = odds ratio comparing likelihood of amenable mortality in this group compared to the reference group; 95% CI = confidence interval; MELAA = Middle Eastern/Latin American/African.

study population who were younger than 75 years old, highlighting its usefulness in health funding allocation.

Internationally, approaches to constructing funding formulae have been described with three purposes; a) identifying factors that predict differential need (such as those in this analysis), b) adjusting for other cost factors (e.g., rurality and visitors), and c) correcting for unmet need (e.g., that which is not evident from historical utilisation).[26] In a review of funding formulae, most jurisdictions included at least one measure of morbidity in the funding formula (but not New Zealand or Stockholm). None of the reviewed jurisdictions[26] used a combination of ethnicity, deprivation and morbidity together. The New Zealand population-based funding formula has been used to distribute regional district health board spending. The formula includes deprivation (NZDep index, quintiles 4 and 5) and ethnicity (Māori, Pacific, Other)[26] but not morbidity. Conversely, the 2026 revised primary care funding formula plans to include deprivation and morbidity but not ethnicity. Our findings support the importance of combining all three ethnicity, deprivation and morbidity measures in funding formula calculations, alongside age, sex and rurality adjustors.

Strengths and limitations

The retrospective cohort design reduces potential biases by defining model variables before amenable mortality occurred (except for sex and ethnicity, which are not time-stamped). A decade of linked data allows for high statistical power in the main analysis. We selected variables and databases available to the health sector to improve the applicability of our findings for use in directing health resources and health services/interventions. We used locally validated indexes of deprivation and morbidity, which are strong predictors of health need. Amenable mortality was a useful measure of health need because it does not depend on healthcare seeking and potentially incorporates an element of unmet need. However, it has been criticised as a poor causal measure of health system performance.[27] Amenable mortality also has limitations in that it considered only a specific group of conditions, ignoring morbidity and excluding a broader set of conditions that may still be preventable. We expect that our findings, e.g., on the importance of ethnicity, would be similar, however, if we had chosen a different measure like ambulatory-sensitive hospitalisation.[14]

Adding other or more precise deprivation or morbidity predictors, or interaction terms, may improve this model's prediction ability. Such factors would need to be available for the whole population and their marginal value may be limited. For example, adding personal income to the model already containing deprivation made a small difference to the magnitude of the ethnicity effects (i.e., the Māori OR decreased from 1.91 to 1.84) and further socio-economic variables may have less additional predictive value. More precise modelling of health need is possible but ensuring modelling is applicable to resourcing and targeting decisions was our focus.

Morbidity data depend on access to hospitalisation and may be under-estimated for those with less hospital and healthcare access. Additional morbidity measures may make further useful contributions to accurately predicting amenable mortality, especially for morbidity that is defined outside of the hospitalisation dataset, e.g., mental health conditions. For example, in other countries multimorbidity measures based on medication prescribed have been found to be useful for predicting health care utilisation,[28] including a simple count of medications prescribed.[29] A mortality index (P3) using pharmaceutical prescribing from primary and secondary care has been developed in New Zealand to predict mortality,[30] but was found to have only marginal benefit for predicting mortality compared with using the M3 index alone (0.2–0.5% improvement), and thus might be expected to have a limited additional predictive effect on amenable mortality in this analysis.[30] This would be a useful area for future research, noting that P3, for example, is still dependent on whether people have access to healthcare and is not adjusted for unmet need.

Misclassification of ethnicity data may affect our results, e.g., if the IDI-ERP undercounts Māori, our estimates of the impact of ethnicity on amenable mortality may be conservative. This study used prioritised ethnicity, where each person is only counted in one ethnic group. This approach will not impact Māori results but will result in the undercounting of Pacific who also identify as Māori, as they will only be classified as Māori in this analysis.

Implications for public health

Ethnicity is an important marker of heath need in New Zealand and remains an important marker of health need after accounting for age, sex, rurality, deprivation, income and morbidity. Markers of ethnicity are critical in the allocation of health resources and targeting of services, alongside other markers such as deprivation and morbidity. Failure to include ethnicity in decision making about access to services and programmes, the primary care funding formula, and other relevant activities will negatively impact on our ability to deliver equal health outcomes to all people in New Zealand, including Māori and Pacific people.

Conclusions

Ethnicity, in addition to socio-economic position and morbidity, is an important independent marker of health need that should be included in funding formulae, prioritisation and targeting of health services.

COMPETING INTERESTS
The authors declare that they have no other known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
A University of Otago research grant 2024 funded all authors.

ACKNOWLEDGEMENTS
Thank you to Professor James Stanley for producing the M3 index code, adapting it to run in the IDI and for advice on survey analyses. Thank you to June Atkinson for advice on socio-economic variables.

AVAILABILITY OF DATA AND MATERIALS
These results are not official statistics. They have been created for research purposes from the IDI, which is carefully managed by Stats NZ. For more information about the IDI please visit https://www.stats.govt.nz/integrated-data/. Applications can be made to Stats NZ to access research data from the IDI in an approved facility. Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the *Data and Statistics Act 2022*. The results presented in this study are the work of the authors, not Stats NZ or individual data suppliers. The results are based in part on tax data supplied by Inland Revenue to Stats NZ under the *Tax Administration Act 1994* for statistical purposes. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the datas' ability to support Inland Revenue's core operational requirements.

AUTHOR INFORMATION
Andrea Teng: Senior Research Fellow, Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.
Melissa McLeod: Associate Professor, Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.
Sue Crengle: Professor, Division of Health Sciences, University of Otago, Dunedin, Aotearoa New Zealand.

CORRESPONDING AUTHOR
Andrea Teng: Senior Research Fellow, Department of Public Health, University of Otago, Wellington, PO Box 7343, Wellington South 6242, Aotearoa New Zealand.
E: andrea.teng@otago.ac.nz

URL
https://nzmj.org.nz/journal/vol-139-no-1628/is-ethnicity-an-independent-predictor-of-health-need-linked-cohort-logistic-regression-analysis-to-predict-amenable-mortality

REFERENCES

1. Cabinet Office Wellington. Circular: Needs-based Service Provision [Internet]. Wellington, New Zealand; 2024 [cited 2025 Nov 25]. Available from: https://www.dpmc.govt.nz/sites/default/files/2024-09/co-24-05-needs-based-service-provision.pdf
2. Loring B, Reid P, Curtis E, et al. Ethnicity is an evidence-based marker of need (and targeting services is good medical practice). N Z Med J. 2024;137(1603):9-13. doi: 10.26635/6965.e1603.
3. Williams DR, Lavizzo–Mourey R, Warren RC. The concept of race and health status in America. Public Health Rep. 1994;109(1):26-41.
4. Jones CP. Invited commentary: "race," racism and the practice of epidemiology. Am J Epidemiol. 2001;154(4):299-304. doi: 10.1093/aje/154.4.299.
5. Harris R, Tobias M, Jeffreys M, et al. Effects of self-reported racial discrimination and deprivation on Māori health and inequalities in New Zealand: cross-sectional study. Lancet. 2006;367(9527):2005-9. doi: 10.1016/S0140-6736(06)68890-9.
6. Jeffreys M, Ellison-Loschmann L, Irurzun-Lopez M, et al. Financial barriers to primary health care in Aotearoa New Zealand. Fam Pract. 2024;41(6):995-1001. doi: 10.1093/fampra/cmad096.
7. Ministry of Health – Manatū Hauora. New Zealand Health Survey [Internet]. [cited 2025 Nov 25]. Available from: https://www.health.govt.nz/statistics-research/surveys/new-zealand-health-survey
8. Pitama S, Haitana T, Patu M, et al. Toitu Te Tiriti. N Z Med J. 2024;137(1589):7-11. doi: 10.26635/6965.e1589.
9. Office of the High Commissioner for Human Rights. UN Declaration on the Rights of Indigenous Peoples [Internet]. United Nations; 2007 [cited 2025 Nov 25]. Available from: https://www.ohchr.org/en/indigenous-peoples/un-declaration-rights-indigenous-peoples
10. Waitangi Tribunal. HAUORA: Report on Stage One of the Health Services and Outcomes Kaupapa Inquiry [Internet]. 2023 [cited 2025 Nov 25]. Available from: https://www.tewhatuora.govt.nz/assets/For-the-health-sector/Specific-life-stage/Health-of-older-people/Hauora-2023-W.pdf
11. Love T, Peck C, Watt D. A Future Capitation Funding Approach - Addressing health need and sustainability in general practice funding [Internet]. Wellington, New Zealand: Sapere for the Health and Disability Review Transition Unit; 2022 [cited 2025 Nov 25]. Available from: https://www.dpmc.govt.nz/sites/default/files/2022-11/HTU-future-capitation-funding-approach.pdf

12. McLeod M, Harris R, Paine SJ, et al. Bowel cancer screening age range extension for Māori: what is all the fuss about? N Z Med J. 2021;134(1535):71-77.
13. Stanley J, Sarfati D. The new measuring multimorbidity index predicted mortality better than Charlson and Elixhauser indices among the general population. J Clin Epidemiol. 2017;92:99-110. doi: 10.1016/j.jclinepi.2017.08.005.
14. Sheridan N, Love T, Kenealy T; Primary Care Models Study Group. Is there equity of patient health outcomes across models of general practice in Aotearoa New Zealand? A national cross-sectional study. Int J Equity Health. 2023;22(1):79. doi: 10.1186/s12939-023-01893-8.
15. Curtis E, Paine SJ, Jiang Y, et al. Examining emergency department inequities in Aotearoa New Zealand: Findings from a national retrospective observational study examining Indigenous emergency care outcomes. Emerg Med Australas. 2022;34(1):16-23. doi: 10.1111/1742-6723.13876.
16. Gibb S, Bycroft C, Matheson-Dunning N. Identifying the New Zealand resident population in the Integrated Data Infrastructure (IDI) [Internet]. Stats NZ; 2016 [cited 2025 Nov 25]. Available from: https://www.stats.govt.nz/assets/Research/Identifying-the-New-Zealand-resident-population-in-the-Integrated-Data-Infrastructure/identifying-nz-resident-population-in-idi.pdf
17. Whitehead J, Davie G, de Graaf B, et al. Defining rural in Aotearoa New Zealand: a novel geographic classification for health purposes. N Z Med J. 2022;135(1559):24-40. doi: 10.26635/6965.5495.
18. Johnston MC, Crilly M, Black C, et al. Defining and measuring multimorbidity: a systematic review of systematic reviews. Eur J Public Health. 2019;29(1):182-189. doi: 10.1093/eurpub/cky098.
19. Tobias M, Yeh LC. How much does health care contribute to health gain and to health inequality? Trends in amenable mortality in New Zealand 1981-2004. Aust N Z J Public Health. 2009;33(1):70-78. doi: 10.1111/j.1753-6405.2009.00342.x.
20. Silwal P, Lopez MI, Pledger M, et al. Association between enrolment with a Primary Health Care provider and amenable mortality: A national population-based analysis in Aotearoa New Zealand. PLoS One. 2023;18(2):e0281163. doi: 10.1371/journal.pone.0281163.
21. Silwal P, Exeter D, Tenbensel T, Lee A. How much do local health systems matter? Variations in amenable mortality across health districts in Aotearoa New Zealand. Public Health Pract (Oxf). 2024;8:100545. doi: 10.1016/j.puhip.2024.100545.
22. Blakely T, Atkinson J, Kvizhinadze G, et al. Updated New Zealand health system cost estimates from health events by sex, age and proximity to death: further improvements in the age of 'big data'. N Z Med J. 2015;239(1422):13-23.
23. Whitehead J, Davie G, de Graaf B, et al. Unmasking hidden disparities: a comparative observational study examining the impact of different rurality classifications for health research in Aotearoa New Zealand. BMJ Open. 2023;13:e067927. doi: 10.1136/bmjopen-2022-067927.
24. Williams DR, Mohammed SA. Discrimination and racial disparities in health: evidence and needed research. J Behav Med. 2009;32(1):20-47. doi: 10.1007/s10865-008-9185-0.
25. Rechel B, Mladovsky P, Devillé W, et al. Migration and health in the European Union [Internet]. Open University Press; 2011 [cited 2025 Nov 25]. Available from: https://eurohealthobservatory.who.int/docs/librariesprovider3/studies---external/migration_rechel.pdf?sfvrsn=7874e121_1
26. Penno E, Gauld R, Audas R. How are population-based funding formulae for healthcare composed? A comparative analysis of seven models. BMC Health Serv Res. 2013;13:470. doi: 10.1186/1472-6963-13-470.
27. Pérez G, Rodriguez-Sanz M, Cirera E, et al. Commentary: approaches, strengths, and limitations of avoidable mortality. J Public Health Policy. 2014;35(2):171-184. doi: 10.1057/jphp.2014.8.
28. Huntley AL, Johnson R, Purdy S, et al. Measures of multimorbidity and morbidity burden for use in primary care and community settings: a systematic review and guide. Ann Fam Med. 2012;10(2):134-141. doi: 10.1370/afm.1363.
29. Perkins AJ, Kroenke K, Unützer J, et al. Common comorbidity scales were similar in their ability to predict health care costs and mortality. J Clin Epidemiol. 2004;57(10):1040-1048. doi: 10.1016/j.jclinepi.2004.03.002.
30. Stanley J, Doughty RN, Sarfati D. A Pharmaceutical Dispensing–based Index of Mortality Risk From Long-term Conditions Performed as well as Hospital Record–based Indices. Med Care. 2020; 58(2):e9-e16. doi: 10.1097/MLR.0000000000001217.