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Complete List of Authors:	Curtis, Elana; University of Auckland, Te Kupenga Hauora Māori Wikaire, Erena; University of Auckland, Te Kupenga Hauora Māori Jiang, Yannan; The University of Auckland, Department of Statistics McMillan, Louise; The University of Auckland, Department of Statistics Loto, Robert; University of Auckland, Te Kupenga Hauora Māori Poole, Phillippa; University of Auckland, Department of Medicine Barrow, Mark; The University of Auckland, Deanery, Faculty of Medical and Health Sciences Bagg, Warwick; University of Auckland, Medical Programme Directorate Reid, Papaarangi; University of Auckland, Te Kupenga Hauora Māori
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Widening access: predicting academic success of medical students admitted via two equity pathways

Elana Curtis[1§], Erena Wikaire[1], Yannan Jiang[2], Louise McMillan[2], Robert Loto[1], Phillippa Poole[3], Mark Barrow[4], Warwick Bagg[5], Papaarangi Reid[1]

[1] Te Kupenga Hauora Māori, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand
[2] Department of Statistics, Faculty of Science, University of Auckland, Private Bag 92015, Auckland, New Zealand
[3] Department of Medicine, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand
[4] Deanery, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand
[5] Medical Programme Directorate, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand
[§] Corresponding author. Email addresses: e.curtis@auckland.ac.nz

Abstract

Objective To determine associations between admission markers of socio-economic status, transitioning, bridging programme attendance and prior academic preparation on academic outcomes for indigenous Māori, Pacific and rural students admitted into medicine under access pathways designed to widen participation. Findings were compared to students admitted via the general (usual) admission pathway.

Design Retrospective observational study using secondary data.

Setting 6-year medical programme (MBChB), University of Auckland, Aotearoa New Zealand. Students are selected and admitted into Year 2 following a first year (undergraduate) or prior degree (graduate).

Participants 1,676 domestic students admitted into Year 2 between 2002-2012 via three pathways: GENERAL admission (1,167), Māori and Pacific Admission Scheme – MAPAS (317) or Rural Origin Medical Preferential Entry – ROMPE (192). Of these, 1,082 students completed the programme in the study period.

Main outcome measures Graduated from medical programme (yes/no), academic scores in Years 2-3 (Grade Point Average, scored 0-9).

Results 735/778 (95%) of GENERAL, 111/121 (92%) of ROMPE and 146/183 (80%) of MAPAS students graduated from intended programme. The graduation rate was significantly lower in the MAPAS students ($p<0.0001$). The average Year 2-3 GPA was 6.35 (SD 1.52) for GENERAL, which was higher than 5.82 (SD 1.65, $p=0.0013$) for ROMPE and 4.33 (SD 1.56, $p<0.0001$) for MAPAS. Multiple regression analyses identified three key predictors of better academic outcomes: bridging programme attendance, admission as an undergraduate and admission GPA/GPE. Attending local urban schools and higher school deciles were also associated with a greater likelihood of graduation. All regression models have controlled for pre-defined baseline confounders (gender, age and year of admission).

Conclusions There were varied associations between admission variables and academic outcomes across the three admission pathways. Equity-targeted admission programmes inclusive of variations in academic threshold for entry may support a widening participation agenda, however, additional academic and pastoral supports are recommended.

Article Summary

Strengths and limitations of this study

- Most comprehensive quantitative analysis of academic outcomes for equity admission pathways into medicine within NZ.
- Examines one of the largest cohorts of indigenous medical students available internationally.
- Confined to a single medical programme and results may not be generalisable to other programmes or tertiary institutions.
- The use of secondary school decile as a proxy for socio-economic position relies on an area-level indicator of deprivation and may not directly reflect the socio-economic position of each individual student or their family.
- This study did not explore the effect of medical interview outcomes due to different processes of selection being used across equity and general admission pathways.

Introduction

Widening participation in the medical profession remains a priority for many countries worldwide.[1 2] Most medical schools acknowledge the need to embrace a widening participation agenda in order to contribute to the development of a health workforce that reflects a community's ethnic, cultural, geographic and socio-economic diversity.[3 4] Health workforce diversity is expected to reduce inequities in health outcomes through enhanced patient-provider interactions, [5 6] increased provision of culturally competent care[7] and better delivery to high-need, underserved population groups. [8 9] In addition to workforce and healthcare delivery benefits, increasing diversity within medical school classes has been associated with positive effects on the medical school context itself including enhanced educational experiences for all students,[10 11] positive student attitudes towards the value of diversity within medicine,[12] and the creation of learning contexts that challenge stereotypes and reduce implicit bias of medical students towards under-represented minorities.[13] Widening participation interventions have been successful at increasing medical school diversity for under-represented ethnic minorities, women and rural students; however, disparities by socioeconomic status remain, as reported in the United Kingdom (UK).[14] Despite the strong rationale and increasing evidence of effectiveness,[4 15] interventions to widen participation, such as medical school quotas, regularly come under attack and are criticised for lowering academic and quality standards.[16 17] Comprehensive data analyses that not only measure outcome differences by admission pathways, but also attempt to examine the likely predictors for any observed differences, are needed.[18] This information is expected to better inform the widening participation debate and assist institutions to provide appropriate recruitment and tertiary support interventions for students admitted under equity-targeted admission pathways.

This study explores the predictors of both short- and long-term academic outcomes for (a) indigenous Māori or Pacific students and (b) rural background students admitted into the medical programme (MBChB) under equity admission pathways, compared to general admission at the Faculty of Medical and Health Sciences (FMHS), University of Auckland (UoA), Aotearoa New Zealand (NZ). This is one of two medical schools in NZ, based in a city of over 1.2 million, about a third of the nation's population. Entry into the MBChB at UoA may occur in two ways as: (1) an undergraduate within the first year of a health sciences or biomedical sciences degree at the UoA or (2) as a graduate with a completed undergraduate or postgraduate qualification. Both pathways equate to 'Year 1' of the MBChB degree at the UoA. The Māori and Pacific Admission Scheme (MAPAS) commenced in 1972 in response to Māori and Pacific health workforce shortages, significant inequities in health outcomes and the indigenous rights of Māori within NZ.[19] MAPAS involves comprehensive recruitment and retention interventions delivered within culturally appropriate contexts of support with approximately 240 MAPAS medical students enrolled in 2017 (approximately 20% of the total cohort).[19 20] The Rural Origin Medical Preferential Entry (ROMPE) pathway began in 2004, in response to NZ government prioritisation of rural healthcare needs and evidence that students from rural backgrounds are more

likely to return to practice in rural regions.[21] ROMPE initially offered 20 places to students of rural origin per year. [22] The number of places available on each pathway has increased with increasing student class sizes and NZ population proportions. Students may apply for only one pathway. The selection tools used to rank GENERAL and ROMPE students for entry include a measure of prior academic performance (60%), medical entry interview (25%) and score on the Undergraduate Medical and Health Sciences Admission Medical Test (UMAT), an aptitude test (15%). MAPAS selection during the study period consisted of a measure of prior academic performance and an assessment via a MAPAS-specific interview. [19]

Over the first 20 years of MAPAS (i.e. 1972-1992), there was a higher withdrawal rate for MAPAS medical students compared to other students admitted; however, the reasons for these findings are unclear and no associations between likely predictor variables and academic outcomes have been investigated to date. [23] We hypothesise that markers of socio-economic status, transition factors, bridging programme attendance (implemented specifically for Māori and Pacific students aspiring to enter medicine from 1999) and prior academic preparation, are likely to impact on both short-term i.e. year 2-3 Grade Point Average (GPA) and long-term i.e. graduation outcomes. This study aimed to examine the association between admission variables and academic outcomes for students admitted into the medical programme under equity admission pathways in comparison to those students admitted under the general (usual) admission pathway.

Methods

Study Design

A retrospective observational study design was used to analyse data from all domestic students entering Year 2 MBChB at the UoA between 2002 and 2012 (with graduation data inclusive of academic outcomes from 2013). International students were excluded from analysis. Individual student demographic, admission and academic results data were sourced from Student Services Online (SSO), the UoA's web-based centralised student data management system, and the Medical Programme Directorate (MPD) within the FMHS. The study period reflects the availability of electronic data from these sources and the time required for students to have graduated from a 6-year medical programme at the time this study commenced. A Kaupapa Māori Research (KMR) framework, supplemented by Pacific research methodology, was used throughout all aspects including study design, data collection, data analysis and research dissemination.[24 25] This approach includes: a commitment to ensuring that the research outputs will have positive benefits for Māori and Pacific participants and communities; an explicit challenge to reject 'victim blame' and 'cultural deficit' analyses when interpreting data; [26] and ensuring that any recommendations made from the research aim to facilitate participant academic success. This broad approach is expected to provide benefit for all study participants. The study was approved by the UoA Human Participants Ethics Committee (UAHPEC) (Reference 8110).

Predictor Variables

Participants were identified by their admission category (MAPAS, ROMPE, GENERAL). The decile rating of secondary school attended was used as a proxy measure of socioeconomic status: low (1 – 3) (high deprivation), medium (4 – 7), and high (8 – 10) (low deprivation).[27 28] High decile schools have a high proportion of students who reside in areas of low deprivation (high socioeconomic status). Attended school in Auckland (yes, no) and admitted into Year 1 as a school leaver (yes, no) were used to measure transitioning effects i.e. impact of relocation to Auckland City (the largest city in NZ with a population of 1.4 million where the UoA medical programme is based) and impact of beginning tertiary study as a mature student or school leaver entrant. School leaver (SL) is defined as enrolment in bachelor level study in the year immediately following secondary school. Completion of a UoA bridging foundation programme (yes, no) that aims to bridge the 'gaps' between secondary and tertiary education contexts was recorded. The entry pathway into Year 2 MBChB was recorded as graduate or undergraduate. Academic preparation for medical entry was measured by the GPA or Grade Point Equivalent (GPE) at the time of admission for undergraduate and graduate applicants respectively (0-9 representing Fail to A+ average grade).

Outcome variables

Two outcome variables were included in this study: Graduated from MBChB (yes, no) and MBChB Year 2-3 GPA (0-9). Graduated from MBChB represents a long-term academic outcome and was only applied to those students who completed the MBChB programme by 2013 i.e. students admitted between 2002-2009. The Year 2-3 GPA represents a short-term academic outcome associated with the two pre-clinical years of the MBChB programme. Data for this measure were available for a larger cohort of current and graduated students i.e. students admitted between 2002 and2012. The Year 2-3 GPA represents the average GPA achieved across Years 2 and 3 for students admitted between 2002 and2011 and the GPA achieved across year 2 only for students admitted in 2012.

Analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided at a 5% significance level. A full statistical analysis plan was developed a priori that incorporated baseline confounders, key predictor and outcome variables of interest, based on concepts identified from relevant health workforce development and tertiary education literature as well as experience within the FMHS context as to the factors likely to impact on student success (Figure 1). Multiple regression analyses with stepwise model selection were used to test the associations between predictor variables and academic outcomes for the total cohort (i.e. MAPAS, ROMPE and GENERAL admission combined) and via entry admission sub-cohorts (i.e. MAPAS and GENERAL). The results on ROMPE were not included due to small number of students in the study cohort.

[Insert Figure 1]

The baseline model has controlled for pre-defined confounders including gender, age, and year of admission into Year 2 MBChB (Model 1) with the addition of predictor variables representing the sequential effect of socioeconomic status (Model 2), transitioning (Model 3), bridging programme (Model 4) and academic preparation (Model 5) on academic outcomes. Each model was initially run with all the pre-specified predictors of interest, and those predictors that were significant at the 5% level were retained in the final model. This analysis was applied to all students admitted under MAPAS, ROMPE and GENERAL categories, with the outcome variables assessed at the time of data collection. For MBChB Year 2-3 GPA, the mean difference was reported with 95% confidence interval (CI) using the linear regression model. For Graduation outcome (yes/no), the odds ratio (OR) was reported with 95% CI using logistic regression model. Similar regression analyses were conducted on the two largest sub-cohorts for MAPAS and GENERAL categories separately, in order to identify significant predictors of academic outcomes specific to that sub-cohort. Ethnicity was added to the baseline model in the sub cohort analyses for MAPAS (Māori, Pacific) and GENERAL (Māori, Pacific, Asian, European/Pākehā, Other/Missing). Missing data were reported in the descriptive summary, but excluded in final regression analysis

Results

A total of 1,676 students were included in the study, representing 1,167 (70%) GENERAL, 317 (19%) MAPAS and 192 (11%) ROMPE admission categories. Cohort demographics are presented in Tables 1 and 2.

[Insert Table 1 and Table 2]

The MAPAS category differs in comparison to the GENERAL category by ethnicity (59% Māori, 41% Pacific, 0.3% Asian, 0.3% Other, p<0.0001), school decile (42% high, 34% medium and 20% low, p<0.0001), having attended an Auckland school (60%, p<.0001) and being admitted into medicine as a school leaver (50%, p<0.0001). The average admission GPA/GPE was approximately 2 points lower for MAPAS compared to GENERAL admission category students (6.22, SD 1.19, p<.0.0001). The ROMPE category differs in comparison to the GENERAL category by mean age (21.5, SD 4.55, p<0.0001), gender (61.5% female, p<0.017), ethnicity (84% European/Pākehā, 11% Asian, 1% Māori, 1% Pacific, 2% Other, p<0.0001), school decile (43% high, 43% medium, 7% low, p<0.0001), having attended an Auckland school (30%, p-value<0.0001), admission into first year as a school leaver (59%, p<0.0001) and entry pathway into medicine (31% graduate, 69% undergraduate, p-value<0.0002). The average admission GPA/GPE was approximately half a point lower for ROMPE compared to GENERAL students (7.74, SD 1.19, p<.0.0001).

Of the 1,082 students who completed the programme in the study period (i.e. admitted between 2002-2009), 95% (735/778) of GENERAL, 92% (111/121) of ROMPE and 80% (146/183) of MAPAS students graduated from MBChB. For the total cohort (admitted between 2002-2012), the mean Year 2-3 GPA was 6.35 (SD 1.52) for GENERAL, 5.82 (SD 1.65, p=0.0013) for ROMPE and 4.33 (SD 1.56, p<0.0001) for MAPAS students. Table 3 presents the multiple regression analysis findings for the Total Cohort.

[Insert Table 3]

Graduated from Medicine

In the unadjusted model, MAPAS students had significantly lower odds of graduating from intended programme compared to GENERAL students (OR:0.231, 95% CI:0.144-0.371). This pattern remained after controlling for age, gender and year of admission i.e. Model 1 (OR:0.235, CI:0.143-0.386). The odds of MAPAS students graduating in comparison to GENERAL students improved with the addition of medium and low school decile i.e. Model 2 (OR:0.291, CI:0.165-0.513), and having attended a school out of Auckland or being admitted into first year as a school leaver i.e. Model 3 (OR:0.296, CI:0.166-0.526, p=0.0002). The addition of having attended a bridging programme increased the odds of MAPAS students graduating from medicine by a further 14% in comparison to GENERAL students i.e. Model 5 (OR:0.440, CI:0.231-0.841). When entry pathway into medicine as a graduate and admission GPA/GPE were added to the analysis i.e. Model 5, the difference in odds of graduating between admission categories became non-significant (OR:1.680, CI: 0.736-3.833). These findings suggest that attending a higher decile school, a school outside of Auckland and admission into first year as a mature student each make a small contribution to the observed difference in graduation between MAPAS and GENERAL students. However, having attended a bridging/foundation programme prior to medical school entry had a stronger association with improved graduation outcome. In addition, both graduate entry admission and admission GPA/GPE are important contributors, after controlling for which the observed difference between the MAPAS and GENERAL students was no longer statistically significant.

No statistically significant difference was observed in graduation outcome between the ROMPE and GENERAL students when all predictor variables were taken into account i.e. Model 5 (OR:0.558, CI:0.227-1.374).

Year 2-3 GPA

In the unadjusted model, the average Year 2-3 GPA was nearly 2 points lower for MAPAS compared to GENERAL students (-1.934, CI:-2.112 to -1.756). This pattern remained after controlling for age, gender and year of admission i.e. Model 1 (-1.994, CI:-2.169 to -1.819) and school decile i.e. Model 2

(-1.936, CI:-2.122 to -1.75). Having attended an Auckland school and being admitted into first year as a mature student reduced the difference in GPA slightly i.e. Model 3 (-1.899, CI:-2.076 to -1.702). Having attended a bridging programme prior to medical study further reduced the difference in GPA between MAPAS and GENERAL students i.e. Model 4 (-1.724, CI: -1.914 to -1.533). When both graduate entry admission and admission GPA/GPE were added in Model 5, no significant difference in Year 2-3 GPA was observed between the admission categories (0.103, CI:-0.103 to 0.309). These findings suggest that having attended a bridging programme, entering medicine as a graduate and a higher admission GPA/GPE are associated with improved performance for MAPAS compared to GENERAL students in the early years of the medical programme.

In the unadjusted model, the average difference between Year 2-3 GPA was approximately half a point lower for ROMPE compared to GENERAL students (-0.449, CI:-0.668 to -0.23). This general pattern remains for Models 1-4. When all predictor variables were taken into account in Model 5, the mean difference in Year 2-3 GPA became non-significant (-0.142, CI: -0.326 to 0.043). These findings suggest that admission as a graduate and admission GPA/GPE are the major contributors to the GPA difference between ROMPE and GENERAL students.

Table 4 presents the multiple regression analysis findings for the sub-cohort analyses for the MAPAS and GENERAL cohorts.

[Insert Table 4]

MAPAS Sub-Cohort

After controlling for pre-defined confounders (e.g. gender, age, ethnicity, year of admission) and all significant predictors, i.e. Model 5, the odds of a MAPAS student graduating from medicine was 86% lower for those MAPAS students who attended a bridging programme versus those who did not (OR: 0.141, CI: 0.042-0.468, p=0.0014) and 83% lower for MAPAS students who entered medicine via the graduate pathway versus the undergraduate pathway (OR: 0.170, CI: 0.043-0.681, p=0.0123). The odds of graduating increased by 1.8 times for every point increase in admission GPA/GPE (OR:1.758, CI:1.05-2.944, p=0.0319). There were mixed findings for school decile across the models and this variable was not significant in the final model that included admission GPA/GPE and entry pathway.

For MAPAS students, the year 2-3 GPA was similar for students regardless of whether or not they had attended a bridging programme (-0.927, CI:-1.209 to 0.645, p<0.0001) and was 25% higher for every point increase in admission GPA/GPA (0.754, CI: 0.647-0.861, p<0.0001). School decile rating was not a significant predictor in the final model for the MAPAS cohort.

GENERAL Sub-Cohort

After controlling for pre-defined confounders (e.g. gender, age, ethnicity, year of admission) and all significant predictors, the odds of a GENERAL student graduating from medicine was lower for students who attended a low decile (OR: 0.137, CI: 0.031-0.6, p=0.0098) or medium decile school (OR: 0.384, CI: 0.164-0.898, p=0.0098) compared to high school decile. Increasing admission GPA/GPE was strongly associated with increased odds of graduating (OR: 2.020, CI:1.46-2.796, p<0.0001). The Year 2-3 GPA was lower for graduate entry GENERAL students compared to undergraduate entry (0.577, CI: 0.377-0.777, p=0.0036) with similar outcomes observed for bridging programme attendance (-1.083, CI:-1.182 to -0.355, p=0.0036) and admission GPA/GPE (0.977, CI: 0.891-1.063, p=<0.0001). School decile rating was not a significant predictor of early academic outcomes for the GENERAL cohort.

Discussion

This study, based on 1676 medical students over a 10 year period compared outcomes and predictor variables of those admitted via two equity-admission pathways with those in the general admission pathway. To our knowledge, this is the first report in the literature describing programme level outcomes to this detail. The descriptive data confirm that it is possible to admit significant numbers of students via these pathways, and have most successfully complete the programme. Nearly all students with Māori and Pacific ethnicity entered via the MAPAS pathway. Furthermore, the MAPAS and ROMPE pathways each contained higher proportions of students from lower socio-economic backgrounds and students who attended schools out of Auckland. These findings underscore the importance of having equity pathways or targets, as it unlikely many of the MAPAS students, and some of the ROMPE students would have been successful in the highly competitive selection process for GENERAL students. Furthermore, to provide workforce benefit, students need to complete the programme. Encouragingly, despite marked differences in background and prior performance there was only a 12-15% difference in the proportion of MAPAS students who graduated in the study period compared to ROMPE or GENERAL admission students respectively. Our hypotheses that markers of socio-economic status, transitioning factors, bridging programme attendance and academic preparation are likely to impact on both short-term and long-term academic outcomes were confirmed, although findings are mixed within and across the entry pathways. When looking within the MAPAS cohort, the odds of a MAPAS student graduating (compared to another MAPAS student) improved with non-bridging programme attendance and most likely reflect cohort differences in admission GPA/GPE. In contrast, our findings suggest that having attended a bridging programme, entering medicine as an undergraduate and higher admission GPA/GPA are the major contributors to reducing the GPA difference observed *between* MAPAS and GENERAL students in the early, non-clinical phase of medical training.

This study represents a comprehensive analysis of academic outcomes for equity admission pathways into medicine within NZ. Similarly, this study explores academic outcomes for one of the largest cohorts of indigenous medical students available internationally. We acknowledge that this study was confined to a single medical programme and that the results may not be generalisable to other programmes or tertiary institutions. In particular, the comprehensive nature of the MAPAS programme with respect to student admission and retention support may not be reflected in other tertiary contexts.[28] The use of secondary school decile as a proxy for socio-economic position relies on an area-level indicator of deprivation and may not directly reflect the socio-economic position of each individual student or their family.[29] Despite this, other school factors (e.g. student attainment, aspirations for future study) have been linked to school decile suggesting that individual students will have been exposed to direct school effects.[29-31] This study did not explore the effect of medical interview outcomes due to different processes of selection being used across equity and general admission pathways.[32 33] The study period spans across and before periods of significant change within the MAPAS and ROMPE pathways with respect to admissions processes (i.e. selection methods and eligibility).[19 34] Therefore, study findings should be interpreted cautiously as 'historical' markers of equity programme delivery or performance rather than accurate representations of the equity processes in operation today.[35]

Our findings are consistent with the existing literature base that GPA at the point of admission is the strongest predictor of academic outcomes within the medical programme.[32 36-38] In a critical appraisal of studies examining medical school failure, O'Neill and colleagues found that lower entry qualifications at admission were linked to higher failure rates. However, they note that many studies did not control for confounding factors, were mostly focused on student attributes, with few studies examining the role of the institution.[39] The fact that 80% of MAPAS students completed medicine despite being admitted with an average GPA approximately 2 points lower than other medical students is encouraging. This suggests that whilst GPA at admission is important, other unmeasured factors may be contributing to our findings. Student pastoral and financial issues (likely to be significant for indigenous students given their socioeconomic and demographic profile),[40] psychological characteristics,[41] student learning styles,[37] and relevant medical curricula or structural factors[39] may also play a role. As noted by Mathers and Parry, graduate applicants to medicine have complex needs arising from their personal social, family and economic circumstances that may affect their academic performance.[42] The UoA's commitment to respond to these student factors (via the provision of comprehensive admission, pastoral and academic support) may be contributing to our outcomes observed, particularly for graduate entry and bridging programme students admitted under MAPAS. The positive effect of bridging programme exposure has also been noted elsewhere[43-47]. However within the MAPAS cohort, those students who did not require additional academic support via a bridging programme experienced better academic outcomes. Therefore, our findings reinforce the need for ongoing bridging programme delivery alongside the elimination of educational inequities

for Māori and Pacific students.[34 48-51] The association between secondary school decile rating (a marker of socio-economic status and school characteristics) and academic outcomes had mixed results and are unlikely to explain the differences observed by admission pathway. Although school decile has been linked to first year academic outcomes for Māori,[52] our findings may reflect the fact that school characteristics have been noted to have less impact on student achievement at the higher end of the achievement scale i.e. GPA ≥ 4.[53] However, the strong association between lower school decile and reduced odds of graduating for the GENERAL admission students challenges this conclusion, differs from other research[39] and is of concern.

Our study reinforces the existing evidence that equity-targeted admission programmes, inclusive of variations in academic threshold for entry, can support a widening participation agenda within medicine.[4] However, tertiary institutions and society at large must accept that ethnic inequities in educational outcomes and rural workforce development needs should be accounted for within admission pathways and retention support.[48 54] Providing comprehensive academic and pastoral assistance to equity-admission and lower socioeconomic students who are operating within complex and academically demanding contexts remains paramount.[28 55 56] Whilst differences in academic thresholds for equity groups appears necessary, it is often criticised as being 'politically correct', providing 'preferential treatment' to one group or individual over another, and has not been universally welcomed by the public or the profession.[16 57-60] Bacchi notes that the framing of widening participation as 'preferential treatment' "undermines the legitimacy of the reform and reduces its impact, limiting the kinds of reforms 'permitted' and alienating those who are targeted. This undoubtedly serves the interests of those who profit under current social arrangements" (p. 144). [58] Given this context, it is perhaps not surprising that whilst medical schools strive to increase diversity and meet the goals of a widening participation agenda, successful implementation is influenced by contextual factors associated with institutional leadership, resource allocation and external stakeholder pressure.[61] Razack et al note that whilst the development of social accountability policy has occurred, medical schools appear to be challenged by the implementation of these policies within student recruitment and selection processes.[62] This study responds to calls for open and inclusive discussions in order to advance admissions practice aiming to enhance social justice and widening participation agendas.[62]

Additional research is warranted (e.g. inclusion of secondary school outcomes, non-cognitive testing and medical interview data beyond 2012). Similarly, exploring the effect of institutional attributes should also be considered.[37 39] Evidence suggests that tertiary and medical school environments may have different effects on indigenous and ethnic minority students who have reported that their ethnicity adversely affects their medical school experience,[63] have described experiences of racism from peers and clinical educators,[28 64] and are adversely effected by an 'othering' medical curriculum that either stereotypes indigenous culture and society or fails to reflect indigenous realities

alltogether.[35 40 65 66] Exploring the impact of these variables on differential academic outcomes for equity admission pathways may require qualitative methods to complement additional quantitative analyses. The impact of a widening participation agenda within medicine must also begin to look beyond the number of students admitted and graduated and extend the analysis to post-graduate clinical contexts including the effect of a diverse health workforce on patient and community outcomes.[1] The ultimate aim of equity-targeted admission pathways into medicine is to enhance healthcare delivery, improve health outcomes and eliminate inequities for underserved communities. Understanding when and how this can be achieved remains a challenge for many countries worldwide.

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A declaration of competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work."

Details of contributors

Dr Elana Curtis (Senior Lecturer Medical) is the guarantor of the study. She led the study design, methodological approach, interpretation of the data analysis and was the primary author for drafting the manuscript. Erena Wikaire (Research Assistant) contributed to study design and provided research assistance to obtain and clean data variables. She contributed to drafting and revising the manuscript and was responsible for producing the data tables. Dr Yannan Jiang (Senior Research Fellow) contributed to the study design and provided senior statistical expertise for data analysis. She contributed to drafting and revising the manuscript. Louise McMillan (doctoral candidate) provided junior statistical expertise and contributed to the study design and revising the manuscript. Robert Loto (Professional Teaching Fellow) contributed to the study design and provided Pacific research methodological expertise in the interpretation of the data and revising of the manuscript. Associate Professor Mark Barrow (Associate Dean Education) contributed to the study design and provided senior tertiary education expertise in the interpretation of the data, drafting and revising of the manuscript. Professor Warwick Bagg contributed to the study design and provided senior medical education expertise in the interpretation of the data, drafting and revising of the manuscript. Professor Phillippa Poole contributed to the study design and provided senior medical education expertise in the interpretation of the data, drafting and revising of the manuscript. Associate Professor Papaarangi Reid (Tumaki, Deputy Dean Māori) provided senior Māori educational, institutional and Kaupapa Māori expertise and contributed to the study design, drafting and revising the manuscript. All authors read and approved the final manuscript for submission.

Ethics approval

The study was approved by the UoA Human Participants Ethics Committee (UAHPEC) (Reference 8110). As this study used de-identified secondary administrative data, study participants were not required to give informed consent.

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and in the decision to submit the article for publication. All researchers were independent of the funder of this study.

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

A transparency declaration

I, Dr Elana Curtis (the manuscript's guarantor) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

A data sharing statement

Data sharing: no additional data available.

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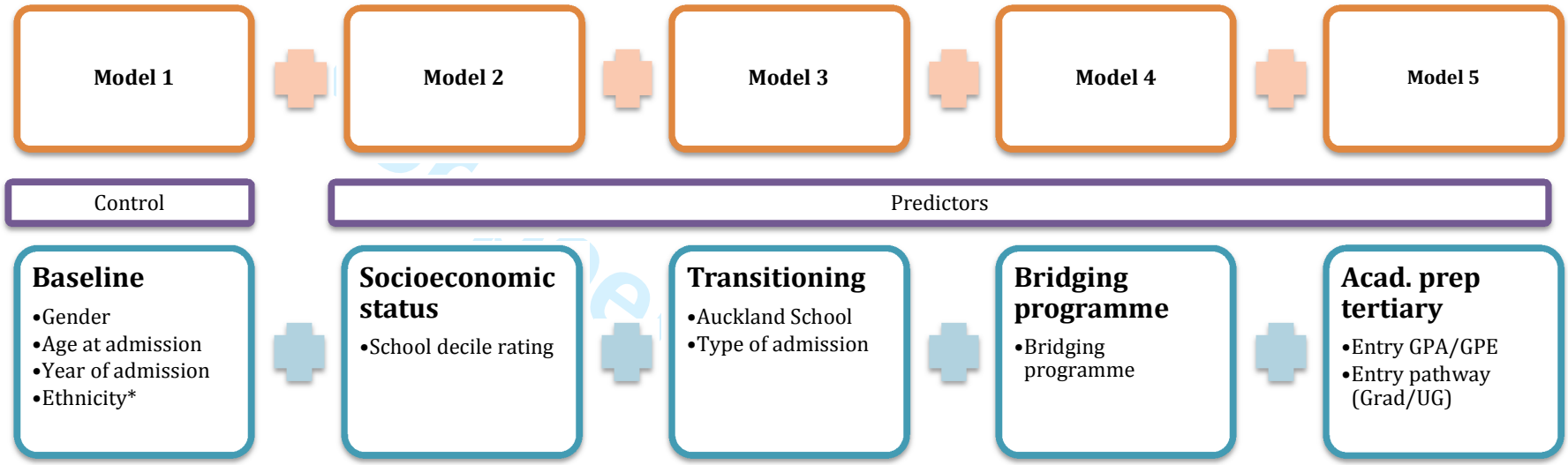
Figure 1: **Conceptual model and multiple regression analysis plan with stepwise model selection.**



*Ethnicity included in GENERAL and MAPAS admission category sub-cohort analyses only.

Table 1: Descriptive variables for GENERAL, MAPAS and ROMPE admission categories, 2002 – 2012.

Descriptive summary variables	Admission category								Total (n=1676)	
	GENERAL (ref) (n=1167)		MAPAS (n=317)			ROMPE (n=192)				
Categorical variables	*n*	*%*	*n*	*%*	*p-value*	*n*	*%*	*p-value*	*n*	*%*
Female	609	52.19	178	56.15	0.2096	118	61.46	0.0170	905	54
Ethnicity					<.0001			<.0001		
Māori	21	1.80	186	58.68		2	1.04		209	12.47
Pacific	14	1.20	129	40.69		2	1.04		145	8.65
Asian	527	45.16	1	0.32		21	10.94		549	32.76
Other	59	5.06	1	0.32		3	1.56		63	3.76
Pākehā/European	532	45.59	0	0.00		161	83.85		693	41.35
Missing/No response	14	1.20	0	0.00		4	1.56		17	1.20
Year of admission					0.0680			<.0001		
2002	109	87.9	15	12.1		-	-		124	7.40
2003	94	82.46	20	17.54		-	-		114	7.14
2004	93	70.99	21	16.03		17	12.98		131	8.21
2005	88	68.75	18	14.06		22	17.19		128	8.02
2006	83	64.84	24	18.75		21	16.41		128	8.02
2007	103	71.03	22	15.17		20	13.79		145	9.09
2008	105	68.18	30	19.48		19	12.34		154	9.65
2009	103	65.19	33	20.89		22	13.92		158	9.90
2010	122	64.89	44	23.4		22	11.7		188	11.78
2011	130	68.78	40	21.16		19	10.05		189	11.84
2012	137	63.13	50	23.04		30	13.82		217	13.60
School decile rating					<.0001			<.0001		
High	838	71.81	134	42.27		82	42.71		1054	62.89
Medium	236	20.22	108	34.07		82	42.71		426	25.42
Low	30	2.57	62	19.56		14	7.29		106	6.32
Missing	63	5.40	13	4.10		14	7.29		90	5.37
Attended school in Auckland	851	72.92	189	59.62	<.0001	58	30.21	<.0001	1098	65.51
Completed bridging programme	10	0.86	78	24.61	<.0001	1	0.52	1.000	89	5.31
Admitted as School leaver (yr 1)	852	73.01	157	49.53	<.0001	114	59.38	0.0001	1123	67.00
Entry pathway					0.3019			0.0002		
Graduate	221	18.94	52	16.40		59	30.73		332	19.81
Undergraduate	946	81.06	265	83.60		133	69.27		1344	80.19
Programme outcome					<.0001			0.3109		
Current students	389	33.33	134	42.27		71	36.98		594	35.44
Completed students	778	66.67	183	57.73		121	63.02		1082	64.56
Graduated MBCHB	735	94.47	146	79.78		111	91.74		992	91.68
Did not graduate	43	5.53	37	20.22		10	8.26		90	8.32
Continuous variables	*Mean*	*SD*	*Mean*	*SD*	*p-value*	*Mean*	*SD*	*p-value*	*Mean*	*SD*
Age at admission (yr 2)	20.09	3.02	21	3.88	<0.0001	21.47	4.55	<0.0001	20.42	3.44
Admission GPA/GPE	8.26	0.86	6.22	1.19	<0.0001	7.74	0.87	<0.0001	7.81	1.22
Year 2-3 GPA	6.45	1.41	4.52	1.48	<0.0001	6.01	1.5	0.0002	6.04	1.62

Cohort 2002-12 comprises students who matriculated into Year 2 of the MBCHB (or Bachelor of Human Biology BHB) programme within FMHS from 2002 to 2012 inclusive, excluding international entry students. Students who repeated Year 2 have been recorded in their first Year 2 year. All variables have been compared for the General vs. MAPAS categories and for the General vs. RRAS categories. Categorical variables have been tested using Chi-squared test, or Fisher's exact test where necessary. Continuous variables have been tested using the ANOVA model, with adjustment for multiple comparisons.

Table 2: Descriptive variables for GENERAL, MAPAS and ROMPE admission categories 2002 – 2009.

Descriptive summary variables	Admission category								Total (n=1082)	
	GENERAL (n=778)		MAPAS (n=183)			ROMPE (n=121)				
Categorical variables	*n*	*%*	*n*	*%*	*p-value*	*n*	*%*	*p-value*	*n*	*%*
Female	427	54.88	103	56.28	0.7319	76	62.81	0.1023	606	56.01
Ethnicity					<.0001			<.0001		
Māori	20	2.57	102	55.74		2	1.65		124	11.46
Pacific	14	1.80	79	43.17		2	1.65		95	8.78
Asian	339	43.57	1	0.55		12	9.92		352	32.53
Other	44	5.66	1	0.55		3	2.48		48	4.44
Pākehā/European	348	44.73	0	0.00		99	81.82		447	41.31
Missing/No response	13	1.68	0	0.00		3	2.48		16	1.48
School decile rating					<.0001			<.0001		
High	545	70.05	80	43.72		54	44.63		679	62.75
Medium	159	20.44	54	29.51		48	39.67		261	24.12
Low	24	3.08	38	20.77		9	7.44		71	6.56
Missing	50	6.43	11	6.01		10	8.26		71	6.56
Attended school in Auckland	565	72.62	115	62.84	0.0017	48	39.67	<.0001	728	67.28
Completed bridging programme	8	1.03	41	22.40	<.0001	1	0.83	1.0000	50	4.62
Admitted as School leaver (yr 1)	565	72.62	91	49.73	<.0001	78	64.46	0.0643	734	67.84
Entry pathway					0.5200			0.0001		
Graduate	121	15.55	32	17.49		36	29.75		189	17.47
Undergraduate (UG)	657	84.45	151	82.51		85	70.25		893	82.53
Graduated (yes)	735	94.47	146	79.78	<.0001	111	91.74	0.2343	992	91.68
Continuous variables	*Mean*	*SD*	*Mean*	*SD*		*Mean*	*SD*		*Mean*	*SD*
Age at admission (yr 2)	20.02	3.10	20.98	3.97	0.0014	21.07	3.80	0.0041	20.3	3.37
Admission GPA/GPE	8.12	0.99	6.04	1.29	<0.0001	7.72	0.88	0.0002	7.72	1.29

Cohort 2002-9 comprises students who matriculated into Year 2 of the MBCHB (or Bachelor of Human Biology BHB) programme within FMHS from 2002 to 2009 inclusive, excluding international entry students. Students who repeated Year 2 have been recorded in their first Year 2 year. All variables have been compared for the General vs. MAPAS categories and for the General vs. RRAS categories. Categorical variables have been tested using Chi-squared test, or Fisher's exact test where necessary. Continuous variables have been tested using the ANOVA model, with adjustment for multiple comparisons.

Table 3: Multiple regression results for Graduated (2002-2009 cohort) and Year 2-3 GPA (2002–2012 cohort) academic outcomes.

Model	Predictor variable (ref)	Comparison	Graduated (n=1082) (2002 - 2009 cohort)			Year 2-3 GPA (n=1676) (2002 – 2012 cohort)		
			Overall p-value	OR	95% CI	Overall p-value	Mean difference	95% CI
Unadj.	**Admission category (GENERAL)**	MAPAS	<.0001	0.23	(0.14, 0.37)	<.0001	-1.93	(-2.11,-1.76)
		ROMPE		0.65	(0.32, 1.33)		-0.45	(-0.67,-0.23)
1	**Admission category (GENERAL)**	MAPAS	<.0001	0.24	(0.14, 0.39)	<.0001	-1.99	(-2.17,-1.82)
		ROMPE		0.70	(0.33, 1.50)		-0.54	(-0.76,-0.32)
				*n=1011**			*n=1586**	
2	**Admission category (GENERAL)**	MAPAS	0.0001	0.29	(0.16, 0.51)	<.0001	-1.94	(-2.12, -1.75)
		ROMPE		0.63	(0.28, 1.44)		-0.54	(-0.77, -0.31)
	School decile (High 8-10)	Medium (4-7)	0.0032	0.56	(0.32, 0.98)	0.0279	-0.16	(-0.32, -0.00)
		Low (1-3)		0.29	(0.14, 0.61)		-0.32	(-0.61, -0.03)
3	**Admission category (GENERAL)**	MAPAS	0.0002	0.30	(0.17, 0.53)	<.0001	-1.89	(-2.08, -1.70)
		ROMPE		0.48	(0.21, 1.12)		-0.53	(-0.76, -0.31)
	School decile (High 8-10)	Medium (4-7)	0.0022	0.52	(0.29, 0.93)	0.0454	-0.15	(-0.31, 0.00)
		Low (1-3)		0.28	(0.13, 0.59)		-0.29	(-0.58, -0.00)
	Auckland school (Yes)	No	0.0030	2.67	(1.40, 5.09)	-	-	-
	Type of admission (SL)	AA	0.0430	0.53	(0.29, 0.10)	0.0004	-0.34	(-0.53, -0.15)
4	**Admission category (GENERAL)**	MAPAS	0.0182	0.44	(0.23, 0.84)	<.0001	-1.72	(-1.91, -1.53)
		ROMPE		0.42	(0.18, 0.10)		-0.61	(-0.83, -0.39)
	School decile (High 8-10)	Medium (4-7)	0.0096	0.58	(0.32, 1.05)	-	-	-
		Low (1-3)		0.31	(0.14, 0.68)	-	-	-
	Auckland school (Yes)	No	0.0062	2.52	(1.30, 4.88)	-	-	-
	Type of admission (SL)	AA	-	-	-	-	-	-
	Bridging Programme (No)	Yes	<.0001	0.16	(0.07, 0.36)	<.0001	-1.24	(-1.56, -0.91)
5	**Admission category (GENERAL)**	MAPAS	0.1251	1.68	(0.74, 3.83)	0.1306	0.10	(-0.10, 0.31)
		ROMPE		0.56	(0.23, 1.37)		-0.14	(-0.33, 0.04)
	School decile (High 8-10)	Medium (4-7)	0.0276	0.66	(0.35, 1.23)	-	-	-
		Low (1-3)		0.31	(0.13, 0.74)	-	-	-
	Auckland school (Yes)	No	0.0030	2.88	(1.43, 5.79)	-	-	-
	Type of admission (SL)	AA	-	-	-	-	-	-
	Bridging Programme (No)	Yes	<.0001	0.17	(0.07, 0.40)	<.0001	-0.90	(-1.18, -0.61)
	Entry pathway (Undergraduate)	Graduate	0.0100	0.45	(0.24, 0.82)	<.0001	0.47	(0.31, 0.64)
	Admission GPA/GPE	per point increase	<.0001	1.95	(1.55, 2.45)	<.0001	0.89	(0.82, 0.95)

** n is the total number in the cohort, number used is the number of students who have complete data for the given model (all other students are excluded from the analysis). In the Total Cohort, 90 did not graduate whereas 992 graduated. Model #2 – 5 cohort sizes reduced to 1011 and 1586 respectively due to missing school decile data; fewer students were excluded due to missing data for the remaining predictors. Logistic regression model applied to graduation outcome, linear regression model applied to Year2-3 GPA outcome. All regression models have controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. All models include the predictor Admission Category. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of odds ratios (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.*

Table 4:

(a) Logistic regression results for Graduated (2002-2009 cohort) academic outcome for MAPAS and GENERAL subgroups.

Model	Predictor variable (ref)	Comparison	Graduated (2002 - 2009 cohort) MAPAS (n=181)			Graduated (2002 - 2009 cohort) GENERAL (n=778)		
			Overall p-value	OR	95% CI	Overall p-value	OR	95% CI
1	**Ethnicity**	Māori	–	–	–	0.0010	0.175	(0.047,0.648)
	(reference group Māori for	Pacific	0.0035	0.285	(0.123,0.662)	–	0.089	(0.023,0.339)
	MAPAS, Pākehā/European for	Asian	–	–	–	–	0.657	(0.286,1.508)
	GENERAL)	Other/Missing	–	–	–	–	0.316	(0.106,0.940)
5				n = 170			n=728	
	School decile (High 8-10)	Medium (4-7)	–	–	–	0.0098	0.384	(0.164,0.898)
		Low (1-3)		–	–		0.137	(0.031,0.600)
	Auckland school (Yes)	No	0.0127	4.571	(1.256,16.629)	–	–	–
	Type of admission (SL)	AA	–	–	–	–	–	–
	Bridging Programme (No)	Yes	0.0014	0.141	(0.042,0.468)	–	–	–
	Entyr pathway (Undergraduate)	Graduate	0.0123	0.170	(0.043,0.681)	–	–	–
	Admission GPA/GPE	per point increase	0.0319	1.758	(1.050,2.994)	< .0001	2.020	(1.460,2.796)

Logistic regression model has controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of odds ratios (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.

(b) Linear regression results for Year 2-3 GPA (2002–2012 cohort) academic outcome for MAPAS and GENERAL subgroups.

Model	Predictor variable (ref)	Comparison	Year 2-3 GPA (2002 – 2012 cohort) MAPAS (n=315)			Year 2-3 GPA (2002 – 2012 cohort) GENERAL (n=1167)		
			Overall p-value	Mean difference	95% CI	Overall p-value	Mean difference	95% CI
1	**Ethnicity**	Māori	–	–	–	<.0001	-0.616	(-1.201,-0.031)
	(reference group Māori for	Pacific	0.0109	-0.425	(-1.018,0.168)	–	-2.226	(-2.939,-1.513)
	MAPAS, Pākehā/European for	Asian	–	–	–	–	-0.191	(-0.358,-0.025)
	GENERAL)	Other/Missing	–	–	–	–	-0.524	(-0.852,-0.196)
5				n=302			n=1104	
	School decile (High 8-10)	Medium (4-7)	–	–	–	–	–	–
		Low (1-3)		–	–		–	–
	Auckland school (Yes)	No	–	–	–	–	–	–
	Type of admission (SL)	AA	–	–	–	–	–	–
	Bridging Programme (No)	Yes	< .0001	-0.927	(-1.209,-0.654)	0.0036	-1.083	(-1.812,-0.355)
	Entry pathway (Undergraduate)	Graduate	–	–	–	< .0001	0.577	(0.377,0.777)
	Admission GPA/GPE	per point increase	< .0001	0.754	(0.647,0.861)	< .0001	0.977	(0.891,1.063)

Linear regression model has controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of odds ratios (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.

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Examining the predictors of academic outcomes for indigenous Māori, Pacific and rural students admitted into medicine via two equity pathways: a retrospective observational study at the University of Auckland, Aotearoa New Zealand.

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Examining the predictors of academic outcomes for indigenous Māori, Pacific and rural students admitted into medicine via two equity pathways: a retrospective observational study at the University of Auckland, Aotearoa New Zealand.

Elana Curtis[1§], Erena Wikaire[1], Yannan Jiang[2], Louise McMillan[2], Robert Loto[1], Phillippa Poole[3], Mark Barrow[4], Warwick Bagg[5], Papaarangi Reid[1]

[1] Te Kupenga Hauora Māori, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand

[2] Department of Statistics, Faculty of Science, University of Auckland, Private Bag 92015, Auckland, New Zealand

[3] Department of Medicine, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand

[4] Deanery, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand

[5] Medical Programme Directorate, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92015, Auckland, New Zealand

[§] Corresponding author. Email addresses: e.curtis@auckland.ac.nz

Abstract

Objective To determine associations between admission markers of socio-economic status, transitioning, bridging programme attendance and prior academic preparation on academic outcomes for indigenous Māori, Pacific and rural students admitted into medicine under access pathways designed to widen participation. Findings were compared to students admitted via the general (usual) admission pathway.

Design Retrospective observational study using secondary data.

Setting 6-year medical programme (MBChB), University of Auckland, Aotearoa New Zealand. Students are selected and admitted into Year 2 following a first year (undergraduate) or prior degree (graduate).

Participants 1,676 domestic students admitted into Year 2 between 2002-2012 via three pathways: GENERAL admission (1,167), Māori and Pacific Admission Scheme – MAPAS (317) or Rural Origin Medical Preferential Entry – ROMPE (192). Of these, 1,082 students completed the programme in the study period.

Main outcome measures Graduated from medical programme (yes/no), academic scores in Years 2-3 (Grade Point Average, scored 0-9).

Results 735/778 (95%) of GENERAL, 111/121 (92%) of ROMPE and 146/183 (80%) of MAPAS students graduated from intended programme. The graduation rate was significantly lower in the MAPAS students ($p<0.0001$). The average Year 2-3 GPA was 6.35 (SD 1.52) for GENERAL, which was higher than 5.82 (SD 1.65, $p=0.0013$) for ROMPE and 4.33 (SD 1.56, $p<0.0001$) for MAPAS. Multiple regression analyses identified three key predictors of better academic outcomes: bridging programme attendance, admission as an undergraduate and admission GPA/GPE. Attending local urban schools and higher school deciles were also associated with a greater likelihood of graduation. All regression models have controlled for pre-defined baseline confounders (gender, age and year of admission).

Conclusions There were varied associations between admission variables and academic outcomes across the three admission pathways. Equity-targeted admission programmes inclusive of variations in academic threshold for entry may support a widening participation agenda, however, additional academic and pastoral supports are recommended.

Article Summary

Strengths and limitations of this study

- Most comprehensive quantitative analysis of academic outcomes for equity admission pathways into medicine within NZ.
- Examines one of the largest cohorts of indigenous medical students available internationally.
- Confined to a single medical programme and results may not be generalisable to other programmes or tertiary institutions.
- The use of secondary school decile as a proxy for socio-economic position relies on an area-level indicator of deprivation and may not directly reflect the socio-economic position of each individual student or their family.
- This study did not explore the effect of medical interview outcomes due to different processes of selection being used across equity and general admission pathways.

Introduction

Widening participation in the medical profession remains a priority for many countries worldwide.[1 2] Most medical schools acknowledge the need to embrace a widening participation agenda in order to contribute to the development of a health workforce that reflects a community's ethnic, cultural, geographic and socio-economic diversity.[3 4] Health workforce diversity is expected to reduce inequities in health outcomes through enhanced patient-provider interactions, [5 6] increased provision of culturally competent care[7] and better delivery to high-need, underserved population groups. [8 9] In addition to workforce and healthcare delivery benefits, increasing diversity within medical school classes has been associated with positive effects on the medical school context itself including enhanced educational experiences for all students,[10 11] positive student attitudes towards the value of diversity within medicine,[12] and the creation of learning contexts that challenge stereotypes and reduce implicit bias of medical students towards under-represented minorities.[13] Widening participation interventions have been successful at increasing medical school diversity for under-represented ethnic minorities, women and rural students; however, disparities by socioeconomic status remain, as reported in the United Kingdom (UK).[14] Despite the strong rationale and increasing evidence of effectiveness,[4 15] interventions to widen participation, such as medical school quotas, regularly come under attack and are criticised for lowering academic and quality standards.[16 17] Comprehensive data analyses that not only measure outcome differences by admission pathways, but also attempt to examine the likely predictors for any observed differences, are needed.[18] This information is expected to better inform the widening participation debate and assist institutions to provide appropriate recruitment and tertiary support interventions for students admitted under equity-targeted admission pathways.

This study explores the predictors of both short- and long-term academic outcomes for (a) indigenous Māori or Pacific students and (b) rural background students admitted into the medical programme (MBChB) under equity admission pathways, compared to general admission at the Faculty of Medical and Health Sciences (FMHS), University of Auckland (UoA), Aotearoa New Zealand (NZ). This is one of two medical schools in NZ, based in a city of over 1.2 million, about a third of the nation's population. Entry into the MBChB at UoA may occur in two ways as: (1) an undergraduate within the first year of a health sciences or biomedical sciences degree at the UoA or (2) as a graduate with a completed undergraduate or postgraduate qualification. Both pathways equate to 'Year 1' of the MBChB degree at the UoA. The Māori and Pacific Admission Scheme (MAPAS) commenced in 1972 in response to Māori and Pacific health workforce shortages, significant inequities in health outcomes and the indigenous rights of Māori within NZ.[19] MAPAS involves comprehensive recruitment and retention interventions delivered within culturally appropriate contexts of support with approximately 240 MAPAS medical students enrolled in 2017 (approximately 20% of the total cohort).[19 20] The Rural Origin Medical Preferential Entry (ROMPE) pathway began in 2004, in response to NZ government prioritisation of rural healthcare needs and evidence that students from rural backgrounds are more

likely to return to practice in rural regions.[21] ROMPE initially offered 20 places to students of rural origin per year. [22] The number of places available on each pathway has increased with increasing student class sizes and NZ population proportions. Students may apply for only one pathway. The selection tools used to rank GENERAL and ROMPE students for entry include a measure of prior academic performance (60%), medical entry interview (25%) and score on the Undergraduate Medical and Health Sciences Admission Medical Test (UMAT), an aptitude test (15%). MAPAS selection during the study period consisted of a measure of prior academic performance and an assessment via a MAPAS-specific interview. [19]

Over the first 20 years of MAPAS (i.e. 1972-1992), there was a higher withdrawal rate for MAPAS medical students compared to other students admitted; however, the reasons for these findings are unclear and no associations between likely predictor variables and academic outcomes have been investigated to date. [23] We hypothesise that markers of socio-economic status, transition factors, bridging programme attendance (implemented specifically for Māori and Pacific students aspiring to enter medicine from 1999) and prior academic preparation, are likely to impact on both short-term i.e. year 2-3 Grade Point Average (GPA) and long-term i.e. graduation outcomes. This study aimed to examine the association between admission variables and academic outcomes for students admitted into the medical programme under equity admission pathways in comparison to those students admitted under the general (usual) admission pathway.

Methods

Study Design

A retrospective observational study design was used to analyse data from all domestic students entering Year 2 MBChB at the UoA between 2002 and 2012 (with graduation data inclusive of academic outcomes from 2013). International students were excluded from analysis. Individual student demographic, admission and academic results data were sourced from Student Services Online (SSO), the UoA's web-based centralised student data management system, and the Medical Programme Directorate (MPD) within the FMHS. The study period reflects the availability of electronic data from these sources and the time required for students to have graduated from a 6-year medical programme at the time this study commenced. A Kaupapa Māori Research (KMR) framework, supplemented by Pacific research methodology, was used throughout all aspects including study design, data collection, data analysis and research dissemination.[24 25] This approach includes: a commitment to ensuring that the research outputs will have positive benefits for Māori and Pacific participants and communities; an explicit challenge to reject 'victim blame' and 'cultural deficit' analyses when interpreting data; [26] and ensuring that any recommendations made from the research aim to facilitate participant academic success. This broad approach is expected to provide benefit for all study participants. The study was approved by the UoA Human Participants Ethics Committee (UAHPEC) (Reference 8110).

Predictor Variables

Participants were identified by their admission category (MAPAS, ROMPE, GENERAL). The decile rating of secondary school attended was used as a proxy measure of socioeconomic status: low (1 – 3) (high deprivation), medium (4 – 7), and high (8 – 10) (low deprivation).[27 28] High decile schools have a high proportion of students who reside in areas of low deprivation (high socioeconomic status). Attended school in Auckland (yes, no) and admitted into Year 1 as a school leaver (yes, no) were used to measure transitioning effects i.e. impact of relocation to Auckland City (the largest city in NZ with a population of 1.4 million where the UoA medical programme is based) and impact of beginning tertiary study as a mature student or school leaver entrant. School leaver (SL) is defined as enrolment in bachelor level study in the year immediately following secondary school. Completion of a UoA bridging foundation programme (yes, no) that aims to bridge the 'gaps' between secondary and tertiary education contexts was recorded. The entry pathway into Year 2 MBChB was recorded as graduate or undergraduate. Academic preparation for medical entry was measured by the GPA or Grade Point Equivalent (GPE) at the time of admission for undergraduate and graduate applicants respectively (0-9 representing Fail to A+ average grade).

Outcome variables

Two outcome variables were included in this study: Graduated from MBChB (yes, no) and MBChB Year 2-3 GPA (0-9). Graduated from MBChB represents a long-term academic outcome and was only applied to those students who completed the MBChB programme by 2013 i.e. students admitted between 2002-2009. The Year 2-3 GPA represents a short-term academic outcome associated with the two pre-clinical years of the MBChB programme. Data for this measure were available for a larger cohort of current and graduated students i.e. students admitted between 2002 and2012. The Year 2-3 GPA represents the average GPA achieved across Years 2 and 3 for students admitted between 2002 and2011 and the GPA achieved across year 2 only for students admitted in 2012.

Analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided at a 5% significance level. A full statistical analysis plan was developed a priori that incorporated baseline confounders, key predictor and outcome variables of interest, based on concepts identified from relevant health workforce development and tertiary education literature as well as experience within the FMHS context as to the factors likely to impact on student success (Figure 1). Multiple regression analyses with stepwise model selection were used to test the associations between predictor variables and academic outcomes for the total cohort (i.e. MAPAS, ROMPE and GENERAL admission combined) and via entry admission sub-cohorts (i.e. MAPAS and GENERAL). The results on ROMPE were not included due to small number of students in the study cohort.

[Insert Figure 1]

The baseline model has controlled for pre-defined confounders including gender, age, and year of admission into Year 2 MBChB (Model 1) with the addition of predictor variables representing the sequential effect of socioeconomic status (Model 2), transitioning (Model 3), bridging programme (Model 4) and academic preparation (Model 5) on academic outcomes. Each model was initially run with all the pre-specified predictors of interest, and those predictors that were significant at the 5% level were retained in the final model. This analysis was applied to all students admitted under MAPAS, ROMPE and GENERAL categories, with the outcome variables assessed at the time of data collection. For MBChB Year 2-3 GPA, the mean difference was reported with 95% confidence interval (CI) using the linear regression model. For Graduation outcome (yes/no), the odds ratio (OR) was reported with 95% CI using logistic regression model. Similar regression analyses were conducted on the two largest sub-cohorts for MAPAS and GENERAL categories separately, in order to identify significant predictors of academic outcomes specific to that sub-cohort. Ethnicity was added to the baseline model in the sub cohort analyses for MAPAS (Māori, Pacific) and GENERAL (Māori, Pacific, Asian, European/Pākehā, Other/Missing). Missing data were reported in the descriptive summary, but excluded in final regression analysis

Results

A total of 1,676 students were included in the study, representing 1,167 (70%) GENERAL, 317 (19%) MAPAS and 192 (11%) ROMPE admission categories. Cohort demographics are presented in Table 1.

[Insert Table 1]

The MAPAS category differs in comparison to the GENERAL category by ethnicity (59% Māori, 41% Pacific, 0.3% Asian, 0.3% Other, p<0.0001), school decile (42% high, 34% medium and 20% low, p<0.0001), having attended an Auckland school (60%, p<.0001) and being admitted into medicine as a school leaver (50%, p<0.0001). The average admission GPA/GPE was approximately 2 points lower for MAPAS compared to GENERAL admission category students (6.22, SD 1.19, p<.0.0001). The ROMPE category differs in comparison to the GENERAL category by mean age (21.5, SD 4.55, p<0.0001), gender (61.5% female, p<0.017), ethnicity (84% European/Pākehā, 11% Asian, 1% Māori, 1% Pacific, 2% Other, p<0.0001), school decile (43% high, 43% medium, 7% low, p<0.0001), having attended an Auckland school (30%, p-value<0.0001), admission into first year as a school leaver (59%, p<0.0001) and entry pathway into medicine (31% graduate, 69% undergraduate, p-value<0.0002). The average admission GPA/GPE was approximately half a point lower for ROMPE compared to GENERAL students (7.74, SD 1.19, p<.0.0001).

Of the 1,082 students who completed the programme in the study period (i.e. admitted between 2002-2009), 95% (735/778) of GENERAL, 92% (111/121) of ROMPE and 80% (146/183) of MAPAS students graduated from MBChB. For the total cohort (admitted between 2002-2012), the mean Year 2-3 GPA was 6.35 (SD 1.52) for GENERAL, 5.82 (SD 1.65, p=0.0013) for ROMPE and 4.33 (SD 1.56, p<0.0001) for MAPAS students. Table 2 presents the multiple regression analysis findings for the Total Cohort.

[Insert Table 2]

Graduated from Medicine

In the unadjusted model, MAPAS students had significantly lower odds of graduating from intended programme compared to GENERAL students (OR:0.231, 95% CI:0.144-0.371). This pattern remained after controlling for age, gender and year of admission i.e. Model 1 (OR:0.235, CI:0.143-0.386). The odds of MAPAS students graduating in comparison to GENERAL students improved with the addition of medium and low school decile i.e. Model 2 (OR:0.291, CI:0.165-0.513), and having attended a school out of Auckland or being admitted into first year as a school leaver i.e. Model 3 (OR:0.296, CI:0.166-0.526, p=0.0002). The addition of having attended a bridging programme increased the odds of MAPAS students graduating from medicine by a further 14% in comparison to GENERAL students i.e. Model 5 (OR:0.440, CI:0.231-0.841). When entry pathway into medicine as a graduate and admission GPA/GPE were added to the analysis i.e. Model 5, the difference in odds of graduating between admission categories became non-significant (OR:1.680, CI: 0.736-3.833). These findings suggest that attending a higher decile school, a school outside of Auckland and admission into first year as a mature student each make a small contribution to the observed difference in graduation between MAPAS and GENERAL students. However, having attended a bridging/foundation programme prior to medical school entry had a stronger association with improved graduation outcome. In addition, both graduate entry admission and admission GPA/GPE are important contributors, after controlling for which the observed difference between the MAPAS and GENERAL students was no longer statistically significant.

No statistically significant difference was observed in graduation outcome between the ROMPE and GENERAL students when all predictor variables were taken into account i.e. Model 5 (OR:0.558, CI:0.227-1.374).

Year 2-3 GPA

In the unadjusted model, the average Year 2-3 GPA was nearly 2 points lower for MAPAS compared to GENERAL students (-1.934, CI:-2.112 to -1.756). This pattern remained after controlling for age, gender and year of admission i.e. Model 1 (-1.994, CI:-2.169 to -1.819) and school decile i.e. Model 2 (-1.936, CI:-2.122 to -1.75). Having attended an Auckland school and being admitted into first year as

a mature student reduced the difference in GPA slightly i.e. Model 3 (-1.899, CI:-2.076 to -1.702). Having attended a bridging programme prior to medical study further reduced the difference in GPA between MAPAS and GENERAL students i.e. Model 4 (-1.724, CI: -1.914 to -1.533). When both graduate entry admission and admission GPA/GPE were added in Model 5, no significant difference in Year 2-3 GPA was observed between the admission categories (0.103, CI:-0.103 to 0.309). These findings suggest that having attended a bridging programme, entering medicine as a graduate and a higher admission GPA/GPE are associated with improved performance for MAPAS compared to GENERAL students in the early years of the medical programme.

In the unadjusted model, the average difference between Year 2-3 GPA was approximately half a point lower for ROMPE compared to GENERAL students (-0.449, CI:-0.668 to -0.23). This general pattern remains for Models 1-4. When all predictor variables were taken into account in Model 5, the mean difference in Year 2-3 GPA became non-significant (-0.142, CI: -0.326 to 0.043). These findings suggest that admission as a graduate and admission GPA/GPE are the major contributors to the GPA difference between ROMPE and GENERAL students.

Table 3 presents the multiple regression analysis findings for the sub-cohort analyses for the MAPAS and GENERAL cohorts.

[Insert Table 3]

MAPAS Sub-Cohort

After controlling for pre-defined confounders (e.g. gender, age, ethnicity, year of admission) and all significant predictors, i.e. Model 5, the odds of a MAPAS student graduating from medicine was 86% lower for those MAPAS students who attended a bridging programme versus those who did not (OR: 0.141, CI: 0.042-0.468, p=0.0014) and 83% lower for MAPAS students who entered medicine via the graduate pathway versus the undergraduate pathway (OR: 0.170, CI: 0.043-0.681, p=0.0123). The odds of graduating increased by 1.8 times for every point increase in admission GPA/GPE (OR:1.758, CI:1.05-2.944, p=0.0319). There were mixed findings for school decile across the models and this variable was not significant in the final model that included admission GPA/GPE and entry pathway.

For MAPAS students, the year 2-3 GPA was similar for students regardless of whether or not they had attended a bridging programme (-0.927, CI:-1.209 to 0.645, p<0.0001) and was 25% higher for every point increase in admission GPA/GPA (0.754, CI: 0.647-0.861, p<0.0001). School decile rating was not a significant predictor in the final model for the MAPAS cohort.

GENERAL Sub-Cohort

After controlling for pre-defined confounders (e.g. gender, age, ethnicity, year of admission) and all significant predictors, the odds of a GENERAL student graduating from medicine was lower for students who attended a low decile (OR: 0.137, CI: 0.031-0.6, p=0.0098) or medium decile school (OR: 0.384, CI: 0.164-0.898, p=0.0098) compared to high school decile. Increasing admission GPA/GPE was strongly associated with increased odds of graduating (OR: 2.020, CI:1.46-2.796, p<0.0001). The Year 2-3 GPA was lower for graduate entry GENERAL students compared to undergraduate entry (0.577, CI: 0.377-0.777, p=0.0036) with similar outcomes observed for bridging programme attendance (-1.083, CI:-1.182 to -0.355, p=0.0036) and admission GPA/GPE (0.977, CI: 0.891-1.063, p=<0.0001). School decile rating was not a significant predictor of early academic outcomes for the GENERAL cohort.

Discussion

This study, based on 1676 medical students over a 10 year period compared outcomes and predictor variables of those admitted via two equity-admission pathways with those in the general admission pathway. To our knowledge, this is the first report in the literature describing programme level outcomes to this detail. The descriptive data confirm that it is possible to admit significant numbers of students via these pathways, and have most successfully complete the programme. Nearly all students with Māori and Pacific ethnicity entered via the MAPAS pathway. Furthermore, the MAPAS and ROMPE pathways each contained higher proportions of students from lower socio-economic backgrounds and students who attended schools out of Auckland. These findings underscore the importance of having equity pathways or targets, as it unlikely many of the MAPAS students, and some of the ROMPE students would have been successful in the highly competitive selection process for GENERAL students. Furthermore, to provide workforce benefit, students need to complete the programme. Encouragingly, despite marked differences in background and prior performance there was only a 12-15% difference in the proportion of MAPAS students who graduated in the study period compared to ROMPE or GENERAL admission students respectively. Our hypotheses that markers of socio-economic status, transitioning factors, bridging programme attendance and academic preparation are likely to impact on both short-term and long-term academic outcomes were confirmed, although findings are mixed within and across the entry pathways. When looking within the MAPAS cohort, the odds of a MAPAS student graduating (compared to another MAPAS student) improved with non-bridging programme attendance and most likely reflect cohort differences in admission GPA/GPE. In contrast, our findings suggest that having attended a bridging programme, entering medicine as an undergraduate and higher admission GPA/GPA are the major contributors to reducing the GPA difference observed *between* MAPAS and GENERAL students in the early, non-clinical phase of medical training.

This study represents a comprehensive analysis of academic outcomes for equity admission pathways into medicine within NZ. Similarly, this study explores academic outcomes for one of the largest cohorts of indigenous medical students available internationally. We acknowledge that this study was confined to a single medical programme and that the results may not be generalisable to other programmes or tertiary institutions. In particular, the comprehensive nature of the MAPAS programme with respect to student admission and retention support may not be reflected in other tertiary contexts.[28] Like similar measures elsewhere (e.g. participation of local areas (POLAR) classification in England), the use of secondary school decile as a proxy for socio-economic position relies on an area-level indicator of deprivation and may not directly reflect the socio-economic position of each individual student or their family.[29] Despite this, other school factors (e.g. student attainment, aspirations for future study) have been linked to school decile suggesting that individual students will have been exposed to direct school effects.[29-31] This study did not explore the effect of medical interview outcomes due to different processes of selection being used across equity and general admission pathways.[32 33] The study period spans across and before periods of significant change within the MAPAS and ROMPE pathways with respect to admissions processes (i.e. selection methods and eligibility).[19 34] Therefore, study findings should be interpreted cautiously as 'historical' markers of equity programme delivery or performance rather than accurate representations of the equity processes in operation today.[35]

Our findings are consistent with the existing literature base that GPA at the point of admission is the strongest predictor of academic outcomes within the medical programme.[32 36-38] In a critical appraisal of studies examining medical school failure, O'Neill and colleagues found that lower entry qualifications at admission were linked to higher failure rates. However, they note that many studies did not control for confounding factors, were mostly focused on student attributes, with few studies examining the role of the institution.[39] The fact that 80% of MAPAS students completed medicine despite being admitted with an average GPA approximately 2 points lower than other medical students is encouraging. This suggests that whilst GPA at admission is important, other unmeasured factors may be contributing to our findings. Student pastoral and financial issues (likely to be significant for indigenous students given their socioeconomic and demographic profile),[40] psychological characteristics,[41] student learning styles,[37] and relevant medical curricula or structural factors[39] may also play a role. As noted by Mathers and Parry, graduate applicants to medicine have complex needs arising from their personal social, family and economic circumstances that may affect their academic performance.[42] The UoA's commitment to respond to these student factors (via the provision of comprehensive admission, pastoral and academic support) may be contributing to our outcomes observed, particularly for graduate entry and bridging programme students admitted under MAPAS. The positive effect of bridging programme exposure has also been noted elsewhere[43-47]. However within the MAPAS cohort, those students who did not require additional academic support via a bridging programme experienced better academic outcomes. Therefore, our findings reinforce

the need for ongoing bridging programme delivery alongside the elimination of educational inequities for Māori and Pacific students (for more information please see *https://www.fmhs.auckland.ac.nz/en/faculty/for/future-undergraduates/undergraduate-study-options/certhsc.html*).[34 48-51] The association between secondary school decile rating (a marker of socio-economic status and school characteristics) and academic outcomes had mixed results and are unlikely to explain the differences observed by admission pathway. Although school decile has been linked to first year academic outcomes for Māori,[52] our findings may reflect the fact that school characteristics have been noted to have less impact on student achievement at the higher end of the achievement scale i.e. GPA ≥ 4.[53] However, the strong association between lower school decile and reduced odds of graduating for the GENERAL admission students challenges this conclusion, differs from other research[39] and is of concern.

Our study reinforces the existing evidence that equity-targeted admission programmes, inclusive of variations in academic threshold for entry, can support a widening participation agenda within medicine.[4] However, tertiary institutions and society at large must accept that ethnic inequities in educational outcomes and rural workforce development needs should be accounted for within admission pathways and retention support.[48 54] Providing comprehensive academic and pastoral assistance to equity-admission and lower socioeconomic students who are operating within complex and academically demanding contexts remains paramount.[28 55 56] Whilst differences in academic thresholds for equity groups appears necessary, it is often criticised as being 'politically correct', providing 'preferential treatment' to one group or individual over another, and has not been universally welcomed by the public or the profession.[16 57-60] Bacchi notes that the framing of widening participation as 'preferential treatment' "undermines the legitimacy of the reform and reduces its impact, limiting the kinds of reforms 'permitted' and alienating those who are targeted. This undoubtedly serves the interests of those who profit under current social arrangements" (p. 144). [58] Given this context, it is perhaps not surprising that whilst medical schools strive to increase diversity and meet the goals of a widening participation agenda, successful implementation is influenced by contextual factors associated with institutional leadership, resource allocation and external stakeholder pressure. Razack et al note that whilst the development of social accountability policy has occurred, medical schools appear to be challenged by the implementation of these policies within student recruitment and selection processes.[61] This study responds to calls for open and inclusive discussions in order to advance admissions practice aiming to enhance social justice and widening participation agendas.[61]

Additional research is warranted (e.g. inclusion of secondary school outcomes, non-cognitive testing and medical interview data beyond 2012). Similarly, exploring the effect of institutional attributes should also be considered.[37 39] Evidence suggests that tertiary and medical school environments may have different effects on indigenous and ethnic minority students who have reported that their

ethnicity adversely affects their medical school experience,[62] have described experiences of racism from peers and clinical educators,[28 63] and are adversely effected by an 'othering' medical curriculum that either stereotypes indigenous culture and society or fails to reflect indigenous realities alltogether.[35 40 64 65] Exploring the impact of these variables on differential academic outcomes for equity admission pathways may require qualitative methods to complement additional quantitative analyses. The impact of a widening participation agenda within medicine must also begin to look beyond the number of students admitted and graduated and extend the analysis to post-graduate clinical contexts including the effect of a diverse health workforce on patient and community outcomes.[1] The ultimate aim of equity-targeted admission pathways into medicine is to enhance healthcare delivery, improve health outcomes and eliminate inequities for underserved communities. Understanding when and how this can be achieved remains a challenge for many countries worldwide.

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A declaration of competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work."

Details of contributors

Dr Elana Curtis (Senior Lecturer Medical) is the guarantor of the study. She led the study design, methodological approach, interpretation of the data analysis and was the primary author for drafting the manuscript. Erena Wikaire (Research Assistant) contributed to study design and provided research assistance to obtain and clean data variables. She contributed to drafting and revising the manuscript and was responsible for producing the data tables. Dr Yannan Jiang (Senior Research Fellow) contributed to the study design and provided senior statistical expertise for data analysis. She contributed to drafting and revising the manuscript. Louise McMillan (doctoral candidate) provided junior statistical expertise and contributed to the study design and revising the manuscript. Robert Loto (Professional Teaching Fellow) contributed to the study design and provided Pacific research methodological expertise in the interpretation of the data and revising of the manuscript. Associate Professor Mark Barrow (Associate Dean Education) contributed to the study design and provided senior tertiary education expertise in the interpretation of the data, drafting and revising of the manuscript. Professor Warwick Bagg contributed to the study design and provided senior medical education expertise in the interpretation of the data, drafting and revising of the manuscript. Professor Phillippa Poole contributed to the study design and provided senior medical education expertise in the interpretation of the data, drafting and revising of the manuscript. Associate Professor Papaarangi Reid (Tumaki, Deputy Dean Māori) provided senior Māori educational, institutional and Kaupapa Māori expertise and contributed to the study design, drafting and revising the manuscript. All authors read and approved the final manuscript for submission.

Ethics approval

The study was approved by the UoA Human Participants Ethics Committee (UAHPEC) (Reference 8110). As this study used de-identified secondary administrative data, study participants were not required to give informed consent.

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All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

A transparency declaration

I, Dr Elana Curtis (the manuscript's guarantor) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

A data sharing statement

Data sharing: no additional data available.

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Figure 1: Conceptual model and multiple regression analysis plan with stepwise model selection.
[See separate attachment]

Table 1: Descriptive variables for GENERAL, MAPAS and ROMPE admission categories 2002 – 2009.

Descriptive summary variables	Admission category								Total (n=1082)	
	GENERAL (n=778)		MAPAS (n=183)			ROMPE (n=121)				
Categorical variables	*n*	*%*	*n*	*%*	*p-value*	*n*	*%*	*p-value*	*n*	*%*
Female	427	54.88	103	56.28	0.7319	76	62.81	0.1023	606	56.01
Ethnicity					<.0001			<.0001		
Māori	20	2.57	102	55.74		2	1.65		124	11.46
Pacific	14	1.80	79	43.17		2	1.65		95	8.78
Asian	339	43.57	1	0.55		12	9.92		352	32.53
Other	44	5.66	1	0.55		3	2.48		48	4.44
Pākehā/European	348	44.73	0	0.00		99	81.82		447	41.31
Missing/No response	13	1.68	0	0.00		3	2.48		16	1.48
School decile rating					<.0001			<.0001		
High	545	70.05	80	43.72		54	44.63		679	62.75
Medium	159	20.44	54	29.51		48	39.67		261	24.12
Low	24	3.08	38	20.77		9	7.44		71	6.56
Missing	50	6.43	11	6.01		10	8.26		71	6.56
Attended school in Auckland	565	72.62	115	62.84	0.0017	48	39.67	<.0001	728	67.28
Completed bridging programme	8	1.03	41	22.40	<.0001	1	0.83	1.0000	50	4.62
Admitted as School leaver (yr 1)	565	72.62	91	49.73	<.0001	78	64.46	0.0643	734	67.84
Entry pathway					0.5200			0.0001		
Graduate	121	15.55	32	17.49		36	29.75		189	17.47
Undergraduate (UG)	657	84.45	151	82.51		85	70.25		893	82.53
Graduated (yes)	735	94.47	146	79.78	<.0001	111	91.74	0.2343	992	91.68
Continuous variables	*Mean*	*SD*	*Mean*	*SD*		*Mean*	*SD*		*Mean*	*SD*
Age at admission (yr 2)	20.02	3.10	20.98	3.97	0.0014	21.07	3.80	0.0041	20.3	3.37
Admission GPA/GPE	8.12	0.99	6.04	1.29	<0.0001	7.72	0.88	0.0002	7.72	1.29

Cohort 2002-9 comprises students who matriculated into Year 2 of the MBCHB (or Bachelor of Human Biology BHB) programme within FMHS from 2002 to 2009 inclusive, excluding international entry students. Students who repeated Year 2 have been recorded in their first Year 2 year. All variables have been compared for the General vs. MAPAS categories and for the General vs. RRAS categories. Categorical variables have been tested using Chi-squared test, or Fisher's exact test where necessary. Continuous variables have been tested using the ANOVA model, with adjustment for multiple comparisons.

Table 2: Multiple regression results for Graduated (2002-2009 cohort) and Year 2-3 GPA (2002–2012 cohort) academic outcomes.

Model	Predictor variable (ref)	Comparison	Graduated (n=1082) (2002 - 2009 cohort)			Year 2-3 GPA (n=1676) (2002 – 2012 cohort)		
			Overall p-value	OR	95% CI	Overall p-value	Mean difference	95% CI
Unadj.	**Admission category (GENERAL)**	MAPAS	<.0001	0.23	(0.14, 0.37)	<.0001	-1.93	(-2.11,-1.76)
		ROMPE		0.65	(0.32, 1.33)		-0.45	(-0.67,-0.23)
1	**Admission category (GENERAL)**	MAPAS	<.0001	0.24	(0.14, 0.39)	<.0001	-1.99	(-2.17,-1.82)
		ROMPE		0.70	(0.33, 1.50)		-0.54	(-0.76,-0.32)
				*n=1011**			*n=1586**	
2	**Admission category (GENERAL)**	MAPAS	0.0001	0.29	(0.16, 0.51)	<.0001	-1.94	(-2.12, -1.75)
		ROMPE		0.63	(0.28, 1.44)		-0.54	(-0.77, -0.31)
	School decile (High 8-10)	Medium (4-7)	0.0032	0.56	(0.32, 0.98)	0.0279	-0.16	(-0.32, -0.00)
		Low (1-3)		0.29	(0.14, 0.61)		-0.32	(-0.61, -0.03)
3	**Admission category (GENERAL)**	MAPAS	0.0002	0.30	(0.17, 0.53)	<.0001	-1.89	(-2.08, -1.70)
		ROMPE		0.48	(0.21, 1.12)		-0.53	(-0.76, -0.31)
	School decile (High 8-10)	Medium (4-7)	0.0022	0.52	(0.29, 0.93)	0.0454	-0.15	(-0.31, 0.00)
		Low (1-3)		0.28	(0.13, 0.59)		-0.29	(-0.58, -0.00)
	Auckland school (Yes)	No	0.0030	2.67	(1.40, 5.09)	-	-	-
	Type of admission (SL)	AA	0.0430	0.53	(0.29, 0.10)	0.0004	-0.34	(-0.53, -0.15)
4	**Admission category (GENERAL)**	MAPAS	0.0182	0.44	(0.23, 0.84)	<.0001	-1.72	(-1.91, -1.53)
		ROMPE		0.42	(0.18, 0.10)		-0.61	(-0.83, -0.39)
	School decile (High 8-10)	Medium (4-7)	0.0096	0.58	(0.32, 1.05)	-	-	-
		Low (1-3)		0.31	(0.14, 0.68)	-	-	-
	Auckland school (Yes)	No	0.0062	2.52	(1.30, 4.88)	-	-	-
	Type of admission (SL)	AA	-	-	-	-	-	-
	Bridging Programme (No)	Yes	<.0001	0.16	(0.07, 0.36)	<.0001	-1.24	(-1.56, -0.91)
5	**Admission category (GENERAL)**	MAPAS	0.1251	1.68	(0.74, 3.83)	0.1306	0.10	(-0.10, 0.31)
		ROMPE		0.56	(0.23, 1.37)		-0.14	(-0.33, 0.04)
	School decile (High 8-10)	Medium (4-7)	0.0276	0.66	(0.35, 1.23)	-	-	-
		Low (1-3)		0.31	(0.13, 0.74)	-	-	-
	Auckland school (Yes)	No	0.0030	2.88	(1.43, 5.79)	-	-	-
	Type of admission (SL)	AA	-	-	-	-	-	-
	Bridging Programme (No)	Yes	<.0001	0.17	(0.07, 0.40)	<.0001	-0.90	(-1.18, -0.61)
	Entry pathway (Undergraduate)	Graduate	0.0100	0.45	(0.24, 0.82)	<.0001	0.47	(0.31, 0.64)
	Admission GPA/GPE	per point increase	<.0001	1.95	(1.55, 2.45)	<.0001	0.89	(0.82, 0.95)

** n is the total number in the cohort, number used is the number of students who have complete data for the given model (all other students are excluded from the analysis). In the Total Cohort, 90 did not graduate whereas 992 graduated. Model #2 – 5 cohort sizes reduced to 1011 and 1586 respectively due to missing school decile data; fewer students were excluded due to missing data for the remaining predictors. Logistic regression model applied to graduation outcome, linear regression model applied to Year2-3 GPA outcome. All regression models have controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. All models include the predictor Admission Category. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of odds ratio or mean difference (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.*

Table 3:

(a) Logistic regression results for Graduated (2002-2009 cohort) academic outcome for MAPAS and GENERAL subgroups.

Model	Predictor variable (ref)	Comparison	Graduated (2002 - 2009 cohort) MAPAS (n=181)			Graduated (2002 - 2009 cohort) GENERAL (n=778)		
			Overall p-value	OR	95% CI	Overall p-value	OR	95% CI
1	**Ethnicity**	Māori	–	–	–	0.0010	0.175	(0.047,0.648)
	(reference group Māori for	Pacific	0.0035	0.285	(0.123,0.662)	–	0.089	(0.023,0.339)
	MAPAS, Pākehā/European for	Asian	–	–	–	–	0.657	(0.286,1.508)
	GENERAL)	Other/Missing	–	–	–	–	0.316	(0.106,0.940)
5				n = 170			n=728	
	School decile (High 8-10)	Medium (4-7)	–	–	–	0.0098	0.384	(0.164,0.898)
		Low (1-3)		–	–		0.137	(0.031,0.600)
	Auckland school (Yes)	No	0.0127	4.571	(1.256,16.629)	–	–	–
	Type of admission (SL)	AA	–	–	–	–	–	–
	Bridging Programme (No)	Yes	0.0014	0.141	(0.042,0.468)	–	–	–
	Entyr pathway (Undergraduate)	Graduate	0.0123	0.170	(0.043,0.681)	–	–	–
	Admission GPA/GPE	per point increase	0.0319	1.758	(1.050,2.994)	< .0001	2.020	(1.460,2.796)

Logistic regression model has controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of odds ratios (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.

(b) Linear regression results for Year 2-3 GPA (2002–2012 cohort) academic outcome for MAPAS and GENERAL subgroups.

Model	Predictor variable (ref)	Comparison	Year 2-3 GPA (2002 – 2012 cohort) MAPAS (n=315)			Year 2-3 GPA (2002 – 2012 cohort) GENERAL (n=1167)		
			Overall p-value	Mean difference	95% CI	Overall p-value	Mean difference	95% CI
1	**Ethnicity**	Māori	–	–	–	<.0001	-0.616	(-1.201,-0.031)
	(reference group Māori for	Pacific	0.0109	-0.425	(-1.018,0.168)	–	-2.226	(-2.939,-1.513)
	MAPAS, Pākehā/European for	Asian	–	–	–	–	-0.191	(-0.358,-0.025)
	GENERAL)	Other/Missing	–	–	–	–	-0.524	(-0.852,-0.196)
5				n=302			n=1104	
	School decile (High 8-10)	Medium (4-7)	–	–	–	–	–	–
		Low (1-3)		–	–		–	–
	Auckland school (Yes)	No	–	–	–	–	–	–
	Type of admission (SL)	AA	–	–	–	–	–	–
	Bridging Programme (No)	Yes	< .0001	-0.927	(-1.209,-0.654)	0.0036	-1.083	(-1.812,-0.355)
	Entry pathway (Undergraduate)	Graduate	–	–	–	< .0001	0.577	(0.377,0.777)
	Admission GPA/GPE	per point increase	< .0001	0.754	(0.647,0.861)	< .0001	0.977	(0.891,1.063)

Linear regression model has controlled for year of admission, gender and age at admission. Pre-defined predictors were added to the baseline model in sequential order to estimate their joint independent effects on the outcome. Each model was initially run with all the specified predictors, then re-run with stepwise selection to include significant predictors only and obtain final estimates of effect size. Model-adjusted estimates of mean difference (compared to the reference level), 95% confidence intervals (CI) and associated individual p-values (in symbols) were reported.

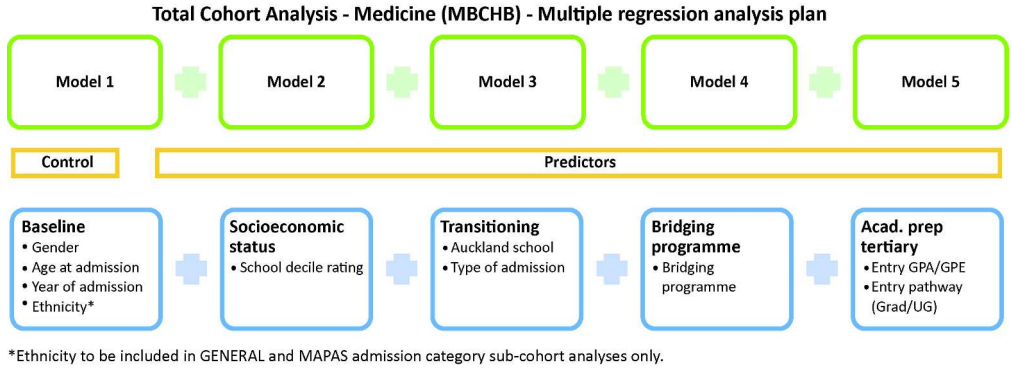

Figure 1: Conceptual model and multiple regression analysis plan with stepwise model selection.

248x90mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Pg.1, Line 5.**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Pg.2, Lines 6-37.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Pgs.4, Lines 3-58, Pg.5, Lines 3-29.**
Objectives	3	State specific objectives, including any prespecified hypotheses **Pg.6, Lines 46-52, Figure 1 Pg. 18, Pg.5, Lines 20-25.**
Methods		
Study design	4	Present key elements of study design early in the paper **Pg.4, Lines 37-41.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Pg.4, Lines 37-58, Pg.5, Lines 3-20.**
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Pg. 5, Lines 34-46.**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed – **N/a** *Case-control study*—For matched studies, give matching criteria and the number of controls per case – **N/a**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Pg. 6, Lines 4-40.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Pg.5, Lines 34-58, Pg.6, Pg. 7, Lines 4-28.**
Bias	9	Describe any efforts to address potential sources of bias **Pg. 7, Lines 7-28.**
Study size	10	Explain how the study size was arrived at **Pg. 5, Lines 43-46. The study size was based on the maximum study period available given availability of electronic data for analysis.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Pg. 6, Lines 4-58.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Pg. 6, Lines 43-58, Pg. 7, Lines 4-28.**
		(*b*) Describe any methods used to examine subgroups and interactions **Pg. 6, Lines 43-58, Pg. 7, Lines 4-28.**
		(*c*) Explain how missing data were addressed

Pg. 7, Lines 27-28.

(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy

Pg. 6, Lines 43-58, Pg. 7, Lines 4-28.

(*e*) Describe any sensitivity analyses

No sensitivity analyses were conducted.

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **See Tables. Pg.s 19-22**
		(b) Give reasons for non-participation at each stage **See Table notes. Pgs. 19-22**
		(c) Consider use of a flow diagram **N/a.**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Table 1. Pg.19, Table 2, Pg. 20**
		(b) Indicate number of participants with missing data for each variable of interest **Pg. 7, Lines 27-28. Within descriptive summary tables**: **Table 1. Pg.19, Table 2, Pg. 20**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) **– N/a**
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time **- (N/a)**
		Case-control study—Report numbers in each exposure category, or summary measures of exposure **- (N/a)**
		Cross-sectional study—Report numbers of outcome events or summary measures **Table 1. Pg.19, Table 2, Pg. 20**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Pg.7, Lines 33-58, Pg. 8, Pg.9, Pg. 10, Lines 3-18.**
		(*b*) Report category boundaries when continuous variables were categorized **See Table notes. Table 1. Pg.19, Table 2, Pg. 20**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **N/a**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **See Pg. 7,Lines 20-28. We ran subgroup analysis by admission category (MAPAS, GENERAL) and the differences between sub-cohorts were tested in the main model. Because we had total cohort available for analysis, no sensitivity analysis was conducted.**
Discussion		
Key results	**18**	**Summarise key results with reference to study objectives** **Pg.10, Lines 21-55.**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Pg.11, Lines 6-26.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Pg.11, Lines 29-58, Pg.12, Lines 3-13.**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Pg.11, Lines 6-58. Pg.12, Lines 3-13.**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable,

for the original study on which the present article is based
Pg. 13, Lines 55-58, Pg.14, Lines 3-4.

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.