



**Starpath**

A University of Auckland Partnership for Excellence



**THE UNIVERSITY  
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**NEW ZEALAND**

Te Whare Wānanga o Tāmaki Makaurau

# **The Impact of a Revised UE Criterion upon Certain Subgroups of Students**



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# 1 EXECUTIVE SUMMARY

In a Starpath technical report Shulruf, Hattie, and Tumen (2007) proposed a number of alternative criteria, different from the criterion currently used by the NZQA (New Zealand Qualifications Authority), for achieving “UE” (University Entrance).<sup>1</sup> The proposed criteria incorporate notions of quality as well as quantity into the process of achieving UE. They are based upon a GPA [grade point average] score calculated from results obtained on NCEA standards.

The over-all goals of Starpath include the identification, evaluation, and consideration of options in respect of systematic obstacles which lead to under-representation of certain subgroups of the New Zealand population, in particular the Māori and Pacific Peoples subgroups, amongst degree-level tertiary education students. In keeping with these over-all goals, the goal of the study undertaken by Shulruf et al. was to understand those factors involved in the criteria for entry to university which contribute to such under-representation and to explore what would happen if these factors were changed. The current study shares this goal.

In this report we investigate alternative criteria which are related to, but different from those proposed by Shulruf et al. (2007). Our proposed alternative criteria were applied to, or tested out upon, national NCEA Level 3 results for the years 2004, 2005, and 2006.

Like those proposed in Shulruf et al. (2007), our criteria are based on the idea of determining UE in terms of a “cutoff ” value of NCEA GPA. We explore three variants:

- (1) An “intake neutral” criterion.
- (2) A regression based criterion according to which first year university GPA results are predicted from NCEA GPA values and a “cutoff ” value of the NCEA GPA is chosen corresponding to a reasonable value of first year university GPA (e.g. to 2, the GPA value of a grade of C). In this variant we include the option of incorporating a lower prediction bound on the fitted values from the regression.
- (3) A “dual entry” criterion (whereby students gain UE if they meet either the old NZQA criterion or the new criterion being proposed) similar to that introduced in Shulruf et al. (2007). The dual entry criterion is implemented in two ways: using the fitted regression line directly, and using a 95% confidence lower prediction bound.

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<sup>1</sup> It is important to understand that this is a qualification awarded by the NZQA in terms of the NCEA structure. It is no guarantee that the recipient will actually be admitted to any university in New Zealand.

We investigate what impact the alternative criteria would have on various subgroups of the student population, and quantify the variability or uncertainty in the estimates of impact. This uncertainty is not amenable to analysis via standard techniques and must be estimated via Monte Carlo techniques.

The most salient finding in this study is that the intake neutral criterion has a consistently positive impact upon the Māori ethnic group, and a consistently negative impact upon the Asian group. The impact on other groups (Pākehā, Pacific, and Other) is in general not statistically significantly different from zero. The impact of the pure regression criterion (without a lower prediction bound being used) is not markedly different from that of the intake neutral criterion, but the results are less clear-cut. When a 95% lower prediction bound is used, the number of students admitted becomes unacceptably small. The dual entry criterion, with no use of a lower prediction bound, is similar in its impact to the corresponding criterion proposed by Shulruf et al. that is, it has a (statistically significantly) positive impact upon the lower deciles. However the dual entry criterion with a 95% lower prediction bound has essentially no discernible impact.



## 2 INTRODUCTION

This report is concerned with alternatives to the criteria for achieving “University Entrance” (UE) as currently specified by the New Zealand Qualifications Authority (NZQA). Note that UE is an NZQA qualification which was established under the Education Act by NZQA in consultation with the New Zealand Vice Chancellors Committee. It may be considered as a “minimal requirement” or first step toward achieving admission to the university of one’s choice. However it does not (any longer) guarantee such admission. Individual universities may have their own sets of entry criteria, and indeed these criteria may vary from program to program within a given university. We do not consider any particular university’s criteria in this report, only the NZQA qualification.

In a Starpath technical report Shulruf et al. (2007) discuss the implications and consequences of adjusting the criteria for achieving UE as currently specified by the NZQA. The authors are particularly interested in the impact of such an adjustment upon groups of students currently under-represented in New Zealand universities, especially students of Māori and Pacific ethnicities, and those students who attend low decile schools. The essence of the adjustments suggested by the authors is to take account of the quality of the students’ results in addition to “quantity”. The current UE criteria (see <http://www.nzqa.govt.nz/ncea/for-students/ue/index.html> for these) are based on counts of the number of NCEA credits achieved, with no extra weighting being given to the quality of the results, i.e. marks of “merit” or “excellence”. Shulruf et al. suggested looking at a form of “grade point average” (GPA) calculated on the basis of 0 points for “not achieved”, 2 points for “achieved”, 3 points for “merit”, and 4 points for “excellence”.

The GPA calculated should of course be a weighted average of the points achieved, with the weights being proportional to the number of credits that each NCEA standard is worth. Shulruf et al. also consider a number of additional weightings that could be factored in, based for example on some assessment of the difficulty of each standard. Finally Shulruf et al. proposed a “dual entry criterion” whereby students would be deemed to have achieved UE if they met either the “old” (current) entry criterion or a new criterion based on a form of the GPA just described.

In the current study we commence by reviewing some of the literature related to entry criteria for tertiary study and the equity issues involved (section 3). We then briefly discuss the calculations involved in setting up the new criteria proposed by Shulruf et al.

(section 4), propose an alternative to the “new criteria” (section 5), and make some remarks (section 6) on idiosyncrasies of the data sets to be analysed, namely NCEA “summary” data sets for the years 2004, 2005 and 2006. In section 7 we calculate and discuss numerical parameters of the modified criterion for each of the aforementioned data sets, and conduct some related analyses of the data sets.

In section 8 we investigate the impact of the modified criterion on certain subgroups of the student population. In section 9 we try a modified calculation which is more closely related to that used by Shulruf et al.. We apply this calculation to “detailed” NCEA data sets (corresponding to the “summary” data sets referred to above) in conjunction with University of Auckland data sets for the succeeding years, i.e. 2005, 2006, and 2007. We then proceed to explore the idea of the “dual entry” criterion, referred to above, as proposed by Shulruf et al.. In section 10 we summarise our findings and suggest some ideas for further research.

### **3 LITERATURE REVIEW**

Equity in higher education has been a major concern of educational policy makers in New Zealand and worldwide. See for instance Anae et al. (2002), Dobric (2005), Halsey (1993), Ministry of Education (2002, 2005a, 2005b), Scott (2004, 2005), and Smyth et al. (2006).

Historically higher education institutions and policy makers have addressed the issue of inequality in higher education largely by modifying admission policies reflecting the belief that the barrier to equality lies with the gatekeeper i.e. the admission criteria. As a result, a range of admission policies have been implemented with the aim of increasing the number of students from traditionally under-represented populations in higher education (Rigol, 2003; Skilbeck and Connell, 2000). Among these the most popular admission policies are the open admission policy (Friedlander, 2008; Schmid, 2008), and ethnicity based affirmative action policies (Bucks, 2005; Donnelly, 1998; Loury and Garman, 1993; Tienda, Alon, and Niu, 2008). Most New Zealand universities, however, have applied special admission policies for traditionally underrepresented populations, particularly aimed at enabling students of Māori and Pacific ethnicities to enroll in degree programs even if they have not met all the admission criteria. Nonetheless, a comprehensive synthesis of the evidence of New Zealand tertiary education outcomes indicates that although the educational attainment of all New Zealanders has increased over the period 1991 — 2005 the gaps between ethnic groups remain the same (Smart 2006).



## **4 DISCUSSION OF THE CRITERIA USED BY SHULRUF ET AL.**

The criteria developed by Shulruf et al. as discussed in section 2 were arrived at by fitting a regression model in which first year university GPA is predicted by the NCEA GPA which the authors calculated. Using the fitted model the authors chose a cutoff value for the NCEA GPA corresponding to a value of university GPA which might be thought of as constituting a reasonable level of success at university. The authors say (Shulruf et al., 2007, page 13) that “a minimum NCEA GPA of 2.32 (falling between achieved and merit) predicted a first year university GPA of 2.0<sup>2</sup> or higher, therefore this NCEA GPA (2.32) was set as the minimum for entry provided that at least 36 credits were obtained from university approved subjects [together with meeting the literacy and numeracy criteria]”.

However the authors' calculations appear to have been a bit more complicated than this. Discussions with the first author revealed that achieving the numeracy and literacy criteria were actually incorporated into the regression modelling exercise in a rather intricate manner. This, and other fine adjustments, made their procedure difficult to implement. We have therefore undertaken a number of independent approaches to the issue of analysing the impact of changes in entry criteria. The first of these approaches, described in section 5, is substantially different. Later we consider ideas more closely related to those of Shulruf et al..

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<sup>2</sup> A GPA of 2.0 corresponds to a letter grade of “C”, i.e. a pass.



## 5 AN INTAKE NEUTRAL CRITERION

The defining feature of our approach is that it aims to formulate an entry criterion which is “intake neutral”. That is, we propose to adjust the (new, “quality-based”) criterion so that it will admit exactly the same fraction of students as were admitted under the “old” (current) criterion. The rationale for an intake neutral approach is to maintain the same expenditure impact upon the universities, and the education system generally. Also an intake neutral criterion is less liable to be subject to suspicions of lowering standards.

The entry criterion that we propose, although based on a very different approach from that used in Shulruf *et al.*, 2007 was also formulated in terms of the NCEA GPA. That GPA was calculated as a weighted average of students’ results with weights equal to the number credits that each standard is worth. Also following the procedure of Shulruf *et al.* we calculated the NCEA GPA on the basis of standards from the Approved List only. Note that scholarship standards were not considered at all since these have no associated credit value and are in practice used in a very different manner from the other standards.

Each student has an NCEA GPA calculated on the basis of numerical scores assigned according to the correspondence “not achieved” equals 0, “achieved” equals 2, “merit” equals 3, and “excellence” equals 4. A weighted average is taken of the student’s scores on all standards from the Approved List of subjects. A student is assigned an NCEA GPA only if he or she has attempted at least “ $\kappa$ ” credits in standards from the Approved List (where  $\kappa$  may be adjusted as desired). Otherwise the student’s NCEA GPA is considered to be a “missing value”. In all of the calculations upon which this report is based, we took the value of  $\kappa$ , rather arbitrarily, to be 30. Other “reasonable” values might be 28 (the minimum number of Approved List credits needed to achieve UE under the current criteria) or 36 (the number used by Shulruf *et al.*).

The new criterion for UE, expressed in terms of the NCEA GPA defined above, is that a student will be credited with having achieved UE if:

- (i) he or she has satisfied the NZQA literacy criterion;
- (ii) he or she has satisfied the NZQA numeracy criterion;
- (iii) he or she attained an NCEA GPA (as described above) of at least  $g_0$ .

The cutoff value “ $g_0$ ” referred to in item (iii) above is a tuning parameter, and may be adjusted at will; increasing  $g_0$  will decrease the fraction of students achieving UE; decreasing  $g_0$  will increase that fraction. Our procedure was to adjust  $g_0$  until the fraction of students achieving UE matched<sup>3</sup> the fraction achieving it under the “old” (current) criterion.

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<sup>3</sup> It may not be possible to make the match absolutely exact due to “granularity” in the data. That is, if  $k > 1$  students have a GPA equal to  $g$  then increasing  $g_0$  above  $g$  decreases the fraction achieving UE by at least  $k/N$  where  $N$  is the total number of students.



## 6 REMARKS ON THE DATA SETS

In the next section we will examine the impact of our proposed alternative entry criterion on numbers and percentages of students achieving UE in three cohorts, namely those students who sat their NCEA Level 3 standards in the years 2004, 2005, and 2006. Before embarking on the relevant calculations, we make some remarks on the data sets on which our calculations are based. The data set, for each of the given years, comprises summary records (as provided to the University of Auckland by the NZQA) of all students who were known to have attempted at least one Level 3 standard in that year.

In 2004 there were 29161 students in the (subset of the) national NCEA database that was used in this analysis. The original database, as it was received, contained the records of 31140 students. Following the procedure of Shulruf et al. (2007) we restricted attention to students whose ages fell between 17 and 20 (inclusive). (Ages were calculated simply by subtracting each student's year of birth from the year under consideration. No attempt was made to take month of birth into account.)

We also eliminated from consideration a certain subset (of size 1445) of students that had been eliminated by Shulruf et al. (2007)<sup>4</sup> in order to make our results as comparable as possible to theirs. For 2005 and 2006 we again restricted attention to students with ages between 17 and 20, but placed no further restrictions on the database.

Our main focus in analysing these data is on students' success, or otherwise, in achieving UE according to the NZQA criteria. An initial calculation of the success rates (according to the currently used NZQA criteria) for the three cohorts revealed another aspect of the data that needs to be allowed for. The initial calculation was done simply by taking the ratio of the number of students who achieved UE to the total number of students in the data set (using the data sets which had been pre-filtered as described above). This gave a success rate of 52% in 2004, 40% in 2005, and 42% in 2006. The disparity in the rates between the first cohort and the latter two is startling. It is also noteworthy that the total number of students in the (pre-filtered) first cohort is 29161 which is strikingly smaller than the numbers in the latter two, which are 41869 and 42971 respectively.

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<sup>4</sup> In this report (page 9) the size of the data set is given as 29695. This is 1445 less than the size of the complete data set as we received it. Note that of these 1445 students, 155 were eliminated anyway on the basis of the age criterion, for a net reduction of 1290.

Investigation revealed that the disparity appears to be due to the presence of students who are enrolled in years earlier than Year 13. The number of such students is very small in the 2004 cohort (only 126) whereas the numbers in 2005 and 2006 are 11322 and 11161 respectively). Part of the explanation for this difference is the fact that 2004 was the first year in which NCEA Level 3 was fully operational. Another part of the explanation is that between 2004 and 2005 the NZQA changed their procedures for reporting Level 3 results to the universities.

The striking disparity between the first and the latter two cohorts is removed by eliminating students who are enrolled in years earlier than Year 13. When these students are removed from consideration the success rates become 54% for 2005 and 56% for 2006. These values are much more commensurate with the success rate for 2004. The data sets which result from eliminating students in years earlier than Year 13 are described as “restricted” throughout the rest of this report. Since we are basically interested in students who are potentially on the verge of entering, or of being able to enter, university, it makes sense to consider only the restricted data sets. Students who are not in the restricted data sets are unlikely to be able to achieve UE in the given year. Potentially a few may be able to do so, but the numbers involved are unknown and are likely to be quite small.

Since Shulruf et al. (2007), who analysed only the 2004 cohort, used the unrestricted data set, we have analysed both the restricted and unrestricted form of this cohort for the sake of comparison. Since the difference in the total numbers is so small here (only 126) the restricted and unrestricted results are virtually identical. The various counts, and the overall success rate, for the unrestricted and restricted 2004 cohorts, and for the restricted 2005 and 2006 cohorts are summarised in Table 3 on page 16.

A major focus of this research is a comparison of the impact of changes in the criteria for achieving UE upon the different deciles. A complication arises here in that there is a substantial number of students in the database whose “provider” is not allocated a decile. Such providers include private schools (which were not allocated deciles until 2008) and the Correspondence School for which the concept of decile is inapplicable. For students of such providers decile appears in the database as a missing value.

After some deliberation we decided not to eliminate from consideration students whose decile value is missing. In various graphs that we have produced the “missing value

decile” appears as a category on its own, separate from deciles 1 through 10. Some pause for thought is called for by the fact that the Correspondence School is arguably categorically different from the other providers whose decile is missing. However since the missing decile providers are of at most peripheral interest from the point of view of this study, it did not seem worthwhile to separate the Correspondence School from the rest. Students from schools without a decile constitute a little over 4% of the total. Of these students, those from the Correspondence School constitute between about 9% and 14% depending on year, for about 0.4% or 0.5% of the total.



## 7 NUMERICAL RESULTS

Summaries of the calculated GPA values for the years 2004, 2005, and 2006 are shown in Table 1 on page 16. The counts of missing values are in effect counts of those students who did not attempt standards worth at least 30 credits from the Approved List. Histograms of the GPA values for each of the three years in question are shown in Figure 1 on page 17. These histograms were created using the unrestricted cohorts. There was very little difference between the histograms for the restricted and unrestricted cohorts. Almost all of the students eliminated due to “restriction” were eliminated in any case by the requirement of having to have attempted at least 30 credits in standards from the Approved List.

The histograms evince no particularly startling characteristics. Using Tukey’s box plot criterion many of the observations in both tails would be considered “outliers” (aberrant or unusual observations). Quantile-quantile plots, on the other hand, reveal the tails of the distribution to be a bit “light” (i.e. to have less “probability mass” than expected according to the standard of a normal distribution). This is unsurprising in view of the fact that the GPA is constrained to lie between 0 and 4. A table of the skewness and kurtosis values for the three samples of GPA values is shown in Table 2 on page 16. These values appear to indicate that the behaviour of these data is acceptably close to that of a Gaussian distribution. (Of course they cannot however be truly Gaussian since, as noted above, they have finite range.)

The NCEA GPA cutoff value  $g_0$ , as described in section 5 (see page 4) was 1.39 for the 2004 results (the restricted and unrestricted data giving the same value to two decimal places), 1.52 for the 2005 results, and 1.51 for the 2006 results. Notice that the cutoffs for 2005 and 2006 are considerably higher than that for 2004 despite the success rates for 2005 and 2006 (54% and 56% respectively) being somewhat higher than for 2004 (i.e. 52%).

We remark that along with the fraction of students meeting the current UE requirements increasing over time, the mean NCEA GPA also has increased by a statistically significant amount. The increase from 2004 to 2005 was particularly substantial. A 95% confidence interval for the mean change from 2004 to 2005 is [0.15, 0.17]. The corresponding interval for the change from 2005 to 2006 is [0.03, 0.06], so the change here is again statistically significant although not so substantial.

Since 2004 was the first year that admission to university was determined on the basis of NCEA results, one might expect that there would be “teething” and settling-in problems, with students and their teachers working through issues in respect of adjusting to the new system. Further progress in adjusting to the new system would be made between 2005 and 2006. Thus the increase in mean GPA — substantial from 2004 to 2005, less so from 2005 to 2006 — is perhaps what one might expect to occur as students and their teachers “learned the ropes”. It is not clear however why the increase in mean GPA is so much more striking than the increase in success rate.

It should be noted that the NZQA official figures for success rates differ from ours, but likewise show a generally increasing trend over the years. The NZQA calculations (at least prior to 2008) were roll-based. Thus the denominator of the success rate is formed from the July 1 roll figures. In 2008 NZQA commenced producing both roll-based and participation-based figures. For the participation-based figures the denominator is “the number of candidates who, on the basis of results prior to, and entries during, a selected year, could potentially complete a given qualification by the end of the selected year.” (See NZQA Statistics Manual, 2009, p.14.) The denominator which we (perforce) used was the number of students who had attempted at least one Level 3 (or higher) NCEA standard in the year under consideration. Despite this difference the general pattern remains the same.

## 8 IMPACT BY DECILE AND ETHNIC GROUP

The main motivation of this investigation was to examine the impact of a change in entry criteria upon the various subgroups of the population of high school students as categorised by school decile and by ethnic group. To this end we calculated the percentage change in the success rate for each population subgroup, for each year, and displayed these graphically, by decile and by ethnic group. An important issue to take account of here is that of *variability*. Each percentage change that we calculate should be considered as a single realisation of all the percentage changes that *could* have occurred under the same circumstances.

We need to ask the fundamental statistical question: “*Could* the change that we observed have happened simply by chance?” In more formal jargon we must ask if the observed percentage change is statistically significant (i.e. is unlikely to have happened simply by chance). The best way to address such questions is to calculate confidence intervals for the population mean percentage changes.

The standard or classical techniques for calculating confidence intervals are not available to us here. The percentage changes involve differences and ratios of *dependent* random variables where the dependence structure is intractably complicated. Hence there is no hope of determining an analytic distribution for these values. Instead, we apply techniques of simulation (Monte Carlo inference, or parametric bootstrapping).

For each category of students with which we are concerned let us say that there are  $n$  students in the category, that  $x$  of these students succeed in achieving UE according to the “old” criterion and that  $y$  of them succeed according to the “new” criterion. We are measuring the impact of the change in criteria by

$$\text{percentage change} = 100 \times \frac{y/n - x/n}{x/n} = 100 \times \frac{y-x}{x}$$

To assess the uncertainty in this quantity we propose to model the structure as multinomial. That is, we consider a sample of size  $n$  to have been drawn from an infinite population comprising four categories with probabilities or proportions as follows:

|                         |                                     |                                  |
|-------------------------|-------------------------------------|----------------------------------|
| Succeed under old crit. | Succeed under new crit.<br>$p_{11}$ | Fail under new crit.<br>$p_{12}$ |
| Fail under old crit.    | $p_{21}$                            | $p_{22}$                         |

We denote the observed counts in the corresponding categories by  $n_{ij}$ ; note that  $x = n_{11} + n_{12} = n_{1\cdot}$ ,  $y = n_{11} + n_{21} = n_{\cdot 1}$ , where a “.” indicates summation over the index which it replaces. We estimate  $p_{ij}$  by  $\hat{p}_{ij} = n_{ij} / n$  where  $n = n_{\cdot\cdot}$ .

We may then draw samples from the multinomial distribution with parameters  $p_{ij}$ ,  $i, j = 1, 2$  and  $n$  (replacing the unknown  $p_{ij}$  by their point estimates  $\hat{p}_{ij}$ ). For each sample that we draw we can calculate the corresponding percentage change, say “PC”. If we draw  $N$  such samples (independently) we obtain  $N$  values of the percentage change,  $PC_i$ ,  $i = 1, \dots, N$ . We can then assess the variability in our observed value of the percentage change either in terms of the sample standard deviation of the  $PC_i$  (and the normal distribution) or in terms of the  $\alpha / 2$  and  $1 - \alpha / 2$  empirical quantiles for the  $PC_i$ .

A plot of the percentage changes, by ethnic group and by decile, for the 2004 NCEA data (unrestricted) with 95% confidence error bars, is shown in Figure 2 on page 34.

The confidence intervals shown in the plots are based on the empirical quantiles; the normal-based intervals are virtually identical. Note that the solid red horizontal line in this figure, and in Figures 3 and 6 to 13 inclusive, on pages 35 and 37 to 44, is at the 0 level. This line is included to provide a contrast with the level of the overall percentage change in student intake, indicated by the horizontal dotted blue line in Figures 8 to 13 on pages 39 to 44. For the intake neutral criterion the level of overall percentage change is of course 0 and so the line indicating this level is omitted. For other criteria this level is different from 0; for the dual entry criterion it is always positive.

A very different visual impression is given by the a figure identical to Figure 2 but without the error bars (see Figure 3 on page 35), or by a bar plot (see Figure 4 on page 35) which is probably the more usual way of graphically displaying results like these. These figures, given here for comparison, demonstrate how important it is to quantify variability or uncertainty of estimates. The figures without the error bars give a strong impression of patterns which turn out to be illusory when variability is taken into consideration.



Plots of the percentage changes, by ethnic group and by decile, for the 2004 restricted data are shown in Figure 5 on page 36. There is essentially no discernible difference between Figures 2 and 5. For the 2005 and 2006 cohorts the impact of restricting the data was substantial. All further analyses in this report are done in terms of the restricted data. The plots of the percentage changes, by ethnic group and by decile, for 2005 and 2006 for the restricted data (only) are shown in Figures 6 on page 37 and 7 on page 38.

The 2004 and 2005 data appear to tell essentially the same story: The Māori group is positively affected (stronger indication from the 2005 data than from 2004) by the criterion change, in other words more Māori students achieve UE under the new criterion. Conversely the Asian group is negatively affected, i.e. fewer Asian students achieve UE under the new criterion. The effect for the Pākehā group is marginally statistically significant (in the positive direction) in 2005.

The percentage changes for the other ethnic groups were not statistically significant. There are also indications that decile 6 is positively affected, the indication being stronger for 2005. There is no statistically significant change for the other deciles.

The pattern for the 2006 data is similar except that deciles 7 and 8 show some small evidence of positive impact, and decile 10 schools and schools without a “decile rating” (including private schools and the Correspondence School) show evidence of a negative impact. The ethnic group “Other” shows up as having been negatively affected in 2006. None of the other subdivisions of the sample is statistically significantly affected by the change.

The most striking feature of the plots for all three years is that the Māori group is positively affected and the Asian group is negatively affected. The absolute numbers involved in these percentage changes are not terribly large; the numbers (increase or decrease in the number of students achieving UE) in each ethnic category) are shown in Table 4 on page 16. Note that these are numbers of students out of the entire population of Year 13 students in New Zealand.

The results of Shulruf et al. are of course not directly comparable since their proposed alternative entry criterion is not intake neutral. The most striking feature of their results is a positive impact of the alternative criterion upon lower decile schools. This feature is not observed for our intake neutral alternative criterion. In the following sections we

explore an approach that is more closely connected with that of Shulruf et al. which permits a more direct comparison with their results.

## 9 REGRESSION BASED CRITERIA

Having explored the impact of the intake neutral criterion as described above we returned to the approach used by Shulruf et al., 2007, which is to say, an approach based on regression of the NCEA GPA on University of Auckland GPA. The data sets used in the implementation of this approach constituted three cohorts, each consisting of two parts. These parts were: complete NCEA records (as provided to the University of Auckland by the NZQA) on Level 3 standards for all students who attempted at least one such standard in each of the years 2004, 2005, and 2006, and first year results of all students who were admitted to the University of Auckland in the succeeding years (i.e. 2005, 2006, and 2007) on the basis of NCEA results.

A substantial number of students in the University of Auckland data set who were listed as having been admitted on the basis of NCEA results had not actually achieved University Entrance according to the NCEA results available to us. It turned out that a substantial number of these were actually admitted according to some entrance qualification other than NCEA (e.g. CIE, provisional entrance, transfer to the University of Auckland, or (in 2004) the old Bursary system). Another substantial segment turned out to be in non-degree programs. After some discussion with the University authorities it was decided that all such students should be eliminated from the analysis, and this was done.

As was the case for the intake neutral criterion it was expedient to restrict the data sets to those students in Year 13 or higher. This has little effect upon the calculation of the regressions and the associated cutoff values, since the students involved attended the University of Auckland in the year after they sat their NCEA Level 3 standards, and thus almost all of them were in Year 13 or higher. However the difference between the use of the restricted and unrestricted data is substantial in respect of determining the impact of the regression based criteria.

The predictive power of the NCEA GPA with respect to first year university GPA is (as was discussed in Shulruf et al., 2007) unusually high. The regression model used to predict University of Auckland GPA from NCEA GPA, referred to above, had an  $R^2$  of 0.49 (equivalently a correlation of 0.70) for the 2004/2005 cohort. The  $R^2$  value was the same for both the restricted and unrestricted data sets. It is marginally different from that reported in Shulruf et al., 2007 due to our having eliminated the set of anomalous students (in non-degree courses etc.) from the University of Auckland data set.

The correlation value of 0.70 contrasts sharply with much lower values found in the literature for correlations between secondary school results and various university GPAs. See Shulruf et al., 2007 for more detail and literature citations.

The 2005/2006 and 2006/2007 cohorts yielded  $R^2$  values of 0.47 and 0.45 to two decimal places. The foregoing  $R^2$  values were calculated using the restricted data. For the record, the corresponding  $R^2$  value using the unrestricted data were 0.47 and 0.46 respectively.

Our regression based procedure, which is intended to mimic to some extent that of Shulruf et al., is specified as follows:

- Consider data consisting of the first year grades of all students who were admitted to degree programs at the University of Auckland on the basis of NCEA results, and the NCEA GPA of those same students in the preceding year.
- Fit a linear regression model with predictor equal to the NCEA GPA and response equal to the corresponding University of Auckland GPA.
- Determine an expression for the  $100(1 - \alpha)\%$  lower prediction bound for the fitted model at each value of the predictor.
- Find the value of  $g_0$  of the predictor such that the corresponding lower prediction bound is equal to the desired value of the University of Auckland GPA (e.g. 2, corresponding to a letter grade of “C”). (In order to find  $g_0$  a quadratic equation has to be solved since the value of the lower prediction bound at  $g_0$  depends on  $g_0$ .)
- This value of  $g_0$  may then be taken to be the cutoff for admission to university, based on the NCEA GPA.

The use of a lower prediction bound (rather than the fitted line — which amounts to a 50% lower prediction bound) was introduced in an effort to add flexibility to the criterion. It has the effect of increasing the cutoff value obtained. That is, higher values of the prediction confidence level give higher values of the cutoff. The higher cutoff value in turn has the effect of tending to admit only those with a high probability of success.

For the NCEA 2004 and University of Auckland 2005 results, with the “usual” confidence level of 95%, and with the desired University GPA set equal to 2, we obtained  $g_0 = 2.51$  which is “not too different” from the value of 2.32 obtained by Shulruf et. al. The interpretation of this is that if students having an NCEA GPA of at least 2.51

(and achieving literacy and numeracy) were admitted, then at least 95% of these would obtain a first year University GPA of at least 2 (corresponding to “C”).

Unfortunately this cutoff reduces the number of students achieving University Entrance to unacceptably low levels. (It was for a similar reason that Shulruf et al. recommended the introduction of a dual entry model.) For the 2004 data the number of University of Auckland students who qualified for UE according to this new criterion would have been only 869 (out of a total of 2382 in the restricted data) or 36%. The number of students nationwide who would have made the cut would have been 3316 out of 29035, or a mere 11%.

If we decrease the confidence level to 50% (which makes the lower prediction bound simply equal to the fitted line) we obtain a value of  $g_0$  equal to 1.52 which is very different from 2.32. The 1.52 cutoff value is not a great deal higher than the “intake neutral” cutoff which was 1.39. The number of University of Auckland students making this cut (in the restricted data) was 2172 out of 2382 or 91%. The number of students nationwide making this cut (and achieving literacy and numeracy) was 13711 out of 29035 or 47%.

Plots of the impact of this version of a new entry criterion are shown in Figures 8, 9 and 10 on pages 29, 40, and 41. The cutoff values for the regression based criterion are 1.52, 1.61, and 1.64 respectively, compared with 1.39, 1.52, and 1.51 which are the intake neutral cutoff values. Notice that the cutoff value increases from 2004 to 2005 just as it does for the intake neutral criterion, but again increases from 2005 to 2006 whereas the intake neutral cutoff value diminishes slightly in this instance. For all three years the regression based cutoff value is higher than the intake neutral cutoff and consequently the overall intake of students is diminished (by 9.3%, 5.7%, and 7.3% respectively) relative to the intake under the current criterion.

In studying Figures 8 to 10 it is important to remember that since there is an overall change in the success rate, it is the relative changes that are important. The dotted blue line is the crucial reference line in these figures. If the error bars for a particular category do not enclose this line, then that category has been statistically significantly affected relative to the other categories.

The regression based criterion appears to have a negative impact on decile 1 and a marginally positive impact on decile 10 and on schools with no decile classification, for

the 2004 cohort. It has a significantly negative impact on the Pacific ethnic group and a marginally positive impact on the “Other” ethnic group. Its impact on the Pākehā, Māori, and Asian ethnic groups appears not to be significant. For the 2005 data there is no significant impact on any decile, positive impact on the Pākehā and Māori ethnic groups, negative impact on the Pacific and Asian ethnic groups, and no impact on the “Other” ethnic group. For the 2006 data the story is similar, with a marginally positive impact on deciles 7 and 8, and with the Pacific and “Other” ethnic groups swapping roles with respect to negative impact and no impact.

Finally we incorporated the “dual entry” idea that was introduced by Shulruf et al., 2007. Under this policy students would be admitted if they achieved UE under either the “old” or the “new” admission criterion. Obviously the intake of students will increase under a dual entry policy. We implemented the “dual entry” idea in two ways: (1) Using the NCEA GPA cutoff values  $g_0$  based on the fitted line (equivalently a “50% lower prediction bound”), and (2) Using the NCEA GPA cutoff values  $g_0$  based on the 95% lower prediction bound. Procedure (1) tends to admit a larger number of students (an increase in intake of the order of 6 or 7 percent) than does procedure (2) which yields increases of less than 1 percent.

Plots of the impact of the dual entry policy incorporating procedure (1) are shown in Figures 11, 12, and 13 on pages 42, 43, and 44.

The corresponding plots for a dual entry policy incorporating procedure (2) are shown in Figures 14, 15, and 16 on pages 45, 46, and 47.

The pattern in Figures 11, 12, and 13 is similar to that observed by Shulruf et al., in that there appears to be a positive impact upon the lower deciles relative to the higher deciles. That is, although the percentage intake is larger for all deciles under the dual entry criterion incorporating procedure (1), the effect is statistically significantly greater in deciles 1 and 2. Figures 11, 12, and 13 consistently show a positive impact on the Māori and Pacific ethnic groups and a negative impact on the Asian group. These patterns are not apparent in Figures 14, 15, and 16 where procedure (2) is incorporated.

## 10 DISCUSSION AND CONCLUSIONS

As emphasised in the introduction, achieving University Entrance according to the NZQA criteria no longer actually guarantees admission to university, and certainly not to the program of one's choice. Nevertheless it is a fundamental first step towards such admission. Moreover the achievement of UE according to the NZQA criterion is a uniform benchmark that applies to all students who attempt NCEA standards, and is independent of the entry criteria of individual universities. The "success" or "amount of added value" provided by individual high schools can be, and often is (see e.g. Wilson, 2008) assessed and compared on the basis of how many students achieve various NZQA certificates or qualifications. On that basis it is useful to explore the impact of possible alternatives to the NZQA criteria.

The NZQA criteria are set in terms of a certain number of credits meeting specified criteria being obtained. There is no specification in terms of a level of achievement or of "quality". Perhaps more importantly, neither is there any consideration of numbers of attempts or numbers of "failures" of standards. As long as the required standards are passed, it does not matter how many other standards have been failed. The alternative criteria that we investigate in this report, in contrast, are based on averages of levels of achievement and expressly include failures in forming this average.

This study provides some evidence that a change from the current NZQA criteria for achieving UE to a criterion based on a grade point average, which maintains the same level of intake as the current criteria, would have a positive impact on the fraction of Māori students achieving UE, and a negative impact on the Asian ethnic group. No explanation for this pattern is immediately apparent. One possible explanation is the fact that Asian students generally attempt a larger number of standards than do Māori students (  $p\text{-value} < 2.2 \times 10^{-16}$  in all three years considered). The consequence might be that some Asian students would fail to achieve a substantial number of the standards that they attempt, which would tend to lower their NCEA GPA. Māori students, by attempting fewer standards, may not achieve sufficiently many to meet the current NZQA requirements for UE, but may attain a reasonably high level of achievement on those standards that they do attempt, and hence a reasonably high GPA.

If we incorporate a regression criterion based simply on the fitted regression line (procedure (1)), then a "dual entry" criterion as suggested in Shulruf et al. (2007) would appear to have a relatively positive impact on deciles 1 and 2. Correspondingly it would appear to have a relatively negative impact on decile 10 schools and schools without a

decile rating. These findings are consistent over the years which have been studied, namely 2005 through 2007. The uncertainty or variability in the findings has been assessed so that it is possible to discern whether an apparent impact is in fact statistically significant and hence meaningful. We see (from the error bars in Figures 11 to 13 on pages 42 to 44) that the percentage change for deciles 1 and 2 was statistically significantly greater than the mean overall change, and that for deciles 10 and "NA" was statistically significantly less.

However if we incorporate a regression criterion based upon the lower 95% prediction bound (procedure (2)), the "dual entry" criterion does not have this sort of effect. Figures 14 to 16 on pages 45 to 47) indicate little or no evidence of statistically significant differences in the impact upon any of the deciles or any of the ethnic groups.

Presumably the incremental number of students achieving UE under the "dual entry" criterion incorporating procedure (2) is simply too small (less than 1%) to have a noticeable impact. On the other hand the increment when procedure (1) is incorporated (nearly 6 or 7%) may be too large to be acceptable. It is conceivably that by "tuning" the confidence level used for the lower prediction bound to be somewhere between 50% and 95% a useful compromise between these two extremes could be found.

Admission of students to university programs is and should be to a large extent based on the likelihood of students' succeeding in the programs to which they are admitted. As a consequence of this principle, modelling students' achievement at university in terms of admission criteria would seem to be fundamental to the formulation of equitable admission criteria. This study makes a small but important step in effecting such modelling.

If criteria based upon regression modelling of university results as predicted by the NCEA GPA were in fact to be implemented by NZQA, it would presumably be necessary to fit the model in terms of first year results at all New Zealand universities, not just the results from the University of Auckland. The University of Auckland results were used in this study because those (and only those) results were accessible to us. Further research on these issues should include the examination of results from other tertiary institutions.



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## 12 TABLES

Note: The annotation “R” in the “year” column of Tables 1 to 4 stands for “restricted” and indicates that the data have been restricted to students in year 13 and higher.

**Table 1:** Summaries of NCEA GPA values

| Year  | Min | Q1    | Median | Mean  | Q3    | Max   | Sample size | Missing |
|-------|-----|-------|--------|-------|-------|-------|-------------|---------|
| 2004  | 0   | 1.368 | 1.780  | 1.804 | 2.222 | 4.000 | 29161       | 5920    |
| 2004R | 0   | 1.368 | 1.780  | 1.804 | 2.222 | 4.000 | 29035       | 5833    |
| 2005R | 0   | 1.559 | 1.963  | 1.965 | 2.360 | 3.933 | 30547       | 7471    |
| 2006R | 0   | 1.614 | 2.000  | 2.010 | 2.400 | 3.935 | 31810       | 8073    |

**Table 2:** Skewness and kurtosis of the NCEA GPA values

| Year  | Skewness | Kurtosis |
|-------|----------|----------|
| 2004  | 0.1417   | -0.1086  |
| 2004R | 0.1418   | -0.1077  |
| 2005R | 0.0786   | -0.0218  |
| 2006R | 0.0697   | -0.0058  |

**Table 3:** Summaries of NCEA data set counts

| Year  | Total number | Reduced number | Number achieving UE | Success rate |
|-------|--------------|----------------|---------------------|--------------|
| 2004  | 31140        | 29161          | 15147               | 52%          |
| 2004R | 31140        | 29035          | 15130               | 52%          |
| 2005R | 51329        | 30547          | 16445               | 54%          |
| 2006R | 52837        | 31810          | 17857               | 56%          |

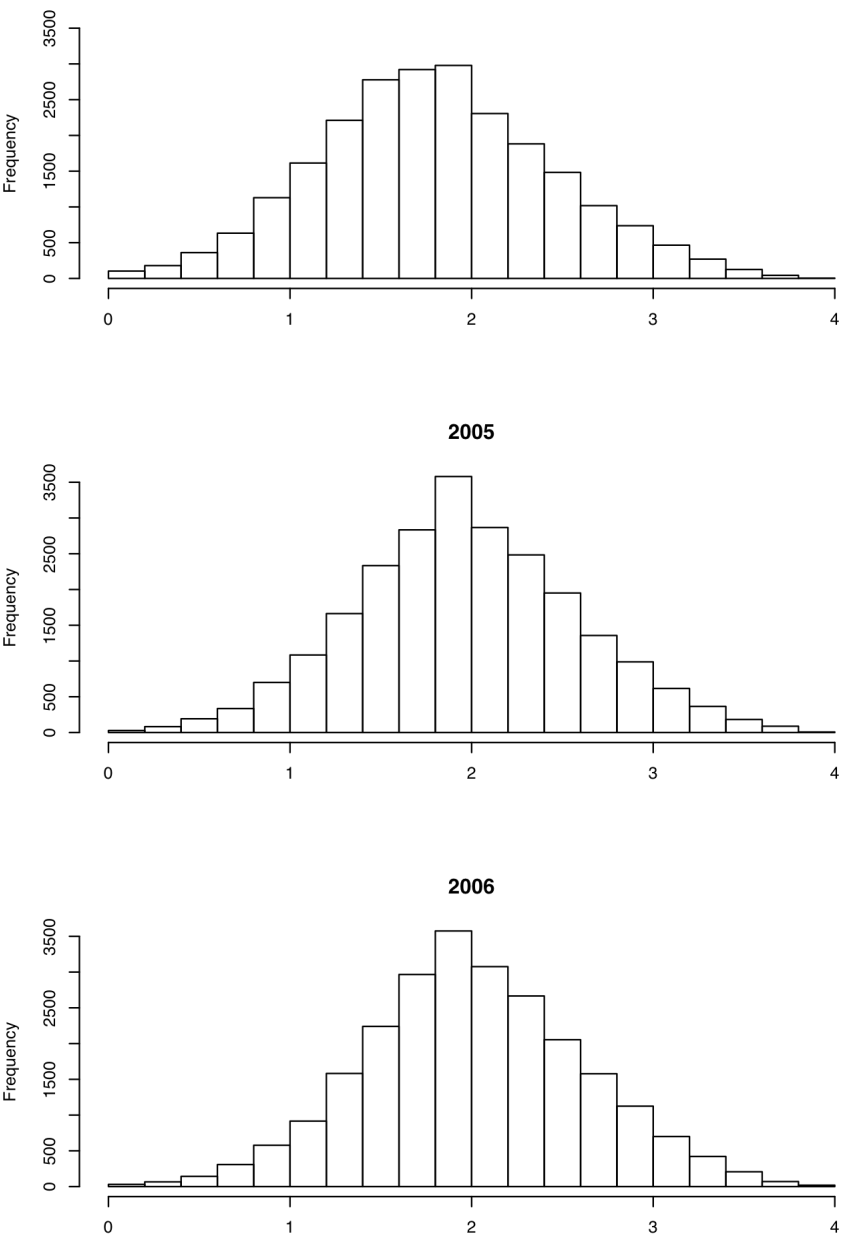
**Table 4:** Changes in number of students achieving UE resulting from application of the “intake neutral” criterion

| Year  | Pākehā | Māori | Pacific | Asian | Other |
|-------|--------|-------|---------|-------|-------|
| 2004  | 47     | 36    | -20     | -80   | 18    |
| 2004R | 47     | 36    | -19     | -80   | 17    |
| 2005R | 115    | 74    | -10     | -170  | -8    |
| 2006R | 95     | 105   | 21      | -191  | -30   |

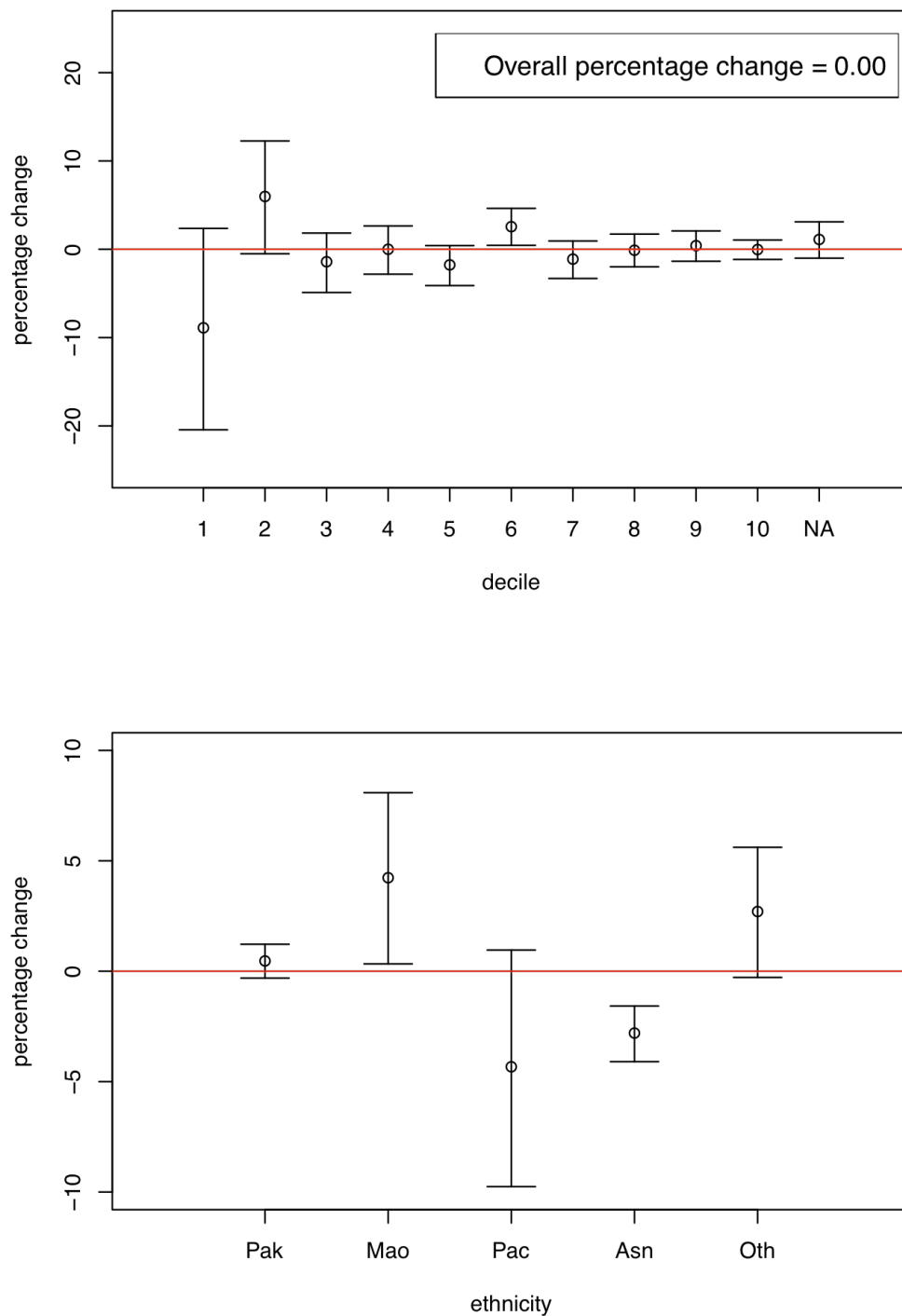


# 13 FIGURES

**Figure 1:** Histograms of GPA values (“unrestricted” data)

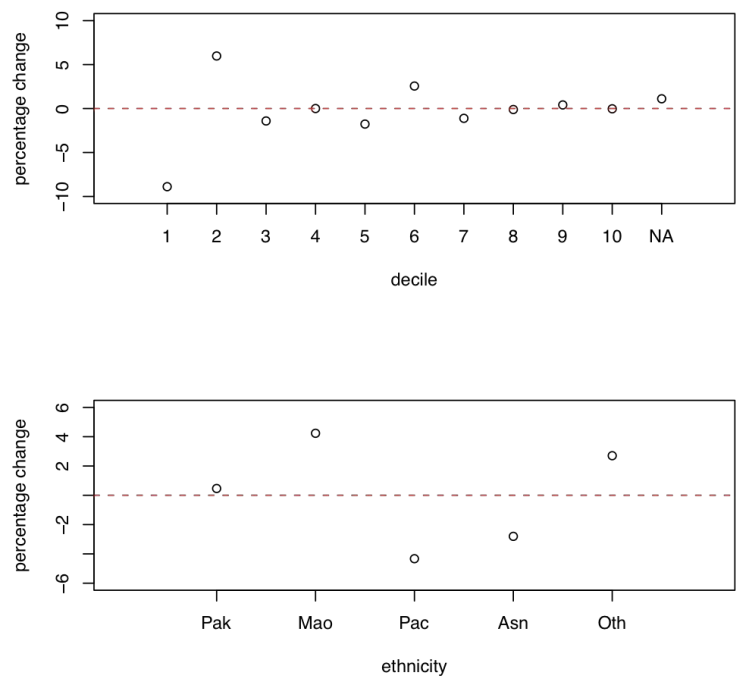


**Figure 2:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2004 (“unrestricted” data)

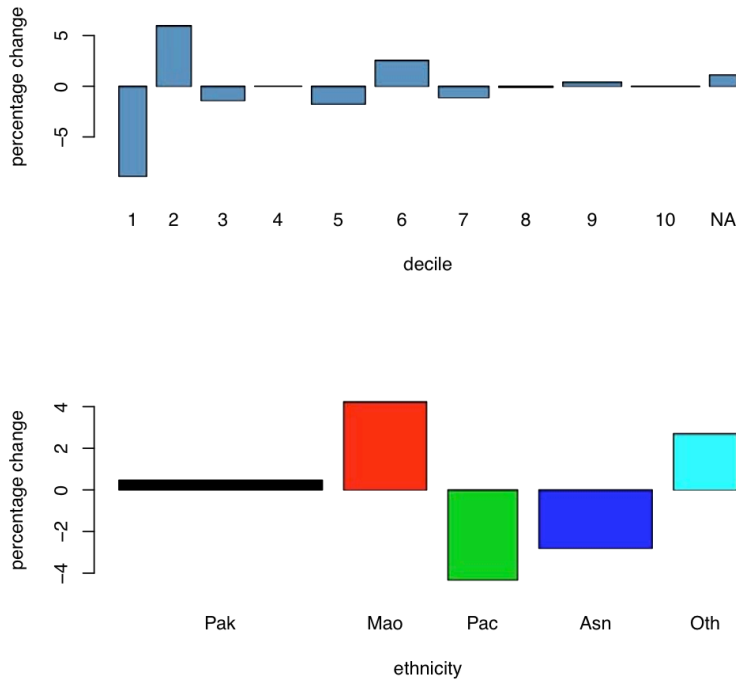


Note that the solid red horizontal lines in this and following figures are at level 0 and are provided to give a basis for reference.

**Figure 3:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2004, without error bars (“unrestricted” data)

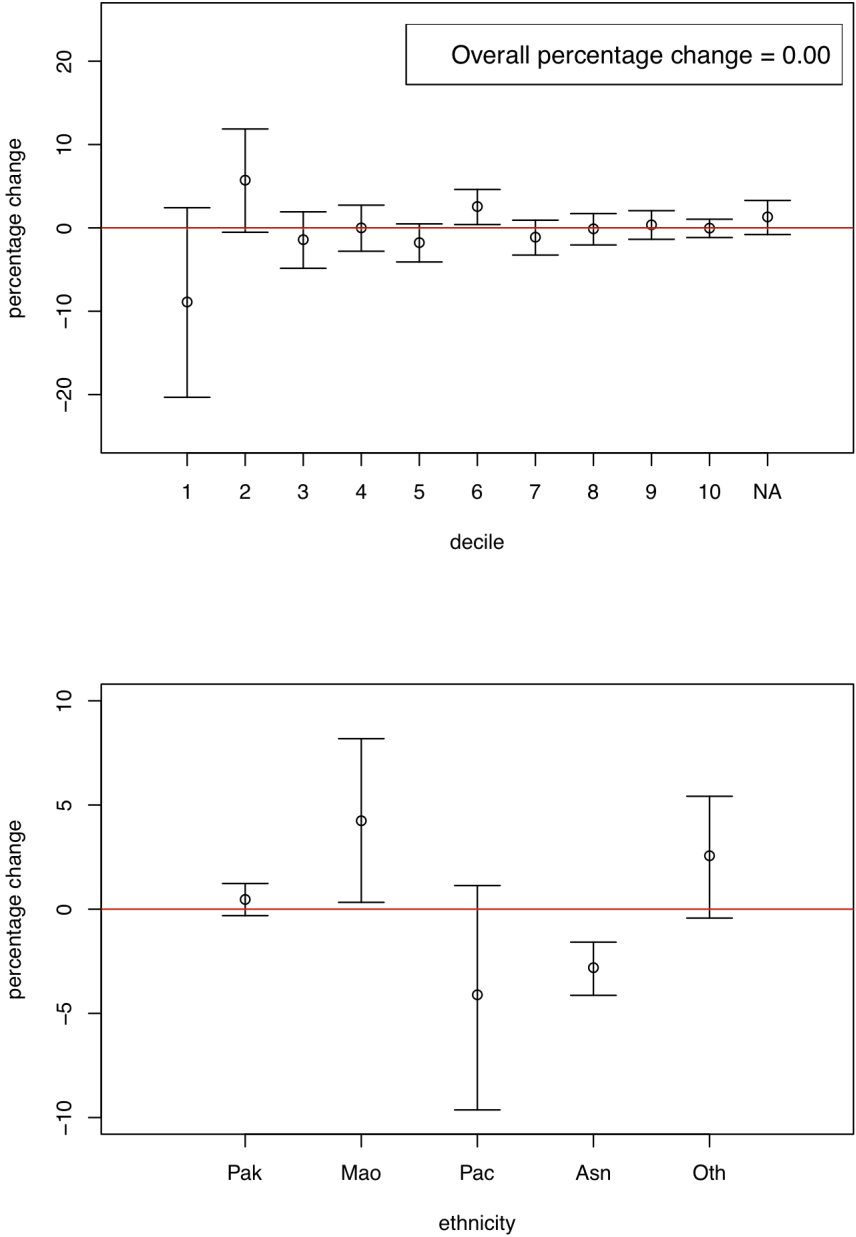


**Figure 4:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2004, as bar plots (“unrestricted” data)



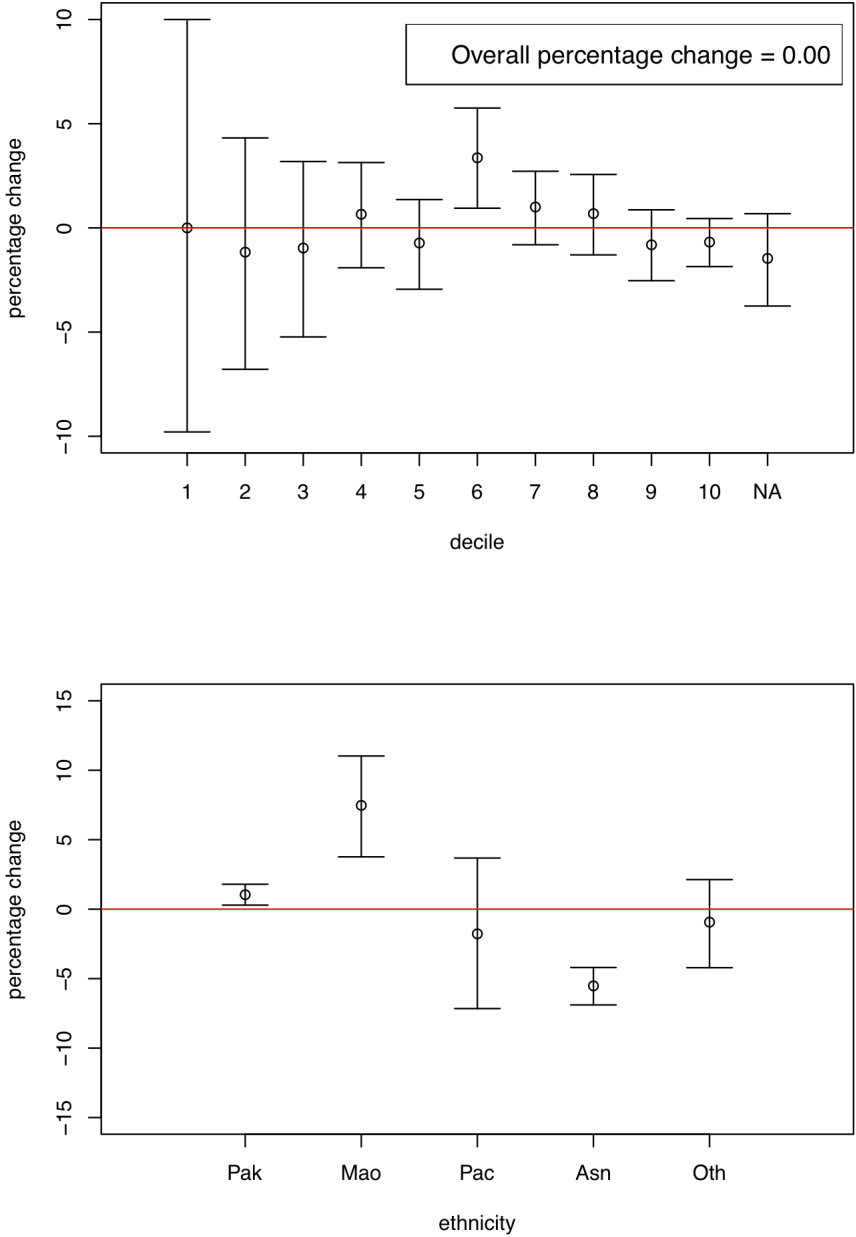
Note: The bar widths are proportional to the square roots of the numbers of students in the corresponding categories.

**Figure 5:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2004 (“restricted” data)

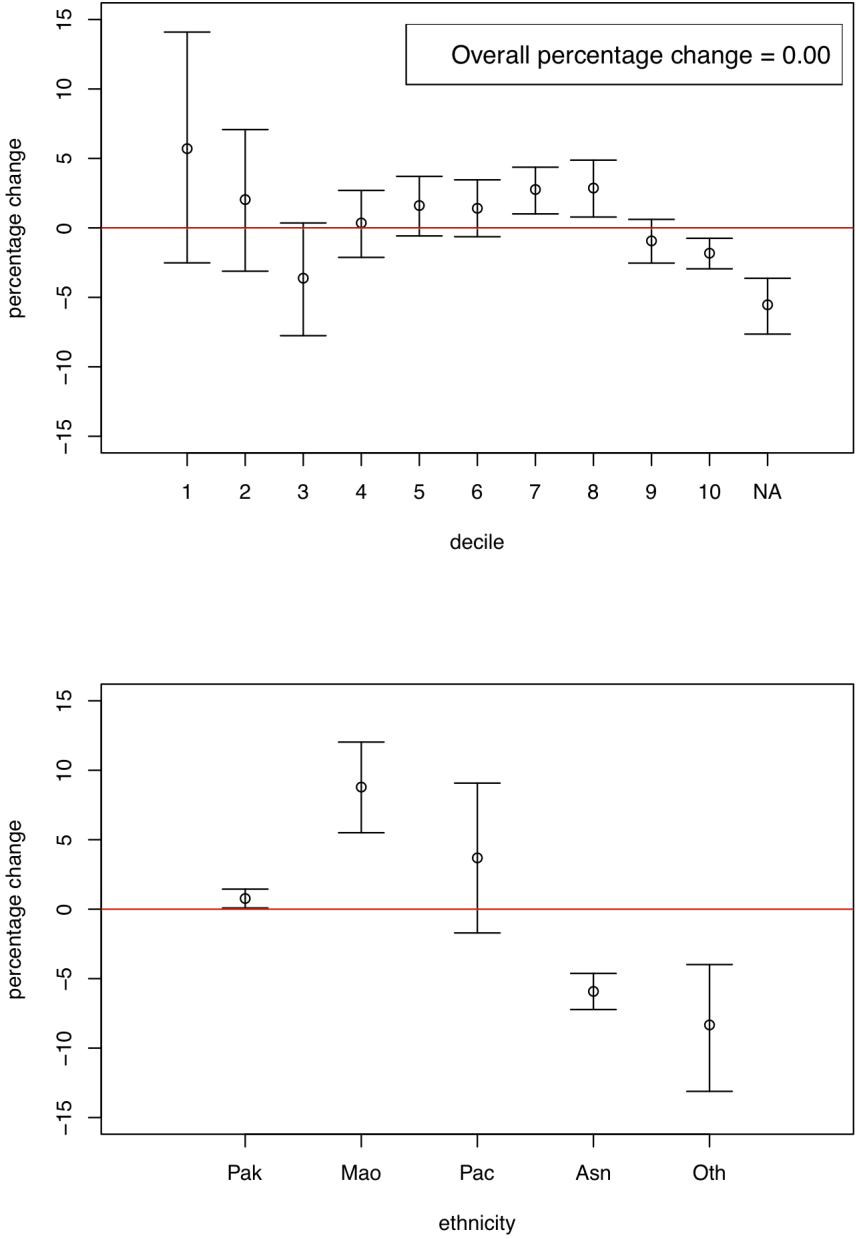




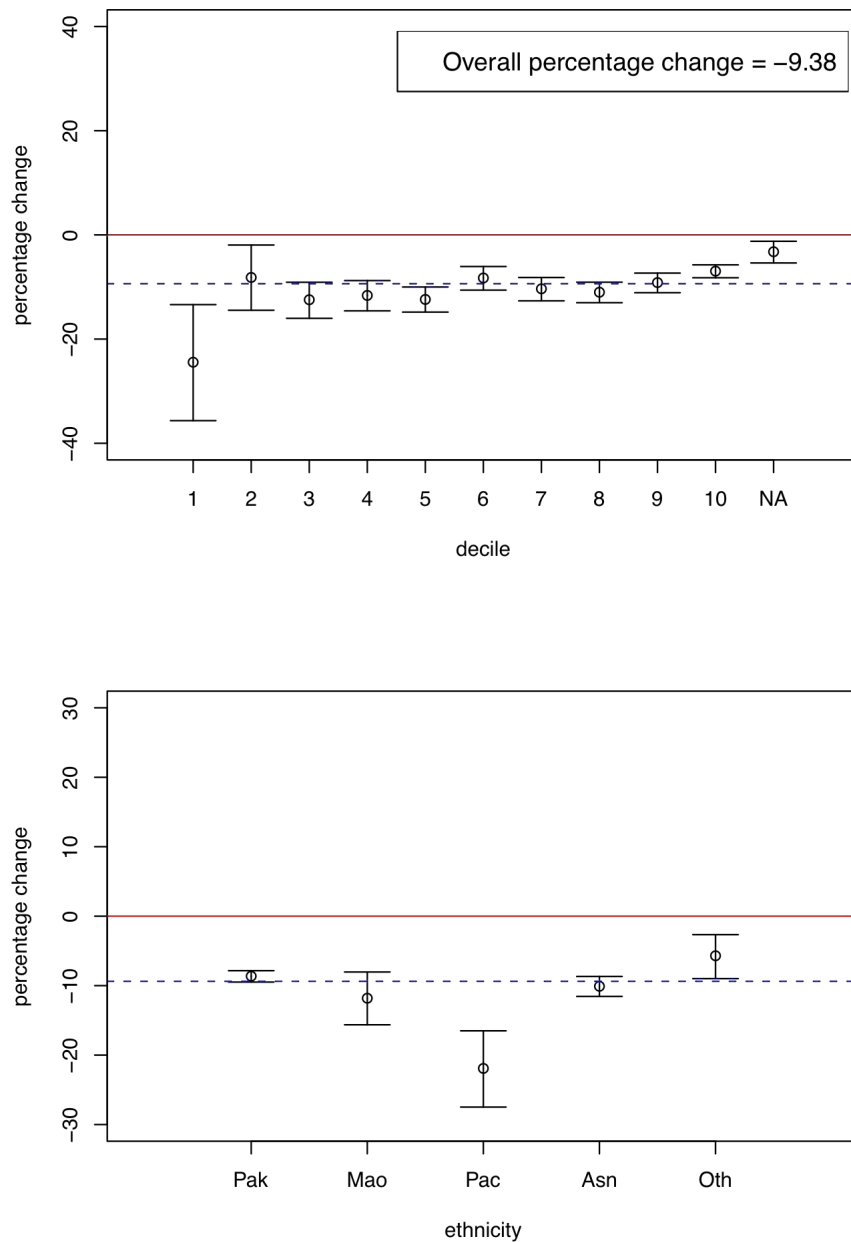
**Figure 6:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2005 (“restricted” data)



**Figure 7:** Percentage changes under the intake neutral criterion, by ethnic group and by decile, 2006 (“restricted” data)

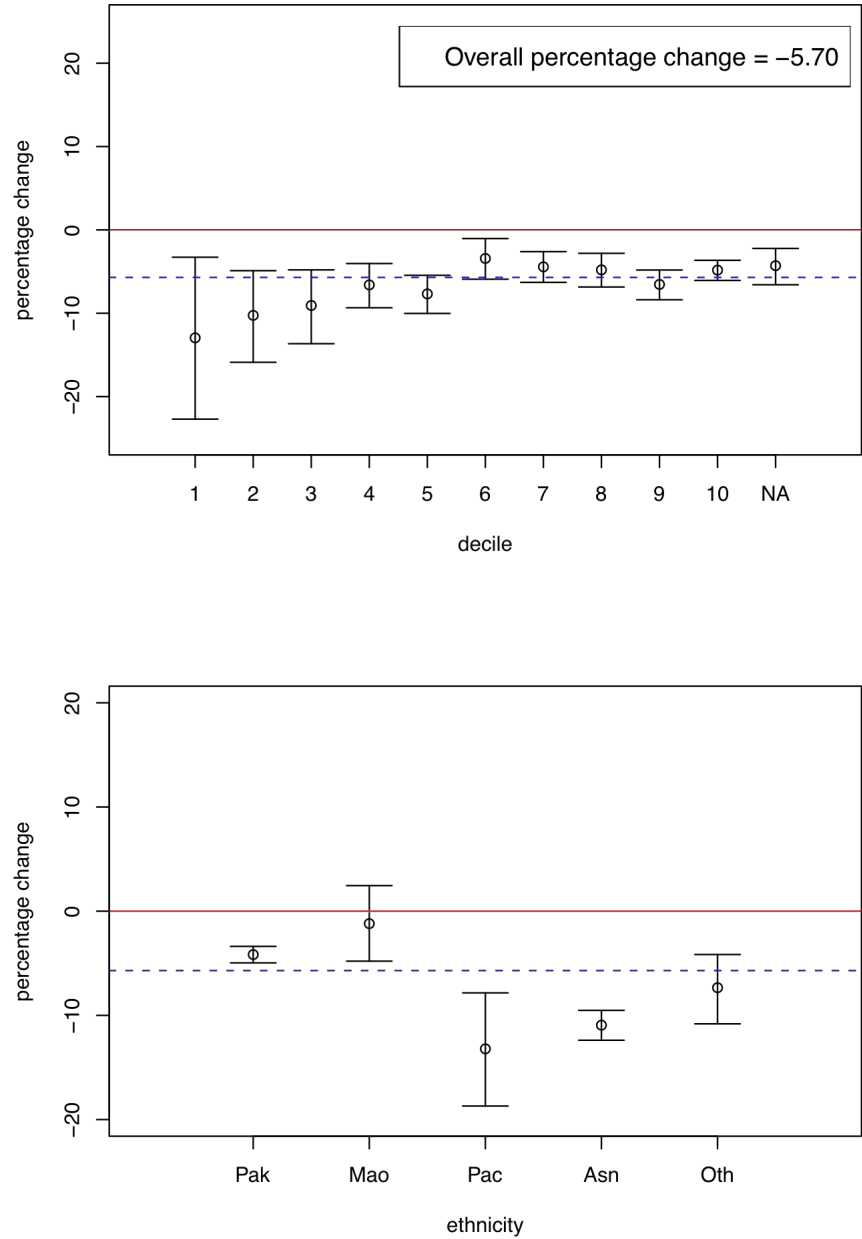


**Figure 8:** Percentage changes under the regression criterion, by ethnic group and by decile, 2004 (“restricted” data)

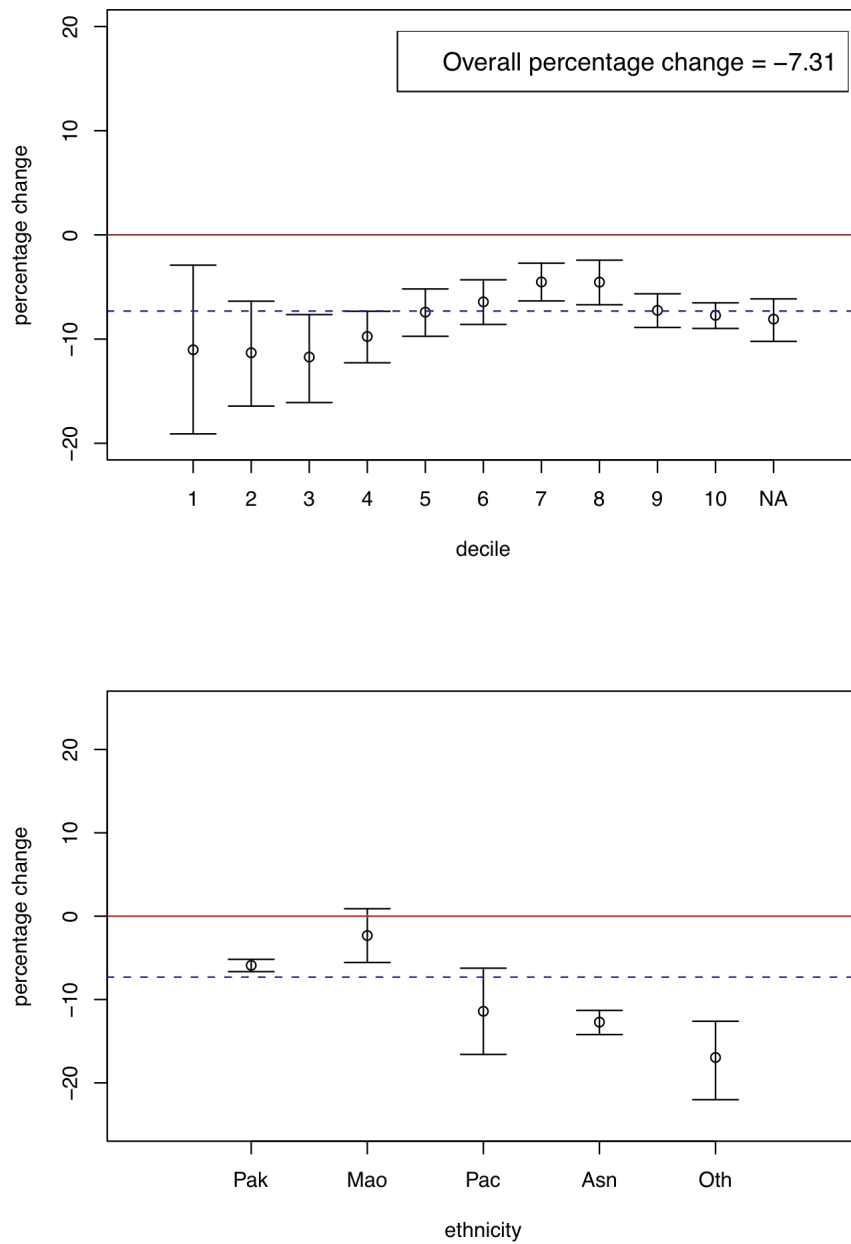


Note that the dotted blue horizontal lines in this and following figures (Figures 8 to 16) are at the level of the over-all percentage change in student intake. In the figures corresponding to the intake neutral criterion these lines would be, of course, at level 0 and hence are omitted. These lines emphasise that the over-all percentage change in student intake differs from zero.

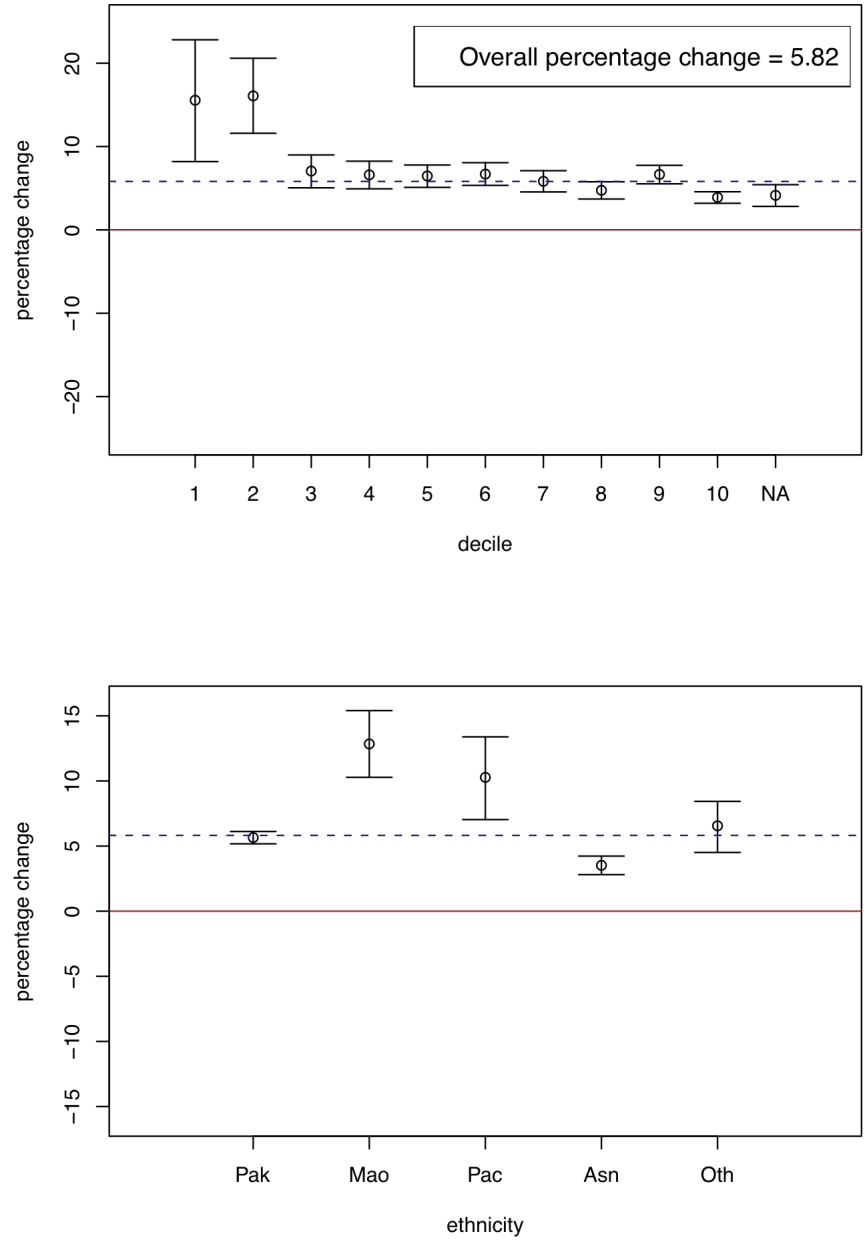
**Figure 9:** Percentage changes under the regression criterion, by ethnic group and by decile, 2005 (“restricted” data)



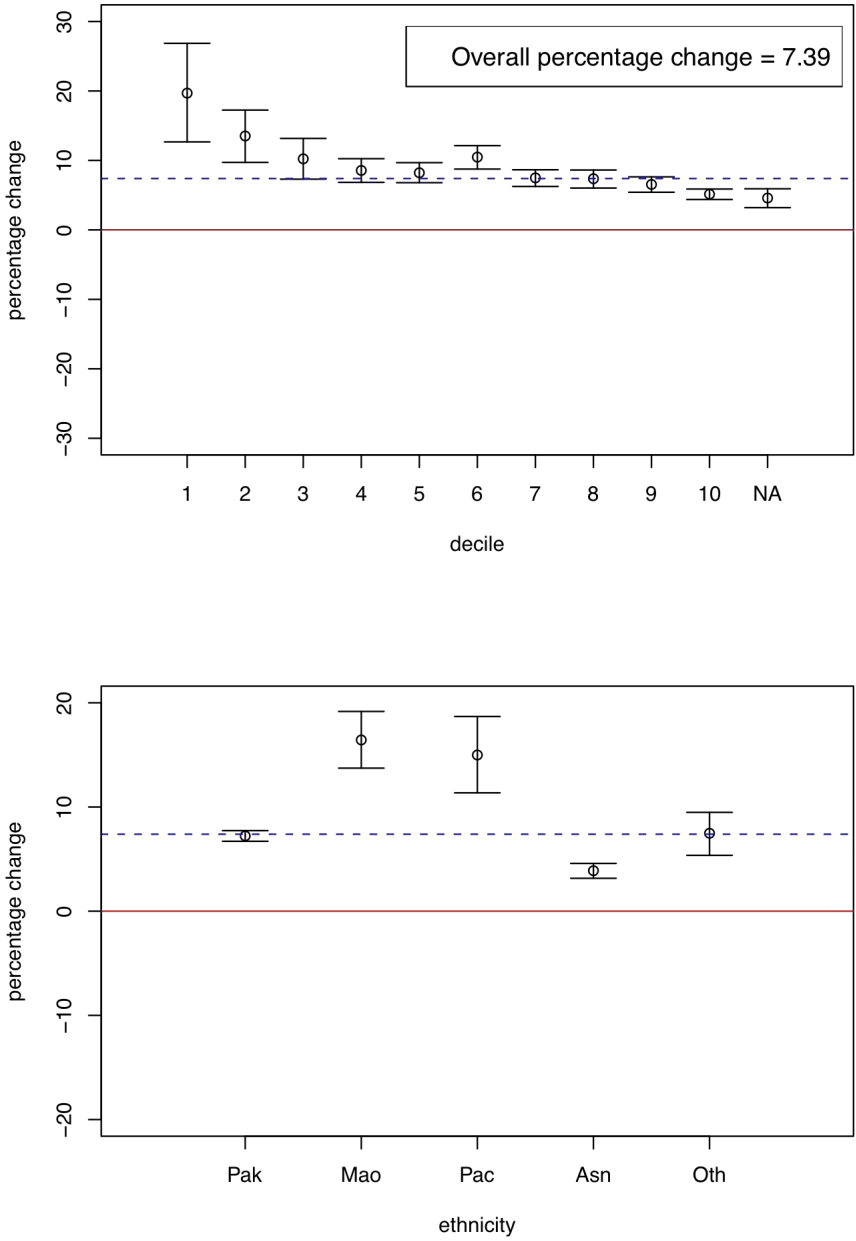
**Figure 10:** Percentage changes under the regression criterion, by ethnic group and by decile, 2006 (“restricted” data)



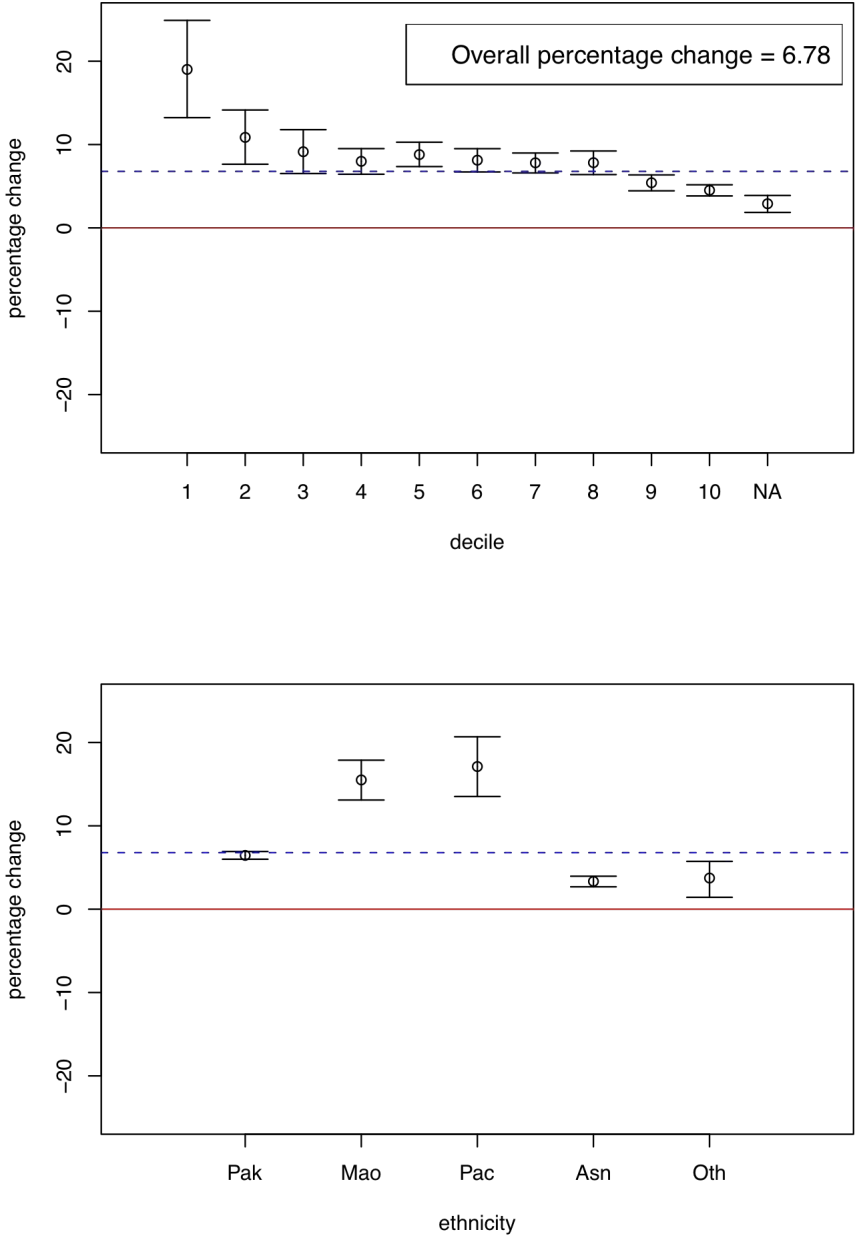
**Figure 11:** Percentage changes under the dual entry criterion, by ethnic group and by decile, 2004 (“restricted” data)



**Figure 12:** Percentage changes under the dual entry criterion, by ethnic group and by decile, 2005 (“restricted” data)

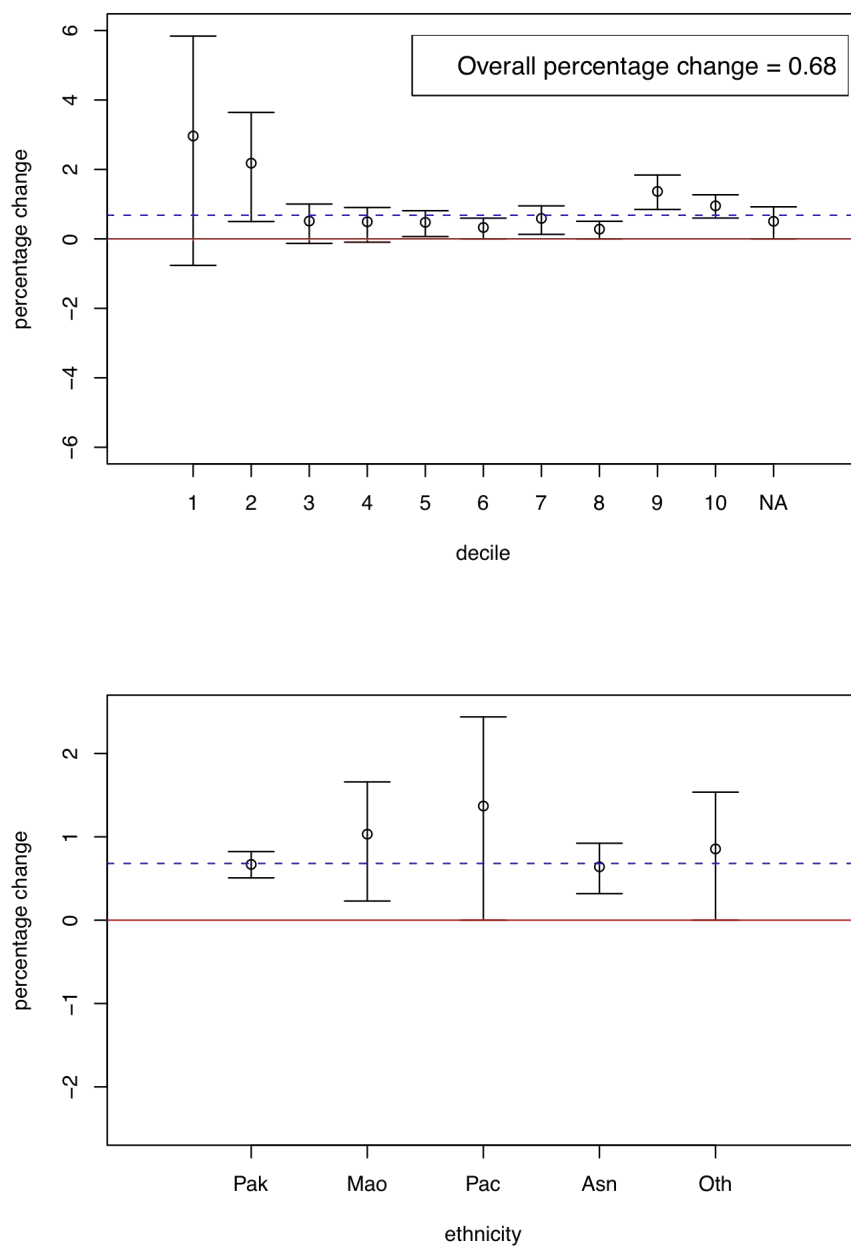


**Figure 13:** Percentage changes under the dual entry criterion, by ethnic group and by decile, 2006 (“restricted” data)

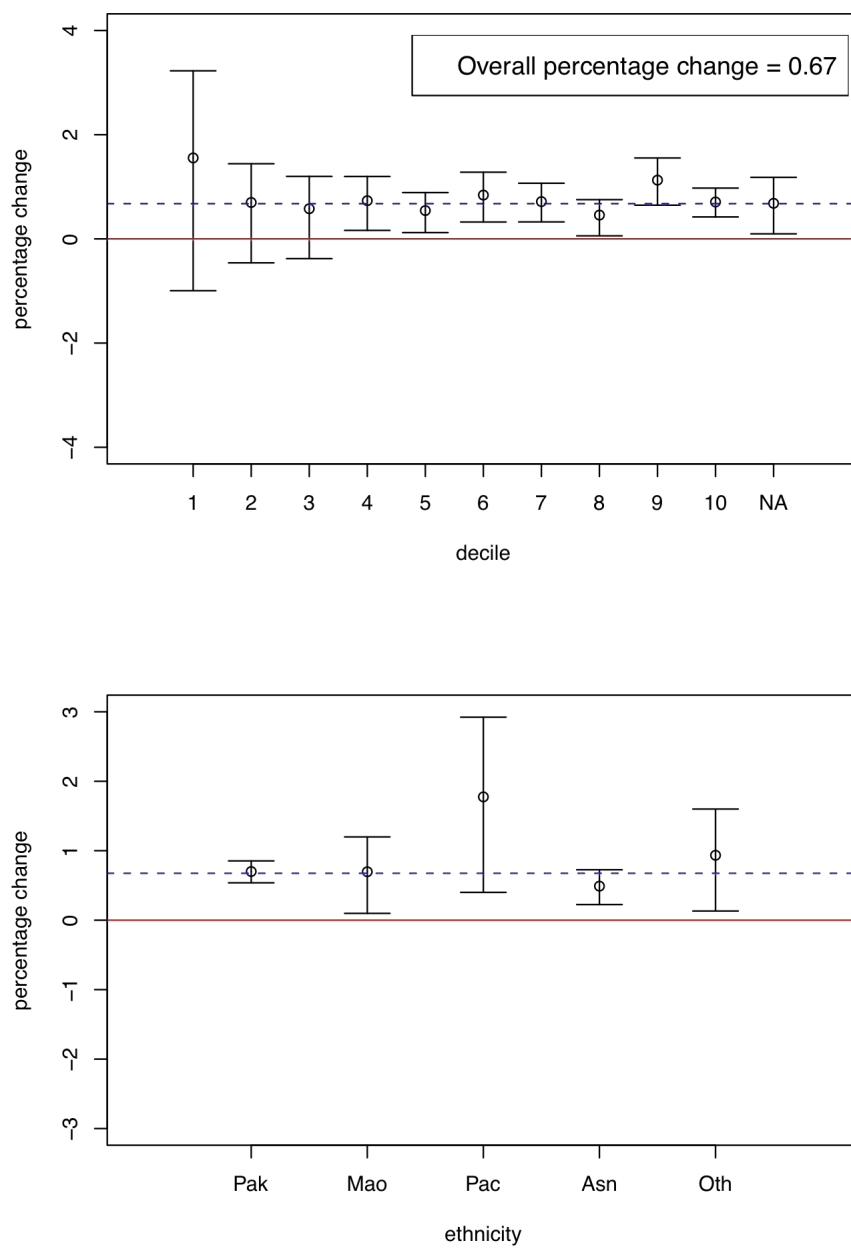




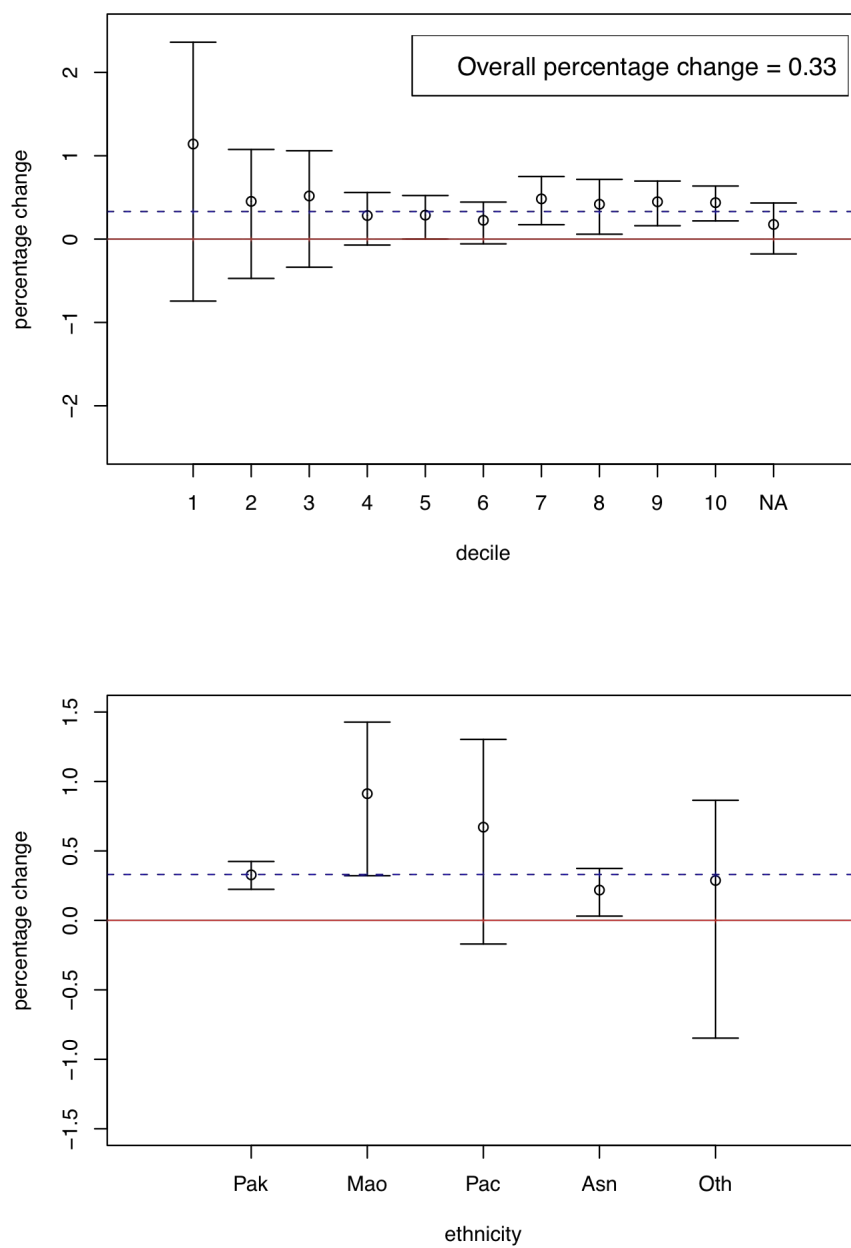
**Figure 14:** Percentage changes under the dual entry criterion, using lower prediction bound, by ethnic group and by decile, 2004 ("restricted" data)



**Figure 15:** Percentage changes under the dual entry criterion, using lower prediction bound, by ethnic group and by decile, 2005 ("restricted" data)



**Figure 16:** Percentage changes under the dual entry criterion, using lower prediction bound, by ethnic group and by decile, 2006 ("restricted" data)





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