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Ethnic Disparities in CPAP Adherence in New Zealand: Effects of Socioeconomic Status, Health Literacy and Self-Efficacy

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Study Objectives: We aimed to investigate the influence of ethnicity on adherence with continuous positive airway pressure (CPAP) in a sample of New Zealand patients.

Design: Observational study over one month.

Setting: A university-based sleep laboratory.

Patients: 126 consecutively consenting CPAP-naïve patients (19.8% Māori, mean ± SD apnea-hypopnea index 57.9 ± 38.9 events/h, CPAP 11.1 ± 3.1 cm H_2O).

Interventions: Patients underwent a 4-week supervised home trial of CPAP following pressure titration.

Measurements and Results: Self-identified ethnicity (Māori/non-Māori), Epworth Sleepiness Scale, Self-Efficacy Measure for Sleep Apnea, Rapid Estimate of Adult Literacy in Medicine, New Zealand Deprivation Index (calculated from residential address), New Zealand Individual Deprivation Index (validated 8-item questionnaire), educational history, income, and employment assessed at baseline were compared to objective CPAP adherence after one month. Māori demonstrated significantly lower usage than non-Māori (median 5.11, interquartile range 2.24 h/night compared with median 5.71, interquartile range 2.61 h/night, P = 0.05). There were no significant relationships between adherence and subjective sleepiness, health literacy, or self-efficacy. In a multivariate logistic regression model incorporating 5 variables (ethnicity, eligibility for government-subsidized healthcare, individual deprivation scores, income, and education), non-completion of tertiary education, and high individual socioeconomic deprivation remained significant independent predictors of average CPAP adherence not reaching ≥ 4 h (odds ratio 0.25, 95% CI 0.08-0.83, P = 0.02; odds ratio 0.10, 95% CI 0.02-0.86, P = 0.04, respectively). The overall model explained approximately 23% of the variance in adherence.

Conclusions: The disparity in CPAP adherence demonstrated between Māori and non-Māori can be explained in part by lower education levels and socioeconomic status.

Keywords: Obstructive sleep apnea, continuous positive airway pressure, compliance, adherence, ethnicity, socioeconomic, deprivation, literacy, self-efficacy

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INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep related breathing disorder in which the upper airway is occluded repeatedly while asleep, and is associated with excessive daytime sleepiness,[1] neurocognitive decline,[2] and the development of cardiovascular disease in the long term.[3-5] Community-based prevalence studies in various locations including North America,[6-8] South America,[9] Spain,[10] Korea,[11] Hong Kong,[12,13] India,[14] Australia,[15] and New Zealand (NZ)[16] have demonstrated that OSA is reasonably common. Few studies have attempted to report ethnic differences in OSA prevalence within a community-based population. Studies comparing African American and white subjects in the US,[17,18] Japanese and white subjects in Brazil,[19] and Māori and non-Māori subjects in NZ[16,20] have found no significant contribution of ethnicity to the prevalence and/or severity of OSA after controlling for measures of body habitus.

Beyond ethnic differences in disease prevalence and presentation, there may also be ethnic differences in adherence to the first-line treatment for OSA, continuous positive airway pressure (CPAP), though research in this area is limited. Studies comparing African American and white patients in the US are conflicting,[17,21] but pilot data from our own NZ laboratory suggest that the significantly lower adherence rate in Māori, Pacific, and Asian groups compared with Europeans is still significant after controlling for socioeconomic status.[22] In the US, greater adherence has been associated with higher socioeconomic status, using an area-based index.[23] A recent Israeli study reported that patients with higher incomes were more likely to accept CPAP.[24] Finally, more patients referred through a publicly funded clinic abandoned CPAP than privately funded patients in a Brazilian study.[25] However, to our knowledge the aforementioned paper from our own laboratory is the only study that has found a significant contribution of ethnicity after controlling for socioeconomic status. Being retrospective, only one measure of socioeconomic status based on neighborhood of residence was available for this sample, and we suspect that after controlling for more specific measures, ethnicity may no longer be a significant independent predictor of adherence.

There are probably aspects of socioeconomic status in addition to the financial cost of treatment that have some bearing on CPAP acceptance and adherence such as education, both in a broad sense as a patient's level of education can strongly influence their healthcare management,[26] and in a specific sense as a patient's level of understanding of OSA and CPAP have been shown to affect adherence.[27,28] Health

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literacy should also be considered as part of education as this can greatly affect a patient's clinical care,[29] but is a hitherto un-researched construct in CPAP adherence studies. Finally, as recently discussed in the literature,[30] there is evidence from the aforementioned Israeli paper that there are ethnic differences in social support when beginning CPAP treatment.[24] The concept of self-efficacy—the extent to which a patient holds attitudes or beliefs that he or she is capable of attaining positive outcomes from treatment—is closely related to the amount of social support available, and has been found to be associated with CPAP adherence.[31]

Given the evidence that OSA is more prevalent in Māori than non-Māori in NZ and that Māori tend to present with more severe symptoms,[16,32,33] there is a need to identify the reasons for poor CPAP adherence and use this knowledge to minimize ethnic disparities in CPAP usage, thereby reducing long-term risk of morbidity and mortality. Hence, we aimed to investigate adherence to treatment in a consecutive sample of NZ patients referred for CPAP, hypothesizing that ethnicity would not significantly predict adherence after controlling for socioeconomic status, health literacy, and self-efficacy.

METHODS

Ethical approval was granted by the Central Region Ethics Committee (CEN/09/11/091), and all patients in the main analyses gave written informed consent. Consent is not required to analyze and report routinely collected data as this is classified as an audit, so CPAP adherence and ethnicity data for non-consenting patients were able to be analyzed (discussed further below).

Recruitment of Patients and Diagnosis of OSA

All adult patients (≥ 25 years of age) living in the Greater Wellington region referred for CPAP treatment for the first time by respiratory/otolaryngology/cardiology physicians over a 9-month period of 2010 were approached to take part in the study. There were no exclusion criteria. Apart from patients referred for split-night diagnostic/titration studies, all had undergone a previous diagnostic sleep study of some description (Figure 1).

CPAP Initiation

Patients were established on CPAP during either a full-night or split-night manual titration following published clinical guidelines,[34] or using an automatically adjusting positive airway pressure (auto-PAP) device (ResMed S8 Autoset II; NSW, Australia) for ≥ 7 nights at home using the mean 95th percentile pressure for ongoing CPAP use. All studies were performed and scored by experienced polysomnographic technologists according to published criteria.[35-37]

All patients referred through the NZ government-funded health system were allocated a Fisher & Paykel (Auckland, NZ) HC608 device and a Fisher & Paykel mask. Patients funding their own treatment were able to choose from a range of Fisher & Paykel, Phillips Respironics (PA, USA), or ResMed devices and masks. Government-funded patients did not contribute financially to their diagnosis or treatment; private patients were required to pay full costs for their physician appointment/s, diagnosis, titration, CPAP device, and mask.

Educational Package and Follow-Up Appointments

The education and follow-up support provided was the same for government- and privately-funded patients, apart from the aforementioned restrictions regarding machine and mask choice. All patients had received some verbal education regarding OSA and CPAP from their referring physician and a mailed brochure, and the technologist responsible for initiating treatment presented a standardized CPAP educational package during the first appointment (verbal introduction, diagrams, and video) designed to optimize adherence. A technologist phoned each patient after the first night of at-home treatment to troubleshoot any initial problems and encourage optimal usage, and patients were encouraged to attend half-hour follow-up appointments after 2 and 4 weeks. These appointments followed a standardized set of interview guidelines, available from the corresponding author. Objective adherence was downloaded from the data-card contained in each CPAP device during both follow-up appointments, and was recorded as the mean hours of use per 24-h period.

Questionnaires

Prior to receiving the educational package, patients were required to fill in 2 questionnaires and were provided with as much time to complete this task as was required. If it was necessary for the questionnaire to be administered verbally by the technologist on duty, this was noted.

The first questionnaire was the Self-Efficacy Measure for Sleep Apnea (SEMSA), which measures 3 aspects of Bandura's social cognitive model and has demonstrated internal consistency of 0.92.[38] The 3 SEMSA subscales are: risk perception (the patient's perceived vulnerability to health risks), outcome expectancy (the patient's perceived expectations regarding the potential of the behavior to reduce those risks), and treatment self-efficacy (the patient's perceived ability to perform the behavior, that is, use CPAP effectively).[38] Each subscale has a maximum score of 4, indicating high self-efficacy.

The second questionnaire was an in-house questionnaire including age, gender, ethnicity, languages spoken fluently, current level of employment, highest level of formal education attained, individual gross annual income (all identical to questions contained in the 2006 NZ census), eligibility for a Community Services Card (issued by the NZ government to subsidize healthcare costs), and method of referral (government- or privately funded). Prioritized ethnicity following NZ Ministry of Health guidelines was assigned when a patient indicated multiple ethnic groups.[39,40]

Embedded in this questionnaire were the questions required for the Epworth Sleepiness Scale (ESS),[41] NZ Deprivation Index (NZDep06),[42] and NZ Individual Deprivation Index (NZiDep06).[43] The ESS was also administered during both follow-up appointments. The NZDep06 is an index of socioeconomic deprivation based on data obtained in the most recent NZ census (2006), which divides the country into geographical mesh-blocks, each containing a median of 87 people. It is the only such measure available in New Zealand. Each mesh-block is assigned a number between 1 and 10 indicating the level of deprivation (10 = most deprived), accounting for income, home ownership, family support, employment, qualifications, living space, communication, and transport.[42] The deciles are then rou-

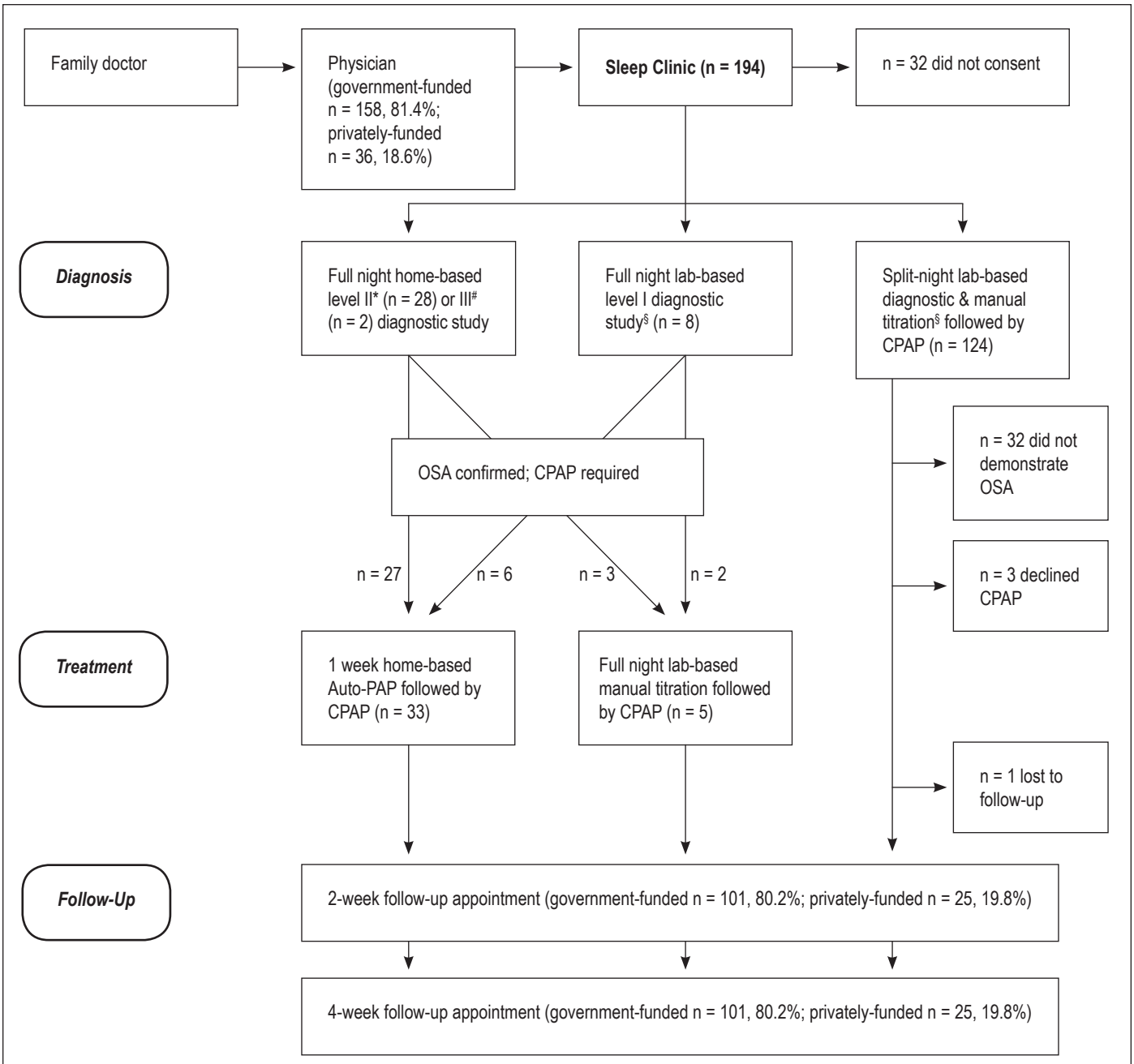

Figure 1—Flowchart of diagnostic and treatment pathways. *Used Compumedics (Victoria, Australia) Somte PSG with Nonin oximeter. #Used Compumedics Somte with Nonin oximeter. §Used Compumedics (Victoria, Australia) Grael with Masimo (CA, USA) Rad 7 oximeter. OSA, obstructive sleep apnea; CPAP, continuous positive airway pressure; auto-PAP, automatically adjusting positive airway pressure.

tinely combined into quintiles for data analysis. The NZDep06 can be calculated based only on a patient's residential address. The NZiDep06 must be collected prospectively and includes 8 dichotomous questions targeting high levels of deprivation.[43]

All questionnaires were scored by author JPB, following published guidelines for the ethnicity, NZ census, ESS, NZDep06, and NZiDep06 questions, and instructions provided by the authors of the SEMSA.

Health Literacy Test

The Rapid Estimate of Adult Literacy in Medicine (REALM)[44] was administered and scored in a standardized manner during the first follow-up appointment, by one of two authors (JPB or KMO). This short reading-recognition test requires the patient to correctly pronounce 66 medical-related words. A raw score is obtained by adding the number of correct responses; this can be categorized to an estimate of the US school grade reading level if necessary.

Statistical Analysis

All data were double-entered before statistical analysis, performed using SPSS (Version 18.0; NY, USA). Missing data were excluded pairwise for all analyses. Continuous data were analyzed for normality of distribution and homogeneity

Table 1—Descriptive comparison of Māori and non-Māori patients

	Māori (*n* = 25) Mean ± SD	Non-Māori (*n* = 101) Mean ± SD	P-value (2-sided)
Age (years)	45.0 ± 11.4	52.5 ± 11.7	< 0.01
Number of males	21 (80.8%)	79 (79%)	0.86
BMI (kg/m^2)	43.4 ± 9.6	37.1 ± 9.0	< 0.01
Baseline ESS (/24)	14.7 ± 5.9	12.6 ± 5.3	0.09
Diagnostic sleep efficiency (%)	77.0 ± 17.9	76.9 ± 14.4	0.61
Diagnostic AHI (events/h)	63.6 ± 35.1	56.3 ± 39.7	0.22
Therapeutic CPAP (cm H_2O)	12.0 ± 3.6	10.9 ± 3.0	0.24
CPAP trial length (days)	34.5 ± 14.5	31.4 ± 14.4	0.30
SEMSA: Risk perception (/4)	2.70 ± 0.56	2.80 ± 0.54	0.41
SEMSA: Outcome expectancies (/4)	3.17 ± 0.54	3.22 ± 0.53	0.89
SEMSA: Treatment self-efficacy (/4)	3.23 ± 0.57	3.25 ± 0.49	0.96
REALM raw score (/66)	61.02 ± 10.60	59.50 ± 13.36	0.36

BMI, body mass index; ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index; CPAP, continuous positive airway pressure; SD, standard deviation; SEMSA, Self Efficacy Measure for Sleep Apnea; REALM, Rapid Estimate of Adult Literacy in Medicine.

of variance. Five-group ethnic and socioeconomic comparisons were performed using Kruskal-Wallis tests; two-group ethnic comparisons were performed using Mann-Whitney tests, independent-samples *t*-tests, or Pearson χ^2 tests. Univariate and multivariate logistic regression forced-entry models were used to assess the ability of hypothesized variables to predict CPAP adherence as a dichotomous outcome. Multicollinearity between predictors was investigated by inspecting variance inflation factors and eigenvalues, as well as simple Pearson correlations. Standardized residuals were inspected to identify potential outliers. All statistical tests were considered significant when $P \leq 0.05$. More details regarding the study procedure and analyses are available from the corresponding author.

RESULTS

Sample Description

Over the 9-month study period, 194 patients were referred for CPAP treatment that met inclusion criteria. Thirty-two were not titrated, as no OSA was demonstrated during the diagnostic period of the split-night study; 3 declined CPAP following a successful titration. Of the 159 patients remaining, 127 consented to the study (recruitment rate 80%); 80.3% of the cohort was referred through the government-funded health system. Adherence data were unavailable for one Māori patient who failed to attend follow-up appointments; the final dataset therefore comprised 79 Europeans (62.2%), 25 Māori (19.7%), 14 Pacific (11.0%), 6 Asian (4.7%), and 2 "other" ethnicity (1.6%). Table 1 summarizes the study sample comparing Māori and non-Māori; the Māori patients were significantly younger with a higher average BMI than the non-Māori patients (both $P < 0.01$).

All patients except one spoke English fluently; this patient (Pacific) spoke only Samoan and brought a translator to all appointments. A further 9 Pacific patients spoke one of the Pacific languages fluently in addition to English; 9 Māori patients spoke Māori fluently in addition to English. Ten of the 126 patients (7.9%) required that the questionnaires be administered verbally; 9 of these were administered by the technologist on duty, and the remaining was administered by the patient's translator.

Missing Data

Eleven patients did not know whether they were eligible for a Community Services Card. Two patients did not indicate their education level; 5 patients did not indicate their income level. Two, 3 and 9 patients did not complete the SEMSA subscales risk perception, outcome expectancies, and treatment self-efficacy, respectively. Seven patients refused to complete the REALM.

Ethnicity, CPAP Adherence, and Socioeconomic Status

Average CPAP adherence for all consenting patients was non-normally distributed around a median of 5.63 h/night (interquartile range [IQR] 2.55). This was not significantly different from the 32 patients who did not consent to the study ($U = 1756.5$, $P = 0.26$), including 13 Europeans (41%), 9 Māori (28%), 4 Pacific (12%), 6 Asian (19%), and 0 "other" patients.

All further analyses used data from consenting patients only. There was no significant difference in adherence between the 5 ethnic groups (median adherence 5.77, 5.11, 5.44, 5.17, and 6.41 h/night in Europeans, Māori, Pacific, Asian, and other groups, respectively; $H(4) = 4.02$ $P = 0.20$); however, Māori used CPAP significantly less than non-Māori (median 5.11 IQR 2.24 and 5.71 IQR 2.61 h/night, respectively; $U = 996.0$, $P = 0.05$). Māori were significantly overrepresented in areas of high socioeconomic deprivation (NZDep06) compared with non-Māori ($\chi^2(4) = 7.56$, $P = 0.05$); however, there was no significant difference between Māori and non-Māori across NZiDep06 categories ($\chi^2(4) = 3.08$, $P = 0.28$) (Figure 2).

There was a significant relationship between the NZDep06 and NZiDep06 data ($\chi^2(4) = 25.99$, $P = 0.03$), indicating that patients reporting high individual deprivation tended to live in neighborhoods of high deprivation, and vice versa. Adherence did not differ significantly between the 5 area-based NZDep06 categories ($H(4) = 4.11$, $P = 0.20$), though there was a significant difference in adherence between patients in the 5 individual NZiDep06 categories ($H(4) = 10.42$, $P = 0.02$), with a drop in adherence occurring at quintile 5 (lowest socioeconomic status) compared with higher socioeconomic status quintiles (Figure 3). There were no significant relationships between adherence and the REALM raw score, which reached the maximum possible for 23% of patients ($r_s = 0.06$, $P = 0.54$), or the 3 SEMSA subscales (risk perception $r_s = -0.06$, $P = 0.51$, outcome expectancies $r_s = -0.04$, $P = 0.68$, and treatment self-efficacy $r_s = 0.05$, $P = 0.63$).

Predictive Models

Table 2 shows the univariate relationships between adherence (categorized as $< / \geq 4$ h/night) and the hypothesized pre-

dictor variables. It was decided a priori to identify 4 predictors in addition to ethnicity (which showed a significant between-group difference) to enter into a multiple logistic regression model as a conservative estimate based on our sample size of 126. Eligibility for a Community Services Card, NZiDep06 quintiles and annual income were added to the model (all univariate $P < 0.05$) as well as education, which approached significance ($P = 0.06$). Table 3 shows the independent significance of each predictor. There was no significant evidence of multicollinearity between predictors, and when one outlier was removed (standardized residual ≥ 3.0) this did not change the results of the model therefore this patient was retained. Overall, the model had a Nagelkerke pseudo-R^2 of 0.23 ($\chi^2(9) = 17.54$, $P = 0.04$), and thus explains approximately 23% of the variability in CPAP adherence.

DISCUSSION

In a sample of 126 CPAP-naïve patients in NZ, this study found that Māori used CPAP significantly less than non-Māori over an average follow-up period of 33 days (median difference of 0:36 hours). A multiple regression model including ethnicity, socioeconomic status assessed individually, annual income, level of formal education, and eligibility for government-subsidized healthcare explained 23% of the total variance in adherence, with only non-completion of tertiary education and high individual socioeconomic deprivation remaining as significant independent predictors of CPAP adherence not reaching ≥ 4 h/night (odds ratios 0.25 and 0.10, respectively), supporting our original hypothesis. Other research studies investigating adherence to CPAP have reported similarly low explanatory power (for example, 24% in a model including psychological constructs, ESS, BMI, AHI, and pressure[45]), indicating that a large variety of variables are likely to be important contributors.

Although in our sample the area-based NZDep06 did not significantly predict CPAP adherence, the individual NZiDep06 was both a univariate and multivariate predictor of average adherence ≥ 4 h. By aggregating and averaging both personal measures (such as income, employment, and education) as well as area-based measures (such as access to transport and communication infrastructure), the NZDep06 is not as specific as the NZiDep06, which may partially explain the lack of association between the NZDep06 and CPAP adherence. Further, while the NZiDep06 was a significant predictor of adherence, individual domains encompassed by this questionnaire (income, employment, eligibility for Community Services Card, and referral type) were not. We believe that this apparent discrepancy can be explained by the fact that the NZiDep06 was designed to target very high levels of deprivation, and as shown in Figure 2, the drop in adherence occurs

Table 2—Univariate predictors of average CPAP adherence ≥ 4 h/night

Predictors	% with adherence ≥ 4 hours	OR (95% CI)	P-value
Ethnicity			
Non-Māori*	79.2		
Māori	73.1	0.83 (0.30-2.34)	0.73
Age (years)			
< 40	73.7	0.77 (0.21-0.28)	0.69
40-49*	78.4		
50-59	70.5	0.80 (0.28-0.27)	0.68
≥ 60	88.9	2.21 (0.53-9.25)	0.28
Gender			
Male*	78.2		
Female	76.9	1.11 (0.38-3.31)	0.85
Treatment type			
Laboratory titration*	78.7		
Auto-PAP titration	96.2	0.80 (0.31-2.06)	0.65
Baseline ESS (/24 points)			
< 11	81.8	1.36 (0.54-3.41)	0.52
≥ 11*	75.9		
Change in ESS over trial (/|24| points)			
Improvement ≥ 10 points	87.5	2.49 (0.76-8.21)	0.13
Improvement < 10 points*	73.8		
No change/Deterioration	87.0	2.37 (0.62-9.06)	0.21
Diagnostic sleep efficiency (%)			
< 70	74.2	0.96 (0.34-2.70)	0.94
70-84.9*	73.5		
≥ 85	84.4	1.81 (0.64-5.11)	0.26
Diagnostic AHI (events/h)			
< 15 (mild OSA)	62.5	0.41 (0.13-1.27)	0.82
15-29.9 (moderate OSA)	82.6	1.15 (0.35-3.84)	0.12
≥ 30 (severe OSA)*	79.5		
Therapeutic pressure (cm H_2O)			
< 10	81.1	1.42 (0.50-4.03)	0.52
10.0-13.9 *	77.9		
≥ 14	71.4	0.71 (0.23-2.14)	0.54
SEMSA: Risk perception (/4 points)			
< 2.5	75.0	1.54 (0.59-4.01)	0.38
≥ 2.5*	82.9		
SEMSA: Outcome expectancies (/4 points)			
< 2.5	76.1	1.96 (0.41-9.27)	0.38
≥ 2.5*	86.7		
SEMSA: Treatment self-efficacy (/4 points)			
< 2.5	78.8	0.94 (0.24-3.67)	0.93
≥ 2.5*	78.6		

*indicates the reference category (chosen due to majority). Auto-PAP, automatically adjusting positive airway pressure; CI, confidence interval; ESS, Epworth Sleepiness Scale; OR, odds ratio; SEMSA, Self Efficacy Measure for Sleep Apnea; REALM, Rapid Estimate of Adult Literacy in Medicine. Odds ratio < 1.0 indicates adherence < 4 h/night. REALM categories defined according to published criteria[44]; SEMSA categories defined according to averages published previously.[38] A Community Services Card is provided by New Zealand government to subsidize healthcare costs. NZDep06 is an area-based measure of socioeconomic deprivation based on 8 variables collected in the 2006 census.[42] NZiDep06 is an individual questionnaire targeting high levels of socioeconomic deprivation.[43] Numbers in bold type P ≤ 0.05.

Table 2 continues on the following page

Table 2 *(continued)*—Univariate predictors of average CPAP adherence ≥ 4 h/night

Predictors	% with adherence ≥ 4 hours	OR (95% CI)	P-value
Referral type			
Government health system*	80.4		
Privately funded	68.0	0.49 (0.19-1.31)	0.16
Community Services Card			
No*	82.8		
Yes	62.1	**0.38** (0.15-0.97)	**0.04**
Health literacy: REALM			
≥ high school grade*	83.5		
< high school grade	69.6	0.45 (0.16-1.23)	0.13
Education			
Primary/secondary education	71.2	0.41 (0.16-1.03)	0.06
Tertiary education*	86.4		
NZDep06 (quintile)			
1 (low deprivation)*	77.5		
2	88.9	2.32 (0.45-12.05)	0.32
3	60.0	0.50 (0.15-1.64)	0.25
4	76.0	0.92 (0.28-2.99)	0.89
5 (high deprivation)	87.5	2.03 (0.49-8.40)	0.33
NZiDep06 (quintile)			
1 (low deprivation)*	84.8		
2	84.2	0.95 (0.23-3.88)	0.95
3	66.7	0.36 (0.11-1.17)	0.09
4	76.9	0.89 (0.17-4.70)	0.89
5 (high deprivation)	45.5	**0.15** (0.04-0.58)	**0.01**
Annual income (NZ dollars)			
< $20,000	57.7	**0.26** (0.08-0.82)	**0.02**
≥ $20,000 < $60,000*	85.1		
≥ 60,000	83.7	0.90 (0.30-2.71)	0.85
Employment			
Full time*	82.7		
Part time	85.7	1.25 (0.14-11.25)	0.84
Unemployed	66.7	0.45 (0.19-1.11)	0.08

*indicates the reference category (chosen due to majority). Auto-PAP, automatically adjusting positive airway pressure; CI, confidence interval; ESS, Epworth Sleepiness Scale; OR, odds ratio; SEMSA, Self Efficacy Measure for Sleep Apnea; REALM, Rapid Estimate of Adult Literacy in Medicine. Odds ratio < 1.0 indicates adherence < 4 h/night. REALM categories defined according to published criteria[44]; SEMSA categories defined according to averages published previously.[38] A Community Services Card is provided by New Zealand government to subsidize healthcare costs. NZDep06 is an area-based measure of socioeconomic deprivation based on 8 variables collected in the 2006 census.[42] NZiDep06 is an individual questionnaire targeting high levels of socioeconomic deprivation.[43] Numbers in bold type P ≤ 0.05.

in the patients of quintile 5 (highest level of deprivation) compared with the patients reporting lower levels of deprivation. Based on these data, we therefore conclude that socioeconomic status is only an important contributor to CPAP adherence when deprivation levels are very high.

These data are in contrast with our retrospective pilot study, which found a significant difference in adherence comparing Māori, Pacific, European, and Asian groups that persisted after controlling for area-based socioeconomic status, with between-group differences in adherence of up to one hour.[22] This retrospective audit was ethically able to include data from all patients established on CPAP over a 10-month period of 2008 without seeking consent, whereas the current prospective study required informed consent, and it seems feasible to hypothesize that patients who did not consent were those more likely to exhibit lower adherence. However, we did not find a significant difference in CPAP adherence between the consenting and non-consenting patients; although the minority groups were more likely not to give consent, almost half of the non-consenting patients were European. We therefore suggest that the discrepancy in results between this study and the pilot was due in part to the sample size being substantially smaller (n = 127 compared with n = 214), as well as the sleep technologists being aware of the pilot data before commencement of the current study. Although efforts were made to standardize patient care, it is possible that staff gave augmented follow-up support to patients of non-European ethnicity, given their knowledge that these patients were more likely to exhibit lower adherence, resulting in increased adherence of these groups comparing 2008 and 2010 data.

In finding that referral type (government- or privately funded) did not significantly predict adherence to CPAP, our results are also in contrast to the aforementioned Brazilian paper, which reported that publicly funded patients were more likely than privately funded patients to abandon CPAP use.[25] Although this conclusion could be explained by considering that patients funding their own treatment at considerable personal expense have a higher incentive to use treatment, it could also be reasonably hypothesized that the knowledge of high ongoing costs associated with treatment could also be a financial disincentive among these patients. Minimal research has addressed this issue, which requires clarification in further studies.

Health literacy and self-efficacy were not significant univariate predictors of adherence in this cohort. A ceiling effect was evident when examining the REALM raw scores; research has shown slightly higher levels of literacy in the NZ population compared with the US[46] where the REALM was developed and validated, and it is therefore possible that an alternative measure of health literacy more appropriate for a NZ sample may be a useful predictor of adherence by giving a larger spread of data. The 3 SEMSA subscales had wide scatter reflected in r_s correlations with adherence of < 0.1. However, an article published after the current study was designed reported that the SEMSA taken post-education and after one week of treatment, though not at baseline, was significantly associated with adherence,[47] suggesting that perhaps we administered this questionnaire too early in the protocol. However, we were attempting to locate baseline variables predictive of adherence in order to design a targeted intervention before beginning treatment.

The major limitation of this study was the reasonably small sample size, which allowed for only four predictors of CPAP

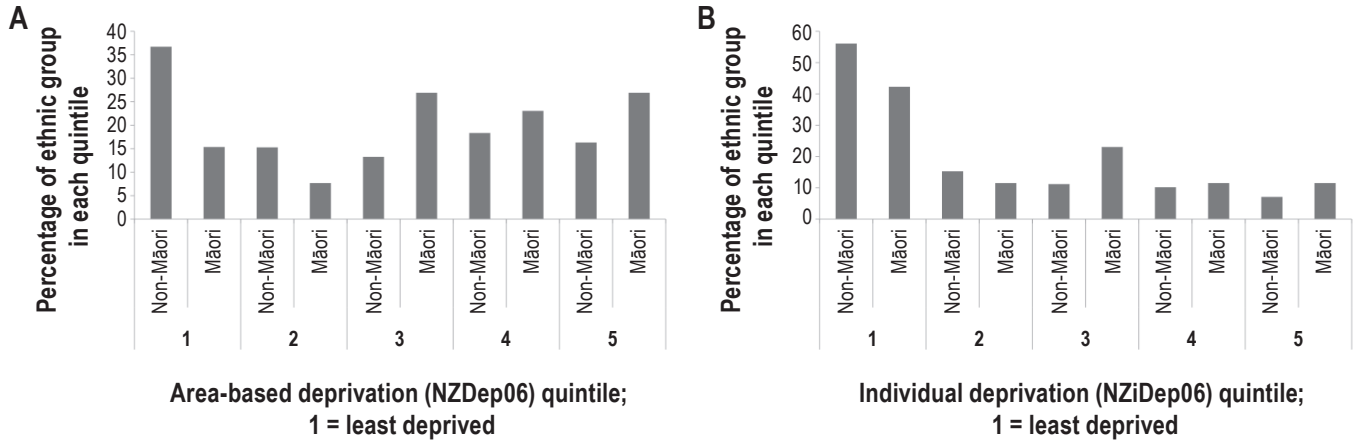

Figure 2—Percentages of Māori and non-Māori in **(A)** each of the 5 area-based socioeconomic (NZDep06) categories ($\chi^2(4) = 7.56$, P = 0.05) and **(B)** each of the 5 individual socioeconomic (NZiDep06) categories ($\chi^2(4) = 3.08$, P = 0.28).

Table 3—Independent predictors of average CPAP adherence ≥ 4 h/night

Predictors	OR (95% CI)	P-value
Ethnicity		
Non-Māori*		
Māori	2.35 (0.51-10.73)	0.27
Education		
Primary/secondary education	**0.25** (0.08-0.83)	**0.02**
Tertiary education*		
NZiDep06 quintile (1 = low deprivation)		
1 (low deprivation)*		
2	1.03 (0.22-4.94)	0.97
3	0.45 (0.09-2.35)	0.34
4	0.92 (0.14-6.15)	0.93
5 (high deprivation)	**0.10** (0.02-0.86)	**0.04**
Annual income (NZ dollars)		
< $20,000	0.24 (0.04-1.64)	0.14
≥ $20,000 < $60,000*		
≥ 60,000	0.65 (0.16-2.61)	0.54
Community Services Card		
No*		
Yes	1.87 (0.25-13.9)	0.54

*indicates the reference category (chosen due to majority). CI, confidence interval; OR; odds ratio. Odds ratio < 1.0 indicates adherence < 4 h/night. A Community Services Card is provided by New Zealand government to subsidize healthcare costs. NZiDep06 is an individual questionnaire targeting high levels of socioeconomic deprivation.[43] Numbers in bold type P ≤ 0.05.

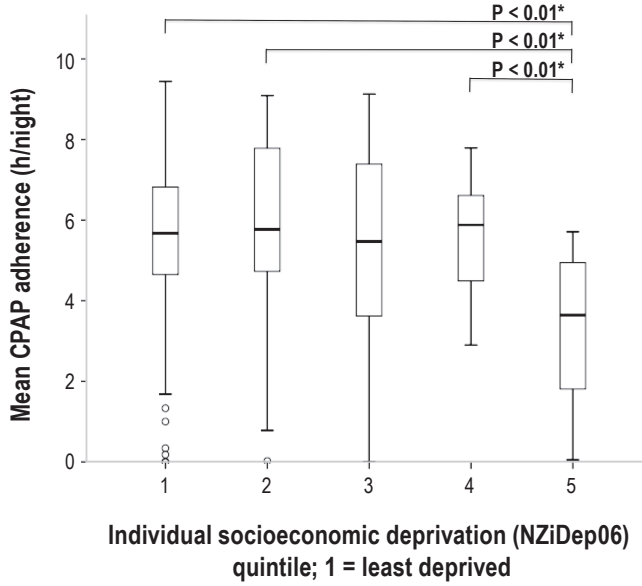

Figure 3—A comparison of mean CPAP adherence in each of the 5 individual socioeconomic (NZiDep06) categories (H(4) = 10.42, P = 0.02). *Denotes post hoc comparisons. Outliers are those which lie > 1.5 interquartile ranges below the lower quartile.

adherence in addition to ethnicity to be added to a multiple regression model. However, it should be noted that this sample of 126 represents 80% of consecutive patients established on CPAP over a nine-month period in one of the largest sleep clinics in NZ, which has a catchment population of just under 400,000, representing approximately 10% of the total population of NZ. The sample sizes of the Māori and non-Māori groups were not even, due to the consecutive approach to recruitment.

The measure of CPAP usage adopted in this study (hours per night averaged over a one-month period) is a simplified metric, and further ethnic and/or socioeconomic differences may have been apparent in measures such as number of nights with > 4 h usage, or number of missed nights. Although research suggests that long-term adherence patterns are established within the first few days of treatment,[21] greater insight would have been gained by regularly downloading adherence over a time period of one year or more. Other limitations include the use of inappropriate measures of health literacy and self-efficacy, which does not allow us to rule out the potentially important contributions of these concepts to CPAP adherence, the absence of either inter-rater or intra-rater reliability data for the REALM scoring which is potentially open to bias, and the absence of a

measure of residual disease as this is not recorded by the Fisher & Paykel devices used by the majority of patients. However, the prescribed pressure for each patient was checked by the referring physician and symptoms were closely monitored; the option to re-titrate was available but not necessary within this sample. Finally, we acknowledge that the use of different treatment pathways and CPAP devices within our cohort may have introduced some bias, although recent evidence suggests that adherence between groups established on CPAP following manual versus auto-PAP titrations is similar when patient support and education is standardized,[48] as it was in our study. All patients in our cohort were treated with standard fixed-pressure humidified CPAP, and 80% were referred through the government-funded health system and therefore used the same Fisher & Paykel device. Titration method and referral type (government- versus privately funded) were not univariate predictors of CPAP adherence in the current study or pilot[22]; we therefore do not believe the differences in CPAP initiation or devices to have led to significant bias.

To our knowledge, this is the first prospective study that has aimed to examine adherence to CPAP treatment among different ethnic groups while controlling for a wide range of socioeconomic variables as well as health literacy and self-efficacy. Other strengths of the study include the high recruitment rate and the successful recruitment of minority ethnic groups. Māori patients were overrepresented in this sample compared to the general population of Greater Wellington (19.7% compared with 14.6%),[49] consistent with the known increased prevalence of OSA among Māori.[16] The median adherence of the whole sample was high at 5.63 h/night, indicating the successful implementation of our sleep services.

The NZiDep06 questionnaire covers mainly financial and employment-related deprivation, which, along with education, significantly predicted CPAP adherence in our sample. The mechanisms by which these factors affect access to healthcare have been widely studied internationally,[50] though why they are associated with poor treatment adherence once help has been sought is less clear. Education increases a person's understanding of the importance of maintaining good health, as well as the ability to navigate health systems and bureaucracies.[51] Further, it has been suggested that people of low socioeconomic standing suffer from a greater degree of stress and depression,[51] leading to a lower prioritization of treatment. These relationships have been demonstrated in other countries and disease states; US-based research has found that lower education and socioeconomic standing predict poor adherence to asthma inhalers and HIV drugs.[52,53] This suggests that our results relating to CPAP adherence are unlikely to be particular to the unique ethnic and socioeconomic make-up of New Zealand, although it is important that future studies in other international communities confirm these findings. Future research should also focus on developing and piloting an intervention package designed to increase CPAP adherence in patients reporting low education and socioeconomic status, in order to minimize long-term morbidity and mortality likely to result from untreated OSA. Although this study did not find that ethnicity was a significant independent predictor of adherence, it is our opinion that any intervention package should be culturally appropriate, and developed with input from patients of a variety of ethnic backgrounds. If successful, such an intervention could conceivably be modified for use in other countries and disease states.

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DISCLOSURE STATEMENT

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