Socioeconomic factors correlating with community antimicrobial prescribing

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ABSTRACT

BACKGROUND: Increasing antimicrobial resistance is a serious concern in New Zealand and worldwide. Antimicrobial resistance is tied to increased community antimicrobial consumption. Investigation of the drivers of antimicrobial prescribing in different locales is needed so that targeted interventions can be devised. Counties Manukau District Health Board (CMDHB) serves a diverse, relatively socio-economically deprived population that has the highest rate of community antimicrobial prescribing in New Zealand. We hypothesise that socio-economic factors are important in determining much of the prescribing of antimicrobials in the CMDHB population.

METHODS: We collected data on the number of antibacterial prescriptions per person in each pre-defined geographical Area Unit in the CMDHB community in 2013, and compared these with demographic and socioeconomic parameters collected in the 2013 New Zealand census. Simple and multiple linear regression analyses were used to identify factors that correlated with antimicrobial prescribing.

RESULTS: Multiple regression analysis showed that antimicrobial prescribing was strongly associated with a higher ratio of number of people to bedrooms in a dwelling (an index of crowding), with some added association with Māori ethnicity. When these factors were accounted for, there was no significant added influence from a range of other factors such as income, smoking or educational qualifications.

CONCLUSIONS: Antimicrobial prescribing may be influenced by different factors within different communities. It is important to target the determinants of antimicrobial prescribing when addressing the issue of high community antimicrobial consumption. In the CMDHB community, crowding in homes is associated with higher rates of antimicrobial prescribing. This association may be because crowding directly increases infection rates, or that crowding serves as a proxy for other factors yet to be identified. Further investigation of the determinants of antimicrobial prescribing is needed.

Introduction

The World Health Organization has recently identified antimicrobial resistance as one of the greatest threats to human health.[1] The use (and overuse) of antimicrobials is an important driver of antimicrobial resistance. It is therefore important that prescribers of antimicrobials make prudent decisions: in the first instance, deciding whether an antimicrobial is indicated at all; and secondly, about the class, dose and duration used.

Antimicrobial resistance has been correlated with the amount of antibiotic used in a community, both in New Zealand and overseas.[2] Recently Thomas et al[2] reported community antimicrobial use in New Zealand and compared it with other nations using daily defined doses (DDD). Although not a perfect measure, and sometimes difficult to calculate, DDD is a parameter adjusting for antimicrobial dose, duration, and age, which allows broad comparisons over time and between locales. It appears that New Zealand's human antimicrobial consumption is higher than previously thought, and that it has increased in recent years. Thomas et al also reported on regional variation in community prescribing of antimicrobials within New Zealand. Antimicrobial prescribing rates were highest in the community served by Counties Manukau District Health Board (CMDHB).

It is clear that New Zealand's rates of community antimicrobial prescribing are

too high and must be reduced. To achieve this goal it is important to understand what determines antimicrobial prescribing in a particular setting. We reasoned that there may be socioeconomic factors (amongst others) that are important in determining antimicrobial prescribing within CMDHB, an area of relative socioeconomic deprivation. We investigated this by examining 2013 census data for defined geographic areas with concurrent data on antimicrobial prescriptions for the same areas.

Methods

Community antimicrobial prescribing data for 2013 for CMDHB were obtained from the Ministry of Health Pharmaceutical collection. The data were presented as the total number of scripts (each individual item was considered a script) for PHARMAC-subsidised, community-dispensed antimicrobials for people living in Area Units (AUs) within the CMDHB geographic area. Area Units are geographic areas of different sizes within New Zealand, used for the purposes of administration and statistical analysis. Area Units are relatively small demographic areas, and although numbers vary, they typically include several hundred to 10,000 residents. The antimicrobial data for 2013 were collected by the Ministry of Health but classified under the older geographic boundaries for Area Units used in the 2006 national census. For the purposes of this paper, the antimicrobial prescription data for 2013 were reallocated to the appropriate redrawn Area Units used in the 2013 census. In some situations aggregation of prescription data and Area Units into larger groupings was necessary to make sure that the correct antimicrobial dispensing data were allocated to the correct population. When Area Units needed combining, the census data for these areas was combined in a weighted fashion to represent the new area (see below). A few small Area Units of fewer than 150 people were excluded.

New Zealand underwent a national census in 2013. Census data for each Area Unit is being released progressively and is available on-line.[3] Area Unit data were collected for: median personal income, median family income, self-reported ethnicity, median age of population, mean

of usual number of residents in a dwelling, mean number of bedrooms in a dwelling (from which the people-bedroom ratio, PBR, was obtained for each Area Unit); and the percentages of Area Unit population who were unemployed, who had no educational qualification, who smoked tobacco, who were born overseas, who were aged <15 years, and the percentage of single parent families. The Area Unit overall New Zealand Deprivation Index (a composite index of proportions of people with no access to the internet; receiving a means-tested benefit; with a low household income; who are unemployed; who have no qualifications; who were not home owners; who lived in a single parent family; who lived in households below a bedroom occupancy threshold; and who had no access to a car) was also collected.[4]

The census characteristics of the Area Units were analysed against the number of antimicrobial prescriptions dispensed in 2013, divided by the resident population in the Area Units, to give the number of per capita prescriptions. Characteristics (independent variables) were first analysed by weighted simple linear regression to identify variables that appeared to correlate with per capita prescriptions, using Area Units as weights. Variables yielding promising relationships with antimicrobial prescribing in weighted simple linear regression were selected for weighted multiple linear regression analysis. A stepwise forward and backward selection of variables (adding and removing variables to the multiple linear regression) was used. A combination of observed significance level and Akaike's information criterion (AIC)[5] was employed to select the model that used the fewest independent variables to best explain most of the behaviour of per capita antimicrobial prescriptions (the dependent variable). Due to high collinearity amongst the identified variables, inclusion and exclusion of pairs of variables was considered at times. Weighted linear regression analyses were performed using the statistical analysis software package R version 3.1.2.[6] Two infectious diseases physicians (DH and GW) and a statistician (ACV) performed the analyses together. All derived quantities such as

ratios of predicted values were obtained from the estimated parameter values and covariance matrices of the fitted regression models, using the multivariate delta method. The coefficient of determination R^2, which denotes the proportion of the variance in the per capita antimicrobial prescriptions explained by the variables in a model, was used to compare models. The partial R^2, which denotes the proportion of variance explained uniquely by one variable in the presence of other variables in the model, was used to compare variables in some instances.

Results

Counties Manukau District Health Board (CMDHB) comprises a large area including urban South and East Auckland, and rural locales. There were 136 discrete Area Units within CMDHB after small Area Units of fewer than 150 people were excluded. It was necessary to combine 37 of the Area Units in to 11 larger composite Area Units to account for redrawn boundaries between the 2006 census and the 2013 census, and to ensure antimicrobial dispensing data were allocated to the correct populations. This gave a total of 110 Area Units as data points for regression analysis.

The total 'usually resident' population in the CMDHB Area Units in the 2013 census was 465,351. The 11 composite areas accounted for 94,242 people. The median population for an Area Unit was 3,911 (interquartile range (IQR) = 2691). The number of antimicrobial scripts prescribed for an Area Unit varied from 0.52 to 2.71 scripts per person per year (median 1.11, IQR = 0.36).

Weighted simple linear regression

The Area Unit-specific covariates (independent variables) were strongly correlated amongst themselves, with absolute correlation coefficient r values ranging from 0.42 to 0.96. The New Zealand Deprivation Index (NZDep) was positively correlated with per capita antimicrobial prescriptions. The most deprived decile population received roughly twice the number of antimicrobial scripts per capita as the least deprived decile (0.84 versus 1.76, estimated ratio 2.1, 95% confidence interval (CI)[1.1, 3.1]).

With the aim of exploring possible drivers of antimicrobial prescribing in the community, we examined several demographic and socioeconomic characteristics, including separate components of the NZDep, to assess their correlation with dispensed antimicrobial scripts.

Median personal income and median family income for each Area Unit were negatively correlated with numbers of antimicrobial scripts dispensed per capita. Percentage of the population unemployed and percentage with no educational qualification displayed positive correlation. The median age of population was negatively correlated, whereas the percentage of the population who were children (aged <15 years) or aged 65 or over correlated positively with number of scripts dispensed per capita. The percentage of the population born overseas was not correlated whereas identifying as being of Pacific Island or Māori ethnicity was positively correlated (the correlation was greater for those of Pacific Island descent). Percentages of the population who smoked tobacco, and who had no access to a vehicle or telecommunications, were both positively correlated.

An Area Unit characteristic with a strong correlation (r=0.71) with antimicrobial prescriptions was the ratio of usually resident household members to the number of bedrooms in the dwelling.

Weighted multiple linear regression

Because of the obvious potential for several census Area Unit characteristics to co-correlate, multiple linear regression was performed, selecting different variables to include in a predictive model.

A predictive model including just two variables – the ratio of usually resident household members to number of bedrooms in the dwelling (people-bedroom ratio, PBR), and percentage of Area Unit population identified as Māori – displayed the best AIC amongst the models surveyed and explained more than half of the variance in per capita antibacterial scripts across Area Units. The coefficient of determination (R^2 value) using just these two variables in the model was 0.55. By comparison, a model with all variables retained reached an R^2 of 0.60. Within the

Figure 1: Antimicrobial scripts per capita versus people-bedroom ratio. The open circles vary in size to represent weighting.
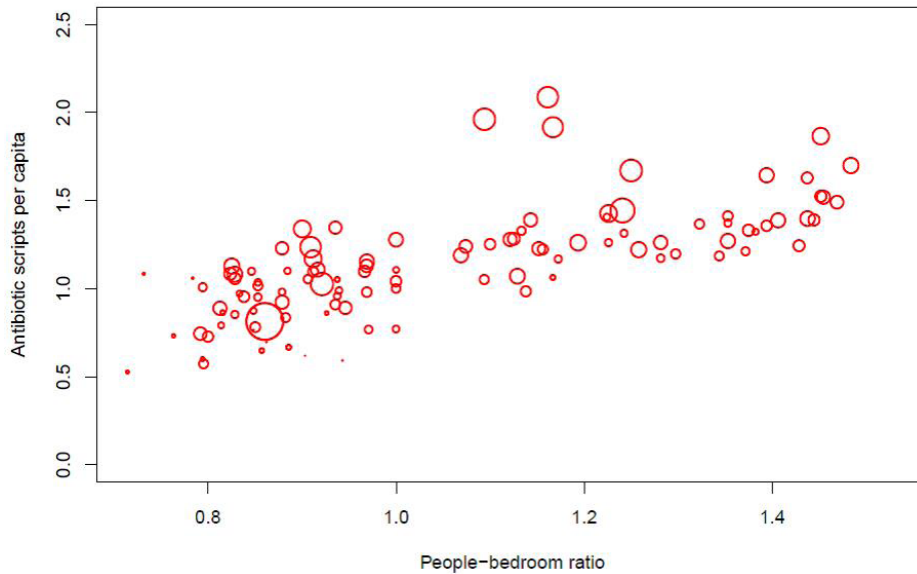
Table 1: Medians and interquartile ranges for census characteristics of CMDHB Area Units, with the coefficient of determination (R^2 value) of the model regressing antimicrobial scripts dispensed per capita in 2013 on the census characteristic. All simple linear regressions were highly significant (p value < 10^{-10}), but census characteristics displayed strong collinearity. Last column shows partial R^2 values (proportions of extra variance explained) for each variable when already accounting for PBR and %Māori to explain antimicrobial prescribing patterns.

Characteristics of census 2013 Area Units	Median (interquartile range)	Coefficient of determination (R^2)	Partial R^2 in a model accounting for %Māori and PBR
PBR (mean ratio of household members to bedrooms in dwelling)	0.97 (0.31)	0.50	40.6%*
% Māori	14.6 (11.4)	0.25	10.1% **
Median personal income ($)	26,400 (11,200)	0.45	0.0%
Median family income ($)	65,500 (33,800)	0.48	0.2%
% with no educational qualification	25.4 (13.5)	0.42	0.0%
% unemployed	5.9 (5.4)	0.51	0.0%
% smokers	16.8 (12.1)	0.41	2.3%
% under 15 years	22.8 (8.1)	0.37	3.7%
% Pacific Islander	14.4 (32.6)	0.43	1.1%
% one parent families	22.3 (16.6)	0.51	0.2%
% with no access to phone, fax, internet	1.8 (2.6)	0.43	0.3%
% with no access to vehicle	6.4 (7.1)	0.44	2.2%

PBR, people-bedroom ratio; * Against a model with % Māori only; ** Against a model with PBR only

retained model, the people-bedroom ratio (PBR) accounted for most of the variance of antimicrobial prescriptions per capita (partial R^2 = 0.41) whereas the proportion of Māori in the Area Unit population accounted for only fractionally more (R^2 = 0.1). Adding other variables did not appreciably increase the proportion of variance explained (Table 1).

Discussion

Antimicrobial resistance is recognised as an immediate and serious concern worldwide,[1] and New Zealand is not immune to the global increase in antimicrobial resistance rates.[7,8] Increased antimicrobial resistance is tied to increased community antimicrobial consumption, amongst other factors.[2]

Thomas et al[2] have demonstrated that community antibiotic use in New Zealand is high compared with many other countries and, perhaps surprisingly, is on a par with countries (such as Italy and France) whose use of antibiotics may be considered excessive. The importance of decreasing community antibiotic prescription, and hence consumption, in New Zealand is emphasised and several strategies to achieve this are strongly advocated.

Within New Zealand, community antimicrobial consumption varies by district health board, with CMDHB recording the highest community consumption of antibiotics among 20 DHBs studied in 2012.[2] Antimicrobial prescription rates are probably influenced by many interacting factors, including the incidence of infectious disease within a community, and prescriber and patient factors such as access to healthcare, socioeconomic status, education, and personal and cultural beliefs (factors which may themselves be linked to rates of infection in a community). Many of these factors will be inextricably intertwined and may affect different communities in different ways.

In this paper, we investigated the hypothesis that socioeconomic factors are important in contributing to the higher rate of community antimicrobial prescribing in CMDHB.

CMDHB is situated in the north of New Zealand's North Island and includes the territorial authorities of Auckland, Waikato District and Franklin District. The DHB serves a diverse population of around 500,000 people (11% of New Zealand's population). The population is relatively young (24% of the population is under the age of 24 and 13% of New Zealand's children live in the CMDHB catchment area) and has a relatively high proportion of people of Māori (15% of the CMDHB population, accounting for 12% of New Zealand's Māori population), Pacific Island (22% of the CMDHB population, accounting for 40% of New Zealand's Pacific Island population) and Asian (22% of CMDHB's and New Zealand's Asian population) ethnicity.[3] The population is growing at a rate of about 1.5–2% per year, which translates to an additional 8,000 to 9,000 residents each year. According to the 2013 census, 36% of the CMDHB population lives in areas classed as the most socio-economically deprived (deciles 9 and 10 according to the NZDep).[3]

This paper looked at antimicrobial prescriptions per head of population in a year, and analysed this against age, ethnicity and several socioeconomic variables. Antimicrobial prescriptions per capita was the measurement used in this paper, rather than DDDs, because data for the former were more readily available. The measurement of antimicrobial prescriptions per capita as a marker for community antimicrobial consumption has been validated in other studies of antibacterial prescribing and deprivation.[9]

Initial analysis showed strong associations between antimicrobial prescription rates and most of the analysed socioeconomic variables. A problem with this kind of analysis is that there are strong associations between the independent variables themselves (eg, smoking was correlated with crowding and income level). Multiple regression analysis showed that the ratio of household members to bedrooms in a dwelling, which could be thought of as representing crowding, accounted for most of the variation in antimicrobial prescription rates. 'Crowding' may serve as a useful marker which summarises the effects of the other variables, such as income, access to telecommunications, education level and so forth; once adjustments for crowding were performed, the

other variables (apart from Māori ethnicity) did not contribute much extra association.

These results–that antibacterial prescriptions per head within the CMDHB community appear to be strongly influenced by the ratio of the number of people in a house to the number of bedrooms (or crowding) are not particularly surprising in themselves, but rather serve as a direction for further investigation. Is crowding more prevalent within CMDHB compared with other DHBs? Is crowding a proxy, representing other factors driving antimicrobial prescription? Do these factors correlate with a greater incidence of infectious disease in the CMDHB area compared with other DHBs? How much of the high CMDHB community antimicrobial prescribing is appropriate (for example, are antimicrobials often prescribed for upper respiratory tract infections in the CMDHB community)?

Poverty and deprivation are known to be associated with increased rates of infectious disease in New Zealand.[10,11] In New Zealand, an association between crowding or other markers of socio-economic deprivation has been shown for infectious diseases such as tuberculosis,[12] rheumatic fever,[13] meningococcal disease,[14] skin and soft tissue infections[15] and serious *Staphylococcus aureus* disease.[16]

New Zealand studies have also shown an increased risk of infectious disease in people of Māori and Pacific Island ethnicities.[10,15,17] There is also some suggestion that geographic location within New Zealand may have an association with some infectious diseases; *S. aureus* sepsis and skin and soft tissue infections, for example, appear to be more prevalent in northern areas,[16] although this may reflect the distribution of other risk factors predisposing to *S. aureus* infection.

An increased ratio of number of people to bedrooms in a dwelling (possibly reflecting crowding in some situations) may serve as a proxy for other as-yet unidentified factors driving antimicrobial prescription. Such factors may include the types of infectious diseases whose acquisition and spread is associated with crowding;[11] the populations disproportionately affected by crowding and infectious disease (e.g. children);[11] the prescribing practices of those working in communities where crowding and deprivation are common; and the presence of community-based interventions targeting infectious diseases.

This study is a preliminary exploration of the potential links between socio-economic factors and community antimicrobial prescribing. There are limitations that may influence the conclusions that can be drawn from this study. Similar analysis needs to be performed in other DHBs before we can conclude that CMDHB's particular demographic and socio-economic composition influences the high antimicrobial prescribing rate. Describing the burden of infectious disease in the CMDHB population is also important when trying to explain high antimicrobial prescription rates and identify whether antimicrobial prescribing is appropriate in the CMDHB community. It is not known from this study who prescribes the majority of antimicrobials, and the indications for these prescriptions.

Further investigation into the determinants of the high rates of community antimicrobial prescription within CMDHB is needed, so that strategies to reduce community antimicrobial use can be developed and targeted. In particular, comparison of the incidence of infectious disease and crowding within the CMDHB community with other DHBs would be of interest. Qualitative and quantitative research relating to prescriber and patient behaviour could also identify areas to target.

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