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Geographical clustering of cannabis use: Results from the New Zealand Mental Health Survey 2003–2004

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Abstract

Background—In epidemiology, it always has been important to study local area patterns of disease occurrence. New methods to quantify local area and household clustering of disease emerged late in the 19th century and were refined during the 20th century. Nonetheless, multi-level models to estimate local area clustering of illegal drug use did not appear until the 1990s, and to date, there is just one study with estimates of local neighbourhood clustering of cannabis use, based on a United States sample. Here, seeking the first replication of that single prior study, we estimate the degree to which cannabis use might cluster within neighbourhoods of New Zealand (NZ), and we also study higher-level clustering and suspected individual-level determinants of recent cannabis use.

Methods—A national probability community sample (n=12,992) of adults aged 16 years or more with standardized assessment of cannabis use. Alternating logistic regression produced estimates for cannabis clustering.

Results—In NZ, use of cannabis was common: 41.6% had ever used it and 13.1% had used it in the past year. There was clustering within the smallest local areas (PairWise Odds Ratio = 1.3–1.5) but not within larger government districts (PWOR=1.02). Age, male sex, ethnicity, education, and marital status were all associated with cannabis use, but did not account for observed clustering.

Conclusions—Neighborhood clustering of recent cannabis use has emerged in New Zealand, as in the US. Standard individual-level characteristics explain only some of this clustering. Other explanations must be sought, perhaps including personal networks and local supply.

Keywords

cannabis; marijuana; epidemiology; New Zealand; alternating logistic regression; spatial clustering

1. Introduction

Epidemiology originated with a tradition of population research on infectious diseases as observed within human populations of rather small local areas in Western Europe and the New World, including communities on small islands, and with case-mapping in relation to city or village blocks and households. Relatively primitive methods to quantify disease clusters within households and local community areas were devised in the 19th century, but a special challenge was encountered when epidemiologists tried to quantify how much local area or household clustering might be left behind, once suspected individual-level causal determinants had been taken into account (Anthony 2006). Facing this challenge, Carey and colleagues (Carey et al. 1993) developed and refined an alternating logistic regressions approach based upon the generalized linear model with generalized estimating equations (ALR; GLM; GEE). In an initial public health application, Katz, Carey, and colleagues used ALR to estimate pairwise odds ratios (PWOR) that directly quantify clustering of diarrheal disease in villages and households of various countries, always with larger estimates of household clustering nested within smaller estimates of village-level clustering, reflecting the prominent influence of individual-level and household-level determinants (e.g., age, presence of a latrine in the household). Nonetheless, even with statistical adjustment for individual-level and household-level covariates of this type, there remained tangible and statistically robust village-level diarrhea clustering, with PWOR ranging upward from 1.03 (95% confidence interval, CI =1.01, 1.07) in Zambia to 2.2 (95% CI = 1.7, 2.8) in Indonesia (Katz et al. 1993) As in other branches of science, this type of epidemiological research gains strength, and the resulting evidence of epidemiological clustering becomes more credible, when the pattern replicates in different areas and countries of the world.

Later application of the ALR approach in epidemiological research on illegal drug involvement in the United States (US) has produced generally consistent evidence that drug involvement shows an epidemiological patterning akin to what has been observed for diarrheal diseases in villages – that is, modest but statistically robust clustering observed for small local areas such as city block groups and census tracts, also with individual-level covariates held constant. Nonetheless, there is only one published study that quantifies local area clustering of cannabis involvement, based upon cannabis use of neighbourhood residents sampled and assessed for national surveys conducted within US metropolitan areas during the early 1990s (Bobashev and Anthony 1998; Bobashev and Anthony 2000; Petronis and Anthony 2003). The extent and nature of clustering may depend on the structure of drug markets and these differ across time and place so that it is important to investigate such clustering in more recent years and in other countries.

We cannot carry out an exact replication of that one prior cannabis study, because the US Substance Abuse and Mental Health Services Administration (SAMHSA) no longer releases the necessary neighborhood level indicators from its annual national surveys of US residents. For non-exact but systematic replication, we now present evidence from another part of the world, New Zealand (NZ), with PWOR estimates made for the NZ neighbourhood level, nested within larger geopolitical units, also with ALR estimation of the PWOR and with individual-level covariates held constant.

Although NZ is separated from the US by more than 6500 miles of open Pacific Ocean water (>10,000 km), these two countries share many features of cannabis epidemiology, including many early-onset users and relatively large population prevalence estimates for recent cannabis smoking. To illustrate, based upon a NZ national survey conducted in 2001, 50% of 15–45 year olds had ever used cannabis and 20% had used it in the last year (Wilkins et al. 2002). According to reports compiled by the United Nations Office on Drugs and Crime (http://www.unodc.org/pdf/WDR_2006/wdr2006_volume2.pdf, last accessed 11 March

2008), both NZ and the USA are in the top rank of countries with the highest prevalence of recent cannabis use, along with Canada and Australia (13%–17% prevalence proportions for 15–64 year olds). Comparatively, within Western Europe the cannabis prevalence estimates are lower, but there is a wide range from Spain, the Czech Republic, England and Wales at 11%, down to 5% in Ireland, with still lower prevalence estimates observed in Scandinavia and Eastern Europe. The phenomenon of early onset cannabis smoking is well known in the US (e.g., see (Degenhardt et al. 2007), and also has been documented in New Zealand. For example, New Zealand research teams studying 1970s birth cohorts estimated that 15% had smoked cannabis by age 15, and that 70–77% had used cannabis by ages 25–26 years (Poulton et al. 2001; Boden et al. 2006).

There has been little reporting of geographic differences within New Zealand, or local characteristics associated with use of cannabis. A comparison of one metropolitan area and one provincial area showed only small differences (Field and Casswell 2001), but larger regional differences across health districts were apparent in the 2002/03 national health survey, even after age standardisation, with the highest prevalence being 1.7 times that of the lowest prevalence (http://www.phionline.moh.govt.nz/, last accessed 18 September 2007). The use of cannabis, mainly in social situations, often for ‘free’, and evidence of the multiple levels within the cannabis market all suggest that social networks are important in the acquisition and use of cannabis (Wilkins et al. 2005; Wilkins and Sweetsur 2006). Therefore local area geographic clustering of cannabis use would be expected.

In summary, aim of this paper is to use data from a national survey to examine whether there is geographical clustering of cannabis use in New Zealand, to investigate possible reasons for this clustering, and to see if any geographic clustering remains once individual-level correlates are taken into account. Because one of the issues in ‘neighborhood’ analyses is what constitutes a neighborhood (Diez-Roux 1998) we will use two levels of clustering, one larger than what would be expected to be a neighborhood, and the other smaller. We will examine:

1. geographic clustering of cannabis use, at a very localised area level (the smallest census area called a ‘meshblock’) and the local government level;
2. associations between cannabis use and individual-level characteristics (age, sex, ethnicity, education, and income);
3. the extent to which geographic clustering might be explained by individual-level characteristics.

The measure of clustering is the pairwise odds ratio obtained from alternating logistic regression (ALR). Odds ratios are commonly used to assess the relationship between an exposure and a dichotomous outcome, for example use of cannabis in the past year. The pairwise odds ratio expresses the odds ratio for randomly chosen pairs within a cluster, that if one member of the pair uses cannabis the other member of the pair will do likewise. One person’s use of cannabis can be thought of as the “exposure” for the other member of the pair. A pairwise odds ratio of 1 indicates no clustering.

The approach of this paper fits within a perspective from infectious disease epidemiology, with all three standard components of a public health model: agents (here the drug cannabis), hosts (humans with individual-level susceptibility/resistance traits), and environments (including drug availability). Evidence on geographic clustering of health conditions is important in this public health perspective; it often points toward environmental or contextual targets for more probing research on mechanisms or targets for preventive activities.

Think about the perspective of a national policy-maker or a local health officer with decisions to be made about whether and how to respond to expressions of public concern about emerging health issues. For illustration, consider the decision-making implications if Katz and colleagues had found no statistically robust village-level clustering of diarrheal diseases, once the ALR approach was used to take into account the underlying influence of individual-level covariates (e.g., age, frequency of hand-washing) and household-level covariates (e.g., presence of a latrine for the household). For the policy-maker or health officer, decision-making about effective prevention and control of these diarrheal diseases would shift in the direction of fundamental individual-level and household-level interventions (e.g., promotion of hand-washing; improvements in household-level human waste disposal), though perhaps not to the exclusion of village-level interventions (e.g., improved sanitary engineering for the public water supply). In contrast, Katz and colleagues actually found statistically robust and tangible PWOR estimates for village-level clustering, even when individual-level and household-level covariates were held constant. From this public health perspective, tangible local community-level clustering sheds light on the potential benefit of village-level interventions, even when the lower-level influences have been taken into account. We will return to this topic in our discussion section, after we have described the materials and methods of this study and presented our findings.

2. Materials and methods

Ethics approval was obtained from all 14 regional health ethics committees and written informed consent was obtained from each participant. Parental consent to participate was not required for 16 and 17 year olds; the age of sexual consent in New Zealand is 16 years and this often is used as an age for consent to survey participation. A chapter in a report to the New Zealand Ministry of Health provides full details of materials and methods http://www.moh.govt.nz/moh.nsf/pagesmh/5223/$File/mental-health-survey-2006-methods.pdf, last accessed 6 September 2008) (Wells et al. 2006). The full report is also available (http://www.moh.govt.nz/moh.nsf/fefd9e667cc713e9cc257011000678d8/3195f8d3155e1c2acc2571fc00131a6d?OpenDocument, accessed 6 September 2008) (Oakley Browne et al. 2006).

2.1 Sampling

Participants were selected through a multi-stage area probability sample of the population aged 16 years and above, living in permanent private dwellings in the North Island and South Island of New Zealand plus Waiheke Island. This region covers 99.99% of the New Zealand population. The Primary Sampling Units were so called ‘meshblocks’, areas originally containing 40–70 households used for each census of population and dwellings. There were 1320 meshblocks selected from a total of 38,365. Within each meshblock, households were selected systematically and then one person was selected per household (Kish, 1965).

The survey was required to produce at least 12,000 interviews, with 2,500 interviews with people of Mäori ethnicity and 2,500 with people of Pacific ethnicity. This required doubling the number of Mäori and quadrupling the number of Pacific people in the sample from what would be expected without measures to oversample these two ethnic groups. Pacific people were targeted by having a High Pacific stratum consisting of meshblocks with 55% or more Pacific people at the 2001 Census; in this stratum meshblocks were selected with higher probability than in the General stratum. Pacific and Mäori were screened for in the General stratum. Within each stratum meshblocks were sorted by District Health Board and then numerically by meshblock number prior to systematic selection. This ensured that meshblocks were selected throughout the whole country. In addition, because adjacent meshblocks generally have similar meshblock numbers, the systematic selection produced non-adjacent meshblocks, particularly in the General Stratum where the population interval in Probability Proportional to Size sampling of meshblocks was 1197.

The response rate was 73.3%. Weighting took account of unequal probabilities of selection and non-response and there was post-stratification jointly by age, sex and ethnicity to the 2001 New Zealand census.

2.2 Interview

The survey was carried out through a laptop computer assisted personal interview (CAPI), using the Composite International Diagnostic Interview Schedule (CIDI 3.0) plus some additional New Zealand demographic questions.

2.3 Variables

Past-year cannabis use—Everyone was asked, "Have you ever used either marijuana or hashish, even once?" Those who said yes were then asked "How old were you the first time you used marijuana or hashish" and then "Did you use marijuana or hashish at any time in the past 12 months".

Ethnicity—The 2001 Census ethnicity question was used in the interview. It asks about which ethnic group or groups the participant belongs to. This allows multiple responses. The prioritization rule is that anyone mentioning Mäori (the indigenous people) is classified as Mäori, anyone mentioning any Pacific Island indigenous ethnicity but not Mäori ethnicity is classified into the Pacific ethnic group and everyone else is classified into the Other category.

Education—Responses to questions about educational qualifications were converted into equivalent years of completed education. Eleven years corresponds to the lowest level of school qualification, 12 years to the next level, 13 years to highest secondary school qualification or a post secondary-school trade certificate, 14 to 15 years to diploma and 16 years to degree qualifications.

Per capita household income—Household income was asked in one question. Because of the 13.0% nonresponse on this question imputation was carried out. Household income was divided by the number in the household and compared against the median. The lowest group had income less than half the median and the highest group had income more than twice the median.

Clustering—The cluster area was the Territorial Local Authority (TLA), the local level of government with an elected mayor and council. There are 73 TLAs in New Zealand for a population of 4 million. The subcluster was the census meshblock (see *Sampling*). TLAs are set up to represent "communities of interest" (http://www.lgc.govt.nz/lgcwebsite.nsf/Files/GuidelinesRepReviews2005/$file/GuidelinesRepReviews2005.pdf, accessed 6 September 2008).

2.4 Data analysis

Weighted prevalence estimates were derived using Taylor series linearization with SUDAAN Version 9.0, which takes account of the complex survey sampling design. Weighting took account of the probability of selection (including oversampling), non-response and post-stratification. Non-response modelling of meshblocks considered meshblock characteristics related to region, urbanicity, number of inhabitants, ethnicity, gender, age, marital status, unemployment and deprivation but these predicted little. Poststratification ensured that the joint age, sex and ethnicity distribution of the weighted sample matched that of the 2001 census.

We then conducted alternating logistic regressions (ALR) (Carey et al. 1993), which explicitly model geographic clustering instead of treating clustering in a survey as a nuisance feature which has to be taken account of (as in SUDAAN) but which is not of interest in itself. PROC GENMOD in SAS Version 9 was used with the NEST1 and SUBCLUST options on the REPEATED statement (Preisser et al. 2003). Wald statistics were used for individual parameter estimates but score tests were used for the overall significance of correlates.

The measure of clustering produced by alternating logistic regression (ALR) is the pairwise log odds ratio which is often exponentiated to produce the pairwise odds ratio (PWOR or POR), sometimes called the pairwise cross-product ratio (PWCPR) (Bobashev and Anthony 2000). Within a cluster, all possible pairs of the individuals in that cluster (each with binary outcome 0 or 1) are compared in a 2 × 2 table. Discordant pairs are split evenly between (0,1) and (1,0) (Katz et al. 1993). PWOR = $(p_{00}p_{11})/(p_{01}p_{10})$, namely the product of the probabilities of concordance divided by the probabilities of discordance. When a common PWOR is calculated across multiple clusters high prevalence clusters will contribute more to p_{11} and low prevalence clusters to p_{00}. If the prevalence does not differ across clusters any more than would be expected from repeated samples from the same underlying binomial distribution, then PWOR will equal 1.

ALR can also deal with multiple levels of clustering, as in this study in which the local authority was the cluster and the meshblock the subcluster. Using the notation of Bobashev and Anthony (Bobashev and Anthony 2000) the pairwise log odds ratio for this nested design is:

$$\log(PWOR_{jklm})=\alpha_0 Z_{0\,jk}+\alpha_1 Z_{1lm}$$

where $Z_{0\,jk}$ is 1 if the pair (j,k) belongs to the same cluster (local authority) and 0 otherwise, and Z_{1lm} is 1 if the pair (l,m) belongs to the same subcluster (meshblock) and 0 otherwise. The parameter α_0 indicates the clustering within local authorities not due to clustering within meshblocks. The parameter α_1 indicates the clustering within meshblocks not due to clustering within local authorities. However because meshblocks are nested within local authorities, the estimated log(PWOR) for a meshblock is $(\alpha_0+\alpha_1)$ as any pair of individuals within a meshblock are also within the same local authority. In SAS output $apha1 = \alpha_0 + \alpha_1$ and $alpha2 = \alpha_0$. ALR models yield population-averaged or 'marginal' model estimates of clustering.

As well as estimating clustering, ALR models also can estimate the association of covariates with binary outcomes by alternating iteratively between the calculation of the clustering parameters and logistic regression. To describe the association of individual-level correlates with cannabis use in the last year, each correlate was analysed on its own in an ALR model. Then, to see if the correlates accounted for any clustering observed, and to see their associations with past-year cannabis use in a joint model, they were all entered into a multiple logistic regression within ALR. The resulting odds ratios (OR) are presented in order to gauge the degree to which the observed associations are statistically independent from one another; the intent is not to make causal inferences from these cross-sectional data.

3. Results

3.1 Sample characteristics

The characteristics of the sample are shown in Table 1. The most notable discrepancy between the unweighted numbers and the weighted percentages is seen for ethnicity. To provide more precision for estimates for Maori and for Pacific people, the number of Māori was doubled and the number of Pacific was quadrupled from that expected from their numbers in the population; with weighting, the percentage in each ethnic group corresponds to that in the 2001 census.

3.2 Cannabis use

Table 1 shows the numbers who reported using cannabis whereas Table 2 provides a breakdown by age at interview. Overall 41.6% reported ever using cannabis and this lifetime use was highest in those aged 25–34 years (61.3%) and declined across older age groups to a low of 3.1% in those 65 years and over. The youngest age group (16–24 years) were less likely to report ever using cannabis (53.6%) than those aged 25–34 years. A different pattern was seen for use of cannabis in the past year. The highest percentage for use (31.2%) was seen in the youngest age group and there was a steady decline down to 0.3% in the oldest age group. Overall 13.1% had used cannabis in the past year.

3.3 Geographical clustering of past-year cannabis use

Table 3 reports estimates of the extent of clustering observed within local authorities and within meshblocks (very small 'neighborhoods'), ignoring the characteristics of the people who lived within each area. It also presents the association between each correlate, one at a time, and cannabis use in the past year with the association expressed both through the percent who used cannabis and through odds ratios. Finally, all correlates are used in one joint model to see a) how much clustering at each geographical level remained taking account of who lived in each area, and b) the associations which remained between correlates and cannabis use in the past year when other correlates were included in the same model.

The analysis with only the clustering variables showed that there was clustering of past-year cannabis use in New Zealand. However this clustering occurred only at the meshblock level (PWOR=1.5, CI=1.4, 1.6), not at the local authority level (PWOR=1.02, CI=0.99, 1.04).

Both the percentages across correlate levels and the associated odds ratios show that there were several socio-demographic characteristics associated with past-year cannabis use. The strongest association was with age, as noted above. Males were nearly twice as likely as females to use cannabis (16.5% vs 9.9%). Māori were the most likely to use cannabis (26.2%) with much lower percentages for use in the composite Other ethnic group (11.5%) and the Pacific group (10.3%). Those with 14 or more years of education were least likely to have used cannabis (8.8%). Cannabis use also varied by marital status: those previously married were slightly less likely to have used cannabis (7.4%) than those who were currently living with a partner (9.0%) whereas use was most likely in those never married (27.1%), a finding highly confounded by age. Cannabis use was more likely the lower the household income (18.0% down to 9.7%).

Several of the associations between correlates and past-year cannabis use changed when all were entered into a joint model. Age associations were slightly reduced but still by far the strongest (a ratio of over 100-fold from the youngest to the oldest). The OR for sex was almost unchanged. Both Māori and Pacific populations are younger than the Other population (Baxter et al. 2006; Wells et al. 2006) so when in a joint model with age, the OR for Māori was reduced from 2.7 to 1.7 but the OR for Pacific people, which was already less than that for Others, fell even further from 0.9 to 0.5. Those with the highest level of education were still the least likely to have used in the past year, although the OR of 1.3 for those with 11–12 years of competed education was not significantly higher (CI 0.9, 1.8). The marital status results were much altered by the inclusion of other correlates in the model, as young people were more likely to be never married whereas they were least likely to be previously married. In the joint model those previously married had an adjusted OR of 1.8 and those never married had an OR of 1.5, relative to those who were living with a partner. In the joint model income was no longer significant overall (p=0.15) although all three lower income categories had ORs of 1.2 to 1.3 relative to the highest category.

Even with the inclusion of the socio-demographic correlates in the model, clustering still remained at the meshblock level (PWOR=1.3, CI 1.2, 1.5) and again there was no clustering at the local authority level (PWOR=1.00, CI 0.98, 1.02). The clustering of past-year marijuana use at the meshblock level could not be explained away by this standard set of characteristics of the people who lived in each area.

4. Discussion

The clustering of cannabis use seen in the US (Bobashev and Anthony 1998; Bobashev and Anthony 2000) is also seen in New Zealand, a country in which, like the US, about 13% of the adult population have used cannabis in the past year. In New Zealand, clustering occurred only at the small area of a census meshblock, not at the larger local authority area. Clustering was reduced but still remained at the meshblock level when a standard set of sociodemographic correlates were taken into account.

In the US, the ‘neighborhoods’ in which clustering was observed were census segments which consist of several to many blocks, so segments are larger areas than meshblocks. Nonetheless the pairwise odds ratios (PWORs) are fairly similar: 1.5 for New Zealand and 1.3 to 1.6 for the US without consideration of who lived in each area, with a reduction of 0.2 to 0.3 when the individual-level characteristics are included. The similar size of the PWORs in spite of differences in the size of segments and meshblocks may arise because of the systematic sampling used in New Zealand which resulted in the geographical separation of most meshblocks, so that they can be thought of as subunits within groupings of around 1000 people, which is about the size of the US segments, referred to as ‘neighborhoods’. These PWORs are comparable to that observed for clustering in neighborhoods for family income categorized into two values (1.5) (Bobashev and Anthony 1998).

One of the difficulties in interpreting these results comes from the conception of ‘neighborhood’. As Diez-Roux (Diez-Roux 1998) has discussed, an individual’s neighborhood may be much broader than a geographically defined area of residence. In New Zealand people live in a meshblock but meshblocks are so small (literally a block in urban or suburban areas) that almost everyone would work, shop and socialize outside their meshblock. However although their connections range far beyond a meshblock, at least for use of cannabis in the past year the connections appear to cover less than the full range of a local authority, even although this is set up to represent a ‘Community of interest’. As suggested above, the ‘neighborhood’, in as much as it exists at all, is perhaps a unit of something like around 1000 people in a contiguous area.

With alcohol it is possible to study the spatial distribution of alcohol outlets and to relate this to alcohol consumption or associated problems (Gruenewald et al. 2006; Gruenewald and Johnson 2006). Because cannabis is an illegal drug, there is no official documentation of the location of supply. In New Zealand many users report that they do not buy the cannabis they use, but are supplied by their friends (Wilkins et al. 2005; Wilkins and Sweetsur 2006). This indicates that friendship networks are extremely important for cannabis use. Only a minority (about 10%) grow any of the cannabis they use. Other means of obtaining cannabis are from buying through personal networks or from drug houses, known locally as ‘tinny’ houses (a ‘tinny’ contains about three joints of cannabis wrapped in tinfoil). The traffic of buyers to tinny houses often results in police raids so to minimize financial risk such houses are rented and are usually in poorer areas; this provides another source of geographical clustering. A contagion-like process may occur whereby regular cannabis users share with uninitiated friends in their neighborhood or at least increase their opportunity to use and perhaps the acceptability of use. Alternative mechanisms discussed by Petronis and Anthony (2003) include the possibility that cannabis users migrate to neighborhoods that are more tolerant of cannabis dealing and smoking; there is also the possibility that non-users become selective out-migrants if they become aware of cannabis use or dealing.

There is negligible clustering associated with local authorities. This finding does not mean that local authorities do not differ in the level of cannabis use. What it means is that the clustering is primarily within meshblocks (or other sub-parts of local authorities). The clustering estimates are obtained across the whole country and are assumed to be constant across all local authorities whereas it may be that there are a few which do differ in the midst of a general pattern of clustering only at the meshblock level. Nonetheless these results suggest that cannabis is available throughout New Zealand, certainly for younger people.

The findings for correlates of cannabis use in the past year are similar to those from numerous other studies (Ministry of Health 2004; Hall and Degenhardt 2007). In this study being male, being Māori, having low levels of education, having been previously married or never being married are all associated with being more likely to have used cannabis whereas being of Pacific ethnicity is associated with being less likely to use cannabis. However the adjusted odds ratios in the joint model are all under 2. This is in marked contrast to the range for age which is more than 100-fold. The main determinant of whether or not someone has used cannabis in the past year is their current age. While it may be appropriate to target prevention and harm reduction to some groups defined by sex or ethnicity to ensure that messages are culturally appropriate the major indication for any targeting must be age. Nonetheless it is not appropriate to focus only on the youngest age group; nearly a third used cannabis in the past year but so did a fifth of 25–34 year olds and over 10% of 35–45 year olds.

Strengths of this survey are that it is a national one with a reasonable response rate of 73.3% which has been analysed taking account of the complex design. In addition, although it cannot resolve just what constitutes a ‘neighborhood’, by using two levels of clustering it has been able to place bounds around what constitutes a neighborhood. The principal limitation of this survey, and all others like it, is that use of cannabis is based on self-report. As use and possession is illegal, it is likely that there was some failure to report use. Such failure may depend on how common, and hence how socially acceptable use is in different subgroups of the population. Very occasional users may have been unclear about whether their use was in the past year or not. Although the response rate was good for such a survey it leaves open the possibility of non-respondents differing systematically from respondents in their use of cannabis which could even have meant that clustering was underestimated. Response rates were known per meshblock but with over 1300 meshblocks there were only 9.9 respondents per meshblock on average which is too few to relate non-response to cannabis use, let alone taking account of the socio-demographic characteristics of who lived in meshblocks (in the non-response modelling which was carried out these characteristics were not important correlates of response).

In summary, this investigation provides evidence of neighborhood clustering of recent cannabis use. The occurrence and clustering of recent cannabis use were found to be dependent, to some extent, upon individual-level characteristics, particularly age. Nonetheless neighborhood clustering remained even when these individual-level characteristics were held constant in a regression model. Alternative explanations for the clustering of cannabis use are discussed, including a ‘contagion’ process that might depend on personal and commercial networks for supply, as well as processes such as selective in-migration or out-migration.

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Table 1

Description and summary overview of the NZMHS sample in relation to cannabis use and selected correlates. (n = 12,992).

		Unweighted n	Weighted %	SE (%)
Individual characteristics				
Age band	16–24 years	1535	15.71	0.54
	25–34 years	2414	18.70	0.55
	35–44 years	2890	20.95	0.44
	45–54 years	2245	17.60	0.46
	55–64 years	1664	12.00	0.32
	65 + years	2244	15.05	0.46
Sex	Female	7358	52.00	0.59
	Male	5634	48.00	0.59
Ethnicity	Mãori	2595	11.17	0.38
	Pacific	2236	4.54	0.22
	Other	8161	84.29	0.50
Education	0–10 years	3052	18.54	0.47
	11–12 years	2990	22.53	0.52
	13 years	3514	28.12	0.53
	>=14 years	3436	30.81	0.69
Marital status	Married/Cohabiting	7653	64.52	0.63
	Previously married	2439	12.13	0.41
	Never married	2900	23.35	0.60
Income[1]	Low	3117	19.82	0.63
	Low-average	4254	31.62	0.57
	High-average	3436	30.15	0.52
	High	2185	18.41	0.47
Cannabis use				
Lifetime use		5292	41.64	0.70
Past-year use		1613	13.05	0.45

[1] Per capita household income according to WMH income categories.

Table 2

Use of cannabis ever and use within the past year, for six age groups. (n = 12,992).

	Use of cannabis ever				Past-year use of cannabis			
	%	**SE**	**OR**	**95%CI**	**%**	**SE**	**OR**	**95%CI**
Age group								
16–24 years	53.6	1.7	0.97	0.83, 1.13	31.2	1.6	3.30*	2.71, 4.01
25–34 years	61.3	1.3	1.34*	1.17, 1.53	21.7	1.0	2.01*	1.69, 2.40
35–44 years	54.3	1.3	1.00	--	12.1	0.7	1.00	--
45–54 years	44.1	1.4	0.67*	0.58, 0.76	7.6	0.7	0.60*	0.48, 0.75
55–64 years	18.1	1.2	0.19*	0.16, 0.22	1.6	0.3	0.12*	0.08, 0.18
65 + years	3.1	0.4	0.03*	0.02, 0.04	0.3	0.1	0.02*	0.01, 0.05
Total	**41.6**	**0.7**			**13.1**	**0.5**		

* $p < 0.05$

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Table 3

Clustering of cannabis use within the past year and selected correlates. (n = 12,992).

Correlate	Level	%	SE (%)	PW OR[1]	95% CI	OR[2]	95% CI	Adj. OR[3]	95% CI
Age band	16–24 years	31.2	1.6			3.2*	2.6, 3.9	2.4*	2.0, 3.0
	25–34 years	21.7	1.0			2.0*	1.7, 2.3	2.0*	1.7, 2.4
	35–44 years	12.1	0.7			1.0	--	1.0	--
	45–54 years	7.6	0.7			0.6*	0.5, 0.7	0.6*	0.5, 0.7
	55–64 years	1.6	0.3			0.1*	0.05, 0.25	0.1*	0.05, 0.2
	65 + years	0.3	0.1			0.02*	0.01, 0.05	0.02*	0.01, 0.04
Sex	Female	9.9	0.5			1.0	--	1.0	--
	Male	16.5	0.8			1.8*	1.6, 2.1	1.9*	1.7, 2.2
Ethnicity[4]	Māori	26.2	1.2			2.7*	2.3, 3.2	1.8*	1.5, 2.1
	Pacific	10.3	1.3			0.9	0.7, 1.2	0.5*	0.4, 0.7
	Other	11.5	0.5			1.0	--	1.0	--
Education	0–10 years	12.7	0.8			1.5*	1.1, 2.0	1.9*	1.4, 2.5
	11–12 years	12.9	1.2			1.8*	1.2, 2.5	1.3*	0.9, 1.8
	13 years	14.3	0.9			2.1*	1.7, 2.7	1.6*	1.3, 2.0
	>=14 years	8.8	0.6			1.0	--	1.0	--
Marital status	Married/Cohabiting	9.0	0.5			1.0	--	1.0	--
	Previously married	7.5	0.7			0.8*	0.7, 1.0	1.8*	1.5, 2.2
	Never married	27.1	1.1			3.6*	3.0, 4.3	1.5*	1.3, 1.7
Income	Low	18.0	1.1			2.0*	1.4, 2.9	1.3	0.9, 2.0
	Low-average	12.2	0.7			1.3*	1.0, 1.7	1.2	0.9, 1.6
	High-average	12.8	0.7			1.4*	1.2, 1.6	1.2*	1.0, 1.4
	High	9.7	0.8			1.0	--	1.0	--

Correlate	Level	%	SE (%)	PW OR[1]	95% CI	OR[2]	95% CI	Adj. OR[3]	95% CI
Geographic clustering	New Zealand meshblock[5]	--	--	1.5*	1.4, 1.6	--	--	1.3*	1.2, 1.5
	Territorial Local Authority[6]	--	--	1.02	0.99, 1.04	--	--	1.00	0.98, 1.02

1 Results from an alternating logistic regression including only the clustering variables (‘intercept-only’ model)

2 Results from alternating logistic regressions including each correlate individually, and the clustering variables. Because the results for the clustering variables depended on which correlate was included, clustering results are not reported here.

3 Results from one alternating logistic regression including all correlates and the clustering variables

4 ALR failed to converge for the model with ethnicity alone so results reported are from SUDAAN

5 PWOR (meshblock) = e^{alpha1}. in SAS notation but parameter naming differs across software

6 PWOR (Territorial Local Authority) = e^{alpha2} in SAS notation but parameter naming differs across software

* Note: indicates p<0.05