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Segregation Intensity for Multiple Groups at Multiple Scales**

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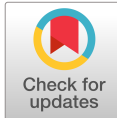
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DECOMPOSING MULTI-LEVEL ETHNIC SEGREGATION IN AUCKLAND, NEW ZEALAND, 2001–2013: SEGREGATION INTENSITY FOR MULTIPLE GROUPS AT MULTIPLE SCALES

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ABSTRACT

There has been a growing appreciation that the processes generating urban residential segregation operate at multiple scales, stimulating innovations into the measurement of their outcomes. This paper applies a multi-level modelling approach to that issue to the situation in Auckland, where multiple migration streams from both Pacific Island and Asian origins have created a complex multi-ethnic city. We identify two distinct trends. For the larger ethnic groups segregation remained static despite rapid growth over a recent twelve-year period. For the smaller groups growth has been combined with considerable change; they initially clustered in a few localities and areas within them but then experienced considerable reduction in the intensity of that segregation. By spatially decomposing the segregation levels, this paper extends our appreciation of its underpinning processes when they apply to migration streams that differ in their nature from those on which traditional residential location-decision theory has been based.

Key words: segregation, scale, multi-group, multi-level modelling, Auckland

INTRODUCTION

There has been a growing appreciation that the processes generating ethnic residential segregation operate at multiple spatial scales; groups tend to concentrate within particular major districts of a city and they have preferred neighbourhoods within their chosen districts (as discussed in detail in Manley *et al.* 2015; Johnston *et al.* 2016). This conceptual change has been associated with innovations in its measurement (see, for example, Reardon *et al.* 2008; Fowler 2015; Clark *et al.* 2015). If segregation operates at a

number of scales, how can its relative intensity at each of those scales be separately identified? In general, researchers have assumed that segregation is greater the more fine-grained the scale of analysis (i.e. the smaller the areas, in terms of population, used in the analysis; for an explicit statement of this belief, see Logan *et al.* 2015; see also Johnston *et al.* 2018). But as was pointed out several decades ago (Duncan *et al.* 1961), if those measures are calculated separately at each scale then the index of segregation at a fine scale necessarily incorporates values at a larger scale. To obtain a 'true' measure of

segregation's intensity at each scale it is necessary to partial out its intensity at the larger scales; such a measure is employed here.

Much of the work on these location decisions and the resulting patterns of segregation derive – indirectly if not directly – from sociologists' pioneering work in the first half of the twentieth century (Park *et al.* 1925; for an overview see Nightingale 2012). The Chicago research represented a very different situation than present in contemporary societies, even if the empirical definition of segregation is similar. Sociologists developed measurements of segregation specifically to deal with 'a particular set of social concerns [...] most segregation indices are designed to measure segregation between two discrete population groups' (Reardon 2006, p. 176). Segregation of recent immigration streams poses different challenges. The immigrant groups studied in early segregation research had little human or financial capital when they reached their urban destination and were constrained to particular, almost invariably relatively low cost, low quality and high density, parts of the housing market. Only a small number of localities was available to them – a number that might be reduced further by discriminatory housing market processes. Furthermore, their cultural differences meant that the areas in which they concentrated – in part for cultural and social solidarity in a strange environment – were largely avoided not only by members of their host society but also by members of other immigrant groups. The different groups not only lived apart from members of their host society but also, again in large part for cultural 'defensive' reasons, apart from other ethnic minority groups too. Thus multi-ethnic cities were characterised by a complex urban mosaic in which the different groups were concentrated in different localities and areas within them.

Over time, that clustering was reduced as a result of a balance between two trends. The first involved economic integration and socio-cultural assimilation into the host society. As group members – usually the children and grandchildren of the initial immigrants – increased their human and financial capital, a wider range of choice within the

housing market became accessible. As they became more assimilated into the wider society's cultural norms and behaviour patterns so they became more accepted as neighbours, and as a consequence the areas to which they moved were less segregated than those from which they were moving. As this process continued, the ethnic enclaves established by the first generations of immigrants declined in relative and then absolute size, unless their populations were continually replenished by new waves of immigrants who could only afford to live in the original enclaves (or their replacement equivalents if the process of 'invasion and succession' saw those enclaves occupied by new waves of immigrants from different origins). New immigrants clustered there until such time as they became able to move out into more mixed neighbourhoods.

That theory of changing patterns of segregation reflected the situation in which much of the original work was done mainly in the United States (see Zhang & Logan 2016). It is less well-suited, however, to at least part of the contemporary situation in countries where the nature of international migration streams has changed in recent decades. Countries such as Australia and New Zealand now operate a variety of systems, some of which limit immigrants (other than refugees and those joining family members already in the country) to those with sufficient human and financial capital so that they would not be constrained to the lower levels of the housing market as was the case for other immigrant groups in previous decades; they are accepted as immigrants because of the skills they bring to the local workforce (see, for example, Ho 2007; Spoonley & Bedford 2012). As such, they may not be as substantially segregated as those predecessor groups. They may choose, for a number of cultural reasons, to locate into particular city localities where their co-ethnics are congregated, but not to cluster together into areas where they dominate the population.

Those arguments were assessed in an earlier paper on changing segregation patterns in Auckland, New Zealand between 2001 and 2013 (Manley *et al.* 2015), using data at three spatial scales for four, broadly-defined, ethnic

groups (New Zealand European, New Zealand Maori, Pacific Island Peoples and Asian). This paper builds on that foundation, using data on all of the separately identified ethnic groups within the Asian and Pacific Island categories (14 and 8 groups respectively) at the 2001 2006 and 2013 censuses to explore whether they vary in the intensity and patterning of segregation; analyses for the New Zealand European and New Zealand Maori populations are included for comparison, giving data for 24 groups in total. Although the data for the four main groups are reported at three nested spatial scales within the Auckland urban region as defined in the New Zealand census – blocks within areas within localities – information is not available at the finest, block, scale for the 22 separate groups so these analyses look at the two higher levels only.¹

Auckland's ethnic composition has changed rapidly in recent decades, through two main migration streams: the first involves immigrants from a number of Pacific Island groups; the second comprises immigrants from a range of countries in northeast, southeast and south Asia, whose numbers have recently increased very rapidly (Table 1; in all of the tables we refer to the country associated with respondents' claimed ethnicity, except for the Fijian Indians).² Those two streams differ considerably in their nature, as discussed below, so that the analyses reported here add to our appreciation of contemporary migration patterns across the Pacific Rim, differentiating between the generally lower human capital resources of those moving to New Zealand from the Pacific Islands, and their dependents, relative to those of most Asian migrants. Reflecting this substantial ethnic diversity, and in response to Grbic *et al.*'s (2000) call for more detailed research into ethnic subgroups, we report analyses using the multi-level modelling approach to multi-scale patterns reported in Manley *et al.* (2015). With such fine distinctions of ethnicity combined with a large number of small areas there are potential problems in using the standard measures of segregation – such as the index of dissimilarity – as they exhibit what is known as 'upward bias of the null' (i.e. they over-estimate segregation levels: Allen *et al.* 2015). This results in potentially large index values even when there is no underlying systematic segregation.

Our modelling approach takes into account the stochastic nature of small absolute counts and hence eliminates that potential problem.

This paper's main goal, therefore, is to explore whether there are differences both between and within the twenty-two Asian and Pacific Island ethnic groups in the intensity of, and any changes in, their residential segregation reflecting variations in the nature of the migration streams involved in their moves to Auckland. Using a multi-scale modelling approach, those explorations inquire into not only whether each group is concentrated in particular major components of the city's residential mosaic – its localities – but also whether its members are also clustered into smaller areas within those localities.

MEASURING MULTI-SCALE SEGREGATION

The method used here is based in the widely-deployed multi-level modelling procedure and associated software (MLwiN: see Jones *et al.* 2015). It calculates the intensity of segregation at each level of the multi-scale hierarchical structure net of that at any coarser-grained scale, as illustrated by the two-scale example in Figure 1.

Figure 1 shows three cities, each divided into six localities, each of which is divided into four areas. Each area has 100 residents, and the figures show the number of members of Group A in each area. In the first case (the left-hand diagram) there is segregation at the locality level, with all Group A members concentrated into two of the six localities. But there is no segregation at the area level within those localities; they form either zero or 60 per cent of the local population in each. In this case, therefore, our measurement procedure should show a high intensity of segregation at the larger (locality) scale but, net of that, none at the smaller (area) scale.

In the second example (the central diagram in Figure 1) there is segregation at both scales. Group A members are concentrated in just three of the six localities, but within them they are unevenly distributed across the four areas. In the final example (the right-hand diagram) there is no

Table 1. *The populations of the ethnic groups at the three census dates, the percentage born in New Zealand in 2013 and the percentage employed in salariat occupations in 2013.*

	2001	2006	2013	%Increase	%NZ Born	%Salariat
China	65,865	92,832	112,248	70.4	27	43
India	40,287	69,282	97,842	142.9	24	39
Korea	13,293	21,345	21,993	65.4	11	45
Philippines	6,336	9,861	20,538	224.2	14	34
Japan	4,197	5,217	6,669	58.9	28	34
Sri Lanka	3,459	4,218	5,793	67.5	15	44
Vietnam	2,241	3,174	4,386	95.7	24	25
Taiwan	2,532	3,921	4,263	68.4	15	52
Cambodia	2,544	3,348	4,224	66.0	30	17
Thailand	2,400	3,210	4,128	72.0	19	21
Indonesia	1,206	2,103	2,490	106.5	23	31
Malaysia	1,020	1,794	2,466	141.8	21	44
Afghanistan	693	1,863	2,442	252.4	25	28
Pakistan	711	1,500	2,262	218.1	26	43
Fiji Indian	1,266	4,149	8,025	533.9	17	32
Samoa	76,602	87,852	95,964	25.3	62	23
Tonga	32,520	40,176	46,953	44.4	59	20
Cook Is	31,068	34,356	36,588	17.8	76	21
Niue	16,026	17,706	18,564	15.8	77	22
Fiji	4,152	5,850	8,496	104.6	39	30
Tuvalu	1,623	2,142	2,577	58.8	45	19
Tokelau	1,512	1,878	1,986	31.3	24	26
NZ Maori	127,713	137,265	142,755	11.8	97	31
NZ Euro	685,947	611,784	696,882	1.6	89	49
Total	1,160,118	1,304,739	1,415,349	22.0	70	44

60	60	0	0
60	60	0	0
60	60	0	0
60	60	0	0
0	0	0	0
0	0	0	0

40	40	0	0
60	60	0	0
40	60	0	0
40	60	0	0
60	40	0	0
40	60	0	0

60	0	0	40
0	40	60	0
40	0	40	0
60	0	0	60
0	0	0	0
40	60	60	40

Figure 1. *Ideal-typical segregation patterns: a city with six localities each containing four areas. (There are 100 persons resident in each area; the numbers show the number of members of Group A in each area.)*

segregation at the locality scale but there is at the finer-grained area scale.

Standard segregation indices, calculated separately for each scale, do not identify these important differences between the three cities. For example, the index of isolation for Group A is 0.60 at both scales for the first city, although as described above there should be no segregation identified at the area scale once the locality-level segregation is 'held constant'. For the second example, the index is 0.50 at the locality and 0.52 at the area scales, which accords with the differences at both scales. But for the third

example it is 0.25 and 0.52 for the two scales respectively, when in effect there is no segregation at the former (locality) scale. When we use the traditional segregation measures, therefore, we may be misattributing the outcome of a process operating at one scale to another and so misrepresenting the segregation pattern.

The multilevel approach to modelling considers observed to expected ratios. The observed counts are the actual number of people of a particular ethnicity at a particular time in an area. The expected number for each area is derived on the assumption of no

segregation. Thus, if an area has 500 people living in it and a particular ethnic group forms 10 per cent of Auckland's total population, an overall even distribution with no segregation would have an expected number of 50 there. The ratio is therefore a comparative measure. A value above 1 indicates a preponderance of a particular ethnic group in comparison to a theoretical even distribution while a value below 1 suggests a comparative absence of an ethnic group's members. It is not the raw counts that are modelled but their log, however. This has two advantages. It is likely to help distributional assumptions so that while ratios based on raw counts are probably positively skewed (because the ratios have a floor of zero and no upper ceiling) the transformed ratios should be more normally distributed. Moreover, logs allow comparisons to be made in the more mathematically tractable differences rather than ratios – a difference in a log is exactly equivalent to the division of a ratio. The comparison between observed and expected is therefore made in terms of additive differential effects and it is possible to exploit this to conceive of area differentials at the lower scale as net of differentials at the higher locality scale. Moreover, use of a hierarchical multilevel structure (i.e. areas nested within localities) allows the assessment of multiple geographies without recourse to data aggregation (smoothing) which would be required in standard segregation measures. An online technical appendix gives the exact specification of the models used.

A multilevel model (Bullen *et al.* 1997) operates at multiple scales simultaneously and estimates the overall mean and variance of the differentials at each level. The variance is the key measure of segregation and summarises the between-locality differentials and the within-locality between-area differentials. A variance of zero at a particular level signifies no segregation as all areas have the observed counts equal to the expected; the larger the variance the greater the segregation with areas having greater or less than equal shares of the ethnic population. We can also estimate the correlation (through covariances) between the differentials at each level to see the extent to which different ethnic groups co-locate geographically and the extent to which patterns remain stable over time. A final part of the model specification jigsaw is that the

modelling has to take account of the natural or stochastic variation of count data. This is especially important when the raw counts are based on small absolute numbers as small chance fluctuations in the counts can lead to large unreliable changes in the ratios (Jones & Kirby 1980). In calculating segregation indices this leads to upward bias and overstatement of the underlying 'true' degree of segregation (Leckie *et al.* 2012). This is handled in the model by specifying a Poisson distribution at the lowest level so that between-area variances at the higher level are net of the stochastic variation. While the mean area count for the data analysed here is 120, the median is only 6 so without such modelling the estimates of segregation for the less numerous ethnic groups are likely to be severely biased upwards.

Estimation of the resultant log-Poisson multilevel model is challenging as we are dealing with the latent (not directly observed) differentials at each level and the focus is on variances. In such circumstances standard maximum likelihood approaches have a tendency to overestimate the variances and the asymptotic normality assumptions generally used to derive uncertainty intervals for the variance estimates are unlikely to be fulfilled (the variance cannot go below zero). To overcome this we have employed a computer-intensive full Bayesian approach where the uncertainty in every estimate takes account of the uncertainty in all other estimates. Moreover, the distribution of the estimated variances is allowed to be skewed, and consequently the credible intervals that give the 95 per cent uncertainty in the estimates can be asymmetrical (Jones & Subramaniam 2014).

While the variances of the log differentials provide the measure of segregation we transform these to median rate ratios (MRRs) for easier comparison and interpretation. The MRR can be conceptualised as the increased rate (on average; hence, the median) if one compares the ratios of two areas chosen at random from the distribution with the estimated variance. If there is no segregation, then the MRR would be 1; a value of 2 would indicate greater segregation within the typical randomly chosen area, with the higher ratio having twice the ratio of the lower area. Calculation of the MRR is a simple transformation of the variance

(exponentiation reverses the log), and the same operation is used to derive the 95 per cent credible intervals (CIs) around each MRR value so that we can judge the support for model estimates. The low and high CIs identified here show the boundaries for the lowest 2.5 and highest 2.5 per cent values. If two ethnic groups have non-overlapping CI boundaries we can judge that they are statistically significantly different in their segregation. The MRR values are akin to widely-used odds ratios and therefore we can use standard cut-offs developed by Cohen (1988) to characterise their relative magnitude. Thus, MRRs greater than 4.3 indicate high levels of segregation; those between 2.5 and 4.5 and between 1.5 and 2.5 indicate medium and small levels respectively.

The MRR values indicate the intensity of segregation for each ethnic group, therefore, contrasting their distribution to that of a hypothetical even distribution consistent with the distribution of the city's total population at each of two scales independent of the other. Further, because the area-level measures are calculated within each locality, the MRRs are not aspatial; spatial clustering is incorporated (Manley *et al.* 2015). To compare the spatial elements of the distributions further, however, either that of the same group at two dates or that of two groups at the same date, the modelling procedure also produces correlation coefficients (ranging between -1.0 and $+1.0$ and interpreted as usual) between the distributions of the modelled ratios. The correlations at each scale are independent of those at the other and their values are net of the stochastic variation that usually accompanies counts with small numbers, enabling evaluations of the closeness of two distributions across the relevant set of areas (in this case, localities or areas).

IMMIGRATION TO AUCKLAND

The Auckland urban region, New Zealand's largest, has received four major migration streams since its foundation. (For an overview of migration to New Zealand, see Spoonley & Bedford 2012; for full annotated bibliographies of the literature on New Zealand migration see Trlin *et al.* 2010.) The

first was dominated by British and Irish immigrants and their descendants, who were later joined by smaller streams from other European countries; these, and the continuing flows from the UK and elsewhere, are the foundation of the current majority population – identified as New Zealand European in official statistics. The second stream comprised the indigenous New Zealand Maori population. After white settlement and colonisation these were largely confined to relatively isolated rural areas, but from the 1920s increasing numbers migrated to the towns and cities: by 2013 there were some 140,000 in the Auckland urban area, compared to nearly 700,000 New Zealand Europeans (Table 1) out of a total population of 1.4 million.

More recently there have been substantial flows from two separate sources. The first involved migrants from Pacific Island territories and, reflecting their home countries' previous relationships with New Zealand, Cook Islanders, Tokelauans and Niueans are entitled to New Zealand citizenship;³ all Samoans resident in New Zealand in 1982 were granted permanent residence there, and were entitled to become New Zealand citizens. (For an overview of the Pacific Islanders' experiences in New Zealand, see Bedford 1994; Lee & Francis 2009.) The second stream comprises immigrants and their descendants from a range of countries in northeast, south and southeast Asia, including the Chinese as the largest group and Indians, with both long-standing and recent immigrants and their offspring (see Ho & Bedford 2006). There are also substantial populations from Korea and the Philippines plus a number of smaller groups. (On Asians in Auckland, see Xu *et al.* 2012; Friesen 2015.) Many of those groups have grown very rapidly in recent years – as has the Fijian Indian population, descendants of indentured labourers who migrated to Fiji to work on the sugar cane plantations, where they became the largest group within the population; many left Fiji following coups against Indian-dominated rule in 1987 and 2005.

Many recent Asian immigrants to New Zealand have obtained visas to reside there under a points system designed to attract

those with the human capital resources needed to contribute to the country's economy.⁴ The dominant criteria are whether the applicant has an offer of skilled employment, has recognised qualifications, and has work experience (Visa Bureau 2016). This system means that most recent immigrants to New Zealand are skilled workers, including the majority of those from Asia, many in white-collar occupations. Their economic situation reduces the usual constraints to the lower price sectors of the housing market. They may prefer to live in parts of the city where their co-ethnics are concentrated, and relatively close to cultural facilities, but they are not constrained to move into ethnic enclaves of the type that characterised low-income migrants to many cities in the twentieth century. Proximity to co-ethnics may characterise their initial location decisions, reflecting links through which their moves to New Zealand were facilitated, but close propinquity in the same areas may not.

One further difference between the post-1990 migrant streams is that whereas recent expansion of the Pacific Island groups has been dominated by natural growth with little further immigration, the Asian groups have grown through large numbers of arrivals. A minority of Asians were born in New Zealand (Table 1); the majority of those identifying with the four largest Pacific Island groups were born in New Zealand, but not of the three smaller, more recently arrived groups, plus the Fijian Indians. For those groups whose recent growth was through births rather than immigration, the continued low status of many of their members within the socio-economic system (as shown by the 2013 percentages employed in salariat – managerial and professional – occupations in the final column of Table 1) probably means that they will be relatively concentrated at both spatial scales because substantial parts of the housing market are inaccessible to them. Their levels of segregation may remain relatively unchanged over the twelve-year period, therefore. With the various Asian migrant streams, on the other hand, that large numbers of them have the resources to access wider segments of the housing market means less need to congregate into particular

localities and areas – though they may choose to for socio-cultural reasons.

PATTERNS OF SEGREGATION

We use data from the 2001, 2006 and 2013 censuses⁵ for a common set of 408 areas nested within 21 local board areas (localities) with 2013 average populations of 3,469 and 67,398 respectively.⁶ Data for the 24 groups were derived from the self-reported ethnicity questions (Table 1). Crucially, the segregation measures presented below for each group are net of those for all other groups; we are not conducting pairwise comparisons – as in studies using multi-group indices (e.g. Reardon & Firebaugh 2002; Iceland 2004) – but comparing all 24 groups simultaneously to a null model of no segregation

As an initial overview of the intensity of segregation, Table 2 shows the MRR values (without associated CIs, for ease of reading), ordered at each scale by the intensity of segregation in 2001. At both scales the New Zealand European and Maori populations were the least segregated, with MRR values classified as low (see Cohen 1988). At the locality scale, most groups have MRR values exceeding 2.5 – medium levels of segregation according to Cohen – and some have high levels exceeding 4.5, notably in 2001 and 2006. For most groups, MRR values changed only slightly over the twelve years. The major changes were for those that were highly segregated in 2001 (in the bottom nine rows of the table); all experienced a considerable diminution in segregation intensity over the succeeding twelve years. Whereas six groups had MRRs greater than 4.5 at the beginning of the period only two did in 2013. Segregation at the locality scale was consistent at a medium level for most ethnic minority groups across the period, and fell substantially towards that level for the remainder. (Insufficient numbers prevented the calculation of the locality scale MRR for Afghanistan immigrants in 2001.)

Little change was also characteristic of the MRR levels at the finer-grained area scale, with many groups having virtually the same low level of segregation in 2013 as in 2001;

Table 2. *The MRR values for the ethnic groups at locality and area scale, ordered according to their magnitude in 2001.*

	Localities				Areas		
	2001	2006	2013		2001	2006	2013
NZ European	1.6	1.7	1.8	NZ European	1.3	1.4	1.4
NZ Maori	1.8	1.7	1.7	NZ Maori	1.5	1.5	1.4
Fiji	1.9	1.9	2.1	Fiji	2.0	1.9	1.8
Thailand	2.0	1.7	1.6	Japan	2.0	2.0	1.8
Philippines	2.1	2.3	2.4	India	2.0	2.1	2.1
India	2.8	2.9	2.7	China	2.1	2.0	2.0
Malaysia	2.8	2.8	2.7	Cook Is	2.1	2.0	1.9
China	2.9	3.0	2.9	Samoa	2.1	2.0	1.9
Japan	3.2	2.9	2.6	Thailand	2.2	2.2	2.0
Cook Is	3.3	3.1	3.3	Tonga	2.3	2.2	2.1
Indonesia	3.4	3.4	3.1	Niue	2.4	2.4	2.2
Niue	3.6	3.3	3.4	Philippines	2.5	2.5	2.3
Samoa	3.7	3.5	3.4	Korea	3.2	2.9	2.9
Korea	3.8	4.0	4.1	Indonesia	3.2	3.2	2.9
Tonga	4.1	3.9	3.9	Malaysia	3.6	3.1	2.8
Tokelau Is	4.3	3.4	3.5	Sri Lanka	4.1	3.8	3.0
Vietnam	4.4	4.2	3.6	Vietnam	4.4	3.9	3.0
Fiji Indian	5.4	4.2	4.2	Tokelau Is	4.6	4.2	3.4
Sri Lanka	7.2	5.3	4.2	Fiji Indian	4.9	3.3	2.7
Taiwan	7.5	4.9	4.1	Cambodia	6.6	5.6	3.7
Cambodia	7.7	4.5	3.4	Taiwan	7.0	4.0	3.7
Pakistan	9.5	6.7	6.5	Pakistan	11.0	6.2	4.7
Tuvalu	13.3	10.1	9.2	Tuvalu	15.6	10.5	8.6
Afghanistan	–	21.1	20.1	Afghanistan	23.5	12.8	6.5

only twelve had MRRs of 2.5 or greater in 2013, with only three exceeding 4.5; for those three (Pakistan, Tuvalu and Afghanistan) the MRRs declined substantially by 2013.

One stand-out feature of Table 2 – which directly contradicts the general belief that segregation is greater at smaller spatial scales – is that most groups' MRRs at the area scale are smaller than those for the locality scale, at all three dates; for some the difference between the two MRR values for 2001 and 2013 exceeds 1.0. Auckland's ethnic minority groups are more concentrated at the macro than at the meso-scale: they apparently gravitate to particular localities within the city, but are not tightly clustered into particular areas within those localities.

Segregation Intensity – Table 3 gives the MRR values for each group at each census date, at each scale, along with their associated Low and High Credible Intervals (CIs).

Two main patterns stand out. First, among the largest groups – both Asian (Chinese, Indian, Korean and Filipino) and Pacific Island (Samoan, Tongan, Cook Island Maori, Niuean and Fijian) – segregation is relatively low and has shown virtually no change at either scale. Despite very rapid numerical growth over the twelve years – especially for the Asians – the MRR values changed very little. Their distributions across the city's localities and areas in 2006 and 2013 – relative to that of Auckland's total population – changed hardly at all, with no statistically significant differences over time. (A statistically significant difference occurs when the CIs of the distributions around the MRR values do not overlap as demonstrated by the area MRRs for Sri Lanka, Vietnam, Cambodia, Afghanistan and Pakistan, plus Fijian Indians, between 2001 and 2013.)

There is one clear difference between the two groups, however. At the locality scale,

Table 3. The MRR values and their associated CIs.

		2001			2006			2013		
		LCI	MRR	HCI	LCI	MRR	HCI	LCI	MRR	HCI
China	Localities	2.1	2.9	4.3	2.2	3.0	4.5	2.1	2.9	4.5
	Areas	1.9	2.1	2.2	1.9	2.0	2.2	1.9	2.0	2.1
India	Localities	2.1	2.8	4.1	2.1	2.9	4.4	2.0	2.7	3.9
	Areas	1.9	2.0	2.1	2.0	2.1	2.2	2.0	2.1	2.2
Korea	Localities	2.6	3.8	6.4	2.7	4.0	6.7	2.8	4.1	7.0
	Areas	2.8	3.2	3.5	2.7	2.9	3.2	2.6	2.9	3.2
Philippines	Localities	1.7	2.1	2.8	1.8	2.2	3.1	1.8	2.4	3.3
	Areas	2.3	2.5	2.7	2.3	2.5	2.8	2.1	2.3	2.5
Japan	Localities	2.3	3.2	4.9	2.1	2.9	4.3	2.0	2.6	3.7
	Areas	1.9	2.0	2.2	1.8	2.0	2.1	1.7	1.8	1.9
Sri Lanka	Localities	3.8	7.2	17.0	3.1	5.3	10.7	2.7	4.2	7.7
	Areas	3.4	4.1	4.9	3.3	3.8	4.5	2.7	3.0	3.4
Vietnam	Localities	3.2	5.4	10.5	2.8	4.2	7.3	2.4	3.6	5.9
	Areas	3.7	4.4	5.4	3.3	3.9	4.6	2.7	3.0	3.5
Taiwan	Localities	4.0	7.5	17.0	3.1	4.9	9.2	2.7	4.1	7.3
	Areas	5.5	7.0	9.2	3.5	4.0	4.8	3.2	3.7	4.3
Cambodia	Localities	4.0	7.7	18.2	2.8	4.5	8.2	2.4	3.4	5.6
	Areas	5.1	6.6	8.8	4.5	5.6	7.0	3.2	3.7	4.3
Thailand	Localities	1.6	2.0	2.6	1.4	1.7	2.2	1.4	1.6	2.0
	Areas	2.0	2.2	2.5	2.0	2.2	2.4	1.8	2.0	2.1
Indonesia	Localities	2.3	3.4	5.7	2.3	3.4	5.5	2.2	3.1	4.9
	Areas	2.9	3.4	4.1	2.8	3.2	3.8	2.5	2.9	3.3
Malaysia	Localities	2.0	2.8	4.4	2.0	2.8	4.2	2.0	2.7	3.9
	Areas	3.0	3.6	4.3	2.7	3.1	3.6	2.5	2.8	3.2
Afghanistan	Localities	–	–	–	7.3	21.1	86.2	7.2	20.2	81.0
	Areas	12.1	23.5	53.8	8.6	12.8	19.9	5.0	6.5	8.7
Pakistan	Localities	4.3	9.5	27.4	3.6	6.7	15.3	3.5	6.5	14.4
	Areas	7.2	11.0	17.5	4.8	6.2	8.2	3.9	4.7	5.8
Fiji Indian	Localities	3.5	6.3	13.9	2.7	4.2	7.4	2.8	4.2	7.4
	Areas	3.9	4.9	6.3	2.9	3.3	3.9	2.4	2.7	3.0
Samoa	Localities	2.6	3.7	5.9	2.5	3.5	5.5	2.4	3.4	5.3
	Areas	2.0	2.1	2.2	1.9	2.0	2.1	1.8	1.9	2.0
Tonga	Localities	2.8	4.1	6.8	2.7	3.9	6.4	2.7	3.9	6.4
	Areas	2.1	2.3	2.4	2.1	2.2	2.4	2.0	2.1	2.3
Cook Is	Localities	2.4	3.4	5.2	2.2	3.1	4.8	2.4	3.3	5.1
	Areas	1.9	2.1	2.2	1.9	2.0	2.1	1.8	1.9	2.0
Niue	Localities	2.5	3.6	5.9	2.4	3.3	5.3	2.4	3.4	5.4
	Areas	2.2	2.4	2.6	2.2	2.4	2.6	2.1	2.2	2.4
Fiji	Localities	1.6	1.9	2.4	1.6	1.9	2.5	1.7	2.1	2.7
	Areas	1.9	2.0	2.2	1.8	1.9	2.0	1.7	1.8	1.9
Tuvalu	Localities	5.8	13.3	40.0	5.1	10.1	25.1	4.8	9.2	21.8
	Areas	10.0	15.6	25.8	7.3	10.5	15.7	6.3	8.6	12.0
Tokelau	Localities	2.8	4.4	8.0	2.3	3.4	5.6	2.4	3.5	4.7
	Areas	3.7	4.6	5.8	3.5	4.2	5.2	2.9	3.4	4.0
NZ Maori	Localities	1.5	1.8	2.2	1.5	1.7	2.1	1.5	1.7	2.0
	Areas	1.5	1.5	1.6	1.4	1.5	1.5	1.4	1.4	1.4
NZ Euro	Localities	1.4	1.6	1.8	1.5	1.7	2.1	1.5	1.8	2.1
	Areas	1.3	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.4



Figure 2. Auckland's localities (the local board areas).

the Pacific Island groups were more segregated than the Asians; among the latter, none were above 4.5 and only Koreans had MRRs exceeding 3.5, indicative of considerable clustering into only a few of the city's 21 localities, and only the Koreans had MRRs greater than 3.0 at the area scale. Within their preferred localities, in general these large Asian groups are not substantially clustered into particular areas. In both 2001 and 2013, half of Auckland's Koreans were concentrated into just four localities, all of them on the North Shore (the Devonport-Takapuna, Kaipatiki and Upper Harbour localities: all localities are identified in Figure

2). Although there is no statistically significant difference across the five groups – in large part because of the relatively small number of localities – the average locality-level MRR for the Chinese, Indian, Japanese and Filipino groups was 2.6 in 2013, compared with 4.1 for the Koreans, whose numbers hardly increased between the 2006 and 2013 censuses. Koreans were also more concentrated at the area scale than those other five groups (on Koreans in Auckland, see Hong & Yoon 2014).

This general pattern of relatively low levels of segregation across most Asian groups contrasts with the Pacific Island groups which, with the

exception of Fijians, have locality-level MRRs exceeding 3.0 at each date. They are more concentrated into particular localities than the large Asian groups, therefore, but within localities there is no difference between the Pacific and Asian peoples in their degree of clustering into particular areas.

The second main pattern is the substantial drop in segregation levels among some of the smaller, but rapidly expanding groups – Sri Lankans, Vietnamese, Taiwanese, Cambodians, Afghans and Pakistanis, those from Tuvalu and the Tokelau Islands, and the Fijian Indians. Their 2013 MRR values are substantially lower than for 2001, at both scales. For localities those differences, although substantial, are not statistically significant because the distributions of their CIs overlap; all of the groups are more widely spread across the localities at the later date, but that conclusion lacks strong statistical backing.

That conclusion does not apply to segregation at the area scale. For all six Asian groups, and for the Fijian Indians, their 2013 area-level MRR is significantly smaller than its 2001 comparator. As they have increased in size, in some cases more than doubling, they have become more widely spread through Auckland's areas, while remaining largely within their preferred localities. The MRRs remain large, although they remain below 4.5 at the later date – exceeding 3.0 in every case except the Fijian Indians; but segregation declined fast. For those from Tuvalu and the Tokelau Islands, the area-level changes in the MRR values between 2001 and 2013, although substantial (from 15.6 to 8.6 for the former group and from 4.6 to 3.4 for the latter), were not statistically significant at conventional levels.

This leaves a third group of rapidly-growing smaller Asian groups – from Thailand, Indonesia and Malaysia – who did not experience similar declines in their segregation levels at either scale; their trends (or lack of them) were comparable to those of the largest five Asian groups.

Examples of the distributions associated with these segregation levels are shown in maps for 2001 and 2013. These divide each ethnic group's population into quartiles based on concentration not absolute

proportions. The first quartile is the smallest number of areas containing one-quarter of the group's members, containing the areas of greatest concentration. The second quartile comprises the areas containing the next quartile (i.e. the first and second quartiles together comprise the smallest number of areas containing one-half of the group's members), and so forth. The inset shows the distributions in the central part of Auckland.

Figures 3 and 4 contrast Cambodians, which experienced substantial desegregation, and Indians, for which the MRRs were virtually unchanged. In 2001, 46 per cent of Auckland's Cambodians were concentrated in just two of the 21 localities – Otara-Papatoetoe and Manurewa (Figure 3). By 2013 this had been reduced to 37 while the percentage living in nearby Howick had increased from 3.8 in 2001 to 15.4 in 2013. Within the localities where they were clustered, there was desegregation at the area level. In 2001 one area within Otara-Papatoetoe contained 9.0 per cent of all Auckland's Cambodians, but by 2013 this had fallen to just 3.3 per cent. In 2001, 24 of that locality's areas contained 24.9 per cent of Auckland's 2,544 Cambodians; by 2013 that had fallen to 15.4. By contrast, Figure 4 shows that in 2001 34.3 per cent of Indians lived in just three localities – Puketapapa, Whau, and Otara-Papatoetoe; nine years later, almost exactly the same percentage (33.8) were living there. Within Puketapapa, the five areas with the largest Indian populations contained 8.3 per cent of Auckland's total in 2001; in 2013, that percentage was 7.7.

Figures 5 and 6 provide a similar contrast between two Pacific Island groups. Those claiming Tuvaluan ethnicity were concentrated at all three dates in just one locality – Henderson-Massey: 64 per cent lived there in 2001, 62.5 per cent in 2006 and 65.2 per cent in 2013. They were increasingly widely distributed through that locality's areas, however. In 2001, Henderson-Massey's ten areas with the largest number of Tuvaluan residents housed 47.3 per cent of Auckland's Tuvaluan population; by 2013 that had fallen to 36.3. (Tuvaluans were a very small component of Henderson-Massey's total population:

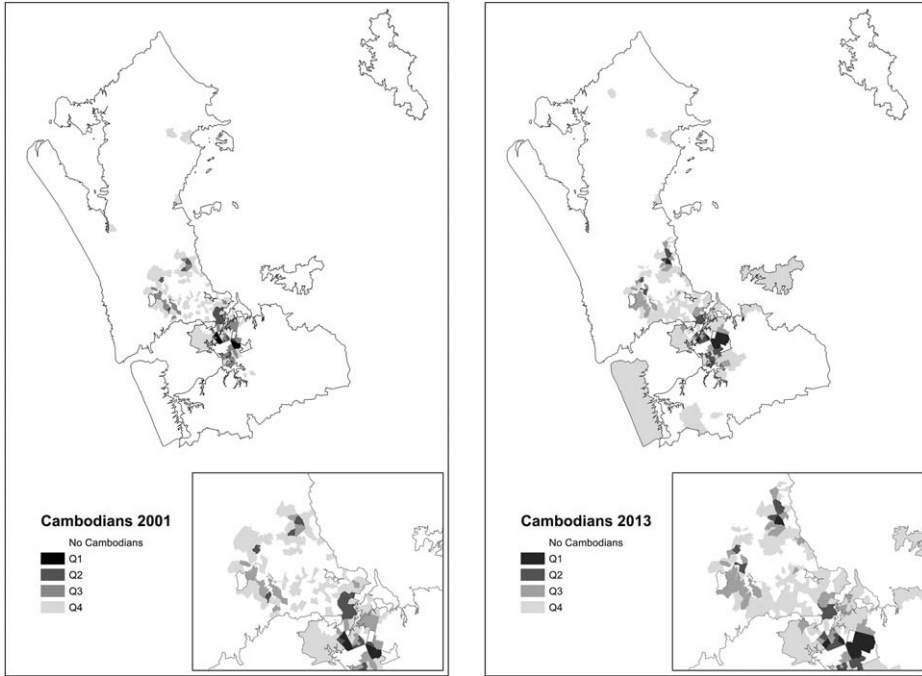


Figure 3. *The distributions of Cambodians in Auckland in 2001 and 2013.*

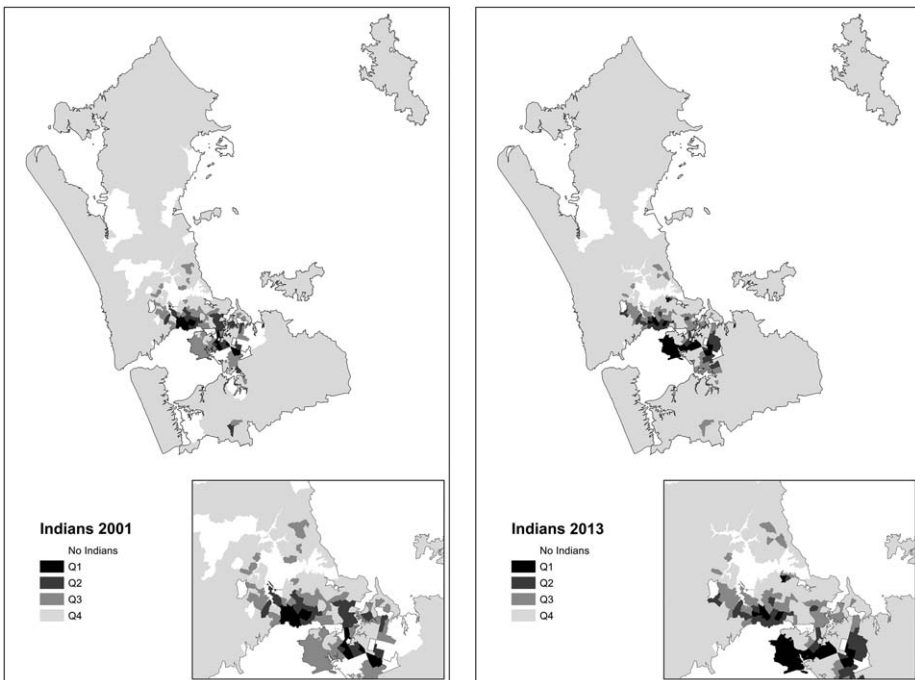


Figure 4. *The distributions of Indians in Auckland in 2001 and 2013.*

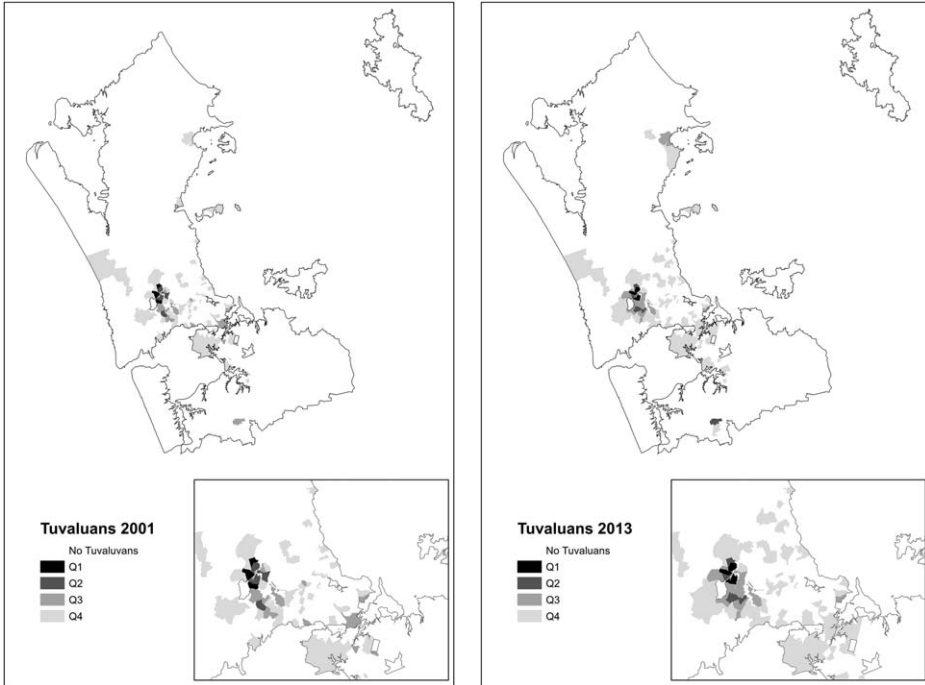


Figure 5. *The distributions of Tuvaluans in Auckland 2001 and 2013.*



Figure 6. *The distributions of Tongans in Auckland 2001 and 2013.*

Table 4. *The self-correlations for each ethnic group at locality and area scales.*

Comparison	Localities			Areas		
	2001:2006	2006:2013	2001:2013	2001:2006	2006:2013	2001:2013
China	0.83	0.83	0.80	0.90	0.91	0.83
India	0.81	0.82	0.81	0.89	0.92	0.80
Korea	0.76	0.77	0.76	0.91	0.87	0.75
Philippines	0.71	0.73	0.71	0.78	0.81	0.72
Japan	0.77	0.79	0.78	0.73	0.80	0.67
Sri Lanka	0.86	0.84	0.83	0.81	0.81	0.69
Vietnam	0.71	0.71	0.73	0.66	0.74	0.64
Taiwan	0.67	0.70	0.66	0.85	0.84	0.77
Cambodia	0.75	0.71	0.72	0.81	0.66	0.60
Thailand	0.72	0.74	0.70	0.65	0.78	0.54
Indonesia	0.79	0.80	0.79	0.63	0.70	0.55
Malaysia	0.81	0.81	0.78	0.58	0.65	0.50
Afghanistan	0.73	0.73	0.72	0.94	0.93	0.89
Pakistan	0.78	0.79	0.75	0.52	0.67	0.54
Fiji Indian	0.81	0.82	0.78	0.67	0.79	0.63
Samoa	0.78	0.77	0.77	0.93	0.92	0.90
Tonga	0.72	0.71	0.71	0.91	0.90	0.83
Cook Is	0.70	0.70	0.71	0.90	0.88	0.84
Niue	0.79	0.79	0.79	0.93	0.92	0.89
Fiji	0.71	0.74	0.64	0.73	0.73	0.60
Tuvalu	0.60	0.60	0.61	0.68	0.66	0.73
Tokelau	0.80	0.76	0.77	0.79	0.68	0.74
NZ Maori						
NZ Euro	0.87	0.87	0.86	0.95	0.87	0.86

just 1.2% in 2001 and 1.5% in 2013. And within that locality's areas, the largest Tuvaluan share of the local population was 6.9%.) By contrast, Figure 6 shows the distribution of Tongans at the two dates. In 2001, 44 per cent were concentrated in just two localities – Mangere-Otahuhu and Maungakiekie-Tamaki; seven years later, those two together housed 42 per cent of Auckland's Tongans. Within Mangere-Otahuhu, in 2001 the ten areas with the largest share of the city's Tongans housed 19 per cent; in 2013 that percentage was 18.3. Stability was the dominant feature of the distribution of Tongans in Auckland over the twelve-year period, at both scales.

Comparative distributions – The MRRs are segregation measures comparable to the traditional indices but, like them, cannot also provide information about the spatial patterning of the distributions. The correlations show the correspondence between two estimated logged

observed:expected rates across a set of areal units, however, and can be deployed to explore two issues: whether the distribution of one group has changed over time (the self-correlations); and the relative distributions of two separate groups at one date (the cross-correlations).

Table 4 shows the self-correlations for each ethnic group at both scales, comparing their distributions in 2001 and 2006, 2006 and 2013, and 2001 and 2013. (The correlations can be interpreted in the same way as product-moment correlations; their squared values indicated the level of agreement between the two distributions.) The majority is large, indicating very considerable stability over time; not only did the intensity of segregation change very little for most of those groups over the twelve-year period (of considerable growth in most cases) but in addition the localities and areas where they were concentrated remained largely the same. Few correlations were less than 0.71; many exceeded 0.80.

Three clear exceptions from this general pattern of stability are the small southeast Asian groups – from Thailand, Indonesia and Malaysia – identified earlier as having little change in their intensity of segregation at either scale, despite more than doubling in size. The self-correlations in Table 4 indicate considerable stability at the locality scale (none are less than 0.70), but the much smaller self-correlations at the area scale suggest more considerable change – a wider distribution of each group across the areas within their preferred localities but without any substantial decline in the (already low) levels of segregation overall. Thus, for example, some of the areas within

Waitemata locality with relatively large shares of the Indonesian population in 2001 contained no Indonesians in 2006 and 2013, and the proportions in several parts of Whau declined while those elsewhere increased. A similar pattern characterised the changing distribution of Malay and Thai ethnics in the localities where they were concentrated.

Tables 5 and 6 report cross-correlations for each pair of ethnic groups within different migration streams, with the correlations between the Pacific Island groups and the New Zealand Maori included in the latter table for comparative purposes; the distributions of Fijian Indians are compared with

Table 5. *The cross-correlations for the Asian ethnic groups at locality and area scale.*

		Localities			Areas		
		2011	2006	2013	2001	2006	2013
<i>Northeast Asia</i>							
Japan	China	0.39	0.47	0.52	0.30	0.32	0.36
Japan	Korea	0.53	0.53	0.54	0.33	0.31	0.42
Japan	Taiwan	0.55	0.56	0.54	0.36	0.31	0.36
China	Korea	0.48	0.43	0.45	0.62	0.64	0.72
China	Taiwan	0.59	0.58	0.65	0.59	0.58	0.65
Korea	Taiwan	0.68	0.64	0.60	0.68	0.64	0.60
<i>South Asia</i>							
India	Pakistan	0.62	0.65	0.61	0.39	0.48	0.48
India	Sri Lanka	0.49	0.47	0.45	0.46	0.62	0.64
India	Afghanistan	0.69	0.69	0.65	0.24	0.26	0.23
India	Fiji Indian	0.63	0.64	0.62	0.54	0.70	0.69
Pakistan	Sri Lanka	0.59	0.56	0.56	0.26	0.39	0.39
Pakistan	Afghanistan	0.73	0.73	0.72	0.73	0.72	0.72
Pakistan	Fiji Indian	0.62	0.61	0.53	0.62	0.61	0.53
Sri Lanka	Afghanistan	0.67	0.55	0.56	0.67	0.55	0.62
Sri Lanka	Fiji Indian	0.51	0.34	0.32	0.51	0.55	0.32
Afghanistan	Fiji Indian	0.72	0.65	0.62	0.72	0.65	0.62
<i>Southeast Asia</i>							
Cambodia	Vietnam	0.52	0.43	0.45	0.35	0.37	0.32
Cambodia	Thailand	0.26	0.21	0.18	0.03	0.34	0.32
Cambodia	Malaysia	0.36	0.32	0.28	0.02	0.18	0.28
Cambodia	Indonesia	0.21	0.08	0.14	0.21	0.08	0.14
Cambodia	Philippines	0.39	0.33	0.38	0.31	0.37	0.41
Vietnam	Thailand	0.23	0.18	0.09	0.23	0.18	0.14
Vietnam	Malaysia	0.30	0.20	0.14	0.30	0.20	0.25
Vietnam	Indonesia	0.15	0.02	0.09	0.15	0.02	0.09
Vietnam	Philippines	0.26	0.22	0.33	0.35	0.35	0.43
Thailand	Malaysia	0.54	0.57	0.52	0.54	0.57	0.51
Thailand	Indonesia	0.59	0.50	0.54	0.59	0.50	0.54
Thailand	Philippines	0.43	0.22	0.47	0.31	0.32	0.44
Malaysia	Indonesia	0.64	0.68	0.56	0.64	0.58	0.56
Malaysia	Philippines	0.49	0.52	0.51	0.24	0.41	0.41

Table 6. *The cross-correlations for the Pacific Island ethnic groups at locality and area scale.*

		Localities			Areas		
		2011	2006	2013	2001	2006	2013
Samoa	Tonga	0.41	0.62	0.64	0.77	0.80	0.75
Samoa	Cook Is	0.66	0.62	0.65	0.79	0.79	0.80
Samoa	Niue	0.47	0.69	0.69	0.77	0.80	0.79
Samoa	Fiji	0.57	0.62	0.66	0.42	0.35	0.34
Samoa	Fiji Indian	0.68	0.66	0.66	0.27	0.12	0.14
Samoa	Tuvalu	0.46	0.39	0.41	0.46	0.52	0.40
Samoa	Tokelau	0.72	0.67	0.67	0.59	0.56	0.50
Tonga	Cook Is	0.60	0.57	0.60	0.70	0.73	0.68
Tonga	Niue	0.65	0.64	0.65	0.68	0.79	0.73
Tonga	Fiji	0.58	0.59	0.63	0.37	0.38	0.36
Tonga	Fiji Indian	0.70	0.60	0.62	0.29	0.15	0.16
Tonga	Tuvalu	0.40	0.33	0.33	0.48	0.44	0.43
Tonga	Tokelau	0.63	0.59	0.60	0.45	0.48	0.36
Cook Is	Niue	0.66	0.63	0.67	0.75	0.80	0.78
Cook Is	Fiji	0.50	0.50	0.60	0.30	0.33	0.28
Cook Is	Fiji Indian	0.62	0.56	0.60	0.23	0.06	0.12
Cook Is	Tuvalu	0.42	0.32	0.36	0.49	0.51	0.32
Cook Is	Tokelau	0.65	0.58	0.63	0.56	0.51	0.47
Niue	Fiji	0.60	0.61	0.65	0.41	0.37	0.33
Niue	Fiji Indian	0.23	0.63	0.66	0.27	0.09	0.17
Niue	Tuvalu	0.49	0.39	0.44	0.46	0.48	0.35
Niue	Tokelau	0.72	0.67	0.69	0.52	0.51	0.45
Fiji	Fiji Indian	0.32	0.65	0.66	0.32	0.35	0.51
Fiji	Tuvalu	0.48	0.41	0.42	0.22	0.31	0.17
Fiji	Tokelau	0.59	0.60	0.65	0.40	0.33	0.24
Fiji Indian	Tuvalu	0.36	0.34	0.37	0.14	0.16	0.11
Fiji Indian	Tokelau	0.70	0.63	0.64	0.19	0.08	0.11
Tuvalu	Tokelau	0.54	0.44	0.44	0.49	0.48	0.26
NZ Maori	Samoa	0.27	0.23	0.42	0.70	0.67	0.64
NZ Maori	Tonga	0.19	0.21	0.34	0.64	0.63	0.56
NZ Maori	Cook Is	0.71	0.24	0.42	0.71	0.80	0.78
NZ Maori	Niue	0.23	0.21	0.38	0.68	0.70	0.64
NZ Maori	Fiji	0.37	0.40	0.36	0.37	0.38	0.31
NZ Maori	Fiji Indian	0.26	0.21	0.27	0.25	0.01	0.02
NZ Maori	Tuvalu	0.30	0.14	0.29	0.49	0.43	0.35
NZ Maori	Tokelau	0.36	0.21	0.41	0.51	0.45	0.42

both the Pacific Island and South Asian groups. These show the degree of similarity between each pair of distributions across the areas, net of the correlations at locality level; they show the degree to which the two groups share area space within the localities.

Table 5 indicates that few Asian groups shared either locality or area space to any substantial extent; very few of the correlations exceed 0.7 – the main exception is the co-location at both scales of immigrants from Afghanistan and Pakistan the majority of whom

share the same religion – Islam; their concentrations are close to the city's major mosques (maps not shown). The correlations among the Southeast Asian groups are generally the smallest. In particular, the Cambodians and Vietnamese tend to live apart from the Filipino, Indonesian, Malay, and Thai populations, at both scales. This probably reflects the prior refugee status of many original Vietnamese and Cambodian arrivals, which will have dictated their initial spatial fixity compared to the other Southeast Asian groups. Such low levels of co-

location are not common to the South and Northeast Asian groups, however. They tend to be concentrated in both the same localities and, for some of them, the same areas within those localities; although those from India, Pakistan and Afghanistan tend to concentrate in the same localities, however, there is much less clustering together in the same areas.

Among Pacific Island groups, the correlations suggest considerable sharing of space at the locality scale, especially by 2013. Of the 28 correlations, all but seven exceed 0.60; these groups tend to be concentrated in the same parts of the city. The exceptions – with correlations of c.0.4 – all relate to the small Tuvalu ethnic group, discussed above (Figure 6). Many Tuvaluans have migrated to New Zealand as a response to population pressure and threats to their island livelihoods and are employed in the orchards and market gardens of West Auckland.

At the area scale, many of the groups tend to live apart from each other, with only small correlations. There are, however, two exceptions. Members of the four largest groups – from Samoa, Tonga, the Cook Islands and Niue – cluster together strongly in the same areas, with an average correlation in 2013 of 0.76. They too are much more likely to be found in larger-than-expected numbers in the same areas as the New Zealand Maori – where both Maori and early Island migrants obtained access to the large state housing estates close to major industrial concentrations (see, for example, Curson 1970; Cheer *et al.* 2002; Sharma & Murphy 2015). Many later arrivals joined earlier settlers from their home villages in these localities and areas; those from Fiji, Tuvalu and the Tokelau Islands – smaller groups that were established later in Auckland – are not as concentrated there; as a consequence, all three have small correlations with the distribution of Maori at the area scale – as also do the Fijian Indians. The Pakistan community also shows higher correlations perhaps as a result of the substantial increase in the size of the group.

DISCUSSION AND CONCLUSIONS

This application of a multi-level, multi-scale modelling approach to the study of ethnic

segregation across a range of groups from diverse geographical backgrounds in New Zealand's largest, most multi-ethnic city has illustrated its value in isolating not only the dominant patterns of segregation but also important inter-group differences. We have reported not only the scale-specific segregation measure (MRR) for each group at each scale at each date but also the correlations that provide strong evidence regarding co-location between groups as well as changes within groups over time.⁷

The MRR measures provide further evidence that segregation is not necessarily more intense at smaller scales. Many previous studies of segregation have used aggregated data to investigate scale. If, instead, we hold the data scale constant but investigate the intensity of segregation (Reardon *et al.* 2008) in successively larger units the process of data smoothing that bedevils aggregated studies is omitted and further processes can be uncovered. Thus, if segregation at the meso (area)-scale is examined independent of its intensity at the macro (locality)-scale it may be, as here, that groups are less intensively concentrated in individual areas than they are in the localities within which those areas are clustered. Groups, for a variety of reasons, may prefer, or be forced through a lack of alternatives to choose from, to live in particular localities, in relative proximity to their co-ethnics and to cultural institutions and facilities, but feel no need to cluster closely together into particular areas. Proximity is desirable, but propinquity less so. This supports Musterd and Ostendorf's (1998) assertion that improvements in transport reduce the importance of place-specific characteristics in residential choices.

This conclusion applies to nearly all of the groups studied – segregation was higher at the locality than the area scale. The exceptions were for the smaller Asian and Pacific Islander groups, most of which expanded rapidly through immigration over the twelve-year period. Critically, this immigration resulted from two processes distinct from the traditional flows upon which models of segregation were developed: one involves highly skilled immigration resulting from a points-based visa system and the other comprises flows stemming from former relationships

with specific (many former-colonial) countries. Those latter groups experienced most change in their segregation intensity; it declined markedly – and in many cases statistically significantly – across the three censuses, notably at the area scale. Each group became established in one or a few (almost invariably adjacent) localities, but within them became less spatially clustered in particular areas: propinquity declined as they spread out, but proximity declined much less. This pattern is equivalent to what Li (1998) terms *ethnoburbs*, suggesting that the settlement pattern identified in Auckland by Johnston *et al.* (2008) is being altered by a process of residential succession or integration over time.

Alongside the segregation intensity measures, the modelling provided indicators of the correlation between distributions, with those at the area scale being net of the correlations at locality scale. For most groups, these indicate considerable stability over time in their relative locations at both scales, with the main exceptions being some of the smaller, rapidly-expanding groups, which have lower correlations between their 2001 and 2013 distributions at the area than at the locality scale. Between groups, there is less communality in their relative distributions at both scales, but again with variations from that general pattern. The four largest Pacific Island groups, along with the New Zealand Maori, tend to concentrate together in the same localities and, within those localities, in the same areas, for example; their geographies are based on both proximity and propinquity, and they are much more likely to share segments of Auckland's residential mosaic than the Asian groups, most of which have their own distinct geographies at both scales.

Each of these identified patterns has its own explanation in the geographies of residential choice within the constraints of housing market operations but together they provide insights into changes in residential landscapes consequent on altered migration patterns. The Pacific Island groups exemplify many of the features of the classic models of ethnic residential segregation; most of them occupy the lower strata of the occupational

hierarchy and are concentrated in localities with relatively low-cost housing – though, unlike the case in many North American cities, those concentrations are not in the inner-city areas (as shown in Manley *et al.* 2015). Most members of the Asian groups have entered New Zealand as relatively skilled and well-paid employees and have experienced fewer housing market constraints – a situation that applies in other Pacific Rim countries which operate similar immigration policies. They prefer to concentrate with their co-ethnics in particular localities, but do not prioritise clustering together in those localities' constituent areas.

The multi-level modelling approach clearly identifies that different spatial patterning and, alongside the specifics of each group's particular geography as shown by case studies, provides the foundation for developing general models of urban residential patterns that reflect the contemporary situation regarding globalisation and international migration. We have built on previous work by demonstrating the unique features of the multi-ethnic city, identifying that segregating processes are operating at multiple scales and that the decomposition by scale is critical to further our understanding. Without the decomposition, processes may be misattributed to scales at which they do not operate or are weaker. We have also identified, as Grbic *et al.* (2010) argued, the necessity of looking at the diversity of ethnic groups. The dichotomy of majority versus minority or even majority compared with super groups (such as Southeast Asians or North Asian) is not sufficient as there is substantial geographical heterogeneity within these subgroups as well.

Notes

1. We accept that the segregation intensities identified are just one set of a very large number that could be derived from alternative spatial configurations – in this case of areas nested within localities – because of the modifiable areal unit problem that is rarely addressed in segregation studies (see Hennerdal & Nielsen, 2017).
2. The drop in the number of New Zealand Europeans between 2001 and 2006 reflects a change in the coding of those who replied 'New

Zealander' to the census question 'Which ethnic group do you belong to?' (see Manley *et al.*, 2015). A considerable number of respondents (c. 160,000 across New Zealand in 2013) give multiple ethnicities. Following the New Zealand census practice, these are double-counted.

3. Most people born in the Cook Islands, Niue or Tokelau prior to 2006 are automatically citizens of New Zealand. Children born after 2005 are also counted as citizens as long as one of their parents is a New Zealand citizen.
4. See <<http://www.visabureau.com/newzealand/emigration-point-system.aspx>>. Accessed 15 November 2016).
5. The proposed 2011 census was delayed for two years because of the extensive damage in New Zealand's third city, Christchurch.
6. Data are also made available for smaller blocks nested within the areas, but these provide only a coarse classification of ethnicity with four main categories: New Zealand European; New Zealand Maori; Pacific Islanders; and Asians – see Manley *et al.* (2015).
7. The model produces the correlation between each pair of distributions at any pair of dates; only a small proportion of that total output has been reported here.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Technical Appendix: Model specification and estimation