Title: A comprehensive systematic review and multilevel meta-analysis of the ethnic density effect in psychosis

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Abstract

Background

An ethnic density effect in psychosis has been observed whereby the risk of psychosis in minority group individuals is inversely related to the neighbourhood-level proportion of others belonging to the same group. However, there is conflicting evidence over whether this effect differs between minority groups and limited investigation into other moderators.

Aims

To conduct a comprehensive systematic review and meta-analysis of the ethnic density effect in psychosis and examine moderators.

Method

Four databases were systematically searched. A narrative review was conducted, and a three-level meta-analysis was performed. The potential moderating effect of crudely and specifically defined minority groups was assessed. Country, time, area size, and whether studies used clinical or non-clinical outcomes were also tested as moderators.

Results

Thirty-one studies were included in the narrative review and ten in the meta-analysis. A ten percentage-point decrease in own-group density was associated with a 20% increase in psychosis risk [OR=1.20 (CI_{95%}=1.09-1.32), $p<0.001$]. The pooled effect was moderated by crudely defined minority groups [$F_{6,68}=6.86$, $p<0.001$], with the strongest associations observed in Black populations, followed by a White Other sample. Greater heterogeneity was observed when specific minority groups were assessed [$F_{25,49}=7.26$, $p<0.001$].

Conclusions

This is the first review to provide meta-analytic evidence that the risk of psychosis posed by lower own-group density areas is not equally distributed across minority groups. The most robust associations were observed in Black individuals. Heterogeneity in effect sizes may reflect distinctive social experiences of specific minority groups. Mechanisms are discussed, along with the implications of findings and suggestions for future research.

Introduction

Compared to their majority counterparts, ethnic minority and migrant groups are at greater risk of mental health difficulties¹, particularly psychosis²⁻⁵. This excess risk is not observed in migrant groups' countries of origin⁶, nor can it be explained by diagnostic biases or genetic risk factors⁷. Interestingly, this elevated risk is context-dependent, such that minority group members living in neighbourhoods with a low proportion of their group are more likely to experience psychosis than those residing in areas where their group is well represented⁸. This association, termed the 'ethnic' or 'group' density effect, operates in a dose-response manner⁹, holds after adjustment for socioeconomic deprivation¹⁰, and is proposed to act as a 'buffer' against social disadvantages experienced by minorities¹¹. Most studies have focussed on minorities classified by their ethnicity or migratory background, but poorer mental health has also been observed in minority groups defined by other characteristics including sexuality^{12,13}, political affiliation¹⁴, and religion¹⁵.

At present, it is unclear whether lower own-group density areas confer the same risk across different minority groups. Of three reviews of the group density effect in psychosis^{10,16,17}, the most recent meta-analysis found that ethnic group did not moderate group density associations¹⁶. However, narrative reviews noted that studies examining pooled ethnic minority samples tended to report more consistent effects than studies assessing specific minorities, which yielded mixed results^{10,17}. Identifying moderators of this phenomenon is important for understanding the aetiological underpinnings of psychotic disorders and for providing targeted clinical and policy interventions for minorities^{7,10,16}. In this review, we aim to conduct a comprehensive systematic review and meta-analysis of the group density effect in psychosis and examine potential moderators, particularly those associated with specific minority groups.

Method

We followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses [PRISMA]¹⁸ and Meta-analyses of Observational Studies in Epidemiology [MOOSE] guidelines¹⁹. The protocol for this review was pre-registered on PROSPERO (reference: CRD42019139384). Deviations from protocol can be found in Supplemental 1.

Search strategy

In May 2019, SJB conducted electronic searches of four databases (PsycINFO Web of Science, PubMed, & CINAHL Plus). Searches were repeated in August 2020. The search strategies were verified and piloted before the final search was executed. Each search utilised truncation and thesaurus tools to find related terms and enhance retrieval of relevant articles. The full list of search terms and an example search strategy for one database can be found in Supplemental 2 and 3. Below is an example of the organisation of search terms:

- A) Population *e.g.* Psychosis OR Psychotic OR Schizophrenia OR Bipolar
 - B) Ethnic density related terms *e.g.* “Ethnic density” OR “Group density” OR “Ethnic composition” OR “Ethnic enclave”
 - C) Outcome measures *e.g.* Incidence OR Prevalence OR Symptom* OR “Ultra-high risk”
 - D) Geographical terms *e.g.* Neighbo* OR Municipal OR “Electoral ward” OR “Output area”
- A AND B AND C AND D.

Eligibility criteria

For the narrative review, we included any peer-reviewed primary study examining the group density effect in psychosis available in English. For the meta-analysis, additional criteria were applied, as follows:

- Primary epidemiological studies assessing a within-group density effect *i.e.* compared psychosis risk within minority groups between different levels of group density.
- Geographical units averaged 50,000 people or less.
- Group density exposure quantified using census data or similar.
- Validated quantitative instrument(s) used to measure psychosis outcomes, including incidence, psychosis experiences, prodromal psychosis, or symptomatology.
- Studies reported Odds Ratios [ORs], Incidence Rate Ratios [IRRs], Hazard Ratios [HRs] or Relative Risks [RRs] effect size measures [ESs] and 95% confidence intervals [CIs].
- Studies used multilevel modelling to account for non-independence of data.
- Studies adjusted for individual- and area-level confounds (minimally age, sex, and area-level deprivation).

Study selection and data extraction

Articles were exported to Mendeley citation management software. After removing duplicates, SJB assessed titles and abstracts for eligibility. To evaluate reliability, thirty included and thirty excluded articles were randomly selected and independently screened by CWNS. Kappa indicated a high level of agreement ($k=.90$).

Full texts of remaining articles were screened and reasons for exclusion recorded. Uncertainties concerning eligibility were resolved through discussion or contacting authors where clarification was needed. Reference sections were hand-searched to identify any further papers. Study characteristics and meta-data from included studies were extracted. Authors were contacted for additional data where necessary. For studies with overlapping datasets, only the study with the largest sample was included in the meta-analysis. If samples were the same size, we included the study where group categories were most compatible with other studies.

Data analysis

A narrative review was conducted and a subset of studies meeting inclusion criteria for meta-analysis were included in the quantitative component of the review. As group density studies often include dependent effect sizes - multiple groups nested within studies, we used ‘multilevel’ meta-analysis^{20–22}, as implemented using the *rma.mv* function in the R package Metafor^{23,24} to appropriately control error rates²².

ESs with CIs were extracted from the fully adjusted models in each paper. As studies quantified exposure differently, we rescaled ESs to reflect a ten percentage-point decrease in group density. ESs and CIs were then converted to their natural logarithmic form, from which log standard errors and sampling variances were computed.

The full three-level model was fitted to estimate the overall pooled ES. To assess fit, we reran the analysis twice, holding the variance component of level 2 or level 3 constant²². Akaike Information Criteria [AIC] for full and reduced models were compared to assess which model fitted best.

The overall pooled ES comprised all samples. Separate pooled ESs were computed for groups defined by ethnicity or migratory background, minority groups classified by other characteristics, and neighbourhood studies only.

Subgroup analyses examined *a priori* hypothesised moderators and the effect of removing individual studies and samples on the pooled effect. For each moderator test, the most common grouping was used as the reference category. To derive subgroups, the 18-group self-ascribed classification system for ethnic groups used by the 2011 UK Census was used to allocate samples into ‘Crude minority groups’ (most included studies were conducted in the UK). Subgroups for the ‘Specific minority groups’ moderator test were informed by the most specific minority group categories reported by the authors of the studies. To assess the moderating effect of area sizes, we calculated area size quartiles using reported average area sizes. If average area sizes were not available, census data were used to derive an estimate. We also stratified data by the geographic unit used: Lower Super Output Area [LSOA] or smaller and all other area sizes.

The quality assessment tool used was developed for ethnic density studies specifically in a previous review¹⁶, see Supplemental 4.

Results

The search identified 2652 unique articles and thirty-one studies were included in the narrative review (Figure 1). Ten studies met inclusion criteria for meta-analysis, comprising 75 samples. Each group contributed <2% weighting to the overall pooled ES.

Figure 1. PRISMA diagram outlining study selection procedure.

Narrative review

Study characteristics

Fourteen studies were conducted (45%) in the UK^{9,11,25–36}, eight (26%) in the Netherlands^{37–44}, and four (13%) in Sweden^{45–48}. Of the remaining five (16%), two were conducted in Denmark^{49,50}, and one of each in the USA⁵¹, Canada⁵², and Australia⁵³.

The majority were retrospective epidemiological studies ($n=26$, 84%)^{9,11,25–36,39–42,45–50,52,53}. Of these, most were cross-sectional and six (four datasets) used longitudinal methods^{32,46–50}. All of these studies were conducted in a neighbourhood context with the exception of one which considered a school setting⁴⁶. The other five studies examined Virtual Reality [VR] environments^{43,44}, *perceived* ethnic density⁵¹, and symptomatology^{37,38} and remission³⁸.

Around half of the studies ($n=15$, 48%) examined first incident cases^{9,25–27,31,35,36,39,41,42,45–47,49,50} and six (19%) used measures of subclinical psychosis^{11,28–30,33,51}. The others assessed symptomatic outcomes^{37,38,43,44}, mortality rates³², inpatient days following admission³⁴, compulsory admission⁴⁸, individuals meeting ultra-high risk [UHR] criteria⁵³, dispensed antipsychotic medication⁴⁰, lifetime prevalence of psychosis⁵², psychophysiological outcomes⁴³, and social distance^{43,44}. Study characteristics are summarised in Table 1.

Summary of results by minority group sample

Combined ethnic minority or migrant groups

Seventeen studies (fifteen datasets) reported associations for aggregated black and minority ethnic or migrant groups^{9,11,26,29,32–36,39,42,45–48,52,53}. In combined minority groups in the UK^{9,11,26,29,33,35,36} and migrant groups in Sweden^{45–47}, the Netherlands^{39,42}, and Canada⁵², all but one study⁴⁵ found associations in the expected direction for clinical^{9,26,35,36,39,42,46,47} and non-clinical outcomes^{11,29,33}, with most finding significant interactions^{9,11,26,33,39,42,46,47}. Between-group density effects tended to be stronger than within-group effects^{35,39} and one study found a significant association for affective but not non-affective psychosis²⁶. For other outcomes, significant interactions were observed for mortality rates³² and compulsory admission⁴⁸, but not for duration of admission⁵⁴ or individuals meeting UHR criteria⁵³.

Black populations

Fourteen studies (twelve datasets) included Black individuals^{11,25,27–33,39,40,47,49,50}. Significant group density associations were found in aggregated Black or Black British clinical and non-clinical samples in the UK^{27,28}. In Black Caribbean populations^{11,25,28–33}, significant interactions were observed for subclinical psychosis^{28,33} and schizophrenia first incident cases³¹, and strong associations were consistently observed in Antillean individuals for non-affective psychosis³⁹ and prescribed antipsychotics⁴⁰ in the Netherlands. Other UK studies reported weaker or no evidence of an interaction in Caribbean groups for subclinical psychosis^{11,29,30}, non-affective psychosis²⁵, and mortality rates³². In Black African individuals^{25,28,31,32,48–50},

a strong association between ethnic density during adolescence and later psychosis was observed in Denmark^{49,50} and Sweden⁴⁷, with one study finding stronger associations in second-generation⁵⁰ and the other, first-generation African migrants⁴⁷. In the UK, a significant interaction was found for Black African individuals and non-affective psychosis²⁵. Other UK studies found no significant associations in Black African groups^{28,31,32}, though one found weak evidence of an association for all-cause mortality ($p=0.068$)³².

Asian populations

Eight studies (seven datasets) examined Asian populations^{11,25,29,30,32,33,47,49}. In combined Asian groups, consistent associations between own-group density and non-affective psychosis were observed in Denmark⁴⁹ and Sweden⁴⁷, with the latter demonstrating a stronger relationship in first-generation Asian migrants⁴⁷. There was also an association with all-cause mortality rates in the UK³². When considering Asian subgroups, UK studies^{11,25,29,30,33}, found associations in the expected direction in Indian and Bangladeshi groups for subclinical psychosis^{11,29,30,33}, however, one study considering first incident psychosis cases reported no evidence of an interaction in Bangladeshi individuals²⁵. Only one study included African Asian and Chinese samples³³, no significant associations were found in either group. In Pakistani individuals, no study found evidence of an interaction^{11,29,30,33}, and two studies in fact noted detrimental relationships^{29,33}.

White Other populations

Seven studies (five datasets) reported results for White Other samples^{11,25,30,32,47,49,50}. In the UK, associations were in the expected direction but non-significant in Irish individuals for subclinical psychosis^{11,30}, and no evidence for an interaction was observed for mortality rates³² or non-affective psychosis²⁵. There was also no association in non-Swedish Nordic or Non-Nordic European migrants in Sweden⁴⁷. However, in Denmark, significant interactions were found in non-Scandinavian European groups for non-affective psychosis⁴⁹, with negligible differences between first- and second-generation migrants⁵⁰.

Other ethnic groups

Seven studies (six datasets) included other ethnic minority and migrant groups^{39,40,42,45,47,49,50}. Longitudinal analyses in Denmark found significant interactions in Middle Eastern individuals for non-affective psychosis⁴⁹, with stronger associations for second-generation migrants⁵⁰. However, in a Middle Eastern and North African sample in Sweden, there was no significant relationship between own-group density at age fifteen and later risk of psychosis⁴⁷. The same study found no interactions in North American, South American, Swedish, and Mixed migrants, with some groups in fact showing (non-significant) detrimental associations⁴⁷. Another Swedish study found no difference in non-affective psychosis risk between Iraqi migrants living in ethnic enclaves and those in predominantly Swedish areas⁴⁵. In migrant groups in the

Netherlands, associations were consistently strong for a combined Surinamese/Antillean group and a Surinamese only sample for both non-affective psychosis³⁹ and antipsychotic usage⁴⁰ respectively. However, results were mixed in Turkish and Moroccan groups^{39,40,42}.

Other social characteristics

Three studies included minority groups classified by characteristics other than ethnicity or migratory background^{28,41,46}, namely single marital/household status^{28,41}, disadvantaged social class^{28,46}, social fragmentation⁴⁶, and low grades⁴⁶. Significantly increased risk of schizophrenia was observed in single individuals living in neighbourhoods with fewer single people in the Netherlands⁴¹, however, a later UK study found a non-significant association with subclinical psychosis²⁸. A longitudinal study in Sweden assessing interactions between school-level own-group density on clinical psychosis found a significant association in socially fragmented groups, but not in those with low grades or deprived status, though the latter approached significance ($p=0.057$)⁴⁶. Again, this relationship was not found in a UK neighbourhood-level study looking at social disadvantage²⁸.

Virtual reality, symptomatology, and perceived ethnic density studies

Five studies used different methods: two used VR^{43,44}, two looked at symptom profiles^{37,38} and remission³⁸, and one examined *perceived* ethnic density⁵¹. VR studies simulated high and low group density environments by manipulating the ethnicity of avatars^{43,44}. Compared to control participants, individuals with psychosis had higher galvanic skin responses in low own-group density conditions⁴³. The second study found no effect of virtual group density on distress or paranoid thoughts⁴⁴.

In symptom studies, an ethnic density interaction for paranoia was observed in ethnic majority, but not ethnic minority, adolescents in a Dutch classroom setting³⁷, whilst another study found no association between group density and symptomatic outcomes³⁸.

The remaining study found that Black, Latino, and Asian individuals in the USA who recounted growing up in neighbourhoods with higher proportions of out-group ethnic minority groups reported more psychotic-like symptoms than those who grew up in ethnically concordant or predominantly White neighbourhoods⁵¹. Further, Black individuals who perceived a change in the ethnic density of their neighbourhood during childhood reported more psychotic experiences than those who did not⁵¹.

Meta-analysis

Ten studies were eligible for meta-analysis^{11,26–29,40,46,47,49,52}. Of the twenty-one studies excluded, five did not adjust for the specified individual and area-level confounds^{25,26,35,36,41}, five used non-eligible outcomes^{32,34,37,38,48}, four used non-eligible exposures (VR simulation^{43,44}, perceived ethnic density⁵¹, and ethnic enclaves⁴⁵), four studies used overlapping^{11,30,49,50} or potentially overlapping datasets^{27,31,39,40}, two only examined between-group density effects^{9,42}, and one did not use multilevel modelling³³.

One eligible study provided separate results for migrants and children of migrants. Given that no

other studies included in the meta-analysis stratified results by generational status, only data for migrants were extracted⁴⁷.

Pooled group density effects

The three-level model was the best fit for the data (Supplemental 5). The overall meta-analytic effect indicated a ten percentage-point decrease in group density was associated with a 20% increase in psychosis risk [OR=1.20 (CI_{95%}=1.09-1.32), $p<0.001$]. A separate effect using only minority groups defined by ethnicity or migratory background was also significant [OR=1.23 (CI_{95%}=1.14-1.33), $p<0.001$]. There was no significant effect in minority groups defined by other characteristics [OR=1.02 (CI_{95%}=0.86-1.20), $p=0.848$]. There was a larger pooled effect after removal of the one school-based study⁴⁶ [OR=1.25 (CI_{95%}=1.15-1.36), $p<0.001$].

Moderator tests

In line with the narrative review, there were moderating effects of crude [$F_{6,68}=6.86$, $p<0.001$] and specific minority groups [$F_{25,49}=7.26$, $p<0.001$]. Said moderator tests were also significant when conducted on ethnic minority and migrant samples only (Supplemental 6). Further analyses examining whether associations differed when minority groups were self-ascribed or defined by birthplace, were non-significant [$F_{1,59}=0.60$, $p=0.443$].

When assessing crude minority groups, the strongest association was observed in the Black group [OR=1.71 (CI_{95%}=1.43-2.03), $p<0.001$], relative to the reference group ('Other ethnic group'). There was also a stronger association in the White Other group [OR=1.23 (CI_{95%}=1.03-1.48, $p=0.024$]. There was weak evidence of a stronger association in Asian populations [OR=1.19 (CI_{95%}=0.98-1.45, $p=0.074$].

Moderator tests for specific minority groups showed the strongest associations in Black Antillean migrants in the Netherlands [OR=3.60 (CI_{95%}=2.22-5.83), $p<0.001$] relative to the reference group ('Combined migrant group'). This was followed by Black or Black British [OR=1.84 (CI_{95%}=1.24-2.74), $p=0.003$] and Black African [OR=1.48 (1.10-2.00, $p=0.011$)] groups in the UK and Denmark. There was also a stronger association in the Non-Scandinavian European group [OR=1.43 (CI_{95%}=1.06-1.92), $p=0.020$] and a significant detrimental association in a South American sample [OR=0.37 (CI_{95%}=0.14-0.99, $p=0.048$]. See Table 3 for moderator test results including crude minority groups, and Supplemental 7 for specific minority group results.

Moderator tests for country, time, and area size were non-significant, though there was some evidence for stronger group density effects at smaller geographic units. There was also a significant moderating effect of psychosis outcome used [$F_{5,69}=2.36$, $p=0.049$], with evidence for stronger associations in studies using clinical outcomes, namely non-affective psychosis cases [OR=1.15 (CI_{95%}=1.04-1.28), $p=0.008$] and cases with a first diagnosis of any psychotic disorder [OR=1.66 (CI_{95%}=1.22-2.27), $p=0.002$].

Table 1. Characteristics of the included studies ($n=31$), meta-analysis ($n=10$)

Author & setting	Datasets & time period	Minority group classification	Psychosis outcome	Geographic unit (n areas/av. pop.)	Group density exposure	Individual & area-level covariates	Statistical analysis	Minority groups (cases/total minority group sample)	Results
Anglin, Lui, Schneider & Ellman, (2020) ⁵¹ Northeastern USA	Public university system. Students recruited via a participant recruitment website. Time period: 2011-2016	Self-ascribed Black/African American/African descent or as a 1 st or 2 nd gen immigrant, answers grouped into USA census categories.	The Prodromal Questionnaire-Likert [PQ-Likert]	Neighbourhood (NA)	Perceived racial composition of neighbourhood prior to age 12 and after age 12 (<i>e.g.</i> mostly Black, mostly Latino, mostly Asian...)	Individual [I]: Immigrant status, poverty index, age, racial & ethnic group, & lifetime cannabis use Area [A]: None	ANCOVA, post-hoc Bonferroni-corrected t-tests	Combined (NR/1330) Black (NR/427) Hispanic (NR/429) Asian (NR/474) 1 st generation migrants (NR/560) 2 nd generation migrants (NR/657) Non-immigrant (NR/112) Mean no. of psychotic experiences endorsed=12.25	More psychotic experiences reported in Ethnic & racial minorities [REM] who recounted living in racially discordant neighbourhoods at age 12 compared to REM participants who grew up in racially concordant, mixed, or majority white areas. REM individuals who perceived change in the racial composition of their neighbourhood after age 12 reported more psychotic experiences than those who perceived no change (in stratified analysis, this was only sig. in the Black group).
Bécares, Nazroo & Stafford (2009) England & Wales, UK	Fourth National Survey on Ethnic Minorities [FNS] & 1991 UK Census. Time period: 1994 (1 year).	Self-ascribed	Psychosis Screening Questionnaire [PSQ]	Electoral ward [EW] (9527, 5327)	Within-groups, 10% increase	I: Age, sex, and socioeconomic position A: Deprivation	Multiple logistic regression	Combined (NR/4277) Black Caribbean (NR/1215) Indian (NR/1278) Pakistani (NR/1190) Bangladeshi (NR/594)	OR=0.99 OR=0.83 OR=0.90 OR=1.44 [SS] ⊖ OR=0.81
Bécares & Das-Munshi (2013) Das-Munshi, Bécares, Boydell et al., (2012) England, UK	Ethnic Minority Psychiatric Illness Rates in the Community [EMPIRIC], merged dataset of the English samples from the 2005 and 2007 Citizenship Survey [CS] & 2001 UK census. Time period: 2005 & 2007 (2 years).	Self-ascribed (Irish – place of birth or parent's place of birth)	PSQ	Middle Super Output Area [MSOA] (7193, 7200)	Within-groups, 10% decrease	I: Age, sex, social class, marital status, education, and generational status A: Deprivation <i>n.b. only 2013 study adjusted for generational status</i>	Multiple logistic regression	Combined (305/3444) Irish (59/733) Black Caribbean (83/694) Indian (58/643) Pakistani (72/724) Bangladeshi (33/650) White British (majority) (50/837)	OR=1.07 [SS] OR=5.44 OR=1.05 OR=1.38 [SS] OR=1.17 OR=1.26 OR=0.91 ⊖ <i>n.b. effect sizes from 2012 study</i>
Bhavsar, Boydell, Murray & Power (2014) Lambeth, South London, UK	Lambeth Early Onset [LEO] case register & 2001 UK census. Time period: January 2000 – December 2007 (8 years).	NR	Schizophrenia [SZ] first incident cases [RDC criteria]	EW (21, NR)	Within-groups, 100% increase	I: Age & sex A: Deprivation	Multilevel Poisson regression	Black Caribbean (NR) Black African (NR)	IRR= 0.003 [SS] IRR=0.04

Boydell, van Os, McKenzie et al., (2001)	Bethlem Royal & Maudsley NHS Trust & 1991 UK census	Any self-ascribed ethnicity other than White (if not available, place of birth, parents place of birth, and any description of colour)	SZ first incident cases [RDC criteria, ICD-9 & ICD-10]	EW (15, 10,000)	Between-groups, each third of non-white ethnic density	I: Age & sex A: Deprivation	Multilevel Poisson regression	Non-white ethnic minority (126/NR)– comprising Black Caribbean, Black African, and other	Lowest third (8-22.8%) IRR=4.40 [SS] Middle third (23-28.1%) IRR=3.63 [SS] Highest third (28.2-57%) IRR=2.38 [SS]
Camberwell, South London, UK	Time period: 1988 – 1997 (9 years)								
Das-Munshi, Schofield, Bhavsar et al., (2019)	South London & Maudsley NHS Trust Clinical Record Interactive Search [CRIS] system & 2011 UK census	Self-ascribed ethnicity grouped using UK Office for National Statistics [ONS] ethnic group classifications	All-, natural, and unnatural-cause mortality in individuals with ICD-10 SMI diagnoses (schizophrenia-spectrum disorders (F2*) and bipolar disorders (F30 and F31)	Lower Super Output Area [LSOA] (NR/1614)	Between-groups, highest and lowest own minority group density	I: Age, sex, diagnosis, marital status, substance use disorders, ethnicity*own ethnic density interaction A: Deprivation, urbanicity, & social fragmentation	Multilevel Poisson regression	Combined (637/9154) Black African (106/2510) Black Caribbean (332/4840) South Asian (95/1256) Irish (104/548) White British (majority) (1130/9047) <i>n.b. above refers to all-cause deaths/sample</i>	IRR=0.96, IRR=0.52 [SS] Interaction: $p=0.036$ [SS] IRR=0.79, IRR=0.25 [SS] Interaction: $p=0.068$ IRR=0.70 [SS], IRR=0.58 [SS] Interaction: $p=0.62$ IRR=1.08, IRR=0.07 [SS] Interaction: $p=0.015$ [SS] IRR=0.97, IRR=1.80 Interaction: $p=0.65$ REF <i>n.b. 1st IRR =lowest own-group density (0%), 2nd IRR=highest ethnic density (95% for combined, 50%, 30%, 90%, & 11% respectively for specific minority groups). Data for specific groups taken from paper's supplementary material</i>
Dykxhoorn, Lewis, Hollander, Kirkbride & Dalman, (2020)	Register of the Total Population, the immigration and emigration register (STATIV), the Multi-Generation register, and the National Patient Register. (Linked by Psychiatry Sweden)	Place of birth & parents place of birth (born outside of Sweden: 1 st gen, born in Sweden, at least one parent born outside of Sweden: 2 nd gen)	NAP (F20-29) [ICD-10]	Small Areas for Market Statistics [SAMS] (9208/726)	Within groups, 5% decrease & effect at different quintiles (highest=REF) <i>n.b. migrant density exposure measured at age 15 or after immigration to Sweden</i>	I: Age, sex, calendar year, generation status, lone dwelling, time since migration, family disposable income, receipt of social welfare & family unemployment A: Population density, proportion of lone dwelling households & deprivation	Multilevel Cox proportional hazards regression	Nordic 1 st gen (103/131882) 2 nd gen (644/766149) European 1 st gen (693/880211) 2 nd gen (270/310934) Asian 1 st gen (297/365971) 2 nd gen (61/92699) Middle Eastern & North African 1 st gen (693/796928) 2 nd gen (349/471962) Sub-Saharan African 1 st gen (550/261899) 2 nd gen (127/72516) North American 1 st gen (50/55558) 2 nd gen (6/6338)	HR=1.01 HR=0.97⊖ HR=0.98⊖ HR=1.06 HR=1.42 [SS] HR=1.15 HR=1.03 HR=1.00 HR=1.28 [SS] HR=0.94⊖ HR=1.77 HR=0.89⊖
Sweden	Time period: January 1982 – December 2016 (35 years)								

South American 1 st gen (79/102857) 2 nd gen (66/84025)	HR=0.67⊖ HR=1.15
Swedish migrant 2 nd gen (390/456995)	HR=0.83⊖
Mixed migrant 2 nd gen (201/153726)	HR=1.17
<i>n.b. second value refer to person-years</i>	Combined migrant density: Quintile 1 (lowest) HR=1.36 [SS]; Q2 HR=1.14 [SS]; Q3 HR=1.11; Q4 HR=1.07; Q5 (highest)=REF

Eilbracht, Stevens, Wigman, van Dorsselaer & Vollebergh (2015) The Netherlands	Dutch Health Behaviour in School-Aged Children [HBSC] Time period: 2005 (>1 year)	Father, mother, or both parents born in a non-Western country	The Community Assessment of Psychotic Experiences [CAPE] positive experiences subscale	Classroom (NR, 21)	Within-groups, assoc. between class proportion of minority group pupils & PEs	I: Age, sex, education, family wealth A: Class size	Multilevel multivariate regression	Combined (NR/769) Moroccan (NR/228) Turkish (NR/182) Surinamese or Antillean (NR/178) Other non-Western (NR/181) Dutch (majority) (NR/3606)	Sig. increase in paranoia with increasing ethnic density in the Dutch majority pupils ($b=0.16, p<0.05$) but no sig. effects in the combined minority group ($b=-0.05, p=0.99$) or for specific minority groups (data NR). No sig. ethnic density effects for any other PEs (AVHs, delusions, grandiosity, or paranormal beliefs)
Halpern & Nazroo (2000) England & Wales, UK	Policy Studies Institute [PSI] National Community Survey in England & Wales 1993/94 & 1991 UK census Time period: 1993 – 1994 (1 year)	Self-ascribed	PSQ	EW (NR)	Within-groups (specific minority groups), within & between groups (combined minority group)	I: Age, sex, hardship, migration & language A: None	Multivariate linear regression	Combined (5226/5196) Black Caribbean (1215/1205) Indian (1278/1273) African Asian (733/728) Pakistani (1190/1185) Bangladeshi (594/591) Chinese (216/214) White (majority) (NR/2867) <i>n.b. 1st value refers to number of PSQ symptoms reported, 2nd value is the sample size.</i>	$b=-.071, p<0.001$ [SS] $b=-.058, p<0.05$ [SS] $b=-.126, p<0.001$ [SS] $b=-.043$ $b=.043$ ⊖ $b=-.140, p<0.001$ [SS] $b=-.044$ $b=-.040, p<0.05$ [SS]
Heslin, Khondoker, Shetty et al., (2018) Lambeth, Lewisham, Croydon, & Southwark, South London, UK	South London & Maudsley NHS Trust Clinical Record Interactive Search [CRIS] system & 2011 UK census Time period: January 2007 – December 2010 (~4 years)	Ethnicity recorded in patient records according to UK ONS ethnic group classifications	Inpatient days following an ICD-10 diagnosis of any psychotic disorder	LSOA (NR, 1500)	Within-groups, regression of inpatient days over 5 years and overall ethnic density	I: Length of time with service, age, sex, & BME status	Negative binomial regression	Combined (NR/1515), Black African (NR/430), Black Other (NR/228), Black Caribbean (NR/209), Indian (NR/32), Pakistani (NR/25), Chinese (NR/21), Bangladeshi, (NR/14), Other Asian (NR/95), Irish (NR/48), White & Black, Caribbean (NR/20), White & Black African (NR/12), White & Asian (NR/7), Other mixed (NR/12), Any other ethnic group (NR/161), White other (NR/201), White (majority) (NR/632)	$b=0.59$ (overall ethnic density) Overall ethnic density was not associated with days as an inpatient

Kirkbride, Morgan, Fearon, Dazzan, Murray & Jones (2007)	Aetiology and Ethnicity in Schizophrenia and Other Psychoses [AESOP] study & 2001 UK census	Self-ascribed, place of birth, & parents place of birth, grouped using UK ONS ethnic group classifications	First incident cases of SZ and other non-affective psychoses [NAP] [ICD-10]	Census Area Statistic [CAS] wards (33/5880)	Within-groups, 1% increase & between-groups at each third of combined minority group density	I: Age, sex A: Area-level variables not included in model <i>n.b. in Kirkbride et al., (2008) voter turnout replaced with social cohesion & trust and social disorganisation</i>	Multilevel Poisson regression	Combined (163/201720) Black Caribbean (NR) Black African (NR) Asian (NR) Mixed ethnicity (NR) White other (NR) Other ethnicity (NR) White British (majority) (55/363856) <i>n.b. 2nd value refers to person-years</i>	Within groups: IRR=1.00 (SZ) Interaction: <i>p</i> =0.19 IRR=1.04 (Other NAP) ⊖ Interaction: <i>p</i> =0.43 Between groups: Lowest third (24.8-47.1%) IRR=6.50 Middle third (47.2-56.1%) IRR=2.13 Upper third (56.4-74.3%) IRR=3.81 <i>n.b. effect sizes from 2007 study</i>
Kirkbride, Boydell, Ploubidis et al., (2008)	Time period: September 1997 – August 1999 (2 years)								
Lambeth & two-thirds of Southwark, South London, UK									
Kirkbride, Jones, Ullrich, & Coid (2014)	The East London first-episode psychosis [ELFEP] study & 2001 UK census	Self-ascribed, place of birth, & parents place of birth, grouped using UK ONS ethnic group classifications	First incidence cases of NAP [DSM-IV]	Super Output Area [SOA] (56, 6195)	Within-groups, 1-SD increase	I: Age, sex, social class A: None	Bayesian Hierarchical Modelling	Black African (49/NR) Black Caribbean (55/NR) Bangladeshi (53/NR) Non-British White (38/NR) White British (majority) (68/NR)	RR=0.70 [SS] NR NR NR <i>n.b. RR shows effect for NAP. Data NR but associations not sig. for Black Caribbean, Bangladeshi, & non-British White groups</i>
City & Hackney, Newham, & Tower Hamlets, East London, UK	Time period: December 1996 – November 1998 (2 years – City & Hackney) December 1998 -November 2000 (2 years – Newham & Tower Hamlets)								
Menezes, Georgiades, & Boyle (2011)	Canadian Community Health Survey [CCHS] & 2001 Canadian census	Immigrant status assigned if individual was born outside Canada and not born a Canadian citizen	Self-reported lifetime prevalence [LTP] of SZ	Dissemination area [DA] (8145, 400-700)	Within-groups, effect of immigrant status and DA level immigrant concentration on LTP of SZ	I: Age, sex, income, marital status, education A: Disadvantage (% with low income, rentals, & that moved in the last year)	Multilevel logistic regression	Immigrant status (born in Asia, Oceania, or Europe) (31/7784)	Immigrant status x concentration interaction: OR=0.81 <i>n.b. lower SZ in immigrants. Additional protective effect of migrant group density but this was not sig.</i>
Canada	Time period: 2002 (1 year)								
Mezuk, Li, Cederin et al., (2015)	Nationwide psychiatric inpatient and outpatient registries. & 2005 Swedish census	Place of birth & parents place of birth (born outside of Sweden: 1 st gen, born in Sweden, at least one parent born outside of Sweden: 2 nd gen)	NAP & AP first incident cases [ICD-10]	SAMS (1490, 1000)	Within-groups, psychosis risk living in an ethnic enclave compared to majority Swedish area	I: Age, sex, education, income, & 1 st or 2 nd gen status A: Deprivation (% with low educational attainment, low income, unemployed, & receiving social welfare)	Multilevel logistic regression	Iraqi (NR/19975) Other (NR/232356) Swedish-born (majority) (NR/698648) <i>n.b. 'Other' group comprised migrants from Finland, Asia (excluding Turkey, Iran or Iraq), countries in Africa, former Yugoslavia, Iran, Poland, Turkey, Bosnia, Chile, and other nations in South America (other than Chile)</i>	OR=1.66 [NAP], OR=1.04 [AP] ⊖ OR=0.93 [NAP], OR=0.93[AP] OR=1.36 [NAP], OR=1.12 [AP] [SS] <i>n.b. results for broadly defined AP & NAP</i>
Stockholm, Gothenburg, & Malmö, Sweden	Time period: 2005 - 2010 (5 years)								

O'Donoghue, Yung, Wood et al., (2015)	The Personal Assessment and Crisis Evaluation [PACE] clinic & 2001 Australian census	Place of birth & parents place of birth (born outside of Australia: 1 st gen, born in Australia, at least one parent born outside of Australia: 2 nd gen)	Meet criteria for at least one of the three Ultra High Risk [UHR] groups	Postcode Area [PA] (57, 13527)	Within-groups, high (REF group), above average, below average, and low ethnic density	I: None A: Social deprivation	Poisson regression	Total migrants (59/NR) 1 st generation migrants (10/NR) 2 nd generation migrants (49/NR)	Total migrants: Low (7.7-23.2%) IRR=0.77 Below av. (24.4-32.5%) IRR=1.46 Above av. (32.7-40%) IRR=1.86 High (42-50.9%) [REF] 1 st generation migrants: Low (7.7-23.2%) IRR=0.72 Below av. (24.4-32.5%) IRR=0.93 Above av. (32.7-40%) IRR=1.29 High (42-50.9%) [REF] <i>n.b. above data from supplementary material (adjusted for deprivation). Percentages for migrant density quartiles provided by author.</i>
Richardson, Hameed, Perez, Jones & Kirkbride (2018)	Social Epidemiology of Psychoses in East Anglia [SEPEA] study & 2011 UK census	Self-ascribed ethnicity grouped using UK ONS ethnic group classifications	NAP & AP first incident cases [ICD-10]	Statistical Ward [SW] (530, 3992)	Within-groups, 1% increase	I: Age, sex, socioeconomic status, ethnicity A: Deprivation, urbanicity, & social isolation (all psychoses). Ethnic diversity, deprivation, social isolation (NAP). Ethnic fragmentation (AP)	Multilevel Poisson regression	Black African (21 NAP, 1 AP/17193), Black Caribbean (6 NAP, 3 AP/5973), Mixed white & black Caribbean (5 NAP, 2 AP/13100), Mixed Other (11 NAP, 6 AP/30927), Indian (2 NAP, 0 AP/27911), Pakistani (13 NAP, 3 AP/20126), Bangladeshi (5 NAP, 1 AP/8403), Arab (4 NAP, 0 AP/4838), Other ethnic group (13 NAP, 2 AP/62875), White Other 50 NAP, 12 AP/207165), White British (majority) (418 NAP, 53 AP/1623285) <i>n.b. 2nd value refers to person-years</i>	OR=1.00 (all psychoses) OR=0.99 (NAP) OR=0.98 (AP) [SS]
Schofield, Ashworth & Jones (2011)	Electronic GP patient records (the Lambeth DataNet) & 2001 UK census	Patient ethnicity codes were grouped using UK ONS ethnic group classifications (Black or Black British)	Psychosis first incident cases [DSM-IV]	LSOA (NR, 1500) CAS wards (NR, 6000)	Between-groups, high & low ethnic density. Within-groups, effect at quintiles of ethnic density (highest=REF)	I: Age & sex A: Deprivation	Multilevel Poisson regression	Black (109/23693) White British (majority) (87/37278)	Between groups (LSOA): High (25-62%) IRR=1.48 Low (0-24%) IRR=2.88 [SS] Within groups (LSOA): Highest (43%) [REF] High (31%) IRR=2.50 [SS] Mid (24%) IRR=3.59 [SS] Low (19%) IRR=5.39 [SS] Lowest (11%) IRR=5.24 [SS] Within groups (CAS ward): Highest (37%) [REF] High (30%) IRR=1.06 Mid (26%) IRR=1.63 Low (22%) IRR=1.90 Lowest (11%) IRR=1.14 <i>n.b. CAS ward data provided by author. Within groups model at CAS level was non-sig. The same within-</i>

<i>groups models for White British sample was non-sig.</i>									
Schofield, Das-Munshi, Bécares et al., (2016)	South East London Community Health [SELCoH] study: 2008-2010 & 2011 UK census Lambeth & Southwark, South London, UK	Self-ascribed Black Caribbean or Black African from UK ONS ethnic group classifications	PSQ	LSOA (322,1500)	Within-groups, 10% decrease	I: Age & sex A: Deprivation	Multilevel logistic regression	Black combined (98/377) Black African (NR/234) Black Caribbean (NR/143) Single household status (51/212) Disadvantaged social class (101/421)	OR=1.34 [SS] OR=1.15 OR=1.99 OR=2.18 OR=0.88 ⊖ <i>n.b. effects for Black African & Black Caribbean are from paper's supplementary material</i>
Schofield, Thygesen, Das-Munshi et al., (2017)	Danish Civil Registration System dataset, the Danish Psychiatric Central Register, & Integrated Database for Longitudinal Labour Market Research	Place of birth & parents place of birth (born outside of Denmark: 1 st gen, born in Denmark, both parents born outside of Denmark: 2 nd gen)	NAP first incident cases [ICD-10]	Parish units (1167, 3564)	Within-groups, effect at quintiles of ethnic density (highest=REF) <i>n.b. variables measured at age 15</i>	I: Age, sex, calendar period, parental psychiatric history & income A: Urbanicity	Multilevel Poisson regression	African (362/13118) 1 st gen (236/7187) 2 nd gen (80/4593) Non-Scandinavian European (1175/58939) 1 st gen (585/24436) 2 nd gen (410/25984) Asian (415/24512) Middle Eastern (529/28762) 1 st gen (412/17983) 2 nd gen (102/10293) Danish (majority) (24410/1921874)	Lowest (<0.4%) IRR=1.94, low (0.4-0.9%) IRR=2.17, mid (0.9-1.7%) IRR=1.11, high (1.7-3.7%) IRR=1.20, highest (3.7-18.5%) [REF] Lowest (<2.3%) IRR=1.99, low (2.3-3.9%) IRR=1.60, mid (3.9-5.9%) IRR=1.39, high (5.9-9.4%) IRR=1.43, highest (9.4-26.4%) [REF] Lowest (<0.6%) IRR=1.63, low (0.6-1.2) IRR=1.00, mid (1.2-2.1%) IRR=0.93, high (2.1-3.9%) IRR=1.00, highest (3.9-14.3%) [REF] Lowest (<0.8) IRR=1.68, low (0.8-1.7%) IRR=1.29, mid (1.7-3.3%) IRR=1.04, high (3.3-6.7%) IRR=1.23, highest (6.7-40%) [REF] <i>n.b. sig differences between highest and lowest quintiles for all minority groups, strongest for African sample. Generational differences (Schofield, Thygesen, Das-Munshi et al., 2018): African IRR=1.33 [SS], Non-Scandinavian European IRR=1.08 [SS], Middle Eastern IRR=1.25 [SS]</i>
Stouten, Veling, Laan, & Van der Gaag (2016)	Centre for Early Psychosis referrals & the Central Bureau of Statistics, the Netherlands	Place of birth & parents place of birth (born outside of the Netherlands: 1 st gen, born in the Netherlands, at least one parent born outside of the Netherlands: 2 nd gen)	NAP first incident cases [DSM-IV], symptom dimensions & remission [PANSS & SCI-SR]	Neighbourhoods (44, max. 38000)	Within-groups, whether baseline ethnic density predicts symptomatic remission at 12 months follow up	I: Age, income & education A: None	Backwards regression models	1 st gen (60/NR) 2 nd gen (56/NR) (Comprising migrants from Morocco, the Netherlands Antilles, Surinam, Turkey, other Western & other non-Western countries)	Baseline ethnic density was not a sig. predictor of any psychosis outcome at follow up.

Terhune, Dykxhoorn, Mackay, Hollander & Kirkbride (2020)	Psychiatry Sweden anonymised database of linked national registers 1985 – December 2016 (~32 years)	Place of birth & parents place of birth (born outside of Sweden: 1 st gen, born in Sweden, at least one parent born outside of Sweden: 2 nd gen)	Compulsory admission status at the time of the first diagnosis of psychotic disorder.	SAMS (7416/1000-2000)	Within-groups, 1-SD increase	I: Age, sex, region of origin A: Population density (no other variables improved the final model fit)	Multilevel logistic regression	Combined (1800 1 st gen, 2605 2 nd gen) European 1 st gen 2 nd gen Asian & Oceanic 1 st gen 2 nd gen Middle Eastern & North African 1 st gen 2 nd gen Sub-Saharan African 1 st gen 2 nd gen North & South American 1 st gen 2 nd gen Swedish-Nordic 2 nd gen Swedish-migrant 2 nd gen Mixed Migrant 2 nd gen	OR=1.12 [SS] OR=1.25 OR=2.19 OR=1.24 OR=1.87 OR=1.45 OR=2.22 OR=1.99 OR=3.59 OR=1.47 OR=2.31 OR=2.41 OR=2.10 OR=1.54
Termorshuizen, Smeets, Braam & Veling (2014)	Psychiatric Case Register Middle Netherlands [PCR-MN] & Dutch population registry (Central Bureau of Statistics, the Netherlands) Time period: January 2000 - December 2009 (9 years)	Assigned by country of birth of parent(s) born outside of the Netherlands. If both parents were born in different countries, maternal country of birth used.	NAP first incident cases [DSM-IV]	Districts (10, 27525) Neighbourhoods (98, 2808)	Between- and within-groups at each third of ethnic density (lowest=REF)	I: Age & sex A: Socioeconomic status (mean income of area)	Multilevel Poisson regression	Turkish (81/12309) Moroccan (222/21409) Surinamese/Antillean (155/13404) Other non-Western (127/20230) Dutch (majority) (1242/284747)	Between groups [SS]: Low (<6.5%) RR=1.39, mid (6.5–9.6%) RR=1.19, high (≥9.6%) RR=0.78. Within groups: Low [REF], mid RR=0.97, high RR=0.63 Between groups [SS]: Low (<11.3%) RR=2.18, mid (11.3–27.6%) RR=1.79, high (≥27.6%) RR=1.01. Within groups: Low [REF], mid RR=1.02, high=0.64 Between groups [SS] Low (<3.2%) RR=3.44, mid (3.2–4.9%) RR=2.32, high (≥4.9%) RR=2.12. Within groups [SS]: Low [REF], mid RR=0.91, high RR=0.51 Between groups [SS] Low (<3.5%) RR=2.74, mid (3.5–6.3%) RR=2.09, high (≥6.3%) RR=1.35. Within groups: Low [REF], mid RR=0.88, high RR=0.67 Sig. increased NAP risk in Dutch majority group with increasing overall ‘Non-Western’ minorities and ‘Other Non-Western’ group at the neighbourhood level <i>n.b. for combined ‘all non-Western minority group’, sig. between-group effects found at the neighbourhood</i>

<i>and district level but effects not sig. for within-groups analyses</i>									
Termorshuizen, Heerdink & Selten (2018) Amsterdam, Rotterdam, the Hague, & Utrecht, the Netherlands	The Health Care Institute Netherlands & Dutch population registry (Central Bureau of Statistics, the Netherlands) Time period: 2013 (1 year)	Assigned by country of birth of parent(s) born outside of the Netherlands. If both parents were born in different countries, maternal country of birth used.	Dispensed anti-psychotic medication [ATC code N05A, including N05AN01, Lithium]	Neighbourhoods (NR/2808)	Within-groups, at each quintile of ethnic density (lowest=REF)	I: Age, sex, & household composition A: Socioeconomic status (At least 138 per 1000 households in a neighbourhood are dependent on the social welfare system)	Multivariable logistic regression	Turkish (3775/105460)	Lowest (<4.9%) [REF], low (4.9–9.4%) OR=1.15, mid (9.4–14%) OR=1.16, high (14–22.5%) OR=1.10, highest (>22.5%) OR=1.05 p=0.0375 [SS]
								Moroccan (5207/115455)	Lowest (<5.7) [REF], low (5.7–10.7%) OR=0.99, mid (10.7–15.8%) OR=1.05, high (15.8–22.1%) OR=0.96, highest (>22.1%) OR=0.93 p=0.0777
								Surinamese (4252/147123)	Lowest (<5.5%) [REF], low (5.5–8.9%) OR=0.84, mid (8.9–11.8%) OR=0.86, high (11.8–18.9%) OR=0.85, highest (>18.9%) OR=0.64 p<0.001 [SS]
								Antillean (949/41430)	Lowest (<1.1%) [REF], low (1.1–2.3%) OR=0.90, mid (2.3–4%) OR=0.73, high (4–5.9%) OR=0.64, highest (>5.9%) OR=0.49 p<0.001 [SS]
								Dutch (majority) (21918/1043732)	Sig. increase in antipsychotic use in Dutch majority with increasing minority group density (for all minority groups)
van Os, Driessen, Gunther & Delespaul (2000) Maastricht, the Netherlands	Maastricht Mental Health Case Register [MHCR] & Municipal authority register Time period: 1986–1997 (11 years)	Marital status reported in the MHCR	SZ/related disorders incident cases [ICD-9]	Neighbourhoods (35/2804)	Within-groups, effect of single marital status in a neighbourhood where the proportion of others living alone is below the city-level mean	I: Age, gender, marital status, age-by-gender interaction and marital-status-by-gender interaction. A: None	Multilevel Poisson regression	Single (141/NR)	RR=10.33, p<0.001 [SS]
Veling, Susser, van Os, Mackenbach, Selten & Hoek (2008) The Hague, the Netherlands	Cases ascertained by Psychiatric residents at the early psychosis department & The Hague municipal population register Time period: 1997–1999, 2000–2007 (7 years)	Assigned by country of birth of parent(s) born outside of the Netherlands. If both parents were born in different countries, maternal	First incident cases of a psychotic disorder [DSM-IV]	Neighbourhoods (44, max. 38000)	Between groups, at high & low ethnic density and continuous ethnic density	I: Age, sex, & marital status A: Socioeconomic level	Multilevel Poisson regression	Combined (240/413586) Moroccan (91/88249) Surinamese (94/203088) Turkish (55/122249) Dutch (majority) (226/1056172)	Low IRR=2.36, high IRR=1.25 Continuous: IRR=0.95, <i>p</i> =0.0001 [SS] Low IRR=4.43, high IRR=1.56 Continuous: IRR=0.93, <i>p</i> =0.002 [SS] Low IRR=1.88, high IRR=1.19 Continuous: IRR=0.98, <i>p</i> =0.334 Low IRR=1.74, high IRR=1.12 Continuous: IRR=0.97, <i>p</i> =0.109 REF

		country of birth used						<i>n.b. second value refers to person- years</i>	<i>n.b. effect sizes for ethnicity stratified as two highest ethnic density neighbourhoods and all other neighbourhoods</i>
Velting, Brinkman, Dorrestijn & van der Gaag (2014)	Participants with FEP [DSM- IV] recruited from a specialist service for early psychosis in the Hague; Controls recruited from Delft University of Technology staff and students Time period: NR	NR	Green Paranoid Thoughts Scale, the Social Interaction Anxiety Scale, the Davos Assessment of Cognitive Biases Scale, the Self-Esteem Rating Scale, distance from avatars, Heart rate & galvanic skin response, subjective distress, & State Social Paranoia scale	VR café	95% of the avatars appeared White European or 75% North African depending on ethnic background of the participant.	NR	Nonparametri c tests and linear mixed model analyses	Non-Dutch origin (11 FEP) Dutch origin (majority) (6 FEP, 24 controls)	Sig. higher galvanic skin response in FEP participants in ‘other’ compared to ‘own’ ethnicity condition [$F_{1,32}$ =9.82, $p=0.004$]. This was not observed in controls. Overall, participants positioned themselves sig. further away from avatars in the ‘other’ ethnicity condition, but only in the low population density environments [$F_{1,39}$ =5.08, $p=0.030$]. No sig. effects for other outcomes.
Velting, Pot-Kolder, Counotte, van Os & van der Gaag (2016)	UHR [CAARMS], FEP [DSM-IV], and sibling groups were recruited from five psychiatric institutes. Controls were recruited via flyers which were distributed to schools, dentist offices, and Psychiatric institutes in the Hague Time period: NR	NR	Green Paranoid Thoughts Scale, Social Interaction Anxiety Scale, Community Assessment of Psychic Experiences, distance from avatars, subjective distress, & State Social Paranoia Scale	VR bar	80% of the avatars appeared Dutch or North African depending on ethnic background of the participant.	I: Age, sex, education & psychosis liability A: NA	Chi square tests, ANOVA & multilevel random intercept regression models	Non-Dutch origin (16 controls, 11 siblings, 5 UHR, 26 FEP) Dutch origin (majority) (37 controls, 31 siblings, 15 UHR, 29 psychosis)	Compared with participants with low psychosis liability, individuals with high psychosis liability had sig. higher paranoia [$b=3.62$ (95% CI 1.39-5.84)] and distress [$b=17.94$ (95% CI 10.99-24.90)] in response to social stress in VR. However, no sig. association between ethnic density and either outcome.
Zammit, Lewis, Rasbash, Dalman, Gustafsson & Allebeck (2010)	The Swedish National Patient Register, Multi- Generation Register, National Schools register, & the Swedish Census Time period: residents born between January 1972 & December 1977 & residing in Sweden on their 16 th Birthday followed up until December 2013 (~31 years)	Being foreign- born, Deprived status (parents unemployed/on benefits/low income), Social fragmentation (single parent family/moved municipality/im migrated during childhood), Low grade (lower than av. School-level grade)	Cases of a psychotic disorder [ICD-8:10]	School (1264, 161)	Within-groups, 10% increase	I: Foreign-born, social fragmentation, grade A: As above & variance components at school, municipality & county levels	Multilevel logistic regression	Foreign-born (NR) Deprived status (NR) Social fragmentation (NR) Low grade (NR) Total sample (328 SZ, 741 other NAP, 355 AP, 953 Other psychoses/203829)	OR=0.95 [SS] Interaction: $p=0.016$ OR=0.92 Interaction: $p=0.057$ OR=0.92 [SS] Interaction: $p=0.004$ OR=1.04 Interaction: $p=0.554$ <i>n.b. above are interaction effects for ‘any psychosis’. Effects broken down by SZ, NAP, AP & ‘Other’ psychoses can be found in the paper’s supplementary material</i>

*n.b. studies in **bold** contributed data to the meta-analysis, $\ominus$ = detrimental effect of group density*

Table 2. Moderator tests

Variable	<i>n</i> samples	<i>n</i> studies	Pooled OR (Lower 95% CI–Upper 95% CI)	Standard error	<i>t</i> value	<i>p</i> value
Country	75	10	$F_{4,70}=0.18$	-	-	0.946
Sweden [REF]	23	2	1	-	-	-
United Kingdom	19	5	1.13 (0.81-1.58)	0.17	0.75	0.456
Canada	1	1	1.01 (0.56-1.82)	0.30	0.02	0.983
Denmark	16	1	1.15 (0.73-1.81)	0.23	0.60	0.550
The Netherlands	16	1	1.07 (0.68-1.68)	0.23	0.29	0.774
Median time cases collected	75	10	$F_{2,72}=1.25$	-	-	0.292
90s and earlier [REF]	43	4	1	-	-	-
2010s	18	2	1.04 (0.82-1.32)	0.12	0.32	0.752
2000s	14	4	1.19 (0.95-1.49)	0.11	1.57	0.121
Area size	75	10	$F_{3,71}=2.50$	-	-	0.066
1 st Quartile (<920) [REF]	24	3	1	-	-	-
2 nd Quartile (920-2532)	8	2	1.38 (1.08-1.77)	0.12	2.62	0.011*
3 rd Quartile (2532-4993)	18	2	1.14 (0.95-1.37)	0.09	1.39	0.168
4 th Quartile (4993-7200)	25	3	1.06 (0.89-1.25)	0.84	0.66	0.513
LSOA or larger	75	10	$F_{1,73}=0.13$	-	-	0.723
≤ LSOA	32	5	1	-	-	-
>LSOA	43	5	0.96 (0.78-1.19)	0.11	-0.36	0.723
Psychosis outcome	-	-	$F_{5,69}=2.36$	-	-	0.049*
Non-affective psychosis [REF]	33	5	1	-	-	-
Subclinical psychosis experiences	13	3	0.97 (0.80-1.17)	0.10	-0.32	0.753
Antipsychotic prescriptions	16	1	1.02 (0.84-1.25)	0.10	0.23	0.817
Any psychosis	4	1	1.66 (1.22-2.27)	0.16	3.26	0.002*
Affective psychosis	5	2	1.04 (0.84-1.30)	0.11	0.39	0.695
Other psychoses	4	1	0.97 (0.78-1.22)	0.11	-0.23	0.818
Clinical or non-clinical outcome	75	10	$F_{1,73}=0.44$	-	-	0.444
Clinical	62	7	1	-	-	-
Non-clinical	13	3	0.92 (0.73-1.15)	0.12	-0.77	0.444
Crude minority groups	-	-	$F_{6,68}=6.86$	-	-	<0.001*
Other ethnic group [REF]	19	3	1	-	-	-
Asian	11	4	1.19 (0.98-1.45)	0.10	1.82	0.074
Black	17	7	1.71 (1.43-2.03)	0.09	6.13	<0.001*
Combined ethnic minority group	2	1	1.17 (0.83-1.65)	0.17	0.93	0.355
Combined migrant group	5	2	1.09 (0.86-1.39)	0.12	0.72	0.476
Other social characteristic	14	2	1.09 (0.87-1.37)	0.12	0.74	0.463
White other	7	3	1.23 (1.03-1.48)	0.09	2.32	0.024*
Minority group allocation	61	10	$F_{1,59}=0.60$	-	-	0.443
Birthplace of individual or parents	44	5	1	-	-	-
Self-ascribed ethnic minority	17	5	1.08 (0.88-1.33)	0.10	0.77	0.443

* $p < 0.05$

Sensitivity analyses

Leave-one-out analysis indicated that removing each study produced negligible changes to the overall pooled effect (Table 3). This was also the case when the 75 effect sizes within the studies were individually removed (see Supplemental 8).

Table 3. Effect sizes by study and leave-one-out analysis

Study, Setting	Minority groupings: crude group (specific group)	Study quality	Pooled OR (Lower 95% CI–Upper 95% CI)	Pooled OR (Lower 95% CI – Upper 95% CI) if study removed	p value if study removed
All studies (n=10)	-	-	1.20 (1.09-1.32), <i>p</i> <0.001	-	-
Bécares, Nazroo & Stafford (2009), UK	Black (Black Caribbean) Asian (Indian, Pakistani, Bangladeshi)	14	1.04 (0.84-1.27)	1.22 (1.10-1.35)	<0.001
Das-Munshi, Bécares, Boydell et al., (2012), UK	Black (Black Caribbean) Asian (Indian, Pakistani, Bangladeshi) White other (Irish)	15	1.63 (0.87-3.05)	1.20 (1.08-1.33)	0.001
Dykxhoorn, Lewis, Hollander, Kirkbride & Dalman (2020), Sweden	Black (Sub-Saharan African) Asian (Asian) Other ethnic group (Middle Eastern & North African, North American, South American) White other (Nordic, Non-Nordic European)	14	1.25 (0.51-3.06)	1.20 (1.08-1.34)	0.001
Menezes, Georgiades, & Boyle (2011), Canada	Combined migrant group (Combined migrant group)	11	1.12 (1.05-1.19)	1.20 (1.09-1.33)	<0.001
Richardson, Hameed, Perez, Jones & Kirkbride (2018), UK	Combined ethnic minority group (Combined ethnic minority group)	12	1.16 (1.00-1.36)	1.20 (1.09-1.34)	0.001
Schofield, Ashworth & Jones (2011), UK	Black (Black or Black British)	11	1.94 (1.34-2.82)	1.15 (1.08-1.23)	<0.001
Schofield, Das-Munshi, Bécares et al., (2016), UK	Black (Black African, Black Caribbean) Other social characteristic (Deprived or disadvantaged, single marital status)	11	1.45 (0.81-2.57)	1.21 (1.09-1.34)	0.001
Schofield, Thygesen, Das-Munshi et al., (2017), Denmark	Black (African) Asian (Asian) Other ethnic group (Middle Eastern) White other (Non-Scandinavian European)	12	1.28 (0.94-1.75)	1.19 (1.07-1.33)	0.002
Termorshuizen, Heerdink & Selten (2018), The Netherlands	Black (Antillean) Other ethnic group (Turkish, Moroccan, Surinamese)	11	1.49 (0.96-2.34)	1.19 (1.06-1.33)	0.005
Zammit, Lewis, Rasbash, Dalman, Gustafsson & Allebeck (2010), Sweden	Combined migrant group (Combined migrant group) Other social characteristic (Deprived or disadvantaged, socially fragmented, low grades)	13	1.07 (0.92-1.24)	1.25 (1.15-1.36)	<0.001

Figure 2. Forest plot of the association between a ten percentage-point decrease in group density.

Discussion

Summary

This is the first review to provide quantitative evidence that the risk of psychosis posed by lower own-group density areas is not uniform across minority groups. Overall, a ten percentage-point decrease in own-group density was associated with a 20% increase in risk of psychosis, but this effect was strongly moderated by minority group.

Comparisons with previous reviews

Our overall pooled effect was similar in magnitude to a previous within-groups meta-analysis¹⁶ but weaker than one examining between-group effects¹⁰. However, contrary to previous analyses¹⁶, we observed a strong moderating effect of minority group, particularly when more fine-grained classifications were tested.

In line with previous narrative reviews^{10,17}, we observed the strongest group density associations in Black individuals. A significant interaction was also found in the White Other group, driven by strong associations in Non-Scandinavian European individuals in Denmark⁴⁹. A reverse relationship was noted in South American migrants to Sweden⁴⁷. Such heterogeneity in effect sizes may reflect distinctive social experiences of specific minority groups^{8,11}.

Limitations

It is important to consider these findings in light of their limitations. Our moderator analyses relied on classifying groups, which required judgements about how to combine them. We sought to be as non-arbitrary as possible by using UK census classifications and author definitions. However, UK studies tended to use self-ascribed ethnicity, whilst studies in Canada, the Netherlands, Denmark, and Sweden classified groups by birthplace. Thus, synthesising these studies is inescapably complicated.

To address variability in how studies quantified group density exposures, effect sizes were standardised to reflect a ten-percentage point decrease in group density. However, this may have been an extrapolation for some smaller minority groups.

There are also broader issues of temporality and consistency in the evidence-base, which are key criteria for assessing causation in epidemiological studies^{55,56}. Most reviewed studies were conducted in similar settings and were cross-sectional, making it impossible to infer causation¹⁴.

Proposed mechanisms

The attenuated risk and impact of racial harassment experienced by minority groups in higher own-group neighbourhoods, has been proposed as a key mechanism underpinning group density interactions^{11,29,30}. Evidence from Europe and the USA suggests that visible minorities⁴⁷, particularly Black individuals, are at especially high risk of experiencing discrimination and coercive pathways to

psychiatric treatment^{7,11,57,58}. Evidence suggests that minorities living in lower-own group density areas also anticipate more discrimination from healthcare services³⁰. Combined with findings that ethnic minorities experience greater mental health-related stigma⁵⁹, this may exacerbate delays in help-seeking⁶⁰ and has important implications for early intervention services.

Factors such as demographic change may moderate exposure to racism, but there is limited examination of this in the context of group density interactions. Some evidence indicates that changes to neighbourhood ethnic composition can drive anti-immigration sentiment, especially areas that have experienced rapid rates of change^{61–63}. The perceived loss of power associated with the prospect of becoming a minority has been suggested to drive majority group individuals' exclusionary and hostile treatment of minorities^{37,64}. As such, some minority groups may in fact be at elevated risk of psychosis in newly high ethnic density areas. This may explain detrimental effects of own-group density observed in some populations^{29,33,47}.

Deprivation

In addition to overt discrimination, disproportionate poverty, or the propensity to 'drift' into more deprived areas were assumed to be key drivers of the excess psychosis risk in ethnic minorities^{65,66}. However, ethnic density associations tend to persist after adjustment for deprivation. Furthermore, given that areas with a high density of ethnic minorities are often more deprived⁶⁷, any residual confounding might be expected to operate in the opposite direction to density effects in minority groups^{10,16}. There is, however, evidence that social drift prior to diagnosis may artifactually produce ethnic density associations in *majority* groups³⁹ which may explain between-group density effects¹⁰ appearing larger than within-group effects¹⁶.

Social capital

Social capital is thought to have a key role in the protective effects of own-group density^{11,35}. It has been defined as "connections among individuals – social networks and the norms of reciprocity and trustworthiness that arise from them" (p.19)⁶⁸. The increased access to social capital garnered by minorities living in high own-group areas is proposed to weaken the impact of social adversity such as discrimination^{11,29} and deprivation⁶⁹. There is evidence that the association between social capital and psychosis risk is non-linear, with neighbourhoods characterised by high and low levels of social capital conferring the highest risk of psychosis³⁶. High social capital, particularly bonding social capital⁶⁸ may increase risk in individuals who experience or perceive exclusion from the networks that it represents⁷⁰, such as ethnic minorities in lower own-group density areas³⁶.

Migration and acculturation

Studies have indicated that the stress of migration and adapting to the host culture contribute to the excess risk of psychosis in minorities, though this risk may be reduced in those who speak the host

language and have higher educational and employment prospects^{4,7}. Whilst we did not find moderation by country, there is some evidence to support this notion, with some studies finding lower psychosis prevalence and weaker or absent group density associations in studies in Canada⁵² and Australia⁵³, countries where immigration policy gives preference to individuals with these characteristics.

Factors related to low acculturation (*e.g.* majority language ability) are more prevalent in first-generation migrants than in their children, who are generally more assimilated with the host culture^{8,47,71}. Recent evidence suggests that linguistic factors confer greater risk of psychosis in first-generation migrants, whilst social disadvantage⁷² and the stress of alienation from both identities (marginalisation) or rejecting culture of origin in favour of the host culture (assimilation) are proposed social processes underpinning risk in subsequent generations^{50,71,73}. Generational differences in the group density effect could therefore shed light on the processes driving the increased risk, however, to date literature examining this is mixed^{16,47,50} and there were too few studies reporting effects stratified by generational status to allow for meaningful moderator analysis in the present review.

Pathways to psychosis

Both material and psychological processes drive the risk of low-own group density and these factors are not mutually exclusive. Material processes refer to factors preventing individuals from accessing the resources and capacities required for achieving autonomy^{74,75}, *e.g.* individuals who do not speak the majority language may find it harder to find work or access appropriate mental health services in low own-group density areas⁶⁰. Disempowerment also arises from deliberate attempts to exclude minority groups and restrict their access to protective aspects of the social environment^{57,75}. This explains why density effects are observed in marginalised groups including ethnic minorities^{10,16,17}, isolated single people^{28,41}, people with deprived social status^{28,46}, and LGBTQ+ individuals¹², while there is evidence that minority groups with a greater share of power do not experience the same degree of risk to their mental health^{4,76}. The present review did not find a significant pooled effect for minorities defined by other social characteristics; however, this could reflect the limited number of studies including such samples. Psychological processes relate to the mental consequences of belonging to a disempowered group. There are several theoretical frameworks for conceptualising the psychological sequelae of marginalised minority group membership, including the minority stress model⁷⁷, social defeat⁷⁸, and social identity theory^{79,80}.

These mechanisms may be especially important in the aetiology of psychotic disorders given that group density interactions appear to have a degree of specificity to psychosis^{16,17}. While the evidence is limited, negative evaluations of one's self and others⁸¹ (which are exacerbated by experiences of racism), appear to have a unique role in paranoia, but not hallucinations^{80,82}. Supporting neurobiological evidence from non-clinical samples has indicated that Black individuals in lower own-group density areas perceive greater social threat in response to White faces⁸³, shedding

light on a possible pathway to paranoia⁸³. Conversely, the social deafferentation hypothesis suggests that social isolation has stronger links with hallucinations⁸⁴. As such, perhaps the former is a more common pathway in Black individuals, and the latter has more of an impact on groups who experience greater linguistic and cultural barriers *e.g.* first-generation migrant groups^{47,51,72}.

These social processes highlight the importance of contextualising psychotic experiences in minority groups and considering to what extent these are understandable responses to chronic experiences of discrimination and social exclusion⁸⁵.

Implications

There has been limited discussion of the implications of group density findings, particularly with regards to policy. This is understandable given that these findings could be viewed as arguments in favour of ethnic segregation. However, residential segregation has instead been associated with *poorer* general health^{54,86}. Further, it is plausible that the risks associated with low own-group density areas are a manifestation of disempowerment experienced by that group and as such, the effect might be attenuated if minority groups experienced less social disadvantage. To appropriately address these issues, the underpinning individual-level and systemic factors must be examined⁸⁷.

It has been argued that focusing on assimilating migrants into host cultures exacerbates the dominant culture's 'othering' of minority groups⁸⁸, creating greater disconnect between their parental and host cultures⁵⁰ which is likely to have unfavourable mental health consequences^{50,71}. As an alternative, strategies to create cross-cutting identities may be efficacious in increasing access to protective bridging social capital^{70,89}. Establishing positive intergroup contact may be especially challenging for individuals prone to psychosis, who may be more likely to perceive others as a threat⁹⁰, however, facilitating positive contact may help foster stable social identities, in terms of minority groups' connectedness with both their cultural group and wider community⁵⁰. That said, creating the social conditions to enable minorities to form strong civic identities and access bridging social capital will only be achieved by systemic changes to reduce community-level social inequality and crucially, the structural racism which sustains inequities in the social, economic, and living circumstances of minority groups^{7,87}.

As well as these wider systemic issues, useful targets for clinical intervention might include strategies to improve clinicians cultural competency^{87,91} and understanding of the disempowerment experienced by minority groups, and this may be amplified in low own-group density areas. Therapeutic approaches that aim to develop strong social identities might also be efficacious.

Future research

The logic of group density designs assumes that individuals living in low and high own-group density areas can be straightforwardly compared¹⁴. Given that the reasons for large minority group populations in particular areas are not arbitrary, rather linked with factors such as family, housing

cost, and employment⁴, this makes it difficult to disentangle the contextual and compositional effects⁹² of own-group density. There is a clear need for longitudinal designs¹⁷ and demonstrations that associations persist across different settings and time periods⁴.

The present review suggests that the group density effect is complex and appears to vary by minority group, with the strongest associations observed in Black populations specifically. To substantiate our findings, more studies examining specific ethnic minorities are required. Future work should also test for group density associations in minorities defined by other characteristics. In addition to epidemiological studies, proposed avenues for future research should be explored using different methodologies, such as qualitative interviews⁹³, experience-based approaches⁹⁴, neurobiological studies⁸³, and VR⁴⁴ to better capture the subjective experiences driving group density effects.

Conclusions

We provide meta-analytic evidence that the risk of psychosis posed by lower own-group density environments is not uniform across groups and is particularly marked in Black populations. Group density designs are a powerful tool for identifying health inequalities, but methodological refinements to improve causal inference and identification of mechanisms would be welcome.

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