TITLE

Do greater neighbourhood fragmentation and crime explain physical victimisation in men and women with mental health problems?

AUTHORS

Vishal Bhavsar[1]

Jyoti Sanyal[2]

Rashmi Patel[3]

Hitesh Shetty[2]

Sumithra Velupillai[2]

Robert Stewart[2, 4]

Matthew Broadbent[2]

James H. MacCabe[3]

Jayati Das-Munshi[2, 4, 5]

Louise M. Howard[2]

AFFILIATIONS

1.King's College London, Department of Health Services and Population Research, London SE5 8AF

2.South London and Maudsley NHS Foundation Trust, Biomedical Research Centre, Maudsley Hospital, London SE5 8AZ

3.King's College London, Department of Psychosis Studies, London SE5 8AF

4.King's College London, Department of Psychological Medicine, London SE5 8AF

5.Centre for Society and Mental Health, King's College London

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ABSTRACT

Background: How the level of fragmentation and crime in neighbourhoods affects the physical safety of people with mental illness is unclear. **Aim**: To examine neighbourhood effects on physical victimisation towards people using mental health services. **Methods**: We developed and evaluated a machine-learning derived free-text based natural language processing (NLP) algorithm to ascertain clinical text referring to physical victimisation. This was applied to records on all patients attending NHS mental health services in Southeast London. Sociodemographic and clinical data, and diagnostic information on use of acute hospital care (from Hospital Episode Statistics, HES, linked to CRIS), were collected in this group, defined as cases, and concurrently-sampled controls. Multi-level logistic regression models estimated associations (odds ratios, ORs) between neighbourhood fragmentation, and neighbourhood crime, and physical victimisation. **Results**: Based on a human-rated gold standard, the NLP algorithm had a positive predictive value of 0.92 and sensitivity of 0.98 for (clinically-recorded) physical victimisation. A one standard deviation increase in neighbourhood crime was accompanied by a 8% increase in odds of physical victimisation in women and an 13% increase in men (aOR for women: 1.08, 95%CI: 1.01,1.15, aOR for men: 1.13, 95%CI: 1.06,1.20, p for gender interaction, 0.34). Although small, adjusted associations for neighbourhood fragmentation appeared greater in magnitude for women (aOR: 1.05 (95%CI: 1.01, 1.10) than men, where this association was statistically significant (aOR: 0.99, 95%CI: 0.95,1.03). **Conclusions**: Neighbourhood factors influencing safety, as well as individual characteristics including gender may be relevant to understanding pathways to physical victimisation towards people with mental illness.

INTRODUCTION

Physical violence is a common and preventable cause of morbidity and mortality in people mental illness[1] and negatively impacts quality of life and treatment response[2]. A 2016 systematic review of 30 studies found strong association of severe mental illness with victimisation in both men and women, in comparison with the general population[3]. Large register-based epidemiological studies in USA[4], Sweden[5], and Denmark[6] confirm association between mental disorders and subsequent experience of violent crime. The WHO *ecological* framework emphasises neighbourhood and community context, alongside victim and perpetrator characteristics, in the occurrence of violence[7]. One important characteristic of neighbourhoods, neighbourhood deprivation, is associated with occurrence of mental disorders, including psychosis[8] and depression[9]. It has also been suggested that public mental health may be improved by nurturing neighbourhood social networks and local reserves of material resources, support, and trusting relationships accessible by people when they experience stress, adversity and disadvantage[10]. A construct that captures these aspects is *neighbourhood fragmentation*, defined as the degree of social disorganization, residential turnover, and relationship breakdown in a neighbourhood. Fragmented neighbourhoods may display greater occurrence of severe mental illness[11, 12], after accounting for individual characteristics[13]. There has been limited study of the impact of neighbourhood fragmentation on victimisation in mental illness.

Victimisation displays important gender differences; in the general population, men experience greater physical victimisation than women, while violence in domestic settings affects more women than men[14]. Although access to social support is proposed to influence risk of victimisation in people with mental illness,[15] it has been suggested that social networks and neighbourhood conditions may be especially important for safety of women[16-18]. Identifying risk factors for physical victimisation in mental illness may provide avenues for developing effective interventions. In surveys of the general population, physical victimisation is associated with individual characteristics such as younger age, minority ethnicity, single marital status, and use of drugs and alcohol, but also with neighbourhood deprivation[19], and population density[20]. Victimisation is also influenced by the availability of settings where violence may more easily occur, the likelihood of interacting with a possible perpetrator, and the local presence of risk factors for violence. The rates of crime in a neighbourhood has therefore been evaluated as a risk factor for victimisation in the general population[21]. However neighbourhood fragmentation and neighbourhood crime have not yet been examined as influences on physical victimisation in people with mental illness. Previous epidemiological investigations have typically used participant interviews, routine data, and surveys to ascertain physical victimisation, with each method introducing possible differential under-ascertainment of all physical victimisation affecting the population[22]. Physical victimisation identified by *clinical* services, e.g. during patient assessments and history-taking, could reflect incidents not collected through other sources, and strengthen evidence for interventions to improve patient safety. We examined neighbourhood effects on physical victimisation towards people using mental health services, testing gender-specific associations with neighbourhood characteristics within a multilevel conceptual framework. We hypothesised an association between neighbourhood fragmentation with physical victimisation in people with mental illness, and stronger effects in women compared to men. Secondarily we hypothesised that neighbourhood crime would be associated with physical victimisation in both men and women.

METHODS

Data source

The study was carried out in accordance with the RECORD statement[23] (see supplement for checklist). We did a case-control study using two linked databases, one containing mental health records and another containing hospitalization data. We used a natural language processing (NLP) algorithm, developed and evaluated for the purposes of this study to define cases and controls. Algorithm development and evaluation is described further in the methodological supplement. The first data source for this study was the South London and Maudsley Biomedical Research Centre Clinical Record Interactive Search (CRIS) system, comprising complete de-identified electronic health records from the comprehensive NHS mental health care provider in South East London, offering services for residents of the London boroughs of Lambeth, Southwark, Lewisham, and Croydon (comprising a total population of around 1.2 million[24]). The register included data from clinical free text entered by clinicians, documents of clinical correspondence, structured fields for scales/questionnaires and sociodemographic data, since 2006 for all SLaM services. The CRIS database has been linked to the Hospital Episode Statistics Admitted Patient Care (HES APC) dataset, a comprehensive record of all NHS hospital inpatient admissions in England since 2014[25]. These linked data were used to provide information on use on inpatient medical care for victimisation. Alongside the NLP-derived definition of cases (described further below) we also inspected associations with a case definition based on HES admission for assault, drawn from linkage with the HES-APC dataset. The aim of using hospital admission cases was to check if associations with the NLP case definition were consistent in their magnitude/direction, when using a different case definition (incorporating HES data). See Figure 1 for a flow diagram summarising the linked databases and flow of participants through the study.

Consent

All individual data was anonymous. Therefore, informed consent from participants was not sought.

Identification of physical victimisation cases and controls

The algorithm was applied to CRIS (May 15th 2017; 284,272 individual patient records). The algorithm generated a binary variable for each participant, for any clinical documentation of physical victimisation, occurring at any time in a person's lifetime (and recorded in clinical records from 2006). This variable was used to ascertain people with a very high probability of lifetime physical victimisation, who were defined as cases. For each case, ten controls, defined as participants who were not identified with physical victimisation by NLP, with referral dates falling within one year of the corresponding case, were also randomly sampled. This was in order to optimise power to detect possibly small associations. Linkage of CRIS with medical inpatient data from hospital episode statistics (HES) data for England and Wales had been previously established and is described elsewhere[24]. We used this linkage to examine the case definition for our analyses. To identify admissions for victimisation, we used these linked data to identify the presence of at least one hospital admission involving ICD-10 codes for assault, which were: X85-99, Y00-Y04, and Y08-Y09. The diagnostic codes included in the HES definition of hospital admission for physical victimisation for this study are displayed in Supplementary material (table S2).

Neighbourhood characteristics

Addresses at which cases and controls were residing at the time of referral to mental health services were used to derive information on neighbourhood characteristics. All neighbourhood characteristics were taken at the geographic level of the 2011 lower super output areas (LSOA), which are small geographic units enclosing an average of 1500 residents. Neighbourhood crime was measured using the index for multiple deprivation crime domain for 2010[26]. Neighbourhood fragmentation was measured using the Congdon Index for neighbourhood fragmentation[27], a composite indicator based on 2011 data on population turnover, percentage of privately rented households, single person households, and unmarried persons. Neighbourhood socioeconomic status was measured using the income deprivation domain of the index for multiple deprivation 2010. We also assessed impact of including overall neighbourhood deprivation, rather than neighbourhood income deprivation, on estimates. Population density was measured using persons per hectare, based on census data from 2011. All neighbourhood characteristics data were positively scaled (i.e. greater scores indicating greater crime, fragmentation, and income deprivation, respectively), and z-standardized for ease of interpretation of estimates, to reflect a mean of 0 and a standard deviation of 1. The measurement of other analysed variables is described in the methodological supplement.

Analysis

Analyses were carried out in STATA 14. We described counts, proportions, and chi-squared tests of physical victimisation with age at referral (categorised for descriptive purposes into age groups 0-15, 16-24, 25-35,36-50, and 51 and older), gender, ethnic group, marital status, primary diagnosis, the presence of comorbid drug or alcohol use disorders, and any record for hospital admission for physical victimisation in HES. Crude associations of physical victimisation with neighbourhood characteristics (neighbourhood fragmentation, neighbourhood crime, neighbourhood income deprivation, and population density) were described by comparing medians, means, and t-tests. The correspondence of NLP-derived physical victimisation with hospital admission data was assessed by calculating the proportion of cases with at least one hospital admission for physical victimisation, and by reporting this proportion within strata of covariates included in this study, including neighbourhood characteristics.

We then modelled association between neighbourhood fragmentation and neighbourhood crime, and physical victimisation, based on the NLP algorithm. Because all neighbourhood characteristics were z-standardized (that is, set to have a mean of 0 and standard deviation of 1), all logistic regression model coefficients for neighbourhood characteristics reflected the relative change in odds of physical victimisation for an increase of one standard deviation in the neighbourhood predictor. To evaluate collinearity affecting the stability and precision of model estimates, crude correlations among neighbourhood characteristics were evaluated using pairwise correlation coefficients and presented in a matrix (see table S2). Continuous variables were not entered in models together if the pairwise correlation between the two variables was greater than 0.7. All continuous covariates were assessed for goodness of fit as linear, quadratic and categorical indicator terms (in quintiles) using the Bayes Information Criteria. In order to account for the clustering of neighbourhood characteristics within individuals residing in the same neighbourhoods, all models included a neighbourhood (LSOA)-level random effect, using the melogit command in STATA, and were estimated using robust standard errors. In primary analyses, age, gender, a multiplicative interaction term for gender, marital status, and ethnic group were included in final models as forced covariates. Diagnostic group, comorbid drug or alcohol use disorders, population density and neighbourhood per cent non-white were evaluated for inclusion in final models, so as to maintain parsimony of the model. These covariates were included only if their inclusion changed the estimate by greater than 10% compared to the crude association[28]. Population density was left out of models, on this basis. Having identified covariates for inclusion in the final model, adjusted estimates were reported by estimating random effects logistic regression models including a. only neighbourhood fragmentation and neighbourhood crime, b. adding only individual level covariates, c. by adding only neighbourhood covariates, and d. including all variables in order to arrive at a fully-adjusted estimate. All models employed linear combinations estimating gender-specific associations between neighbourhood fragmentation, and neighbourhood crime, and physical victimisation, and we reported model estimates associations for women, and post-estimation fitted estimates for the association in men. Finally, we estimated absolute risk differences for a difference in one standard deviation from the mean, for neighbourhood fragmentation and neighbourhood crime by gender, based on final model estimates. Missing data on all variables included in final models were described by case-control status, and missing data proportions compared.

RESULTS

Descriptive results

We identified 7213 users of mental health services with a history of physical victimisation based on the natural language processing algorithm described, giving an overall prevalence of 2.5%. A total of 72130 concurrently sampled controls, without recorded physical victimisation, indicated association of physical victimisation with younger age, male gender, black and mixed ethnic group, and single and divorced marital status (all $p<0.001$, see table 1). Individuals with physical victimisation were most commonly diagnosed with psychotic disorders (20.4%) and mood disorders (16.3%). Based on HES-linkage, 8.8% of those identified as cases through natural language processing experienced at least one hospital admission for physical victimisation (table 1).

Case status was associated with greater neighbourhood fragmentation, higher neighbourhood crime, and higher neighbourhood income deprivation, compared to controls (all $p<0.001$, table 2). Compared to controls, NLP-defined cases who also experienced hospital admission for physical victimisation were more commonly from younger age groups, male, of single marital status, diagnosed with comorbid alcohol and drug use disorders, and resided in neighbourhoods with higher neighbourhood fragmentation and neighbourhood crime, and lower neighbourhood income deprivation (table S3).

Pairwise correlations all suggested low or moderate correlation among neighbourhood fragmentation, neighbourhood crime, neighbourhood income deprivation, and neighbourhood per cent ethnic minority (see table S4). Associations of each covariate with physical victimisation did not vary when using a more restrictive outcome definition, based on the presence of both the NLP case definition and hospital admission for physical victimisation (see table S5).

The associations of neighbourhood fragmentation and neighbourhood crime with physical victimisation

Table 3 presents partially- and fully-adjusted model estimates for women and for men, all based on 44475 individuals with complete data on modelled variables, clustered in 2794 lower super output areas. For women, neighbourhood fragmentation was associated with 7% higher odds of physical victimisation, which attenuated to 5% (OR: 1.05, 95%CI: 1.01,1.10) on adjustments, and neighbourhood crime was associated with 22% higher odds of physical victimisation, brought down to 8% after adjustments (OR: 1.08,95%CI: 1.01,1.15, see table 4). In men, there was a close to null association of neighbourhood fragmentation with physical victimisation after all adjustments (OR:0.99, 95%CI:0.95,1.03) . The point estimate for association of neighbourhood crime with physical victimisation for men suggested similar estimate to those for women (OR: 1.11,95%CI: 1.04, 1.17). Our hypotheses focused on the possible different associations between neighbourhood fragmentation and crime with victimisation between men and women. Therefore, we did not produce estimates pooled across the genders in the primary analysis, but report final model estimates pooled across men and women in supplementary table S6. Estimates were unchanged when we included neighbourhood deprivation, rather than neighbourhood income deprivation in final models. Absolute risk differences ranged from -0.10% (95%CI: -0.58, 0.38) for neighbourhood fragmentation in men, to 1.31%(95%: 0.64, 1.98), for neighbourhood crime in men.

Covariate model estimates

Neighbourhood income deprivation (OR: 1.08, 95%CI: 1.03, 1.13) was associated with physical victimisation in the final model. Among individual level covariates, statistical associations with physical victimisation were evident in final models for younger age, male gender, both Mixed and Black ethnic groups (compared to the White reference group), divorced or separated marital status (compared to the single reference group), psychotic, mood, personality, and learning disability diagnostic groups (compared to the organic syndromes reference group), and the presence of a comorbid drug and alcohol use disorders (see table 4).

Missing data

Complete data was included in models from 44475 individuals. Age and gender were missing in less than 1% of both cases and controls (table S7). Controls had lower proportions of missing data than cases for ethnic group, marital status, and diagnosis. Missing data on neighbourhood fragmentation was between 10 and 15% for both cases and controls, and between 5% and 7% for other neighbourhood characteristics. Crude associations between case-control status and both neighbourhood crime and neighbourhood fragmentation with groups with missing data on each covariate were between 0.98 and 1.24, consistent with final estimates in this study.

DISCUSSION

Summary of findings

We present the first, to our knowledge, multilevel examination of neighbourhood associations with physical victimisation in people with mental illness, ascertained through natural language processing. In accordance with our hypothesis, we found evidence for association between neighbourhood fragmentation and physical victimisation among women, but not men. In contrast, neighbourhood crime remained associated with physical victimisation in both women and men, after accounting for individual characteristics and neighbourhood income deprivation. Physical victimisation in people using mental health services was associated with younger age at referral, male gender, and non-white ethnic group, diagnosis of psychotic, mood, and personality disorders, and comorbid drug and alcohol use disorders[14].

Explanation of findings

Our results suggest that while neighbourhood crime may influence physical victimisation in both men and women (after accounting for individual level factors and neighbourhood material deprivation), fragmentation is associated with physical victimisation in women, but not men, consistent with a small number of general population studies[16, 29-31]. Fragmented neighbourhoods are considered to offer more limited support structures at times of stress, need, and privation, including access to third sector support services. They may also offer fewer opportunities for meaningful activity, coping, safe physical activity, and safe routines, which may all be necessary for maintaining personal safety. Neighbourhoods with greater levels of crime, antisocial behaviour, and rule breaking may also contain greater prevalence of perpetrators liable to commit crimes, including crimes towards people with vulnerabilities. It is possible that neighbourhood patterning of violent behaviour is one explanation for associations reported in this paper. This violence could be more likely to occur outside the home, consistent with the gender differences observed in this study. On the other hand, violence against women with mental illness could be specifically driven by factors influencing the ability to access support, help, advocacy, and resources in the wider community, partly reflected in the neighbourhood fragmentation variable investigated in this study. This is consistent with some literature on gender differences in neighbourhood associations with violence in the general population. In a study focusing specifically on dating violence, rather than any physical violence, Jain et al[16] found that neighbourhood factors (concentrated poverty, perceived violence, collective efficacy) were more strongly associated with physical victimisation in men, than women. Cunradi and others[18] examined the association of neighbourhood poverty with intimate partner violence, finding statistical evidence remained after adjusting for income, marital status, number of children, educational attainment, and socioeconomic status of both the victim and perpetrator. Although we were not able to distinguish between domestic and other types of violence in this study, it is possible that the observed neighbourhood differences between genders was related to neighbourhood factors being relevant to different types of physical victimisation. In the general population, most violence occurs within the home, and in the context of intimate and family relationships. De Mooij et al examined the occurrence of victimisation in a Dutch outpatient sample of people with severe mental illness, which identified housemates as the most common perpetrators of victimisation (21%), followed by neighbours, with a prevalence of 16%; although we had no information on the identity of perpetrators in this study, it is possible that neighbourhood patterns we observed were explained partly by an association between neighbourhood crime and the prevalence of perpetrators with propensity to be violent in each neighbourhood.

In the general population, routine activities theory has been proposed to explain observed neighbourhood variation in the occurrence of physical victimisation. This model suggests that physical victimisation occurs as a result of perpetrators and vulnerable would-be victims coming together in spaces which are poorly supervised, and where perpetrators may perceive there to be a lower risk of getting caught[32]. The association we reported for neighbourhood fragmentation persisted after taking account of neighbourhood crime, suggesting that social networks and access to support could be relevant in protecting individuals from physical victimisation. More fragmented neighbourhoods may reflect weaker community structures allowing residents to live safely. It may be more difficult in fragmented neighbourhoods for people with existing vulnerabilities to access support that may protect against experiencing violence. It is also possible that other area characteristics, not measured in the current study, could account for the associations we observed. For example, research suggests geographic variation exists in gender norms, beliefs which condone domestic violence[33-35], and stigmatizing attitudes towards people with mental illness[36, 37]; neighbourhood patterns in violence towards people with mental illness observed in this study could reflect regional differences in attitudes.

Strengths and limitations

Few studies to our knowledge have employed more than one method to identify or confirm physical victimisation in people with mental illness. The measurement of violence, and the possible role of gender in shaping measurement accuracy for different forms of violence, is complex[38, 39], and may call for a broad range of measurement approaches. We used natural language processing to identify cases, and investigated data from administrative linkage of mental health records data with acute medical admissions to confirm our results. In this study, we were able to demonstrate similar associations with risk factors between an NLP-derived physical victimisation measure based on clinical text, and diagnoses from acute medical inpatient admissions for the same population.

However, our focus on any clinical recording of physical victimisation in electronic health records did not distinguish between violence experienced in childhood, adulthood, or distinguish among different settings and perpetrators for violence (including identifying partners as perpetrators). Physical violence can be accompanied by other types of violence and abuse, including psychological coercion and control, financial abuse, and sexual exploitation/abuse, which were not directly assessed in this study, and may have substantial impact on health outcomes[40]. Residual confounding of our final estimates is likely, for example by family or household characteristics. The temporal relationship between physical victimisation and onset and occurrence of mental disorders could not be evaluated. Given that our study focused on neighbourhood associations, the absence of information on where instances of physical victimisation took place is also a limitation. Individuals included in this study may have been residing in areas very different to those where instances of physical victimisation actually took place, which is also a limitation to the analysis.

Both NLP and hospitalization data on physical assault used in this study likely under-ascertained the occurrence of the outcome. We found a low prevalence of physical victimisation in comparison with other studies employing self-report[41, 42]. The NLP algorithm was developed to ascertain clearly worded instances of physical victimisation in the records, in order to minimise false positives, so this is likely to represent a subset of wider cases, accounting for the low overall prevalence of physical victimisation identified. Considering the primary findings, and given that the algorithm was developed using machine learning to ascertain clinically-identified instanced of physical victimisation, it is unlikely that this misclassification was driven by neighbourhood characteristics of interest in this study. Other possible explanations for a low prevalence of recorded physical victimisation in these routine data, could be low levels of violence enquiry and disclosure in clinical settings, which have been consistently observed[43]. Perpetration of violence has also been linked to neighbourhood characteristics in previous research, however information on whether subjects were perpetrators of violence was not available in this study.

In line with previous literature on neighbourhood fragmentation and crime, we identified small effects, and absolute risk differences which ranged from -0.1% to 1.3%. The strength of statistical evidence on the association of neighbourhood fragmentation with physical victimisation was limited. The study was based on a population drawn from mental health services, and is therefore only generalizable to that group - the study did not directly investigate pathways to physical victimisation in the general population. Cases were defined through natural language processing of electronic health records, and these cases could be non-representative of the mental health service user population as a whole- for example, individuals with extensive records, such as those with more severe illnesses necessitating greater recording, could have been over-represented among the cases than the controls. Conscious or unconscious bias affecting the recording of information by clinicians cannot be excluded as an explanation for the patterns shown. Few previous studies have examined clinical recordings of physical victimisation, and this may have allowed investigation of a different population to those captured in national crime data and general population surveys, given that mental illness is associated with non-participation and non-reporting of crimes in research studies[4]. On the other hand, our findings may not be generalizable to people using mental health services experiencing physical victimisation, but where this is not identified and clinically recorded by mental health professionals.

Conclusions

Physical violence towards people with mental illness is a fundamental health and social disparity. Where a person with mental illness lives may matter for their risk of experiencing physical violence. Strengthening social organization and support in neighbourhoods could have an impact on the physical safety of people with mental illness, particularly women. Neighbourhood, as well as personal, safety factors may be relevant for understanding physical violence towards people with mental illness. Public health strategies to improve the safety of community residents with mental illness could benefit from being gender sensitive. Incorporating information on physical victimisation from a number of measurement sources may be helpful for future research.

ETHICS STATEMENT

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval for CRIS was granted by the Oxford REC, reference 18/SC/0372.

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DECLARATION OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

Analyses were carried out by VB, HS, and JS. The manuscript was finalised by LMH and VB with substantial text contributions from JS, RP, SV, and JDM, and further comments and significant input from all remaining co-authors. RS, MB also oversaw the planning and development of the SLAM BRC
Case Register.

DATA AVAILABILITY

Researcher access to data used in this study is available on application to the SLAM BRC Case Register Oversight Committee.

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AUTHOR DETAILS

[Corresponding author] Vishal Bhavsar PhD, NIHR Preparatory Fellow, Section of Women's Mental Health, IOPPN, King's College London, UK. Email address: vishal.2.bhavsar@kcl.ac.uk

Jyoti Sanyal, Clinical Informatics, BRC Nucleus, South London and Maudsley NHS Foundation Trust, UK

Rashmi Patel PhD, Academic Clinical Lecturer, Department of Psychosis Studies, IOPPN, King's College London, UK

Hitesh Shetty, Clinical Informatics, BRC Nucleus, South London and Maudsley NHS Foundation Trust, UK

Sumithra Velupillai PhD, Senior Lecturer, King's College London, UK

Robert Stewart PhD, NIHR Professor, BRC Nucleus, South London and Maudsley NHS Foundation Trust, UK

Matthew Broadbent, Clinical Informatics, BRC Nucleus, South London and Maudsley NHS Foundation Trust, UK

James H. MacCabe PhD, Professor of Epidemiology, Department of Psychosis Studies, King's College London, UK

Jayati Das-Munshi PhD, Senior Lecturer, Department of Health Services and Population Research, King's College London, UK.

Louise M. Howard, NIHR Senior Investigator, Section of Women's Mental Health, IOPPN, King's College London, UK