PsyMaptic Version 1+

Release Notes

Release Notes version 1.02

Last updated: 1st August, 2014

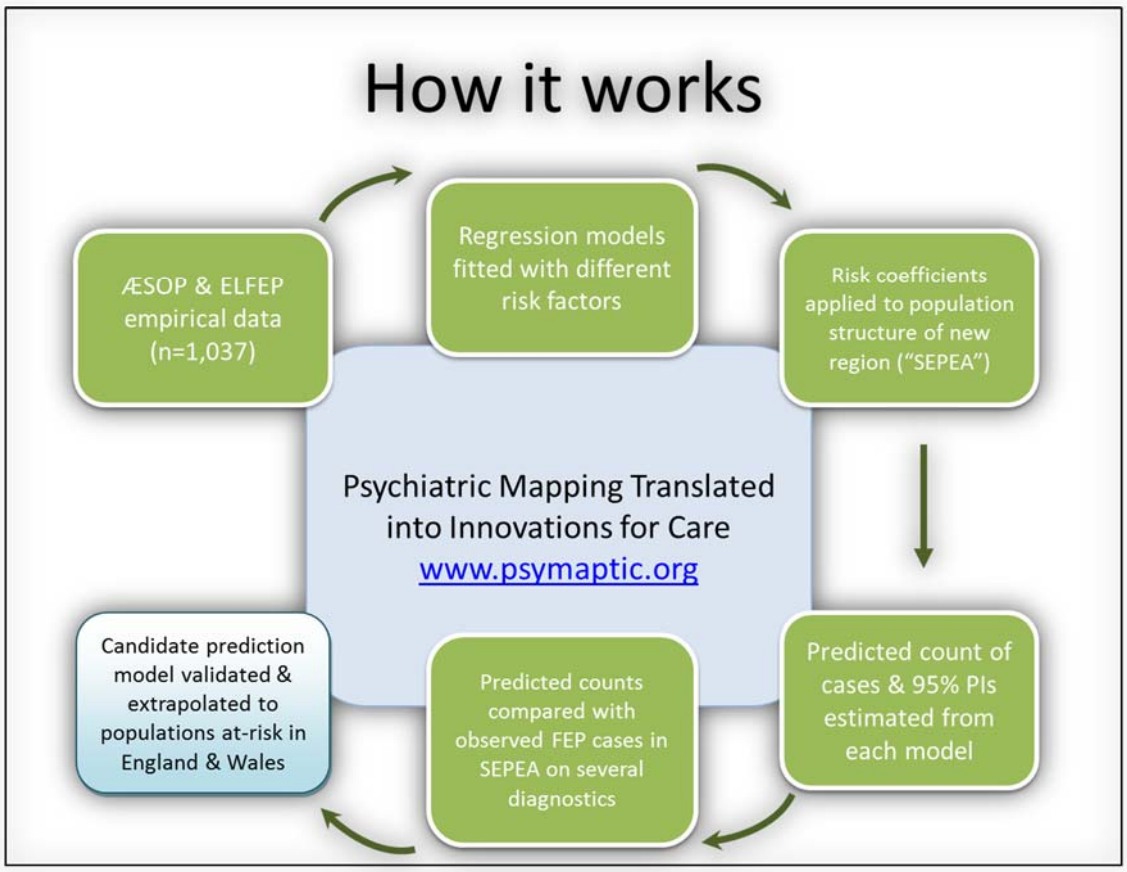
Table of Contents

1. Introduction

a. Overview

PsyMaptic uses empirical, evidence-based data from two large, major studies of first episode psychosis in England (Kirkbride *et al.*, 2006, Kirkbride *et al.*, 2008) to make predictions about the expected incidence (new cases) of such disorders in different parts of the country, based on these risk estimates and the unique population structure of different regions (local authority level), by age, sex, ethnicity and local authority level characteristics (such as deprivation or population density) (Figure 1).

Figure 1: An overview of how PsyMaptic works



AESOP: Aetiology and Ethnicity in Schizophrenia and Other Psychoses study (Kirkbride *et al.*, 2006)
ELFEP: East London First Episode Psychosis study (Kirkbride *et al.*, 2008)
SEPEA: Social Epidemiology of Psychoses in East Anglia study (Kirkbride *et al.*, 2012)
FEP: First Episode Psychosis; 95%PI: 95% Prediction Intervals

The tool currently predicts the number of new cases of first episode psychosis (ICD-10 F20-33) which would be expected to occur in England and Wales each year, based on what we know empirically about risk in different sociodemographic groups and by characteristics of people's environments.

The tool was developed to assist NHS Clinical Commissioning Groups [CCG] in planning services for people with first episode psychosis in England and Wales, including, but not limited to Early Intervention in Psychosis [EIP] services. It is free at the point of use. The tool will also be of utility to Mental Health Trusts and individual mental health services in planning both the expected number of new people developing psychotic disorder in their region per year, as well as the broad sociodemographic profile of this group.

Use of the tool should be done with caution. The models underlying the tool are based on robust epidemiological data on first episode psychosis from two major studies of more than 1000 people with disorder in England (Kirkbride *et al.*, 2006, Kirkbride *et al.*, 2008). The predictions have been validated in a third study (Kirkbride *et al.*, 2012, Kirkbride *et al.*, 2013), where we were initially able to compare the predicted numbers of people developing FEP over a 2.5 year period with the actual numbers observed via this study. This validation has now been extended to 3.5 years of observational data. External validation was possible for people aged 16-35 years old, which is where the data are most robust. We have not externally validated the tool in people aged 36-64 years old, so these predictions should be used with caution, although internal validation suggested acceptable predictions (Kirkbride *et al.*, 2013).

The tool was developed by Dr James Kirkbride while in the Department of Psychiatry, University of Cambridge. The tool development was supported by the Wellcome Trust, via a personal fellowship, and via the NIHR Collaborations for Leadership in Health Research & Care [CLAHRC]. Predictions from the tool are freely available at www.psymaptic.org.

b. Use of predictions from the tool

Users of predictions from the tool should bear in mind the following:

- **Predictions are only estimates** from statistical models. Observed numbers may differ from predictions for reasons not captured by the models.
- **Use the 95% prediction intervals when considering predictions**: these give the most likely range within which the observed number of cases are likely to fall.
- Predictions are the number of ***new*** cases of first episode psychosis per year, not the total number of cases (prevalence) in the community
- Predictions are of clinically-relevant ICD-10 first episode psychotic disorder (ICD-10 codes F20-33). Mental health services, especially Early Intervention in Psychosis [EIP] services, will be referred an additional proportion of people who require psychiatric triage, and who consume service resources, but who do not meet criteria for ICD-10 disorder. **In using our predictions to plan services, NHS Commissioners should make additional resource allowances for the proportion of people coming to EIP and other mental health services who do not meet FEP criteria**. Estimates from 6 EIP services in East Anglia suggest approximately an additional 33% of people will meet this criteria, over and above the numbers meeting criteria for FEP.
- **EIP and other services may offer additional care for people for whom our models do not make predictions.** i.e. 14 and 15 year olds, or services which provide Early Detection services (of people at ultra-high risk of psychosis) on top of care services for people in the first episode of clinically-relevant disorder. These features will need factoring in to any commissioning decisions.

2. Update methodology

a. Summary of changes

The table below shows the main differences between PsyMaptic v0.5 and v1+ For more details on these changes, read the relevant sections in this document.

Table 1: Model comparisons between PsyMaptic Versions 0.5 and 1.1

	Version 0.5	Version 1.1
Models tested	7	36
Denominator source	2009 mid-year Census estimates	2011 Census
Observation period (for validation)	2.5 years	3.5 years
Person-years at-risk (16-35 years)	1,397,305	2,021,663
Minimum level of geography	Local Authority	Local Authority
Best-fitting model covariates	Age group, sex, age*sex interaction, ethnicity, population density	Age group, sex, age*sex interaction, ethnicity, population density, extent of deprivation, quadratic for extent of deprivation
Observed FEP cases (ICD-10)	522	670
Predicted FEP cases (ICD-10) [95% CI]	508 [459, 559]	667 [610, 722]
Equivalised RMSE (EIP level)[1]	20.0	16.8
Equivalised RMSE (LAD level)[1]	8.1	6.6
EIP Correct (N=6)[2]	5	4
LAD Correct (N=21)[2]	19	19

FEP: First Episode Psychosis; 95% CI: 95% confidence interval; RMSE: Root Mean Squared Error; EIP: Early intervention psychiatry; LAD: Local Authority District

[1]RMSE gives a measure of how closely each predicted value was to the observed value, either at LAD or EIP level. Lower scores indicate better model fit. Because versions 0.5 and 1+ used different denominators, direct comparisons between the original RMSE values for version 0.5 (published in Kirkbride *et al*.(2013) and the new version 1+ were not possible, so equivalised RMSE values for model 0.5 are presented, based on the denominator used in model 1+

[2]The number of times the observed number of FEP cases (from the SEPEA study) fell within the 95% CIs of the prediction at EIP level (out of 6) or LAD level (out of 21). Both models perform equivocally at LAD level, though our new model predicts less accurately in 1 of 6 EIP than model 0.5. However, the overall RMSE scores provide better evidence of improved fit, favouring model 1+.

b. Denominator data changes

Previous versions of PsyMaptic (v0.5 and earlier) were based on 2009 mid-year Census estimates of the population at-risk, aged 16-64 years, broken down by age group, sex and ethnicity. These estimates were provided by the Office for National Statistics [ONS] and were based on the 2001 Census of Great Britain and adjusted for year-on-year births, deaths, immigration and emigration. The Census Geography used were 2009 unitary authorities.

The new version of PsyMaptic (version 1+) replaces mid-year estimates with population data estimates directly from the 2011 Census of Great Britain. This represents a significant advance in the precision of PsyMaptic predictions at local authority and national levels as the data are based on the most recent and most comprehensive survey of the population of England and Wales. PsyMaptic predictions are now based on 2011 Census Geography at Local Authority level.

Version 1.0 released these predictions at local authority and national levels.

Version 1.1 added predictions at English County level. These new prediction maps use the same predictions as for the local authority level, based on Version 1.0 models (i.e. the prediction data are unchanged), but they simply sum up predictions at county-level from all of a given county's non-metropolitan districts (i.e. Local Authorities). Because London Boroughs, Unitary Authorities (England and Wales) and Metropolitan Districts are independent of counties, predictions for these areas remain unchanged in county-level data. County level predictions are the sum of all relevant predictions for its constituent districts, with 95% prediction intervals recalculated at the county-level. County data is available in both *map* and *tabular* format.

The 2011 estimates also provide more accurate and detailed enumeration of different ethnic groups than the 2009 mid-year estimates, which allow us to better forecast the predicted number of cases of FEP which would be expected in major ethnic groups (see Section 3c). This is particularly important as the 2011 data takes into account best estimates of new migrant populations following EU expansion in the inter-decennial period between the 2001 and 2011 Censuses.

Overall the population of England and Wales, aged 16-64, rose slightly from 35.57m using 2009 estimates to 36.27m in 2011 (+2%), however the proportion of ethnic minority groups rose from 6.48m to 7.54m (+16.4%) over the same period. Given ethnic minority groups are known to be at increased risk (Cantor-Graae and Selten, 2005), this would be expected to have some impact (upwards) on the number of predicted cases in England and Wales, depending on the exact composition of groups (see Section 3).

c. Validation data & changes to the PsyMaptic algorithm

Update 1+ allows us to use more observational data from the Social Epidemiology of Psychoses in East Anglia [SEPEA] study (www.sepea.org) (Kirkbride *et al.*, 2012, Kirkbride *et al.*, 2013) to validate

our prediction models (see Table 1). SEPEA is an epidemiological study of all cases of first episode psychosis, as incepted through Early Intervention in Psychosis [EIP] services in East Anglia. Our previous versions of PsyMaptic were externally validated against observational epidemiological data obtained during the first 2.5 years of case ascertainment in this study. This led to robust predictions of the expected cases, aged 16-35 years, in the SEPEA study region compared with the number empirically observed at three levels of geography (over the entire study region, at EIP level and at Local Authority [LA] level). Our best performing model, on which previous versions of PsyMaptic were based, took into account population variation by age, sex, their interaction, ethnic group and population density (LA level).

Version 1+ uses the complete dataset available from the SEPEA study over the 3.5 year period of case ascertainment of the study. It is based on SEPEA analysis Version 20140222, which includes 665 people with clinically diagnosed FEP. Using this additional validation information, our best performing model across the three aforementioned levels of geography now incorporates more complexity, which should allow more precise predictions across England and Wales. The model includes age, sex, their interaction, ethnic group and LA population density as before. Additionally, it also includes the extent of deprivation at LA level, and a non-linear (quadratic) term to model the extent of deprivation (which gives more weight to more deprived communities). The extent of deprivation is taken from the 2010 English Indices of Deprivation. It estimates how widespread deprivation is within a local authority by measuring the proportion of the population in each LA living in the most deprived 30% of lower super output areas [LSOA] (a smaller unit of geography, containing 1500 people on average) nationally. The Extent of Deprivation is calculated on a sliding scale. It includes 100% of people in the 10% most deprived LSOA in England, 95% in the 11th percentile and 5% in the 29th percentile. Full details of this measure are given in McClellan *et al.*, (2011).

We have shown changes to external model validity in Table 1, as measured by the Root Mean Squared Error [RMSE] at EIP and LA levels. Version 0.5 of PsyMaptic predicted accurately in 5 of 6 EIP and 19 of 21 LA in the SEPEA catchment region (observed numbers from the SEPEA study fell within the 95% prediction intervals of each prediction on 5 out of 6 and 19 out of 21 times, respectively). Version 1+ has predictive accuracy in 4 out of 6 and 19 out of 21 EIP and LA, respectively. Although on face value it appears that our new prediction model performs slightly worse at EIP level than before (i.e. predicting less accurately in one EIP), the RMSE provides a better overall indicator of

predictive accuracy since it takes into account the actual distance of the observed value from the prediction. To illustrate this, consider the hypothetical example in Table 2.

Table 2: Hypothetical example of divergent predictive fit by number correct versus RMSE

Model	Observed	Expected (95% PI)	Correct?	Distance	RMSE
Model 1					
Area A	10	7 (3, 11)	Yes	-3	
Area B	40	25 (15, 40)	Yes	-15	
Overall			**2/2**	**-18**	10.8
Model 2					
Area A	10	5 (1, 9)	No	-5	
Area B	40	41 (30, 51)	Yes	+1	
Overall			**1/2**	**-4**	3.6

In this hypothetical example we see predictions from two different models in two different areas (A and B) in comparison with the observed number of cases in each area. Model 1 predicts correctly in both areas, whereas Model 2 predicts correctly only in Area B. However, a closer look at this hypothetical data shows that predictions from Model 2 are, overall, a much closer fit to the observed data. The RMSE takes into account the distance of the prediction from the observation. In Model 1, overall, predictions are 18 "cases" away from what is observed. In Model 2 this is just 4. Correspondingly the RMSEs are 10.8 and 3.6, where a lower RMSE (favouring Model 2) indicates a more precise fit to the data.

A similar pattern has occurred in our empirical dataset (Table 1). The RMSE values for Version 1+ of our model are lower (better fit) than those obtained on the same validation data using our model from Version 0.5. It should be noted that these RMSE values differ from those originally presented in Kirkbride *et al.* (2013) because that data was validated on the previous validation sample (2.5 years), using different denominator data (2009 vs 2011 estimates), which results in incomparable scales for RMSE comparison. Hence the RMSE values for Versions 0.5 and 1.1 were obtained from the same validation sample (both 3.5 years), on the same (2011) denominator, and are therefore presented as equivalised RMSE.

We were unable to externally validate our PsyMaptic models for the 36-64 year old age range because no data observational data from the SEPEA study are available for this group. Here, we estimated the *apparent* validity of our models, by reporting how closely the predictions from our models fitted the internal, empirically observed data driving the models (from the AESOP and ELFEP studies) (Kirkbride *et al.*, 2006, Kirkbride *et al.*, 2008). We used the same methodology as in Kirkbride *et al.* (2013) by applying k-fold cross-validation techniques to repeatedly randomly divide the sample into *training* and *test* datasets. The data were randomly divided into 20 samples with k-1 samples providing the training data and the k^{th} sample providing the *test* sample. Each k^{th} dataset was used as the *test* data once, and this process was repeated over 10 different randomised divisions of the dataset, leading to 200 sampling points. We obtained bootstrapped mean RMSE and Lin's Concordance Correlation Coefficient values over these 200 iterations, where RMSE assesses model fit, as before, and Lin's CCC givs an indication of the correlation between predicted and observed values. For the age range 16-64 years mean RMSE of our Version 1+ Model was 0.74 (s.d. 0.11) and Lin's CCC was 0.77 (95% CI: 0.75, 0.78). This represented a marginal improvement in apparent validity over Version 0.5 (RMSE: 0.76 (s.d. 0.13); Lin's CCC: 0.76 (95%CI: 0.74, 0.77)) (Kirkbride *et al.*, 2013) and indicated acceptable apparent validity over the entire adult age range (16-64 years old).

3. Resultant changes to Prediction Data

a. National differences in per annum predictions

The summary of changes in the predicted number of cases of first episode psychosis per year from Models 0.5 and 1+ are given in Table 3.

Overall in England and Wales there are very small changes to the number of total predicted cases, with either small or no net decrease in the number of cases expected per annum in the three age ranges included. In England we observe a 2-3% fall in the number of predicted cases per annum. Our model predictions are substantially increased for Wales (over 70% increases in each age category), although absolute numbers remain low relative to England.

b. Local authority level differences in per annum predictions

Version 1+ updates PsyMaptic predictions to use 2011 Census denominator (see Section 2b) and a more sophisticated modelling algorithm (see Section 2c). This new algorithm gives more weight to deprived areas, both urban and rural, while taking into account population density. At Local

Authority level this results in some changes compared with previous versions, which were solely based on population density (in addition to age, sex, their interaction and ethnicity, included in all models). For two areas with identical levels of urbanicity (population density) and equivalent denominator sizes, this means our algorithm would predict more cases of FEP per year in the more deprived area. The effects of this can be seen in Figure 1, and can be explored more fully online using our tool (www.psymaptic.org/prediction/psychosis-incidence-map).

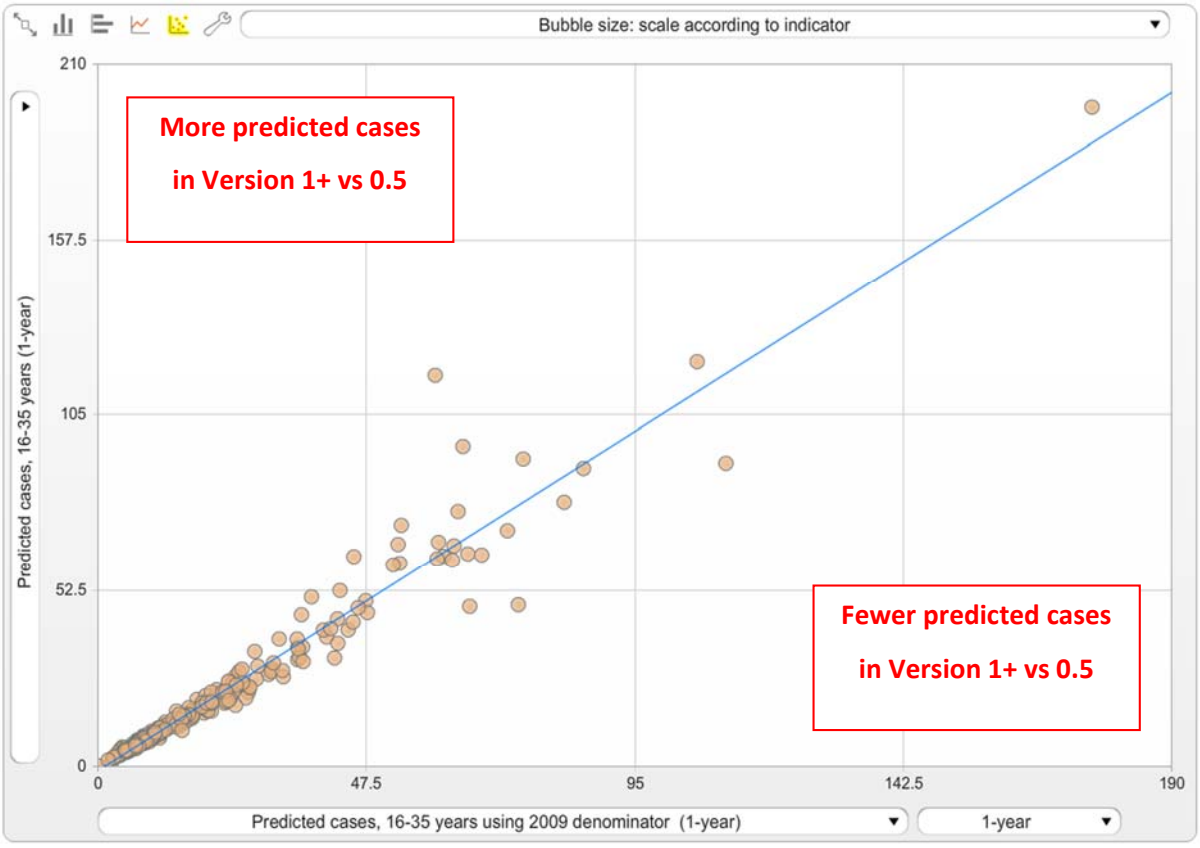
Table 3: Predicted national counts of FEP per year, 16-64 years, in different PsyMaptic versions

	Version 0.5 Predicted cases (95% PI)	**Version 1+ Predicted cases (95% PI)**	**Change -/+ to 2011 (%)**
Denominator source	2009 mid-year estimates	2011 Census	
16-64 years			
England & Wales	8745 (8558, 8933)	8686 (8493, 8874)	-59 (-0.7%)
England	8569 (8390, 8774)	8321 (8115, 8501)	-248 (-2.9%)
Wales	176 (151, 203)	304 (268, 341)	+128 (+72.7%)
16-35 years			
England & Wales	5939 (5785, 6102)	5939 (5785, 6109)	0 (0.0%)
England	5826 (5656, 5990)	5696 (5533, 5848)	-130 (-2.2%)
Wales	113 (92, 135)	196 (167, 224)	+83 (+73.5%)
36-64 years			
England & Wales	2806 (2696, 2911)	2747 (2642, 2858)	-59 (-2.1%)
England	2743 (2634, 2856)	2625 (2523, 2729)	-118 (-4.3%)
Wales	63 (48, 81)	108 (87, 128)	+45 (+71.4%)

c. Extended scope of PsyMaptic

We believe that the external validity of PsyMaptic Version 1+ is now sufficient to allow publication of predictions by broad ethnic group. Our external validation of Version 1+ in the 16-35 year old age category lead to valid predictions for 6 of the original 10 ethnic groups included in our models (see Table 4). Validity was also acceptable for two further ethnic groups (mixed white and black Caribbean and other mixed ethnicities) when amalgamated into a single category, leading to acceptable external validity in 6 out of 9 ethnic groups. The ethnic groups in which we could not establish validity were the non-white British, Indian and other ethnic group populations. We have not published predictions for these three ethnic groups separately. Overall RMSE was acceptable (18.2).

Figure 1: Changes in predicted counts of cases, 16-35 years, between PsyMaptic versions 1+ & 0.5



Legend: Predicted cases from version 1+ are plotted on the y (vertical axis) against predicted cases from version 0.5 on the x (horizontal) axis, per year in people aged 16-35 years old. Each circle represents a local authority and the blue line represents no difference between versions in predicted cases. Circles above and left of the blue line show local authorities which are predicted to see more cases of first episode psychosis under Version 1+, areas right and below the blue line will see less cases as predicted by Version 1+. This figure can be recreated at www.psymaptic.org/prediction/psychosis-incidence-map.

Table 4: External validity of predicted FEP cases by ethnic group

Ethnic group	Observed FEP	Expected FEP	Lower 95% PI bound	Upper 95& PI bound	Observed FEP within 95% PI
White British	501	453.1825	404	503	YES
White, non British	68	95.32451	75	116	NO
Black African	21	16.56341	9	24	YES
Other ethnicities	20	34.5058	23	47	NO
Mixed other*	18	10.46772	4	17	NO
Pakistani	15	9.245198	4	16	YES
Black Caribbean	10	16.55449	9	25	YES
Mixed white & black Caribbean*	9	15.29655	8	23	YES
Bangladeshi	6	3.975364	0	9	YES
Indian	2	11.516	5	18	NO
Mixed ethnicities*	26	25.76428	16	36	YES
Other ethnicities	89	141.3463	116	166	NO

*Acceptable validity when amalgamated into Mixed Ethnic grouping

Ethnic specific data are published online in sections 1c (16-64 years old), 2c (16-35 years old) and 3c (36-64 years old). Predicted counts for some ethnic minority groups in some local authorities are small and imprecise and should be used with extreme caution. Predicted counts and incidence rates by ethnicity will be most useful for those in major urban populations with diverse ethnic composition.

4. Conclusions

We believe that PsyMaptic Version 1+ will provide an accurate estimate of the number of people in the population developing first episode psychosis per annum in England and Wales. As the predictions become more fine-grained (by geography and specific sociodemographic group) the precision of these predictions will be smaller, meaning that we can be less sure about the expected numbers of cases which will occur per year. 95% prediction intervals are provided with all predictions and should be used as the lower and upper bounds of possible case numbers. As with all predictions, it is possible (indeed likely) that a small proportion of sociodemographic or geographical regions will see observed numbers of cases fall short or exceed our predictions in certain years. This could indicate areas where further enhancements to the model are necessary, or may simply be due to natural sampling variability. This will require ongoing monitoring and funding support.

PsyMaptic predictions have been externally validated in the age group 16-35 years old and internally validated for all ages (16-64 years). Data for the 36-64 year old age group should be used with additional caution given we have not been able to externally validate these. We are always interested in doing so, and would be interested in comparing our predictions with observed data from any services, institutions or organisations with available empirical data.

Our models were based on empirical data from England, but we have attempted to forecast results for England and Wales. Results for Wales should be interpreted with this caveat, though we have no reason to assume the risk of first episode psychosis by broad sociodemographic factors would differ in Wales. Unfortunately, it is not possible to include data for Scotland or Northern Ireland at present due to different methodologies used to collect deprivation data.

Our predictions forecast the expected incidence of FEP and do not predict the additional burden of psychiatric morbidity that will present to psychosis services, by people who may require triage and signposting to other, more appropriate mental health services. Of the 996 cases aged 16-35 years old referred to EIP in East Anglia over a 3.5 year period, 665 (66.8%) met criteria for FEP. These results require validation, and have not presently been peer-reviewed, but provide a very tentative indication of the proportion of people who may consume service resources for varying lengths of time, but who are later discharged without FEP. Any commissioning decisions need to consider not only the number of incident cases of disorder per annum but this additional demand for services. Our models make no predictions for people aged younger than 16 years old, where the epidemiological evidence-base is much weaker.

Future PsyMaptic updates will be subject to continued funding support.

5. Contact details

PsyMaptic was developed by Dr James Kirkbride at the Department of Psychiatry, University of Cambridge, in conjunction with Professor Peter Jones, Dr Daniel Jackson and other colleagues. Dr Kirkbride currently runs and manages PsyMaptic from UCL, London, UK.

The tool should be cited as

Kirkbride, J. B., Jackson, D., Perez, J., Fowler, D., Winton, F., Coid, J. W., Murray, R. M. & Jones, P. B. (2013). A population-level prediction tool for the incidence of first-episode psychosis: translational epidemiology based on cross-sectional data. *BMJ Open* **3**:2 e001998

Contact

Dr James Kirkbride

Sir Henry Dale Fellow, Division of Psychiatry, UCL, London, W1W 7EJ

+44 (0) 20 7679 9297

info@psymaptic.org

Twitter: @psymaptic

6. References

Cantor-Graae, E. & Selten, J.-P. (2005). Schizophrenia and Migration: A Meta-Analysis and Review. *Am J Psychiatry* **162**, 12-24.

Kirkbride, J. B., Barker, D., Cowden, F., Stamps, R., Yang, M., Jones, P. B. & Coid, J. W. (2008). Psychoses, ethnicity and socio-economic status. *British Journal of Psychiatry* **193**, 18-24.

Kirkbride, J. B., Fearon, P., Morgan, C., Dazzan, P., Morgan, K., Tarrant, J., Lloyd, T., Holloway, J., Hutchinson, G., Leff, J. P., Mallett, R. M., Harrison, G. L., Murray, R. M. & Jones, P. B. (2006). Heterogeneity in Incidence Rates of Schizophrenia and Other Psychotic Syndromes: Findings From the 3-Center ÆSOP Study. *Archives of General Psychiatry* **63**, 250-258.

Kirkbride, J. B., Jackson, D., Perez, J., Fowler, D., Winton, F., Coid, J. W., Murray, R. M. & Jones, P. B. (2013). A population-level prediction tool for the incidence of first-episode psychosis: translational epidemiology based on cross-sectional data. *BMJ Open* **3**, e001998.

Kirkbride, J. B., Stubbins, C. & Jones, P. B. (2012). Psychosis incidence through the prism of early intervention services. *The British Journal of Psychiatry* **200**, 156-7.

McClellan, D., Barnes, H., Noble, M., Davies, J., Garatt, E. & Dibben, C. (2011). The English Indices of Deprivation 2010. Department for Communities and Local Government: London.