Mental Health Allocations Formula

Person-based Resource Allocation for Mental Health model (PRAMH2)

For 2019/20 to 2023/24 revenue allocations

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Promoting equality and addressing health inequalities are at the heart of NHS England's values. Throughout the development of the policies and processes cited in this document, we have:

Given due regards to the need to eliminate discrimination, harassment and victimisation, to advance equality of opportunity, and to foster good relations between people who share a relevant protected characteristic (as cited under the Equality Act 2010) and those who do not share it;

Given regard to the need to reduce inequalities between patients in access to, and outcomes from, healthcare services and in securing that services are provided in an integrated way where this might reduce health inequalities.

Contents

1 Introduction and Summary

This paper describes the Person-based Resource Allocation for Mental Health model (PRAMH2[1]) that has been developed for the 2019/20 CCG allocations round. The previous allocation round used a mental health formula based on an update in 2012 (Person-based Resource Allocation for Mental health, (PRAM)[2]). The model has been refreshed for three main reasons:

(1) to reflect more accurately current mental health need patterns through using more recent data;
(2) to include the use of Improving Access to Psychological Therapies (IAPT) services and test new need variables, for which data are now available; and
(3) to explore the potential of linking different data feeds at individual person-level.

The refreshed model uses person-level data on the use of secondary mental health services, learning disability services, Improving Access to Psychological Therapies services, and general and acute hospital services, as well as demographic and personal characteristics and attributed 'need' and 'supply' variables. A single person-based linear regression model emerged as the most appropriate to estimate the total cost of an individual's usage of mental health services.

Specialised mental health services, which are commissioned by NHS England, were excluded from the model whenever data would allow. The service use captured in the model covered inpatient bed days, community care contacts and IAPT contacts. Children and young people (ages 19 and under) were not included in the analysis.

The rest of this paper focuses on the development of the model and the resulting model that has been implemented. Section 2 outlines the key data and datasets explored in developing PRAMH2, along with a summary of the data quality checks performed. Section 3 explains the costing methodology employed to estimate the total mental health care costs for individuals in 2015/16. Section 4 outlines the approach taken to develop the model and the details of the final model. Section 5 outlines how the model has been implemented within CCG allocations 2019/20 to 2023/24 and Section 6 summarises the key methodological advances from the previous model (PRAM).

2 Data and Datasets

To capture service usage, the two main datasets used were the Mental Health Services Data Set (MHSDS), and prior versions, and the IAPT dataset. A number of additional datasets were also used to estimate unit costs for different care activities, validate the quantified service

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[1] Anselmi, L., Everton, A., Shaw, R., Suzuki, W., Burrows, J. N., Weir, R., Tatarek-Gintowt, R., Sutton, M. & Lorrimer, S. *Estimating local need for mental health care to inform fair resource allocation within the NHS in England: cross-sectional analysis of national administrative data linked at person-level*, in: British Journal of Psychiatry, 1-7, doi: 10.1192/bjp.2019.185. https://www.cambridge.org/core/journals/the-british-journal-of-psychiatry/article/estimating-local-need-for-mental-healthcare-to-inform-fair-resource-allocation-in-the-nhs-in-england-crosssectional-analysis-of-national-administrative-data-linked-at-person-level/6B460AFAA4FE77DBDFE57B92255510CA

[2] Sutton, M., et al. *Developing Mental Health funding formula for allocations to general practices - Phase 3: Estimation of a formula based on person-level data, Report to the Department of Health*, 2012.

usage, and for explanatory variables capturing need and supply. Further details of these datasets are provided in the rest of this section.

All data was psuedonomised and provided in-line with NHS England and Improvement data minimisation requirements.

Appendix A summarises the patient level variables considered, along with the information sources and time periods covered. Sections 2.1 to 2.4 provide an overview of the datasets and any processing that was required. Section 2.5 outlines the data quality checks that were completed.

2.1 Patient List

A master patient list was generated using the Master Person Index (MPI) by NHS England's data services. The MPI includes person-level information from the National Health Applications and Infrastructure Services (NHAIS) for all patients registered or who have been registered with a GP in England and Wales[3]. We retained individuals registered with a GP practice in England and alive at 1 April 2015, therefore excluding all patients not active or who had moved out of England. We retained information as outlined in Appendix A and linked data from other sources as summarised in Sections 2.2 and 2.3. In addition, we derived the ethnicity of the patient through using a number of data sources to account for where individuals were not present in all the datasets.

2.2 Service Usage Data

The model is based on national datasets for 2015/16, that capture person-level mental health service usage across England in a consistent and comparable way, as outlined below.

2.2.1 Hospital Inpatient Stays, IAPT Contacts and Care Contacts in the Community

We extracted information on the use of mental health services from two datasets: the Mental Health and Learning Disabilities Dataset (MHLDDS) covering 1 April 2015 to 31 December 2015 and the Mental Health Services Dataset (MHSDS) covering 1 January 2016 to 31 March 2016. These datasets cover individuals in contact with secondary mental health and learning disability services, provided in hospitals and the community[4] [5].

The total numbers of inpatient bed days were capped at 365 days per person and were calculated based on the reported start and end date of each ward stay, or, when these were missing, on the beginning or end of the financial year. We differentiated between intensive and general care based on clinical intensity codes (Appendix B Section B.1.1). We excluded bed

[3] NHS Digital. *National Health Application and Infrastructure Services (NHAIS).* 2018; Available from: https://digital.nhs.uk/services/nhais.

[4] NHS Digital. *Mental Health Services Data Set (MHSDS).* 2018; Available from: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-sets/mental-health-services-data-set

[5] NHS Digital. *Mental Health and Learning Disabilities Data Set (MHLDDS).* 2018; Available from: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-sets/mental-health-services-data-set/mental-health-and-learning-disabilities-statistics-mhlds-monthly-reports

days in secure wards as these include specialised services that are not expected to be commissioned by CCGs[6].

We also counted contacts with different types of health care professionals, and included consultations face-to-face, by telephone, by web-cam or needing a translator and that were attended on time or attended late but the patient could be seen. Health care professionals were classified by NHS Agenda for Change[7] pay band, from two to eight or nine (Appendix B Section B.1.2).

2.2.2 Improving Access to Psychological Therapies

The Improving Access to Psychological Therapies (IAPT) dataset collects information about adults in contact with psychological therapy services. We counted the number of consultations face-to-face, by telephone, by webcam, or needing a translator, and that were attended or attended late, for patients seen in the financial year 2015/16[8].

2.2.3 Secondary Uses Service

To ensure all service usage was captured we also used the Secondary Uses Service (SUS) dataset, which is the single, comprehensive repository for healthcare data in England.

For each individual we extracted inpatient admissions and outpatient consultations from SUS records related to mental health. We checked for any overlapping information between SUS and the MHLDDS by patient and dates of admission and discharge or date of the consultation. We identified mental health related spells and consultations by the spell core Healthcare Resource Group (HRG), by the treatment function or main specialty code, as outlined in Appendix B Section B.3. We added any non-overlapping spells to the count of general inpatient bed days and the count of non-overlapping outpatient consultations to the count of contacts with a health care professional in pay-band 7.

2.3 Additional Explanatory Need and Supply Variables

As well as the patient characteristics outlined in previous sections, the final model included a set of additional explanatory variables that were found to be associated with the use of mental health care, including both need and supply variables. These variables included:

- Physical health diagnostic flags (for which the full list considered is outlined in Appendix B Section B.4);
- Household composition;
- Proportion of the population residing in a given LSOA and receiving out of work benefit;
- Student GP practice;
- Prevalence of severe mental illness;
- CCG of the GP practice where the individual is registered;

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[6] NHS England. *Manual for Prescribed Specialised Services 2017/18*, 2017, NHS England Analytical Services (Finance): London.

[7] NHS Employers. *Agenda for Change pay scales - Annual,* 2017, NHS Employers: London.

[8] NHS Digital. *Improving Access to Psychological Therapies Data Set*. 2018; Available from: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-sets/improving-access-to-psychological-therapies-data-set.

- The degree of service use for each GP practice at each mental health trust (proportion of patients registered with a GP practice who used the provider at least once in 2013/14 according to MH records); and
- Average driving distance between the LSOA centroid (of patient residence) and the closest provider (mental health trust headquarters).

Additional need and supply variables were also considered, and these are further detailed in Appendix A.

2.4 Cost of Services Data

A number of data sources were used in calculating the costs of different services, these included:

- for the average cost of IAPT contacts, information from Reference Costs 2015/16[9];
- for inpatient bed day costs, information from Reference Costs 2015/16 (and for bed day costs by intensity, Reference Costs 2011/12 as the last collection containing this information); and
- for the cost of care contacts, job role[10], occupation code[11] and speciality of the care professional[12] from the MHLDDS[5]. This information was mapped to a pay band according to the latest NHS Agenda for Change pay scale[7] and the Agenda for Change pay scales were used to estimate costs.

The Costing Methodology (Section 3) outlines details of the approach taken to calculate costs.

2.5 Data Quality

A number of data quality checks were performed to ensure the data used in the final model were reliable. These included:

- analysing the Monthly Data Quality Reports for mental health data published by NHS Digital[13] [14] which identified providers with missing data submissions, other issues and unusual increases or decreases in activity or patient numbers;

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[9] Department of Health and Social Care. *NHS reference costs 2015 to 2016*, 2016, Department of Health and Social Care: London. Available from: https://www.gov.uk/government/publications/nhs-reference-costs-2015-to-2016.

[10] NHS Digital. *NHS Data Dictionary, Job role*. 2018; Available from: https://www.datadictionary.nhs.uk/data_dictionary/attributes/j/job_role_code_de.asp?shownav=1.

[11] NHS Digital. *Occupation Code Manual v 13.1*. 2015; Available from: https://digital.nhs.uk/data-and-information/areas-of-interest/workforce/nhs-occupation-codes#previous-version-of-the-nhs-occupation-code-manual.

[12] NHS Digital. *NHS Data Dictionary, Main specialty code*. 2018; Available from: http://www.datadictionary.nhs.uk/data_dictionary/attributes/m/main_specialty_code_de.asp

[13] NHS Digital. *Mental Health Bulletin, Annual Report 2014-15*. 2015; Available from: https://digital.nhs.uk/data-and-information/publications/statistical/mental-health-bulletin/mental-health-bulletin-annual-report-2014-15.

[14] NHS Digital. *Mental Health Bulletin, Annual Report 2015-16*. 2016; Available from: https://digital.nhs.uk/data-and-information/publications/statistical/mental-health-bulletin/mental-health-bulletin-2015-16-annual-report.

- using SUS data with no overlapping records in the mental health datasets to ensure all the activity was captured.
- Performing checks of the impact of additional activity data from SUS on the model, compared to the model based solely on MHSDS data;
- comparing total patient numbers in our dataset to those published by NHS Digital[13] [14]; and
- investigating the geographical concentration of the 2.1% of patients who did not have an NHS number, and whether the providers with higher numbers of patients with no NHS numbers had other data quality issues logged.

We collated the results of the NHS Digital data quality reports and our own analysis of missing NHS numbers, rated each issue logged and generated an overall data quality rating for each provider. We tested different weighting options of the data quality issues encountered to produce an overall data quality rating. A group of providers with relatively low data quality ratings emerged consistently under different weighting methodologies. We then ran a number of sensitivity analyses on different versions of the model excluding those providers and found that the coefficients of the model did not change.

3 Costing Methodology

For each individual patient we calculated the total mental health care cost in 2015/16. This was the sum of costs associated with mental health IAPT contacts, inpatient bed days and community care contacts.

3.1 Unit Cost Calculations

Unit costs for each type of care contact were determined as described below.

Cost of IAPT Contacts

We calculated the average unit cost of an IAPT consultation (£94) by adding the costs across clusters within the Reference Costs 2015/16 data and by dividing through the total number of low and high intensity contacts from the IAPT individual level data, excluding initial assessments[8].

Cost of Inpatient Bed Days

We calculated the average unit costs for general and for intensive bed days by matching the total costs (from Reference Costs 2015/16 data) with data from the MHLDDS on length and clinical intensity of all ward stay episodes and on patient cluster assignment. We weighted intensive bed days as 1.97 general bed days, based on the ratio of intensive to general bed day unit cost, as reported in the Reference Cost 2011/12**Error! Bookmark not defined.**. We assumed constant service delivery over the year and we multiplied the annual cost of admitted care days per cluster by 0.75, to obtain the equivalent for 1 April and the 31 December 2015 (the period covered by the MHLDDS with information consistently recorded). We divided by the weighted sum of general and intensive bed days to obtain the cluster specific unit cost of a general inpatient bed day, and then multiplied by 1.97 to obtain the cluster specific costs of an intensive bed day. These were averaged across clusters, weighting for the number of bed days within each cluster, to obtain the unit cost of general (£371) and inpatient (£752) bed days.

Cost of Care Contacts

The average unit cost of care contacts was calculated by using Agenda for Change pay bands[7] of the care professionals delivering the care provided, derived using MHLDDS data on job role, occupation code and specialty and on the cluster assignment of the patient. We weighted each contact by the ratio of the mid-point salary of the pay band to the mid-point salary of pay band two. This information was used to calculate the average salary of professionals which corresponded to pay band six, which was then used for the 2.7% of care contacts where pay band of the professional could not be determined. We averaged across clusters, weighting for the number of contacts within each cluster. Thus, we obtained the following average unit costs of contacts with care professionals by pay band: two (£109), three (£117), four (£134), five (£158), six (£194), seven (£230), eight or nine (£274).

4 Statistical Modelling

The Person-based Resource Allocation for Mental Health Model (PRAMH2) uses individual level data to develop the econometric model that best predicts the cost of care use as a function of a set of 'need' and 'supply' variables. The model is then used to predict individual level 'need' by sterilizing the effect of 'supply' variables.

Linking person-level data allowed us to advance the previous mental health allocations model (PRAM) through:

- using a wider set of personal characteristics and physical and mental drivers of need measured at the individual level for both mental health service users and non-users;
- verifying and correcting demographic characteristics and GP practice registration information reported in the mental health data; and
- estimating cost by applying a linear probability model on the whole adult population, aligning to the methodology for general and acute component of the CCG allocations formula[15].

4.1 Estimating Predictors of Costs and Model Development

Mental health care costs for individuals were estimated as a function of need and supply variables using a linear regression model (OLS) with CCG dummy variables and robust standard errors[16]. Total costs for any individual were truncated at £100,000 per year, as in previous work[2]. The model was developed using a random selection of half the GP practices and the remaining records served as a validation sample.

4.1.1 Initial Findings

Out of the 43,751,535 registered adults aged 20 years or older, 4% had some contact with secondary mental health and IAPT services in 2015. The average cost per registered person

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[15] Chaplin, M., et al., *Refreshing the Formulae for CCG Allocations For allocations to Clinical Commissioning Groups from 2016-17, Report on the methods and modelling*, 2015, NHS England, Analytical Services (Finance) – Allocations team: Leeds, UK.

[16] NHS England. *Technical Guide to CCG Allocations 2019-20 to 2023/24: Spreadsheet files for CCG allocations 2019-20 to 2023/24; Spreadsheet D – Mental Health Need 2019/20 to 2023/24*. 2019. Available from: https://www.england.nhs.uk/publication/technical-guide-to-ccg-allocations-2019-20-to-2023-24-spreadsheet-files-for-ccg-allocations-2019-20-to-2023-24/

was £81. The cost per service user ranged from £94 to £1,040,963 and was £2,008 on average. 49% of the sample were men and the majority were aged between 25 and 60 years and of white British ethnic background (72%). See Table D1 in Appendix D for a full list of use and cost for need and supply variables.

4.1.2 Sensitivity Analysis and Variables in the Final Model

We estimated a number of alternative models either to: (1) test the inclusion of additional variables, (2) understand the changes associated with the use of updated definitions and cost of activities with respect to PRAM, or (3) test whether data quality issues would affect the coefficients of the model.

In the final model: for individual need indicators we included the interactions between gender and five-year age bands and sets of binary indicators for ethnicity, household type and physical health diagnosis. As attributed need variables we included the proportion of LSOA population receiving out of work benefit, student GP practice [17]and GP practice mental health prevalence. As it is commonly accepted in formulae for CCG allocations[16], a set of supply variables were also included to control for differences in supply side issues, these were the average driving distance between the LSOA centroid (of patient residence) and the closest provider (mental health trust head-quarter), indicators for GP practice usage of, and access to, each provider and CCG dummy variables (a flag to indicate if the patient is registered with a particular CCG – to control for differences in supply between CCGs).

A number of other individual level need variables were tested throughout the model development, including: mental health diagnostic flags; mental health risk indicators; flags indicating whether a person had been attributed to a given mental health care cluster; flags indicating if the person was diagnosed other forms of heart disease and disease of liver during an inpatient admission; flags indicating if the person had attended at least once accident and emergency with a diagnosis of: central nervous system conditions, excluding strokes; psychiatric conditions; and social problem, including chronic alcoholism and homelessness.

We also tested the inclusion of the following attributed variables, either included in PRAM or suggested in advisory group meetings: the LSOA proportion of population providing more than 19 hours unpaid care per week; the LSOA proportions of population which is widowed, which is single (never married) and which is divorced; the under 75 standardised mortality ratios for all causes, the Index of Multiple Deprivation; a rurality indicator for LSOAs that are classified as rural village and dispersed in a sparse setting; GP practice dementia prevalence; GP practice long standing health problem, disability or infirmity; GP practice average of each component of EQ5D[18] score.

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[17] A GP practice with a proportion of young people greater than 40% or located in proximity to university or college sites

[18] EQ-5D is a standardized instrument developed by the EuroQol Group to reflect health-related quality of life that can be used in a wide range of health conditions and treatments. The EQ-5D consists of a descriptive system which comprises of five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Information for these dimensions are collected based on the self-rated health of patients. Further details are available at: https://euroqol.org/eq-5d-instruments/

The final model did not include need variables derived from the MHSDS, namely mental health diagnostic flags. The PRAM model included diagnoses of mental health disorders and risk flags derived from the MHSDS or MHLDDS, namely a previous inpatient stay of at least two nights and previous treatment from a number of different types of health professional. Although the inclusion of diagnoses and risk indicators increased the predictive power of the model, we did not include them because of substantial heterogeneity in data reporting across providers. This would have led us to underestimate need in areas served by providers who reported information incompletely.

We also tested the inclusion of three need variables derived from the SUS Accident and Emergency dataset indicating whether the person had attended Accident and Emergency with a diagnosis related to mental health. While the coefficients associated with these variables were high and significant, suggesting a strong association with mental health care cost, we did not include these variables in the model, due to the high variability in reporting.

4.2 Model Selection and Validation

Model selection was based on predictive and redistributive performance, as well as on the data reliability of the data source used for the variables included.

We compared alternative models using the coefficient of determination (R-squared), the Mean Absolute Prediction Error and the proportion of GP practice predictions not within 10% of the actual cost, as measures of predictive performance at the GP practice level[16].

We started by replicating the model developed from PRAM and testing the inclusion of new variables available at the individual level. We retained the new variables available at the individual level when they improved the model predictive performance or when they could replace information previously available through attributed variables. We tested new attributed variables and retained them if they were improving the predictive performance and their estimated effect was in line with the existing evidence. More parsimonious models were preferred when the performance was similar – for simplicity and to avoid overfitting the model.

Table 1 summarises the performance of the final model (PRAMH2). The final model performed the best at the GP practice level in both the estimation (R-squared 0.81) and the validation samples (R-squared 0.79). The predictive power of the selected model on the validation sample, was higher compared to alternative models including age and gender only (R-squared 0.40), all need variables at the individual level (R-squared 0.40), all need variables at the individual, LSOA and GP practice level (R-squared 0.54), or all need and supply variables (R-squared 0.54). The inclusion of the CCG binary indicators and the indicators of each Mental Health Trust usage by GP practices explained an additional 25% of the variation. Supply variables such as distance were also included to improve the precision of the estimated coefficients and of the predictions after controlling for supply, even though they did not improve the explanatory power of the model. When controlling for supply variables, need variables alone predicted 52% of the variation in cost across GP practices.

We compared the distribution of need against the distribution of actual costs across GP practices using three measures. The Redistribution Index is the proportion of the total budget redistributed from ‘losing’ practices to ‘gaining’ practices, which is the sum across all GP practices of the absolute values of the differences between shares of need and actual cost, divided by two. The Mean Absolute Percentage Change in Share is the average across GP practices of the absolute difference between the share of actual cost and the share of need, divided by the shares of actual cost. The Proportion of GP Practices with Share Substantially

Affected indicates the proportion of practices whose absolute percentage change in share is equal or greater than 5%.

Table 1: Summary of predictive and redistributive power measures for the final model

R2 (Estimation sample)	Mean Absolute Error (Estimation Sample)	R2 (Verification Sample)	Mean Absolute Error (Verification Sample)	Proportion of GP practices not within 10%	Redistribution Index	Mean Absolute Percentage Change in Share	Proportion of GP Practices with Share Substantially Affected
0.8078	100,000	0.7929	100,000	0.8297	0.1879	63.7975	0.9180

The Redistribution Index (0.1879) indicated that compared to the distribution of mental health services cost in 2015, 19% of the total budget should be redistributed to match the distribution of need across GP practices. For 92% of the GP practices the difference in share would be higher than 5% of their share of cost in 2015, as indicated by the proportions of GP practice shares substantially affected (0.918). When calculated across CCGs, the Redistribution Index indicated that 14% of the total budget should be redistributed to match the distribution of need.

4.3 Coefficients from Preferred Model

Appendix C presents the coefficients associated with each need and supply variable included in the final preferred model (PRAMH2). The coefficients report the difference in cost by categories, controlling for everything else.

Age Band and Gender

The coefficients associated with the age and gender groups indicated that mental health care costs increased between 20 and 45 years of age and then decreased steadily until 75 years with a more marked reduction for over 85 years. The cost was higher for men than women between 20 and 30 years and vice-versa between 30 and 65 years of age.

Ethnicity

Compared with white British, some other ethnic groups had on average costs per year higher e.g. costs for the Irish group were £34 higher. Costs were substantially higher for White and Black Caribbean (£140 higher), Caribbean (£134 higher) and Any Other Black Background (£125 higher). Negative coefficients were associated with Any other White background, Indian, Pakistani, Bangladeshi, Any other Asian Background and Chinese and Any other Ethnic background groups. However, these were interpreted as a reflection of barriers to access and unmet need, rather than lower need, given a lack of evidence indicating the opposite. These were replaced with the national average when calculating need predictions.

Household Type

Compared with individuals living in a two-adult mixed gender household, individuals living alone had a higher cost (on average £101 higher per year), as did individuals living in a communal household (£147 higher) or in care homes (£437 higher). Individuals living in households with two or more adults and/or children had lower costs.

Physical Health Diagnoses

The average cost per year was higher for individuals who had experienced at least one admission with a diagnosis of poisoning by drugs, medicaments and biological substances (£1,699) and viral hepatitis (£285). The cost was also moderately higher for individuals who had

an admission with a diagnosis of diabetes (£70), endocrine nutritional and metabolic diseases (£63), cerebrovascular diseases (£52), or chronic lower respiratory diseases (£73). Previous admissions with symptoms and signs involving cognition, perception, emotional state and behaviour were also associated with higher mental health costs (£838).

Attributed Need Variables

As expected, residing in a LSOA with higher concentration of individuals receiving out of work benefits was associated with increased cost (£2.70 per extra percentage point of the percentage of those receiving out of work benefits in the LSOA of residence) and so was being registered with a GP practice with higher prevalence of severe mental illness (£22 per extra percentage point). Being registered with a student GP practice was associated with a £28 lower cost indicating lower need for mental healthcare compared with a population of similar age and socioeconomic conditions but registered with a practice with a different patient list composition.

Attributed Supply Variables

An extra 10 minutes' drive time to the headquarters of the closest mental health Trust reduced the cost by £3.30, indicating that lower supply was associated with lower cost for mental health care.

5 Model Implementation

5.1 Need Estimates by GP Practice, Age and Gender Groupings

Using the PRAMH2 model, we produced person-level need weights by taking predictions from the model with the supply variables fixed at their population average values, to avoid variations in access to care influencing the need-based target allocations. We also fixed at the population average value the need variables, such as specific ethnic groups with an unexpected negative coefficient, which was interpreted as a sign of unmet need for that population group. We generated need weights for the capitation formula by averaging the individual need estimates by combinations of GP practice, age and gender groupings.

The geographical distribution of the need estimates for the PRAMH2 model is broadly similar to the one obtained from the PRAM model but it attributes a higher weight to urban centres with deprived populations, and areas with more deprived and older populations.

5.2 CCG Need Indices

To estimate CCG level need indices, we multiplied the GP-age-gender-specific need weights by the number of patients by age and gender registered in each GP practice (average between November 2017 and October 2018). We aggregated the weighted populations by CCG (192 in 2018) and normalised them to the total population registered with a GP in England to derive the weighted populations for each CCG[16]. A CCG's need index is its weighted population divided by its unweighted population and provides an indication of need relative to other CCGs; a value higher than 1 indicates need higher than average and a value lower than 1 indicates need lower than average.

6 Methodological Advancements

The development of the model led to some improvements and methodological advancements related to data availability and the inclusion of variables not previously used.

We used linked person-level data for all adults registered with a GP practice in England to model an updated formula for secondary mental health care, including learning disabilities and IAPT services. We applied a person-based methodology aligned with the one used for other components of CCGs allocations. The model estimated to generate weights for the capitation formula included individual, area or GP practice level need variables along with supply variables (distance from the closest mental health trust, CCG and indicators of past Mental Health trusts GP practice usage). The model explains up to 81% of the variation in cost across GP practices, with need variables alone explaining 52% of the variation.

The formula developed differs from the previous PRAM as it includes learning disabilities and IAPT services and it is based on fully linked person-level data for all patients registered with a GP practice, rather than for patients using mental health care only. The linkage allowed us to use a simpler model that estimated directly the cost of mental health care for the whole population, rather than a two-part model to estimate separately the probability of using services for the whole population and the cost of using services for users only. We could also use ethnic background and household type at individual rather than area level. The use of person-level information, more informative in predicting cost, led to the exclusion of area and GP practice level need variables previously used, as they would not contribute to explaining variation.

We included a set of indicators of past Mental Health trusts GP practice usage, which are the share of patients registered with a given GP practice who were in contact at least once with each of the 66 public Trusts providing mental health care (reported in the MHLDDS and MHSDS) over the financial years 2013/14 and 2015/16. These variables allowed us to better account for differences in supply, and particularly in providers intensity of coding. However, as they are calculated based on service use, which is determined by both need and supply, there is a possibility that they also reflect differences in need, not accounted for by the need variables included in the model.

Appendix A: Person-level Variables

Table 1 summarises the patient level variables considered, along with the data sources and time periods covered.

Table A1: Person-level Data

Data Item / Variables	Time period	Data Source	Additional details in Section
Age (derived from the month of birth)	Information as at 1/4/15	Master Person Index (MPI) based on National Health Applications and Infrastructure Services (NHAIS)[3]	2.1 Patient List
Gender	Information as at 1/4/15	MPI based on NHAIS[3]	2.1 Patient List
GP practice of registration	Information as at 1/4/15	MPI based on NHAIS[3]	2.1 Patient List
LSOA of residence	Information as at 1/4/15	MPI based on NHAIS[3]	2.1 Patient List
Household composition	Information as at 1/4/15	Based on the postcode captured within the MPI	2.1 Patient List and Section 2.3 Additional Explanatory and Supply Variables
Ethnicity	Information as at 1/4/15	Derived, in order of preference, from SUS[19] inpatient, outpatient and Accident and Emergency, MHSDS[4], MHLDDS[5] and IAPT[8] records, for individuals who used services between 1 April 2013 and 31 March 2016, and merged with MPI records, to derive a set of binary indicators for each ethnic group category. A value equal to the LSOA proportion of residents in each ethnic category was imputed for 30% of individuals with missing information.	2.1 Patient List
Contacts with secondary services provided in hospitals, outpatient clinics and the community*	Activity from 1/4/15 to 31/12/15	Mental Health and Learning Disabilities Dataset (MHLDDS)[5]	2.2 Service Usage Data 2.2.1 Hospital Inpatient Stays, IAPT Contacts and Care Contacts in the Community
	Activity from 1/1/16 to 31/3/16	Mental Health Services Dataset (MHSDS)[4]	
Contacts with psychological therapy services	Activity from 1/4/15 to 31/3/16	Improving Access to Psychological Therapies (IAPT) Dataset[8]	2.2 Service Usage Data 2.2.2 Improving Access to Psychological Therapies

[19] NHS Digital. *Secondary Uses Service (SUS)*. 2018; Available from: https://digital.nhs.uk/services/secondary-uses-service-sus.

Inpatient admissions and outpatient consultations	1/4/15 to 31/3/16	Secondary Uses Service (SUS) Dataset[19]	2.2 Service Usage Data 2.2.3 Secondary Uses Service
Physical diagnostic flags	1/4/13 to 31/3/15	From inpatient diagnoses	2.3 Additional Explanatory Need and Supply Variables
Attributed variables			
LSOA proportion of population receiving out of work benefit	May 2014 to Feb 2015	Office for National Statistics (ONS)[20]	2.3 Additional Explanatory Need and Supply Variables
Person registered with a student GP practice	Based on people registered at GP practice on 1/4/15	A binary indicator for whether the person was registered with a student GP practice (defined as having a proportion of young people higher than 40% or located in close proximity to University or Colleges sites).	2.3 Additional Explanatory Need and Supply Variables
Prevalence of severe mental illness as recorded in the GP	2014/15	The measure covering the prevalence of severe mental illness as recorded in the GP Quality and Outcomes Framework (QOF)	2.3 Additional Explanatory Need and Supply Variables
A set of variables indicating the CCG of the GP practice where the individual is registered	For individual's registered on 01/04/2015	MPI	2.3 Additional Explanatory Need and Supply Variables
Degree of service use for each GP practice at each mental health trust	01/04/2013 to 31/03/2015	Variables indicating the degree of service use for each GP practice at each mental health trust (proportion of patients registered with a GP practice who used the provider at least once in 2013/14, according to MH records).	2.3 Additional Explanatory Need and Supply Variables
Distance between patient residence and the closest provider	For individual's registered on 01/04/2015	The average driving distance between the LSOA centroid (of patient residence) and the closest provider (mental health trust head-quarter), calculated based on geo-coordinates.	2.3 Additional Explanatory Need and Supply Variables

** The MHLDDS[5] comprises data from the financial years 2014/15 and 2015/16 (up to month 9) on adults aged 18 or over (including elderly adults). Unlike previous versions of the dataset it comprises data on who receive specialist secondary learning disabilities or autism spectrum disorder services and/or are thought to have a learning disability or autism spectrum disorder.*

The MHSDS[4] comprises data from financial year 2015/16 (from month 10) for patients in contact with mental health services. It covers services provided in hospitals and also in outpatient clinics and in the community. The MHSDS brings together key information on mental health, learning disabilities or autism spectrum disorder and early intervention care pathway that has been captured on clinical systems as part of patient care.

[20] ONS. *Out-of-work benefit claimants – working age clients for small areas*. 2015 AccessedJanuary 2018]; Available from: https://www.nomisweb.co.uk/query/construct/summary.asp?mode=construct&version=0&dataset=12.

Appendix B: Data Definitions and Selection

B.1 Mental Health Care Use Data

B.1.1 Clinical Intensity Codes for Bed Days

For each person we calculated the number of non-secure inpatient bed days in 2015/16, distinguishing general and intensive bed days. Those relative to low, medium and high security wards were excluded, as these were considered specialised services and thus outside the scope of the intended formula. Episodes were split in general and intensive based on the clinical care intensity code. Intensive bed days are defined by the following intended clinical intensity codes: 11 (for general patients for normal therapy: intensive therapy, including high dependency care), 51 (for patients with mental Illness: Intensive Care - specially designated ward for patients needing containment and more intensive management (e.g. Psychiatric Intensive Care Unit (PICU)), not to be confused with intensive nursing where a patient may require one-to-one nursing while on a standard ward, 61 (for patients with Learning Disabilities: Designated or interim secure unit).

General bed days are defined by the following intended clinical intensity codes: 12 (for general patients for normal therapy: where resources permit the admission of patients who might need all but intensive or high dependency therapy), 52 (for patients with mental Illness intended to stay less than a year), 53 (for patients with mental Illness intended to stay for a year or more), 62 (for patients with Learning Disabilities intended to stay less than a year) and 63 (for patients with Learning Disabilities intended to stay for a year or more) or unknown intended clinical intensity code[21].

B.1.2 Health Care Professional Agenda for Change Pay Bands

For each person we calculated the number of contacts with a health care professional in 2015/16 by pay band of the health care professional. Each professional was classified into a pay-band based, in order of priority, on their job role[11], occupation code[12], or specialty[13]. Band nine was considered equal to eight in terms of skills specialisation. Each job role, occupation code and specialty was attributed a pay band according to Agenda for Change[7], NHS job adverts, and the judgement of experienced NHS colleagues, as outlined below.

Each pay band was identified based on the following set of codes.

- **Pay band 2:** Job role: 1010 or 1011or 7012 or 7015
- **Pay band 3:** Job role: 7000, 7001, 7002, 7004, 7027, 8000, 8001, 8002, 8003, 9001; Occupation code: N9E, H2, H1D, G2D, S4C.
- **Pay band 4:** Job role: 2000, 2001, 2003, 2004, 2007, 2010, 2012, 2016, 2018, 2022, 2023, 7005, 7009, 7010, 7019, 7023, 7029, 7031, 8003, 8004, 8005, 8006; Occupation code: H2D, S4, N1B, S5U, S5L.

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[21] NHS Digital. *NHS Data Dictionary, Intended Clinical Intensity Code*. 2018; Available from: http://www.datadictionary.nhs.uk/data_dictionary/data_field_notes/i/in/intended_clinical_care_intensity_code_(mental_health)_de.asp?query=intended%20intensity%20code&rank=1&shownav=1; and http://www.datadictionary.nhs.uk/data_dictionary/attributes/c/cla/clinical_care_intensity_de.asp?shownav=1.

- **Pay band 5:** Job role: 1023, 3000, 3007, 3008, 3015, 5000, 5011, 5012, 7028; Occupation code: N6, NAD, N9D, S8M, S1B; Specialty: 900, 950, 700.
- **Pay band 6:** Job role: 1009, 3014, 4000, 4001, 4009, 4025, 4041, 4057, 5003, 5007, 5008, 5009, 5010, 5015, 5021, 7011, 8007; Occupation code: N7E, S1, N6E, N4, N0, S1U, N4D, G2A, N6F, N6D, NAE, N7D; Specialty: 960, 901, 710, 725, 727; Job role, occupation code and specialty: missing.
- **Pay band 7:** Job role: 1004, 1024, 3003, 3005, 3006, 4003, 4004, 4007, 4012, 4013, 4015, 4016, 4017, 4018, 4019, 4021, 4027, 4028, 4042, 4044, 4059, 4060, 5004, 5014, 5016; Occupation code: S1C, S8L, SAM, N7, S1J, S1H, S1M, N0D, G0A, N60, NCE, S4L, S9J, G2, S1L, S3L; Specialty: 713.
- **Pay band 8 or 9:** Job role: 1000, 1006, 1013, 1022, 3002, 3004, 5005, 8009, 1001, 1002, 1005, 1012, 1016, 1017, 1018, 1019, 1032, 1035, 1037; Occupation code: S0C, S2L, G2C, S0L, SAL, N0E, S0M, S2M.

B.3 SUS HRG, Treatment Function and Speciality Codes

Mental health inpatient stays and outpatient visits were identified by: spell core Healthcare Resource Groups PA52Z (Behavioural Disorders with length of stay 1 day or less), PA52B (Behavioural Disorders with length of stay between 2 and 7 days), PA52C (Behavioural Disorders with length of stay 8 days or more), PA53A (Eating Disorders with length of stay less than 8 days), PA53B (Eating Disorders with length of stay 8 days or more), VC26Z (Rehabilitation for Drug and Alcohol Addiction), VC28Z (Rehabilitation for Other Psychiatric Disorders), or by the treatment function or main specialty codes 700, 710 (Adult Mental Illness), 711 (Child And Adolescent Psychiatry), 712 (Forensic Psychiatry), 713 (Psychotherapy), 715 (Old Age Psychiatry), 720 (Eating Disorders), 721 (Addiction Services), 722 (Liaison Psychiatry), 723 (Psychiatric Intensive Care), 724 (Perinatal Psychiatry), 725 (Mental Health Recovery and Rehabilitation Service), 726 (Mental Health Dual Diagnosis Service), 727(Dementia Assessment Service).

B.4 Physical Health Diagnostic Flags

From the Secondary Uses Service (SUS) dataset we also extracted physical health diagnoses from both the admitted care records and the Accident and Emergency regards, to be tested for inclusion in the model. We considered primary and secondary diagnosis (all diagnostic positions) for the codes outlined below.

Using the physical health diagnoses from admitted care records we generated seven flags that indicate if the person had been admitted with each of the following diagnoses codes (ICD-10 codes):

(1) viral hepatitis (B15-B19);
(2) symptoms and signs involving cognition, perception, emotional state and behaviour (R40-R46);
(3) poisoning by adverse effect of and under dosing of drugs, medicaments and biological substances (T36-T50);
(4) diabetes mellitus (E10-E14);
(5) endocrine nutritional and metabolic diseases (E15-E90);
(6) cerebrovascular diseases (I60-I69); and
(7) chronic lower respiratory diseases (J40-J47).

The first three flags were used in PRAM while the remaining were suggested by mental health experts within Public Health England following research on co-morbidity between physical health conditions and severe mental illness[22].

[22] Public Health England. *Severe mental illness (SMI) and physical health inequalities: briefing*, 2018, Public Health England: London, 27 September 2018.

Appendix C: Final Preferred Model

Table C1: Coefficients associated with need and supply variables, selected model

	Coefficient	95% Confidence interval	p-value
Age band (and gender) Base category: 20-24 years Female			
20-24 years Male	11.811	[7.371; 16.251]	(0.0000)
25-29 years Female	-0.455	[-4.241; 3.332]	(0.8140)
25-29 years Male	12.574	[8.083; 17.065]	(0.0000)
30-34 years Female	8.312	[4.493; 12.130]	(0.0000)
30-34 years Male	13.196	[8.817; 17.575]	(0.0000)
35-39 years Female	17.607	[13.720; 21.495]	(0.0000)
35-39 years Male	14.089	[9.668; 18.510]	(0.0000)
40-44 years Female	22.547	[18.626; 26.469]	(0.0000)
40-44 years Male	14.297	[10.107; 18.488]	(0.0000)
45-49 years Female	13.809	[10.025; 17.594]	(0.0000)
45-49 years Male	2.851	[-1.041; 6.742]	(0.1511)
50-54 years Female	3.515	[-0.309; 7.339]	(0.0716)
50-54 years Male	-8.151	[-12.018; -4.285]	(0.0000)
55-59 years Female	-11.087	[-15.062; -7.111]	(0.0000)
55-59 years Male	-19.567	[-23.629; -15.505]	(0.0000)
60-64 years Female	-29.366	[-33.294; -25.438]	(0.0000)
60-64 years Male	-28.665	[-32.936; -24.394]	(0.0000)
65-69 years Female	-26.666	[-30.989; -22.342]	(0.0000)
65-69 years Male	-29.11	[-33.582; -24.638]	(0.0000)
70-74 years Female	-22.038	[-27.119; -16.956]	(0.0000)
70-74 years Male	-24.743	[-29.964; -19.522]	(0.0000)
75-79 years Female	-22.513	[-28.349; -16.678]	(0.0000)
75-79 years Male	-19.835	[-25.620; -14.051]	(0.0000)
80-84 years Female	-28.236	[-34.822; -21.649]	(0.0000)
80-84 years Male	-5.964	[-13.725; 1.797]	(0.1320)
85 years or older Female	-91.622	[-97.581; -85.663]	(0.0000)
85 years or older Male	-51.257	[-58.320; -44.195]	(0.0000)
Ethnicity (Base category: White British)			
Irish	33.914	[20.819; 47.009]	(0.0000)
Any other White background	-24.562	[-28.243; -20.881]	(0.0000)
White and Black Caribbean	140.276	[108.048; 172.505]	(0.0000)
White and Black African	53.718	[18.928; 88.508]	(0.0025)
White and Asian	79.916	[44.033; 115.798]	(0.0000)
Any other mixed background	17.851	[2.698; 33.003]	(0.0209)
Indian	-21.811	[-27.336; -16.287]	(0.0000)
Pakistani	-15.173	[-22.627; -7.720]	(0.0001)
Bangladeshi	-23.162	[-35.369; -10.955]	(0.0002)
Any other Asian background	-6.963	[-15.034; 1.108]	(0.0909)
Caribbean	133.693	[118.540; 148.846]	(0.0000)

African	29.735	[19.425; 40.045]	(0.0000)
Any other Black background	124.854	[108.283; 141.425]	(0.0000)
Chinese	-49.287	[-58.808; -39.766]	(0.0000)
Any other ethnic group	-18.62	[-24.810; -12.429]	(0.0000)
Household Type (base category: two adults diff gender)			
Care home	436.937	[410.665; 463.209]	(0.0000)
Missing	59.225	[54.736; 63.715]	(0.0000)
Multi-adult	-9.11	[-10.727; -7.493]	(0.0000)
Multi-adult and one or more children	-39.761	[-41.663; -37.859]	(0.0000)
Multi-child	-37.547	[-61.615; -13.480]	(0.0022)
Other communal	146.814	[131.932; 161.695]	(0.0000)
One adults and one or more children	-21.878	[-25.034; -18.722]	(0.0000)
Single person	101.47	[98.753; 104.187]	(0.0000)
Two adults and one or more children	-42.885	[-44.765; -41.006]	(0.0000)
Two adults of the same gender	29.895	[25.949; 33.840]	(0.0000)
Physical health diagnosis			
Viral hepatitis (ICD-10 codes B15-B19)	284.688	[204.185; 365.192]	(0.0000)
Symptoms and signs involving cognition, perception, emotional state and behaviour (ICD-10 codes R40-R46)	838.115	[800.583; 875.647]	(0.0000)
Poisoning by adverse effect of and under dosing of drugs, Medicaments and biological substances (ICD-10 codes T36-T50)	1698.611	[1623.271; 1773.951]	(0.0000)
Diabetes mellitus (ICD-10 codes E10-E14)	70.49	[62.606; 78.375]	(0.0000)
Endocrine nutritional and metabolic diseases (ICD-10 codes E15-E90)	63.484	[57.044; 69.924]	(0.0000)
Cerebrovascular diseases (ICD-10 codes I60-I69)	52.102	[27.494; 76.710]	(0.0000)
Chronic lower respiratory diseases (ICD-10 codes J40-J47)	72.956	[67.041; 78.870]	(0.0000)
Attributed need variables			
Proportion receiving out of work benefits in LSOA	269.048	[253.966; 284.130]	(0.0000)
Serious mental illness prevalence in GP practice	22.323	[18.448; 26.198]	(0.0000)
Student GP practice	-28.164	[-34.305; -22.024]	(0.0000)
Attributed supply variables			
LSOA time mins drive from MH Trust	-0.331	[-0.405; -0.257]	(0.0000)
CCG indicators	YES		
Mental Health Trusts GP practice usage	YES		
Constant	YES		
Adjusted R-squared	0.008		
Observations	21,319,709		

Appendix D: Summary statistics

Table D1: Mental health service use and cost (2015) and need and supply variables (2013-2014)

	All adults			Users only		
	Mean	Min	Max	Mean	Min	Max
Mental Health care user	0.040	0	1			
Cost (£) per person	80.598	0	1,040,963	2,008.46	94	1,040,963
Male	0.493	0	1	0.406	0	1
Age						
20-24 years	0.082	0	1	0.101	0	1
25-29 years	0.091	0	1	0.104	0	1
30-34 years	0.093	0	1	0.099	0	1
35-39 years	0.086	0	1	0.089	0	1
40-44 years	0.089	0	1	0.093	0	1
45-49 years	0.094	0	1	0.091	0	1
50-54 years	0.090	0	1	0.084	0	1
55-59 years	0.077	0	1	0.063	0	1
60-64 years	0.068	0	1	0.045	0	1
65-69 years	0.070	0	1	0.041	0	1
70-74 years	0.053	0	1	0.038	0	1
75-79 years	0.042	0	1	0.045	0	1
80-84 years	0.032	0	1	0.048	0	1
85 years or older	0.035	0	1	0.061	0	1
Ethnicity						
White British	0.719	0	1	0.801	0	1
Irish	0.006	0	1	0.008	0	1
Any other White background	0.052	0	1	0.043	0	1
White and Black Caribbean	0.003	0	1	0.004	0	1
White and Black African	0.001	0	1	0.001	0	1
White and Asian	0.002	0	1	0.002	0	1
Any other mixed background	0.005	0	1	0.005	0	1
Indian	0.022	0	1	0.016	0	1
Pakistani	0.017	0	1	0.014	0	1
Bangladeshi	0.006	0	1	0.005	0	1
Any other Asian background	0.014	0	1	0.011	0	1
Caribbean	0.010	0	1	0.014	0	1
African	0.014	0	1	0.011	0	1
Any other Black background	0.007	0	1	0.009	0	1
Chinese	0.004	0	1	0.002	0	1
Any other ethnic group	0.022	0	1	0.020	0	1

Table D1: Mental health service use and cost (2015) and need and supply variables (2013-2014) (continued)

	All adults			Users only		
	Mean	**Min**	**Max**	**Mean**	**Min**	**Max**
Physical health diagnoses						
Viral hepatitis (ICD-10 codes B15-B19)	0.001	0	1	0.002	0	1
Symptoms and signs involving cognition, perception, emotional state and behaviour (ICD-10 codes R40-R46)	0.005	0	1	0.027	0	1
Poisoning by drugs, medicaments and biological substances (ICD-10 codes T36-T50)	0.002	0	1	0.018	0	1
Diabetes mellitus (ICD-10 codes E10-E14)	0.020	0	1	0.037	0	1
Endocrine nutritional and metabolic diseases (ICD-10 codes E15-E90)	0.029	0	1	0.053	0	1
Cerebrovascular diseases (ICD-10 codes I60-I69)	0.003	0	1	0.009	0	1
Chronic lower respiratory diseases (ICD-10 codes J40-J47)	0.030	0	1	0.061	0	1
Household type						
Care home	0.005	0	1	0.027	0	1
Missing	0.061	0	1	0.050	0	1
Multi-adult	0.254	0	1	0.218	0	1
Multi-adult and one or more children	0.123	0	1	0.095	0	1
Multi-child	0.000	0	1	0.000	0	1
Other communal	0.014	0	1	0.014	0	1
One adults and one or more children	0.024	0	1	0.041	0	1
Single person	0.132	0	1	0.212	0	1
Two adults and one or more children	0.130	0	1	0.114	0	1
Two adults of different gender (base category)	0.223	0	1	0.187	0	1
Two adults of the same gender	0.033	0	1	0.044	0	1
Attributed variables						
Need						
Proportion in LSOA receiving out of work benefits	0.088	0.001	0.490	0.101	0.001	0.490
Registered with Student GP practice	0.018	0	1	0.016	0	1
Prevalence (%) of Severe Mental Illness in GP practice	0.881	0.059	15.567	0.927	0.059	15.567
Supply						
Drive time to closest mental health trust (mins)	22.606	0.28	105.83	22.084	0.280	105.83