Applying resolved and remission codes reduced prevalence of multimorbidity in an urban multi-
ethnic population

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Highlights

- Omitting resolve and remission codes increased multimorbidity prevalence by 18%.
- Asthma and depression accounted for 73% of LTC resolve and remission codes.
- Twice as many multimorbid patients of “working age” (18-64 years) than older ages.
- 35.3\% of currently registered black patients have multimorbidity.

Abstract

Objective: To estimate the prevalence and determinants of multimorbidity in an urban,
multi-ethnic area over 15-years and investigate the effect of applying resolved/remission
codes on prevalence estimates.

Study Design and Setting: This is a population-based retrospective cross-sectional study
using electronic health records of adults registered between 2005-2020 in general practices in
one inner London borough (n=826,936). Classification of resolved/remission was based on
clinical coding defined by the patient's general practitioner.
**Results:** The crude and age-adjusted prevalence of multimorbidity over the study period were 21.2% (95% CI: 21.1-21.3) and 30.8% (30.6-31.0), respectively. Applying resolved/remission codes decreased the crude and age-adjusted prevalence estimates to 18.0% (95% CI: 17.9-18.1) and 27.5% (27.4-27.7). Asthma (53.2%) and depression (20.2%) were responsible for most resolved and remission codes. Substance use (Adjusted Odds Ratio 10.62 [95% CI: 10.30-10.95]), high cholesterol (2.48 [2.44-2.53]), and moderate obesity (2.19 [2.15-2.23]) were the strongest risk factor determinants of multimorbidity outside of advanced age.

**Conclusion:** Our study highlights the importance of applying resolved/remission codes to obtain an accurate prevalence and increased burden of multimorbidity in a young, urban, and multi-ethnic population. Understanding modifiable risk factors for multimorbidity can assist policymakers in designing effective interventions to reduce progression to multimorbidity.

**Keywords**

Primary care, Multimorbidity, Prevalence, Chronic disease

**What is new?**

**Key findings**

The crude and age-adjusted prevalence of multimorbidity was 21.2% and 30.8%, respectively. Applying resolved/remission codes decreased the respective prevalence estimates to 18.0% and 27.5%. Asthma and depression accounted for 73% of LTC resolve/remission codes.

Age, female sex, black ethnicity, deprivation, and clinical risk factors are all independently associated with multimorbidity. The clinical risk factors were the strongest determinants of multimorbidity outside of advanced age.

**What this adds to what is known**

To our knowledge, this is the first study to investigate the effect of applying resolve and remission codes on estimates of the prevalence and determinants of multimorbidity. Furthermore, we estimated the prevalence and determinants of multimorbidity in a young, urban, and multiethnic population using an expanded and locally adapted definition of multimorbidity.
1. Introduction

1.1 Background

The prevalence of multimorbidity is rising over time, posing challenges for healthcare systems due to poor patient outcomes and costly healthcare utilisation. At the patient level, those with multimorbidity have an increased risk of disability, mental health issues, and a reduced quality of life compared with those without.[1,2] At the healthcare level, individuals with multimorbidity have more consultations, prescriptions, hospital admissions, and longer lengths of hospital stay than those without.[3–5]

Research on multimorbidity has been hampered by the absence of a standardised definition and terminology.[6] A systematic review found a cut-off point of two or more long term conditions (LTCs) was used in 37% of multimorbidity studies, the considered LTCs ranged from 4 to 147, and 71% created a definition of multimorbidity instead of using an existing one.[7] Additionally, multimorbidity and comorbidity are often used interchangeably, demonstrated by the fact that until 2018 “multimorbidity” was not assigned a distinct MeSH term.[8]

Most studies have identified multimorbidity as a manifestation of ageing, focusing on adult populations with an average age of over 60 years.[9] Although the prevalence of multimorbidity is higher among older people, in population-based studies the majority of those multimorbid are younger than 65 years [10] with the threshold age group for becoming majority multimorbid decreasing from 70-74 in 2004/05 to 65-69 in 2012/13.[11]

Information on whether an LTC has resolved or gone into remission can be extracted from electronic health records (EHRs) via clinical coding such as SNOMED-CT. Nevertheless, a systematic review of multimorbidity studies found 21 retrospective studies that used health records or registers as their sole data source, only 7 of which explicitly accounted for LTCs resolving or going into remission.[12] Studies that do not account for the status of LTCs may be overestimating the prevalence of multimorbidity.

The aim of the current study is to investigate the burden of multimorbidity in an urban, multi-ethnic, and deprived community, using a locally adapted definition of multimorbidity to
examine prevalence with and without age-adjustment, and the effect of accounting for LTCs which may either resolve or go into remission.

2. Materials and Methods

2.1 Study design

This is a population-based retrospective cross-sectional study based on patient-level data extracted from primary care EHRs.

2.2 Study setting and participants

The study was set in an urban borough in south London with a deprived, multi-ethnic, and youthful population. Adult patients registered between 1st April 2005 and 2nd May 2020 were included.

2.3 Data Source

The Lambeth DataNet (LDN) collects anonymised primary care data extracted from the EHRs of general practices in Lambeth since 2005. At the time of data extraction (May 2020), information on 826,936 unique, adult (≥ 18 years of age) individuals were held in the database. The data includes information on socio-demographic characteristics, clinical diagnoses, referrals, consultations, medication, lab test results and public health initiatives, such as Quality and Outcomes Framework (QOF) data.[13] The study population consisted of all patients registered at general practices (n = 41) in Lambeth. Patients that opted out of anonymised data sharing for research purposes (3.2%) were omitted.

2.4 Measures

2.4.1 Multimorbidity and long-term conditions

Multimorbidity was defined as two or more of 32 LTCs.[14] Twelve LTCs had resolved/remission codes that were considered in the study. S1 Table lists the selected LTCs, their definitions, whether they are a QOF condition, and whether they had resolved/remission codes applied. Resolve or remission might be permanent if the LTC completely resolves or intermittent if the LTC relapses. Patients with a resolved/remission code would be reinstated if their LTC recurred.
2.4.2 Clinical risk factors

Six clinical risk factors (CRFs) for multimorbidity were analysed in this study. S2 Table lists the selected CRFs, their definitions, and whether they had resolved/remission codes applied. Patients with a resolved/remission code would be reinstated if their CRF recurred.

2.4.3 Resolved and remission codes

Resolved/remission codes were considered for LTCs and CRFs if they were either QOF conditions with validated resolved/remission codes [13] or non-QOF conditions where it was considered that resolved/remission codes were clinically plausible and that there was evidence GPs were using these codes. The classification of resolved/remission was based on clinical coding defined by the patient's general practitioner (S3 Table).

2.4.4 Sociodemographic characteristics

Information on patient sex, age in years (at last known follow-up), and self-identified ethnicity were obtained from the EHRs. Social deprivation data derived from residency data were based on the Index of Multiple Deprivation (IMD) 2019 classification at lower super output area, stratified into nationally based quintiles.[15]

2.5 Statistical analysis

The sociodemographic characteristics and CRFs of the sample were summarised using counts and percentages. Temporal trends were examined by the stratification of people into time cohorts according to their year of last known follow up (2005-2010, 2011-2015, and 2016-2020; with the latter group containing currently registered patients) and compared using the Cochran-Armitage test for trend. Age-adjusted prevalence of multimorbidity was estimated using the direct method, with cohorts adjusted to the 2011 census population of England and Wales.[16] Associations between multimorbidity, sociodemographic characteristics and CRFs were explored using logistic regression. Unadjusted and adjusted odds ratios (ORs) were reported with 95% confidence intervals (CIs).

2.6 Sensitivity analysis

Due to many patients with missing ethnicity, we assessed how robust the ORs were to the assumption that all patients with missing ethnicity were white. All analyses were conducted using the R software (version 3.6.2).
3. Results

3.1 Study participants

Data on 826,936 patients aged ≥ 18 years were extracted from LDN. 816,901 were included in the study sample after exclusion of 10,035 patients with missing information on sex (<0.1%, n=5), registration end date (<0.1%, n=5), and IMD (1.2%, 10,025). 160,576 patients (19.7%) did not have a recorded ethnicity but were kept in the sample under an “unknown” category.

Table 1 summarises the sociodemographic characteristics and CRFs of the study sample, stratified according to year of last known follow-up. 10.9% of patients were registered throughout the entire 15-year period and were included in the final cohort; 41.8% of patients were currently registered (S4 Table). Most patients in the study were female (52.0%), aged <40 years (61.4%), white (53.9%), and reside in the two most deprived quintiles (64.9%).

3.2 Multimorbidity prevalence and temporal trends

3.2.1 Without consideration of resolve and remission codes

The crude prevalence of multimorbidity in the study sample was 21.2% (95% CI: 21.1-21.3; S5 Table) and the age-adjusted prevalence was 30.8% (30.6-31.0; Table 2). Age-adjusted prevalence was higher among females (34.4% [95% CI: 34.1-34.6]) than males (27.7% [27.5-27.9]) and highest among patients of black ethnicity (37.7 [37.3-38.1]). Age-adjusted prevalence of multimorbidity increased over time, from 23.1% (95% CI: 22.8-23.4) in 2005-2010 to 34.8% (34.6-35.0) in 2016-2020 (Table 2). Comparisons between current and previously registered patients can be found in S6 and S7 Table. Most patients (53.5%) in the 50-54 age group and older had 1+ LTCs and most (53.2%) in the 65-69 age group and older had 2+ LTCs (Fig 1).

The most prevalent LTCs in the study were anxiety (14.1%), chronic pain (12.6%), and depression (10.9%) (Fig 2). Chronic pain (51.7%) was most prevalent among multimorbid patients whereas asthma (26.6%) was most prevalent among patients with only one LTC (S1 Fig). Asthma had the youngest age of diagnosis and dementia had the oldest (S8 Table). Asthma had the youngest age at remission and chronic kidney disease had the oldest.

3.2.2 With consideration of resolve and remission codes
After accounting for resolved/remission codes, the crude prevalence of multimorbidity among the study sample decreased from 21.2% to 18.0% (95% CI: 17.9-18.1) and the age-adjusted prevalence decreased from 30.8% to 27.5% (27.4-27.7) (Table 2). Age-adjusted prevalence increased over time from 19.4% (95% CI: 19.1-19.7) in 2005-2010 to 31.7% (31.5-31.9) in 2016-2020. Prevalence remained higher among females than males and highest among patients of black ethnicity. Most patients (58.0%) in the 55-59 age group and older had 1+ LTCs and most (61.2%) in the 70-74 age group and older had 2+ LTCs (S2 Fig).

The most prevalent LTCs in the study were anxiety (14.1%), chronic pain (11.5%), and hypertension (8.7%) (Fig 2). Chronic pain (54.7%) was still most prevalent among multimorbid patients whereas anxiety (26.6%) was now most prevalent among patients with only one LTC (S3 Fig). Chronic pain was the most paired condition for 27 of the 32 LTCs studied (S8 Table).

The most common resolved/remission codes were for asthma (53.2%), depression (20.2%), and chronic pain (7.2%) (S4 Fig). Patients aged 18-49 accounted for 46.0% of all recorded LTCs and 68.0% of resolved/remission codes, while those aged ≥ 60 years accounted for 38.8% of all recorded LTCs and 20.5% of resolved/remission codes (S9 Table).

### 3.3 Sociodemographic determinants of multimorbidity

Without the application of resolved/remission codes, female sex, increasing age, black and mixed ethnicity, and deprivation were all independently associated with increased odds of having multimorbidity (Table 3). Patients of black (AOR 1.16 [95% CI: 1.14-1.18]) and mixed (1.08 [1.04-1.11]) ethnicity were more likely than white patients to have multimorbidity. Patients in the most deprived quintile were more likely than those in the least to have multimorbidity (AOR 1.34 [95% CI: 1.26-1.41]). The effect size of age and area deprivation increased after accounting for resolved/remission codes (Table 4).

### 3.4 Clinical risk factor determinants of multimorbidity

Without the application of resolved/remission codes, adjusting for CRFs in addition to sociodemographic characteristics reduced the effect size of age, mixed ethnicity, increasing area deprivation, and year of last known follow-up, the remaining variables had increased effect size (Table 3). Patients in the most deprived quintile were still more likely than those in the least to have multimorbidity but the odds decreased (AOR 1.17 [95% CI: 1.11-1.25]). Females were almost 50% more likely to have multimorbidity than males (1.47 [1.45-1.49]).
Each CRF was independently associated with increased odds of having multimorbidity. Substance use had the largest odds (AOR 10.00 [95% CI: 9.70-10.32]) and high alcohol consumption the lowest (1.26 [1.20-1.32]). Similar changes in effect size were seen after accounting for resolved/remission codes (Table 4). The results of the sensitivity analysis can be found in S11 and S12 Table.

4. Discussion

4.1 Key results

In this young, urban population, 1 in 5 (21.2%) adults have multimorbidity, and the prevalence is highest among females, people of black ethnicity, and the most recent cohort. The median age of the multimorbid cohort was 52 years, with 2.5 times more multimorbid patients of ‘working age’ (18-64 years) than older ages. Age adjustment increased the estimated prevalence to 30.8%. Anxiety, chronic pain, and depression were the most prevalent LTCs overall. Chronic pain was most prevalent among multimorbid patients and asthma was most prevalent among non-multimorbid patients.

Applying resolved/remission codes reduced prevalence to 18.0%; median age of multimorbid patients increased to 55 years and there were now twice as many multimorbid patients of working age than of older ages in the entire sample. This is one of the first studies to analyse the effect of accounting for clinical resolution and remission. Asthma and depression, two high prevalence conditions, accounted for 53% and 20% of LTC resolved/remission codes, respectively. The most common pairings for each LTC appears to be prevalence driven with chronic pain being the most paired condition.

The prevalence of age-adjusted multimorbidity increased from 23.1% in the 2005-2010 cohort to 34.8% in the 2016-2020 cohort and from 19.4% to 31.7% when resolved/remission codes were applied. The combination of the final cohort containing patients currently registered at a general practice and a ‘healthy cohort’ effect resulting in greater likelihood of housing mobility among those with fewer LTCs, may partly explain these changes. After adjustment, age, female sex, black ethnicity, and area deprivation are all associated with increased odds of multimorbidity. Substance use was the CRF associated with the largest odds of multimorbidity.
4.2 Comparison with previous studies

We only compared previous studies with our results that accounted for resolved/remission codes as we believe these to be more accurate.

Previous studies on multimorbidity prevalence are typically based on cross-sectional data applied to currently registered patients. Therefore, we compared their results with the age-adjusted prevalence among patients that were currently registered in our sample. Before applying resolved/remission codes, the crude prevalence among currently registered patients was 26.9% and adjusting for age increased the prevalence to 35.2%. Accounting for resolved/remission codes decreased the age-adjusted prevalence to 32.2%. Barnett et al [10] found that 23.2% of Scottish primary care patients had multimorbidity, which they defined as two or more of 40 LTCs. Cassell et al [3] found that 27.2% of UK primary care patients had multimorbidity, which they defined as two or more of 36 LTCs. Both studies considered LTCs resolving or going into remission and found the prevalence to be higher among females, older age groups, and more deprived quintiles. Studies outside of the UK have similar findings: Spain (23.6% to 24.5%),[17,18] Denmark (21.6%),[19] the Netherlands (29.7%),[20] Sweden (21.6%),[21] and the US (22.6%).[22]

Studies exploring the trends in multimorbidity over time report increasing prevalence even after age standardisation.[11,23] King et al attributed this trend to an increase in the prevalence of obesity over time.[23] In our study, the prevalence of moderate obesity increased from 6.9% in the 2005-2010 cohort to 13.3% in the 2016-2020 cohort. We also found that moderate obesity was independently associated with having multimorbidity (AOR 2.19 [95% CI: 2.15-2.23]). Another driver of this trend could be the increasing prevalence of high cholesterol (>5mmol/L) over time. Hypercholesterolemia has a well-established association with cardiovascular disease,[24] consequently, patients with high cholesterol are more likely to develop new diseases. In this sample, high cholesterol was associated with a more than doubled (AOR 2.48 [95% CI: 2.44-2.53]) likelihood of having multimorbidity.

Unlike age, sex and deprivation, few studies have investigated the relationship between ethnicity and multimorbidity. Focussing on patients with high healthcare utilisation, Ashworth et al [25] found that south Asian ethnicity was positively associated with multimorbidity whereas other ethnicities were negatively associated. Mathur et al [26] found that south Asian patients were twice as likely as white patients to have cardiovascular
multimorbidity and black patients 23% more likely. Our study found that black and mixed ethnicity were positively associated with multimorbidity prevalence compared to white ethnicity whereas Asian and other ethnicities were negatively associated. Differences in direction may be attributed to restricted samples and a narrower definition of multimorbidity.

4.3 Implications for clinical practice and future research

In an urban setting, multimorbidity is becoming increasingly common among younger populations and poses a particular burden to black ethnic groups and patients living in deprived areas. Healthcare providers could use this study’s prevalence estimates to support efficient resource allocation of the costly management of multimorbidity. Furthermore, providers should create interventions which are targeted at all age groups, not just older cohorts. Regular updates of prevalence, adjusted for LTCs which may resolve or remit over time, are essential to keep a relevant picture of multimorbidity against the backdrop of a dynamic and highly migrant population. Our findings of the most common pairs of LTCs can be used in conjunction with established clusters,[27] to aid the synthesis of a fragmented healthcare system that is not currently catering for individuals with multiple LTCs.

While we have shown the importance of applying resolved/remission codes for accurate prevalence estimates among youthful adult populations, their omission may have less of an impact on elderly cohorts. The UK NHS benefits from a longitudinal primary care record which consistently reports resolved/remission codes for many LTCs. Other healthcare systems may have less reliable reporting of disease status. This poses a problem for reliable comparisons of multimorbidity prevalence between countries. We suggest that studies that don’t have access to or have poorly reported resolved/remission codes should utilise LTC resolved/remission rates from previous studies with similar sample demographics and healthcare standards. These rates should be applied to the study sample over multiple simulations with mean simulated prevalences serving as estimates of multimorbidity prevalence accounting for clinical resolution and remission.

Our study found that CRFs had a stronger association with multimorbidity than any sociodemographic determinant outside of advanced age. Future policy measures should focus on meaningful interventions that target these modifiable risk factors at both the individual and population level.[28,29] Effective interventions have the potential to help prevent the
development of multimorbidity, which would improve health outcomes for patients and reduce the substantial time and resources healthcare systems spend on multimorbidity.

4.4 Strengths and limitations

This is the first UK study to investigate how prevalence estimates for multimorbidity differ before and after applying resolved/remission codes. Omitting resolved/remission codes for LTCs inflated estimates of multimorbidity prevalence. By accounting for resolved/remission codes, we present a more accurate prevalence estimate for the sample. This study stresses the importance of not overestimating asthma and depression prevalence, two high-prevalence LTCs common among younger age groups, but with high resolve and remission frequency.

A strength of this study is that the LTCs were derived following a consensus exercise of local stakeholders selecting LTCs which reflected an urban, multi-ethnic, deprived community.[14] Although our unique definition of multimorbidity provides strong local relevance, it reduces the national generalisability. However, the definition can be generalisable to urban populations with a high proportion of ethnic minorities, migrant populations, and deprived areas.

As EHRs are collected during routine clinical practice, they are susceptible to misclassification and information bias. For example, the increased prevalence of moderate obesity and high cholesterol might be due to increased recording of BMI and cholesterol measurements over time. Among the LTCs considered in the study, 18 were QOF conditions and 14 were non-QOF; coding of QOF conditions is likely to be more standardised. However, even for QOF conditions, anomalies arise such as cancer diagnoses only being recorded for QOF if the onset was after 2003. Additionally, undiagnosed diseases may result in an underestimate of multimorbidity prevalence. Furthermore, the study results are only generalisable to people that consult general practitioners, residents that do not seek health care are not captured in the sample.

This study has relatively complete data with all key variables apart from ethnicity only 1% missing. Nevertheless, 19.7% of all patients had missing information for ethnicity, this decreases to 11% among currently registered patients. This problem is well-documented in primary care and financial incentives have been introduced to try to improve the recording of ethnicity.[30] The missing ethnicity could make spurious associations between study variables and multimorbidity. Our sensitivity analysis imputed the missing ethnicities and
showed that our results are reasonably robust but also highlighted the importance of complete records when studying the association between ethnicity and multimorbidity. Additionally, our general categories for ethnic groups do not account for differences in culture and health outcomes between ethnic subgroups.

### 4.5 Conclusion

Our study highlights the increasing burden of multimorbidity among a young, urban, and multi-ethnic population. The use of age adjustment and application of resolve/remission codes is essential to create accurate, up to date, and comparable estimates of prevalence; Omitting resolve/remission codes can inflate prevalence estimates, particularly in youthful cohorts. Our analysis has shown that multimorbidity is more common among females, older ages, black ethnic groups, and those from deprived areas. Apart from age, clinical risk factors were stronger determinants than sociodemographic factors for multimorbidity. Understanding these modifiable risk factors may provide policymakers with a route to effective interventions to reduce the risk of developing multimorbidity, resulting in improved patient outcomes and reduced healthcare resources.

### Author contributions

Lesedi Ledwaba-Chapman: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Investigation, Visualisation, Project administration; Alessandra Bisquera: Conceptualization, Methodology, Software, Validation, Writing - Review & Editing, Investigation, Project administration; Martin Gulliford: Writing - Review & Editing, Funding acquisition; Hiten Dodhia: Project administration, Conceptualization, Resources, Writing - Review & Editing, Investigation, Funding acquisition; Stevo Durbaba: Data curation, Software, Writing - Review & Editing; Mark Ashworth: Conceptualization, Methodology, Resources, Writing - Review & Editing, Investigation, Supervision, Project administration, Funding acquisition; Yanzhong Wang: Conceptualization, Methodology, Resources, Writing - Review & Editing, Investigation, Supervision, Funding acquisition.
All authors have verified the underlying data and accept responsibility to submit for publication.

**Patient consent for publication:** consent was not required.

**Data sharing**

The data are not publicly available to share, but the research group can provide descriptive data in table form. Requests should be made to Mark Ashworth (mark.ashworth@kcl.ac.uk).

**Author contributions**

Lesedi Ledwaba-Chapman: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Investigation, Visualisation, Project administration; Alessandra Bisquera: Conceptualization, Methodology, Software, Validation, Writing - Review & Editing, Investigation, Project administration; Martin Gulliford: Writing - Review & Editing, Funding acquisition; Hiten Dodhia: Project administration, Conceptualization, Resources, Writing - Review & Editing, Investigation, Funding acquisition; Stevo Durbaba: Data curation, Software, Writing - Review & Editing; Mark Ashworth: Conceptualization, Methodology, Resources, Writing - Review & Editing, Investigation, Supervision, Project administration, Funding acquisition; Yanzhong Wang: Conceptualization, Methodology, Resources, Writing - Review & Editing, Investigation, Supervision, Funding acquisition.

All authors have verified the underlying data and accept responsibility to submit for publication.
Declarations of interest

None.

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Table 1. Sociodemographic characteristics and clinical risk factors of patients over the 15-year study period stratified by year of last known follow-up (n = 816 901). Results are given as column percent (n). Risk factors are summarised with and without considering resolved and remission codes.

| Sociodemographic characteristics | All patients | 2005-2010 | 2011-2015 | 2016-2020 |
|----------------------------------|--------------|-----------|-----------|-----------|
| Registration year                |              |           |           |           |
| 2005 or prior                    | 35.9 (292 956) | 72.7 (115 927) | 34.7 (61 430) | 24.1 (115 599) |
| 2006-2010                        | 21.0 (171 657) | 27.3 (43 540) | 36.0 (63 818) | 13.4 (64 299)  |
| 2011-2015                        | 23.4 (191 188) | 0.0 (0) | 29.3 (51 917) | 29.1 (139 571) |
| 2016-2020                        | 19.7 (160 800) | 0.0 (0) | 0.0 (0) | 33.5 (160 800) |
| Sex                              |              |           |           |           |
| Female                           | 52.0 (425 132) | 53.7 (85 582) | 52.1 (92 295) | 51.5 (247 255) |
| Male                             | 48.0 (391 769) | 46.3 (73 885) | 47.9 (84 870) | 48.5 (233 014) |
| Age at last known follow-up (years) |            |           |           |           |
| 18-29                            | 27.8 (226 812) | 30.0 (47 804) | 28.2 (49 958) | 26.9 (129 050) |
| 30-39                            | 33.6 (274 252) | 35.0 (55 736) | 37.6 (66 676) | 31.6 (151 840) |
| 40-49                            | 16.4 (133 634) | 14.7 (23 497) | 16.7 (29 588) | 16.8 (80 549) |
| 50-59                            | 9.9 (81 126) | 6.6 (10 511) | 7.7 (13 581) | 11.9 (57 034) |
| 60-69                            | 5.8 (47 182) | 5.1 (8207) | 4.0 (7036) | 6.7 (31 939) |
| 70-79                            | 3.4 (27 542) | 3.8 (6020) | 2.6 (4530) | 3.5 (16 992) |
| 80+                              | 3.2 (26 353) | 4.8 (7692) | 3.3 (5796) | 2.7 (12 865) |
| Ethnicity                        |              |           |           |           |
| White                            | 53.9 (440 356) | 38.8 (61 885) | 55.6 (98 497) | 58.3 (279 974) |
| Black                            | 13.8 (112 717) | 9.5 (15 072) | 11.7 (20 785) | 16.0 (76 860) |
| Asian                            | 6.0 (48 995) | 3.5 (5614) | 6.0 (10 696) | 6.8 (32 685) |
| Mixed                            | 3.8 (30 881) | 1.8 (2802) | 3.2 (5672) | 4.7 (22 407) |
| Other                            | 2.9 (23 376) | 2.0 (3245) | 2.8 (4886) | 3.2 (15 245) |
| Unknown                          | 19.7 (160 576) | 44.4 (70 849) | 20.7 (36 629) | 11.1 (53 098) |
Table 2. Age-adjusted multimorbidity prevalence by sociodemographic characteristics and clinical risk factors with and without considering resolved and remission codes for long-term conditions and clinical risk factors (n=816 901).

| Sociodemographic characteristics | MM prevalence, % (95% CI) a | MM prevalence, % (95% CI) b |
|----------------------------------|-----------------------------|-----------------------------|
| All patients                     | 30.8 (30.6-31.0)            | 34.8 (34.6-35.0)            |
| Registration year                |                             |                             |
| 2005 or prior                    | 31.3 (31.1-31.5)            | 41.5 (39.7-43.6)            |
| 2006-2010                        | 29.9 (29.4-30.4)            | 36.5 (35.8-37.2)            |
| 2011-2015                        | 27.6 (27.1-28.1)            | 29.4 (28.8-30.0)            |
| 2016-2020                        | 25.9 (25.3-26.5)            | 25.9 (25.3-26.5)            |
| Sex                              |                             |                             |
| Female                           | 34.4 (34.1-34.6)            | 38.2 (37.9-38.5)            |
| Male                             | 27.7 (27.5-27.9)            | 31.6 (31.3-31.9)            |
| Age at last known follow-up (years) |                            |                             |
| 18-29                            | 9.5 (9.4-9.6)               | 11.9 (11.7-12.1)            |
| 30-39                            | 11.9 (11.8-12.0)            | 14.6 (14.5-14.8)            |
| 40-49                            | 19.9 (19.6-20.1)            | 23.7 (23.4-23.9)            |

Abbreviations: BMI, Body mass index; IMD, Index of multiple deprivation.
| Clinical risk factors | MM prevalence, % (95% CI) | MM prevalence, % (95% CI) | MM prevalence, % (95% CI) | MM prevalence, % (95% CI) | Pb | MM pre |
|----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----|--------|
| Alcohol > 14 units/week | No | 30.6 (30.3-30.8) | 23.0 (22.7-23.4) | 24.9 (24.5-25.2) | 34.7 (34.5-34.9) | * | 27.4 (27.3-27.6) |
| Yes | 40.3 (38.8-41.9) | 43.1 (33.4-56.0) | 39.8 (35.5-44.7) | 41.2 (39.5-42.9) | 0.420 | 34.6 (32.9-36.3) |
| Cholesterol >5mmol/L | No | 22.9 (22.7-23.1) | 17.7 (17.4-18.0) | 18.3 (17.8-18.7) | 27.7 (27.4-28.1) | * | 19.8 (19.6-20.0) |
| Yes | 44.1 (43.7-44.5) | 40.8 (39.7-41.9) | 40.7 (39.8-41.7) | 45.5 (45.0-46.0) | * | 39.8 (39.4-40.2) |
| Hypertension | No | 23.2 (23.1-23.4) | 16.5 (16.1-16.8) | 18.1 (17.7-18.5) | 27.4 (27.1-27.7) | * | 19.7 (19.5-19.9) |
| Yes | 68.2 (66.9-69.6) | 60.2 (57.6-63.0) | 63.3 (60.4-66.5) | 71.6 (69.9-73.4) | * | 63.8 (62.5-65.1) |
| BMI ≥30 & <40 kg/m² | No | 26.4 (26.2-26.5) | 20.6 (20.3-21.0) | 22.1 (21.7-22.4) | 29.9 (29.7-30.2) | * | 24.6 (24.4-24.8) |
| Yes | 47.2 (46.8-47.6) | 39.0 (37.9-40.2) | 39.3 (38.3-40.3) | 50.3 (49.8-50.8) | * | 41.6 (41.1-41.2) |
| Smoking | No | 24.3 (24.1-24.5) | 15.9 (15.3-16.2) | 18.3 (17.9-18.8) | 29.5 (29.2-29.8) | * | 26.2 (26.1-26.3) |
| Yes | 38.0 (37.7-38.2) | 33.7 (33.1-34.4) | 33.5 (32.9-34.1) | 40.6 (40.3-40.9) | * | 32.5 (32.1-32.9) |
| Substance Use | No | 29.3 (29.2-29.5) | 21.9 (21.6-22.3) | 23.7 (23.4-24.1) | 33.3 (33.1-33.5) | * | 26.1 (26.0-26.2) |
| Yes | 73.1 (71.8-74.4) | 70.0 (67.3-74.0) | 70.7 (67.5-74.1) | 74.5 (73.0-76.1) | * | 67.5 (66.2-68.7) |

Abbreviations: CI, Confidence interval, using Fay and Feuer’s method for exact approximation.; CRF, Clinical risk factor; IMD, Index of multiple deprivation; MM, Multimorbidity; NA. Not Applicable; SD, Standard deviation.

*Statistically significant difference in multimorbidity prevalence (p<0.05) between categories within sex, age at last known follow-up, ethnicity, IMD quintile, and clinical risk factors for the entire sample and the time cohort subsets (chi-squared test).

P-value for trend of multimorbidity prevalence within each variable over time is calculated using Cochran-Armitage trend test, * indicates p < 0.001.
Table 2. Crude and adjusted odds ratios and 95% confidence intervals for the presence of multimorbidity by sociodemographic characteristics and clinical risk factors. Resolved and remission codes are not considered.

| Sociodemographic characteristics | Crude OR | 95% CI | Adjusted model 1* OR | 95% CI | Adjusted model 2* OR | 95% CI |
|-------------------------------|---------|--------|----------------------|--------|----------------------|--------|
| Female sex                    | 1.20    | (1.18 to 1.21) | 1.39 | (1.37 to 1.41) | 1.47 | (1.45 to 1.49) |
| Year of last known follow-up  |         |         |         |         |         |         |
| 2005-2010 Ref                 |         |         | Ref     |         | Ref     |         |
| 2011-2015 0.99 (0.97 to 1.01) | 0.95 (0.93 to 0.98) | 0.92 (0.90 to 0.94) |
| 2016-2020 1.83 (1.80 to 1.86) | 1.58 (1.55 to 1.61) | 1.38 (1.35 to 1.41) |
| Age at last known follow-up (years) |         |         |         |         |         |         |
| 18-29 Ref                     |         |         |         |         |         |         |
| 30-39 1.28 (1.26 to 1.31)     | 1.33 (1.31 to 1.36) | 1.14 (1.12 to 1.16) |
| 40-49 2.36 (2.31 to 2.41)     | 2.56 (2.51 to 2.62) | 1.61 (1.58 to 1.65) |
| 50-59 5.2 (5.09 to 5.30)      | 5.44 (5.33 to 5.55) | 2.73 (2.67 to 2.80) |
| 60-69 9.36 (9.15 to 9.58)     | 10.34 (10.09 to 10.59) | 4.99 (4.85 to 5.12) |
| 70-79 20.73 (20.13 to 21.34) | 24.21 (23.49 to 24.95) | 12.28 (11.87 to 12.69) |
| 80+ 40.87 (39.51 to 42.28)   | 51.61 (49.83 to 53.46) | 31.37 (30.22 to 32.57) |
| Ethnicity                      |         |         |         |         |         |         |
| White Ref                     |         |         |         |         |         |         |
| Black 1.66 (1.63 to 1.68)     | 1.16 (1.14 to 1.18) | 1.19 (1.17 to 1.21) |
| Asian 0.91 (0.89 to 0.93)     | 0.78 (0.76 to 0.81) | 0.92 (0.89 to 0.95) |
| Mixed 1.00 (0.97 to 1.03)     | 1.08 (1.04 to 1.11) | 1.06 (1.03 to 1.10) |
| Other 0.61 (0.59 to 0.63)     | 0.57 (0.55 to 0.59) | 0.63 (0.60 to 0.65) |
| Unknown 0.49 (0.48 to 0.49)  | 0.40 (0.39 to 0.41) | 0.56 (0.55 to 0.57) |
| Borough                       |         |         |         |         |         |         |
| Lambeth Ref                   |         |         |         |         |         |         |
| Southwark 1.05 (1.03 to 1.08) | 0.98 (0.95 to 1.00) | 1.00 (0.98 to 1.03) |
| Other 1.02 (1.01 to 1.04)     | 1.04 (1.02 to 1.07) | 1.06 (1.03 to 1.08) |
| IMD quintile                  |         |         |         |         |         |         |
| Most deprived - 1 1.59 (1.51 to 1.67) | 1.34 (1.26 to 1.41) | 1.17 (1.11 to 1.25) |
| 2 1.25 (1.19 to 1.31)         | 1.14 (1.08 to 1.21) | 1.03 (0.97 to 1.09) |
| 3 1.21 (1.15 to 1.27)         | 1.07 (1.01 to 1.13) | 0.98 (0.92 to 0.94) |
| 4 1.09 (1.04 to 1.15)         | 0.93 (0.88 to 0.99) | 0.90 (0.85 to 0.96) |
| Least deprived - 5 Ref        |         |         |         |         |         |         |

Adjusted for all sociodemographic characteristics.

Abbreviations: IMD, Index of multiple deprivation; OR, Odds ratio; Ref, Reference category.
Adjusted for all sociodemographic characteristics and clinical risk factors.

Table 4. Crude and adjusted odds ratios and 95% confidence intervals for the presence of multimorbidity by sociodemographic characteristics and clinical risk factors. Resolved and remission codes are considered for long-term conditions and risk factors.

| Sociodemographic characteristics | Crude OR (95% CI) | Adjusted model 1 OR (95% CI) | Adjusted model 2 OR (95% CI) |
|----------------------------------|-------------------|-------------------------------|-------------------------------|
| Female sex                       | 1.20 (1.19 to 1.21) | 1.41 (1.40 to 1.43)          | 1.46 (1.44 to 1.48)          |
| Year of last known follow-up     |                   |                               |                               |
| 2005-2010 Ref                    | Ref               | Ref                           | Ref                           |
| 2011-2015 1.04 (1.02 to 1.06)    | 1.05 (1.02 to 1.07) | 1.02 (0.99 to 1.05)          |
| 2016-2020 2.09 (2.06 to 2.13)    | 1.92 (1.88 to 1.96) | 1.73 (1.69 to 1.77)          |
| Age at last known follow-up (years) |                   |                               |                               |
| 18-29 Ref                        | Ref               | Ref                           | Ref                           |
| 30-39 1.32 (1.29 to 1.35)        | 1.37 (1.34 to 1.40) | 1.23 (1.20 to 1.25)          |
| 40-49 2.63 (2.57 to 2.69)        | 2.83 (2.76 to 2.89) | 1.90 (1.85 to 1.94)          |
| 50-59 6.23 (6.09 to 6.37)        | 6.39 (6.24 to 6.54) | 3.46 (3.38 to 3.55)          |
| 60-69 11.70 (11.42 to 11.99)     | 12.90 (12.58 to 13.24) | 6.87 (6.67 to 7.07) |
| 70-79 26.21 (25.44 to 27.00)     | 31.57 (30.60 to 32.57) | 18.30 (17.69 to 18.94) |
| 80+ 52.54 (50.79 to 54.36)      | 71.48 (68.97 to 74.08) | 49.61 (47.77 to 51.52) |
| Ethnicity                        |                   |                               |                               |
| White 1.77 (1.74 to 1.79)        | 1.21 (1.19 to 1.23) | 1.18 (1.16 to 1.20)          |
| Black 0.99 (0.96 to 1.01)        | 0.85 (0.83 to 0.88) | 0.93 (0.90 to 0.96)          |
| Mixed 1.01 (0.98 to 1.04)        | 1.11 (1.07 to 1.14) | 1.07 (1.04 to 1.11)          |
| Other 0.66 (0.63 to 0.68)        | 0.62 (0.59 to 0.64) | 0.65 (0.63 to 0.68)          |
| Unknown 0.46 (0.45 to 0.47)     | 0.38 (0.37 to 0.39) | 0.48 (0.47 to 0.49)          |
| Borough                          |                   |                               |                               |
| Lambeth Ref                      | Ref               | Ref                           | Ref                           |
| Southwark 1.05 (1.03 to 1.07)    | 0.96 (0.94 to 0.99) | 0.97 (0.95 to 1.00)          |
| Other 1.03 (1.01 to 1.05)        | 1.07 (1.04 to 1.09) | 1.07 (1.04 to 1.09)          |
| IMD quintile                     |                   |                               |                               |
| Most deprived - 1 1.74 (1.65 to 1.84) | 1.46 (1.37 to 1.55) | 1.29 (1.20 to 1.37) |
| 2 1.33 (1.26 to 1.41)            | 1.22 (1.15 to 1.30) | 1.10 (1.03 to 1.17)          |
| 3 1.27 (1.20 to 1.34)            | 1.10 (1.03 to 1.17) | 1.01 (0.95 to 1.08)          |
| 4 1.13 (1.07 to 1.20)            | 0.94 (0.88 to 1.00) | 0.89 (0.83 to 0.96)          |
| Least deprived - 5 Ref           | Ref               | Ref                           | Ref                           |
| Clinical risk factors            |                   |                               |                               |
| Alcohol > 14 units/week          | 1.41 (1.35 to 1.48) | 1.19 (1.12 to 1.27)          |
| Cholesterol >5mmol/L             | 7.80 (7.71 to 7.90) | 2.48 (2.44 to 2.53)          |
| BMI ≥30 & <40 kg/m²              | 3.86 (3.80 to 3.92) | 2.19 (2.15 to 2.23)          |
| Smoking                         | 1.27 (1.26 to 1.29) | 1.51 (1.49 to 1.54)          |
| Substance Use                   | 8.22 (8.00 to 8.44) | 10.62 (10.30 to 10.95) |

Abbreviations: IMD, Index of multiple deprivation; OR, Odds ratio; Ref, Reference category.
Adjusted for all sociodemographic characteristics.

Adjusted for all sociodemographic characteristics and clinical risk factors.