Prevalence and patterns of testing for anaemia in primary care in England

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Abstract 248 words currently

Background

Despite epidemiological data on anaemia being available on a global scale, its prevalence in the United Kingdom is not well described.

Aim

To describe anaemia prevalence and testing patterns for haemoglobin and other blood parameters.

Design and Setting

A descriptive population-based cohort study using data drawn from the Clinical Practice Research Datalink Aurum database in 2019.

Method

We extracted demographic data for each person who was registered at their current practice during 2019, including linked data on Index of Multiple Deprivation. We calculated anaemia prevalence in 2019 based on World Health Organization specified age and gender thresholds for haemoglobin. We classified anaemia based on mean corpuscular volume and ferritin. We followed up people with anaemia for up to one year to investigate longitudinal testing patterns for haemoglobin.

Results

The cohort contained 14 million people. Anaemia prevalence in 2019 was 4.1% (5.1 % females and 3.1% males). Prevalence was higher in people aged >65 years, Black and Asian ethnicities, and people living in areas with higher social deprivation. Only half of people with anaemia and a mean corpuscular volume of ≤100 fL had an accompanying ferritin value recorded. About half of people with anaemia had a follow-up haemoglobin test within one-year, most of which still indicated anaemia.

Conclusion

Anaemia is prevalent in the UK with large disparities between levels of demographic variables. Investigation and follow-up of anaemia is suboptimal in many patients. Health interventions aimed at improving anaemia investigation and treatment are needed, particularly in the most at-risk groups.

Keywords.

Anaemia, epidemiology, haemoglobin, ferritin, mean corpuscular volume, primary health care

How this fits in

- The Global Burden of Disease Study estimates anaemia prevalence in Europe to be 6.0%, but there are no recent studies in the United Kingdom.
- We estimated a prevalence of 4.1% (5.1 % females and 3.1% males) in England in 2019, but some demographic groups have much higher prevalence.
- Ferritin testing was not always done in people with microcytic or normocytic anaemia.
- People with a haemoglobin test indicating anaemia did not always seem to be followed up in primary care.

Introduction

Anaemia is a global health problem. Whilst anaemia prevalence is highest in low-middle income countries the Global Burden of Disease Study estimated that its prevalence in Western Europe in 2021 was 6.0%.[1] The aetiology of anaemia is multifactorial, however iron deficiency, where there are insufficient stores of iron in the body or an inability to utilise them, remains the commonest cause, yet is potentially readily treated.[2] Other causes of anaemia in the general population include deficiencies of other nutrients (usually B12 or folate), anaemia of chronic disease and inherited causes. There is less information on the relative proportion of these different aetiologies.[3]

Anaemia contributes significantly to the morbidity and mortality of a population. [1,4,5] Appropriate diagnosis and treatment is imperative, and tests that are commonly used in the diagnostic work-up of anaemia, such as haemoglobin (Hb) and serum ferritin, are readily available. [6] Despite this, identifying and treating iron deficiency anaema (IDA) can be challenging, partly because ferritin can be elevated in inflammation. Common underlying causes of iron deficiency include dietary insufficiency, malabsorption and menorrhagia. However IDA may also be an indication of underlying gastrointestinal malignancy and endoscopic examination may not always detect these cases.[7]

Despite epidemiological data on anaemia being available on a global scale, the prevalence in the United Kingdom (UK) is not well described. The National Institute of Health and Care Excellence (NICE) states that the prevalence of IDA in the UK is around 3% and 8% for adult males and adult females respectively. [8] However, sources for these statistics are not obvious. In addition, the few studies that have examined the management of anaemia in the UK have concluded that anaemia was being inadequately investigated. [9–11]

As part of a programme of research to address the burden of anaemia, this study aims to describe anaemia prevalence, and patterns of Hb and serum ferritin testing in England. These contemporary estimates will inform researchers, clinicians, and policy makers so that anaemia and its consequences can be better addressed. We use the Clinical Practice Research Datalink (CPRD) Aurum database, which is a database of anonymised data from UK Primary Care, containing records from 41 million patients registered at 1,489 practices. [12]

Methods

The study population consisted of people with acceptable data in CPRD Aurum (February 2022 database) [13] who were registered in their current practice in 2019 and were born in 2017 or before. The acceptable flag means that the patient was permanently registered, and that the data meet basic quality requirements. We excluded people recorded as having indeterminate gender. We chose 2019 because this predates the COVID-19 pandemic which may have altered typical testing patterns. We also specified that included patients were eligible for linkage to data on Index of Multiple Deprivation (IMD) meaning that our study population was restricted to people registered at practices in England. We used the CPRD Aurum pregnancy register to identify pregnancy dates in 2019. [14] We classified ethnicity into five categories (Asian, Black, Mixed, Other, White), [15] or missing in people with no recorded ethnicity codes.

For each patient, we counted the number of Hb tests in 2019 and we extracted the date and lowest Hb value in 2019. We extracted the concomitant value for mean corpuscular volume (MCV) and the ferritin value when one was recorded within the next 0-90 days. The 90-day window allowed for ferritin tests to be done in response to a low Hb. If there was more than one ferritin value, then we chose the one closest in date to the Hb test.

We used World Health Organization (WHO) age-specific cut-offs for Hb to assess whether patients had anaemia (130 g/L if male and age >=15 years; 120 if female and age >=15 years; 120 g/L if age 12-14 years; 115 g/L if age 5-11 years; 110 g/L if age<5 years; 110 g/L for Hb tests done in pregnancy).[16] About 29% of pregnancies had no outcome recorded and dates associated with these pregnancies are more likely to be inaccurate.[17] Based on a sensitivity analysis (Supplementary Table S1) we nevertheless used the same date-specific Hb cut-off for these pregnancies. Analyses were done separately by gender. We calculated the percentage of people who had at least one Hb test in 2019 and the percentage of those tested who had anaemia. Anaemia prevalence was estimated from the number of people with anaemia divided by the total number of people (whether or not they received an Hb test). Prevalence was calculated overall, and stratified by IMD, ethnicity and age group. We plotted prevalence by 5-year age group for each category of IMD or ethnicity. Confidence intervals for proportions were calculated using the normal approximation.

We further categorised patients with anaemia according to MCV category (microcytic (<80 fL) normocytic (80 – 100 fL) macrocytic (>100 fL)). We calculated the percentage of these patients with low ferritin i.e. iron deficiency anaemia (IDA). We used WHO guidelines for ferritin concentrations assuming no inflammation (12 µg/L children age <5 years; otherwise 15 µg/L),[18] and a cut of 30 µg/L as a sensitivity analysis to allow for increased ferritin levels where co-existing inflammation may be present.[8,19]

We also followed a subpopulation of patients who had an Hb test indicating anaemia in January-March 2019, for a maximum of one-year. We calculated the percentages who had another Hb test 3-6 months after that initial test and the percentages of these that remained below the threshold for anaemia. We did the same for the period 6-12 months after the initial test.

Analyses were done using Stata software. [20]

Results

The study population contained 14,207,841 people, with an approximately equal gender ratio (Table 1). Nearly half the females (over 3.5 million) were age 15-49 years old, representing this population during their reproductive years. Approximately 9% of these were pregnant in 2019.

Haemoglobin (Hb)

Anaemia prevalence was 5.1% in females and 3.1% in males (4.1% overall). Hb tests were recorded in 29.1% of females and 20.6% of males, but only 8.7% and 6.7% respectively had more than one test. The relative frequency of Hb testing increased with age in both sexes (Table 2, Supplementary Table S2). Anaemia was most common in people aged >65 years. Of those tested in this age group, 25.3% of females and 29.6% of males had low Hb, giving an anaemia prevalence of 13.8% in females and 16.1% in males. Amongst the 15–49-year-olds, the proportion of females tested was double that of males (25% and 12.5%, respectively). Furthermore, more tests indicated anaemia in females than in males, resulting in prevalences of 4.0% of females and 0.5% of males.

Variation in anaemia prevalence between females of different ethnicities was evident from late childhood (Figure 1). Similar percentages (approximately 30%) of Asian, Black, and White females received tests in 2019, but within those twice as many Asian and Black females had Hb values below the threshold for anaemia compared with White females (Table 2, Supplementary Table S2). Anaemia prevalence was therefore higher in Asian and Black females (9.4% and 10.1% respectively) compared with White females (4.7%). Prevalence was higher in Black compared with Asian females up until about age 45 years, but the reverse was true in older females. Anaemia prevalence in

females also increased with social deprivation (Table 2, Supplementary Table S2), and differences were again evident from around late childhood (Figure 1). Asian and Black males and males living in areas with higher deprivation also had higher prevalence of anaemia (Table 2, Supplementary Table S2), although differences were not obvious until after about age 35 years (Figure 1).

Mean corpuscular volume (MCV)

Some 565,098 (96.8%) of the 583,847 people with anaemia had an MCV result on the same day as their Hb test. The percentage with microcytic anaemia, often indicative of iron deficiency, decreased with older age. Microcytic anaemia accounted for a higher proportion of anaemia cases in females than in males from around age 35 years. (Figure 2). However, when we excluded pregnant females, who tend to have higher MCV measurements in pregnancy, microcytic anaemia accounted for relatively more anaemia cases in females from around age 15 years (Supplementary Figure S1). Macrocytic anaemia increased gradually with age up to 7.7% (females) and 10.0% (males) of all anaemia cases in those aged >65 years (Figure 2).

Ferritin

Within people with anaemia and an MCV result, 266,665 (48.2%) had a ferritin value within 90 days. Of these ferritin results, 73.8% were on the same day as the Hb and MCV. NICE recommends ferritin testing to confirm IDA in all people with an MCV of <95fL.[8] Only 67.3% and 45.9% of females with microcytic or normocytic anaemia respectively had ferritin tested (Table 3, Supplementary Table S3). Equivalent percentages in males were lower, 57.5% and 40.0% respectively. However, nearly 40% of both males and females with macrocytic anaemia still had a ferritin value recorded.

In females with microcytic or normocytic anaemia who were tested for ferritin, 63.5% and 27.8% respectively had IDA (Table 3, Supplementary Table S3). When the higher threshold of 30 fL was applied to allow for inflammation, the percentages of females potentially with IDA were 78.7% and 49.1%, respectively. In males with microcytic or normocytic anaemia only 39.1% and 6.8% respectively of those tested had IDA. Applying the higher ferritin threshold 57.6% and 19.6 % respectively may have had IDA.

Females aged 15-49 years made up the majority of people with confirmed IDA (Table 3, Supplementary Table S3). Most people aged >65 years with anaemia had normocytic anaemia. Only 12.9% (or 31.6% allowing for inflammation) of the females in this age group who were tested for ferritin and 5.7% (or 18.4% allowing for inflammation) of the males had IDA.

Follow up haemoglobin (Hb) tests

Overall, 34.7% of females with anaemia had another Hb test in the following 3-6 months (Table 4). Percentages retested increased with age from 14.4% in children to 41.3% in those >65 years old. The percentage with a retest within 6-12 months was slightly higher but trends were similar. Similar patterns were seen in males.

Discussion

Summary

The overall anaemia prevalence was 4.1% indicating a burden comparable to those of other common disorders, such as diabetes or heart disease. Some population groups had much higher prevalence of anaemia, including older people, people of Black or Asian ethnicity, and those living in areas with high social deprivation. Females of reproductive age also had higher levels of testing and anaemia.

Differences between ethnic groups and quintiles of IMD were evident in females of reproductive age as well as in older males and females.

Our data also raises questions about inconsistency in testing. NICE recommends that ferritin should be checked in everyone with an MCV of less than 95fL. However, many people with microcytic or normocytic anaemia were missing a corresponding ferritin value. Longitudinal analyses also suggested that Hb tests indicating anaemia are often not followed up.

Strengths and limitations

The strength of this study is the very large database of real-world data, which allowed a detailed breakdown of anaemia prevalence and testing. The database is approximately representative of the population in age and gender distribution.[12] However, tests would be conducted for a clinical indication so anaemia prevalence in our study is for known or suspected anaemia and is likely to be lower than from prevalence surveys. The degree of underestimation of the population prevalence is likely to vary with demographic group. Underestimation is most likely to be in those with mild anaemia symptoms or in those who do not interact with health services.

Full blood counts requested in other healthcare settings may not be incorporated into primary care records. Therefore we may have missed anaemia in patients receiving care elsewhere, particularly those with poorer health receiving care in secondary or tertiary centres. A further limitation is that we reported on pregnant and non-pregnant females together as we plan to research anaemia in pregnant females separately. We also did not have exact dates for some pregnancies, and additionally physiological changes in pregnancy mean that anaemia is less straightforward to define from laboratory tests.[21] Overall, we may have slightly over-estimated anaemia prevalence in females aged 15-49 years.

Comparison with existing literature

Our overall estimate of anaemia prevalence is slightly lower than the 6.0% from the GBD study. [1] Higher prevalence of anaemia at older age, in females of reproductive age, in Black and Asian ethnicities, and at higher levels of social deprivation are broadly consistent with our understanding of anaemia on a global scale.[22,23]

We found that 14-16% of people in the >65 years age group had anaemia, which is consistent with a systematic review of studies done in various settings in developed countries and probably associated with chronic disease and inflammation.[24] Our findings for this age group are also like those of a study done on older primary care patients with full blood counts in Oxfordshire in 2012-2013,[10] not only in the prevalence of anaemia but also in the degree of incompleteness of ferritin testing and lack of follow-up for further Hb testing.

One population based cross-sectional study of European and Asian populations in Newcastle (UK found anaemia to be more prevalent in females of Asian ethnicity than those of White ethnicity.[25] We could not find any other UK studies of anaemia by age group and ethnicity. Data from the United States National Health and Nutrition Examination Survey reported similarly wide differences in anaemia prevalence in older people of Black ethnicity compared to White,[26] and between Black and White ethnicities in females of reproductive age.[27] Causes of differences in anaemia prevalence between ethnicities are likely to be multifactorial including higher rates of menorrhagia in Black females, differences in social deprivation, diet, prevalence of other chronic diseases and of inherited causes of anaemia.[28–30]

Implications for research and practice

This study has highlighted a high burden of anaemia throughout all ages, with public health implications for better understanding the consequences, and for implementing strategies for optimal diagnosis and management.

Differences in anaemia prevalence between ethnicities and levels of social deprivation that vary with age and gender may be due to multiple underlying factors, and disentangling these influences should be a priority for further research.[3031] Investigation of high anaemia prevalence and its management in Black and Asian females of reproductive age is of particular importance given the association of anaemia with poorer pregnancy outcomes and clinical guidelines already emphasise early detection and treatment of anaemia in pregnancy.[21] Our results suggest that there should also be emphasis on diagnosing and managing anaemia prior to pregnancy particularly in these high risk groups. The increase in macrocytic anaemia in people aged >65 years may be due in part to the increase in disorders such as myelodysplasia,[31] and monitoring older patients with macrocytic anaemia may help to understand and predict bone marrow disorders.[32]

Around half of people with microcytic or normocytic anaemia had a ferritin test result recorded even though NICE recommends testing in all people with an MCV of <95fL.[8] This represents a missed opportunity for identification of IDA and treatment initiation which clinicians can address. Further research using primary care records could tell us whether patients who do not have a ferritin result are also less likely to be prescribed iron and to have a persistent anaemia at 3-12 months. Primary care data and linked secondary care data could be used to evaluate treatment and patient outcomes following an initial diagnosis of anaemia in primary care and how prompt treatment can influence outcomes. For example, patients are often seen primary care during preparation for surgery, and anaemia is a risk factor for poorer surgical outcomes in tertiary settings.[33] Most ferritin tests were recorded on the same date as an Hb value, the utility and cost-effectiveness of routinely testing ferritin at the same time as Hb should also be investigated. This could have the added benefit of detecting patients with iron deficiency without anaemia which is increasingly being recognised as a clinical condition requiring treatment.[34]

Our findings also suggest that there may be a longitudinal burden of under investigated and untreated anaemia over the life-course. However, lack of follow-up Hb tests for people with an initial low Hb may not necessarily indicate that there was no intervention as the Hb may have been borderline, symptoms may have improved without treatment or follow-up may have been in secondary care. Nevertheless, we need research to further understand why some low Hb results do not appear to be followed up.

In summary, our data indicate a high prevalence of anaemia in the UK population, with many areas of research needed. Primary care offers the ideal setting to detect and manage anaemia accordingly, which may prevent poor health from occurring downstream. There appears to be suboptimal adherence to published guideline particularly in relation to performing additional tests (e.g. ferritin) when indicated. An implementation science approach may be required to address this. Predictive models e.g. machine learning algorithms could be developed to identify at-risk individuals so they can be treated in a timely manner.

Ethical approval: body giving ethics approval with reference number where appropriate

The study obtained ethics approval through CPRD Research Data Governance process (Protocol Number 22_001873).

Data availability

Data can be accessed by application to the Clinical Practice Research Datalink. We have uploaded codelists to Github. See https://github.com/ndpchs-cprd/22-001873-Anaemia/tree/main/

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Competing interests

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References

1. Gardner WM, Razo C, McHugh TA, Hagins H, Vilchis-Tella VM, Hennessy C, et al. Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990–2021: findings from the Global Burden of Disease Study 2021. Lancet Haematol. 2023;10:e713–34.

2. Cappellini MD, Musallam KM, Taher AT. Iron deficiency anaemia revisited. J Intern Med. 2020;287:153–70.

3. Brittenham GM, Moir-Meyer G, Abuga KM, Datta-Mitra A, Cerami C, Green R, et al. Biology of Anemia: A Public Health Perspective. J Nutr. 2023;153:S7–28.

4. Palapar L, Kerse N, Rolleston A, Den Elzen WPJ, Gussekloo J, Blom JW, et al. Anaemia and physical and mental health in the very old: An individual participant data meta-analysis of four longitudinal studies of ageing. Age Ageing. 2021;50:113–9.

5. Benson CS, Shah A, Stanworth SJ, Frise CJ, Spiby H, Lax SJ, et al. The effect of iron deficiency and anaemia on women's health. Anaesthesia. 2021;76 Suppl 4:84–95.

6. Kumar A, Sharma E, Marley A, Samaan MA, Brookes MJ. Iron deficiency anaemia: pathophysiology, assessment, practical management. BMJ Open Gastroenterol. 2022;9.

7. Stone H, Almilaji O, John C, Smith C, Surgenor SL, Ayres L, et al. Original research: The dedicated iron deficiency anaemia clinic: a 15-year experience. Frontline Gastroenterol. 2022;13:20.

8. Anaemia - iron deficiency | Health topics A to Z | CKS | NICE. [Accessed 2024 Apr 1]. Available from: https://cks.nice.org.uk/topics/anaemia-iron-deficiency/

9. Logan ECM, Yates JM, Stewart RM, Fielding K, Kendrick D. Investigation and management of iron deficiency anaemia in general practice: a cluster randomised controlled trial of a simple management prompt. Postgrad Med J. 2002;78:533.

10. McCartney D, Shine B, Hay D, Lasserson DS. The evaluation of anaemia in an older primary care population: retrospective population-based study. BJGP Open. 2017;1(4).

11. Hamid M, Naz A, Alawattegama LH, Steed H. The Prevalence of Anaemia in a District General Hospital in the United Kingdom. Cureus. 2021; 13(5):e15086

12. Wolf A, Dedman D, Campbell J, Booth H, Lunn D, Chapman J, et al. Data resource profile: Clinical Practice Research Datalink (CPRD) Aurum. Int J Epidemiol. 2019;48:1740.

13. CPRD Aurum February 2022 dataset | CPRD. [Accessed 2024 Mar 20]. Available from: https://www.cprd.com/cprd-aurum-february-2022-dataset

14. Campbell J, Shepherd H, Welburn S, Barnett R, Oyinlola J, Oues N, et al. Methods to refine and extend a Pregnancy Register in the UK Clinical Practice Research Datalink primary care databases. Pharmacoepidemiol Drug Saf. 2023;32:617–24.

15. Ethnic group by age and sex, England and Wales - Office for National Statistics. [Accessed 2024 Apr 26]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/articles/ethnicgroupbyageandsexenglandandwales/census2021#ethnic-group-by-age-and-sex

16. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. [Accessed 2024 Feb 21] Available from: https://www.who.int/publications/i/item/WHO-NMH-NHD-MNM-11.1

17. Campbell J, Bhaskaran K, Thomas S, Williams R, Mcdonald HI, Minassian C. Investigating the optimal handling of uncertain pregnancy episodes in the CPRD GOLD Pregnancy Register: a methodological study using UK primary care data. BMJ Open. 2022;12:55773.

18. WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations. WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations. 2020 [Accessed 2024 Mar 19]; Available from: https://www.ncbi.nlm.nih.gov/books/NBK569880/

19. Snook J, Bhala N, Beales ILP, Cannings D, Kightley C, Logan RPH, et al. British Society of Gastroenterology guidelines for the management of iron deficiency anaemia in adults. Gut. 2021 ;70:2030.

20. Stata. (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC.

21. Pavord S, Daru J, Prasannan N, Robinson S, Stanworth S, Girling J. UK guidelines on the management of iron deficiency in pregnancy. Br J Haematol. 2020 Mar;188(6):819-830.

22. Safiri S, Kolahi AA, Noori M, Nejadghaderi SA, Karamzad N, Bragazzi NL, et al. Burden of anemia and its underlying causes in 204 countries and territories, 1990–2019: results from the Global Burden of Disease Study 2019. J Hematol Oncol. 2021;14:1–16.

23. Stauder R, Valent P, Theurl I. Anemia at older age: etiologies, clinical implications, and management. Blood. 2018;131:505–14.

24. Gaskell H, Derry S, Andrew Moore R, McQuay HJ. Prevalence of anaemia in older persons: systematic review. BMC Geriatr. 2008 ;8:1.

25. Fischbacher C, Bhopal R, Patel S, White M, Unwin N, Alberti KGMM. Anaemia in Chinese, South Asian, and European populations in Newcastle upon Tyne: cross sectional study. BMJ : British Medical Journal. 2001 ;322:958.

26. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood. 2004 ;104:2263–8.

27. Gupta PM, Hamner HC, Suchdev PS, Flores-Ayala R, Mei Z. Iron status of toddlers, nonpregnant females, and pregnant females in the United States. American Journal of Clinical Nutrition. 2017;106:1640S-1646S.

28. Alisonchapplergn B, Hons, Ma. Iron deficiency anaemia in women of south Asian descent: A qualitative study. Ethn Health. 1998 ;3:199–212.

29. Hayanga B, Stafford M, Bécares L. Ethnic inequalities in multiple long-term health conditions in the United Kingdom: a systematic review and narrative synthesis. BMC Public Health 2023 23:1. 2023 ;23:1–24.

30. Weyand AC, Mcgann PT. Eliminating race-based reference ranges in haematology: a call to action. Lancet Haematol. 2021;8:462–6.

31. Stauder R, Valent P, Theurl I. Anemia at older age: etiologies, clinical implications, and management. Blood. 2018 ;131:505–14.

32. Koshiaris C, Van Den Bruel A, Oke JL, Nicholson BD, Shephard E, Braddick M, et al. Early detection of multiple myeloma in primary care using blood tests: a case–control study in primary care. British Journal of General Practice. 2018 ;68:e586–93.

33. Fowler AJ, Ahmad T, Abbott TEF, Torrance HD, Wouters PF, De Hert S, et al. Association of preoperative anaemia with postoperative morbidity and mortality: an observational cohort study in low-, middle-, and high-income countries. Br J Anaesth. 2018;121:1227–35.

34. Al-Naseem A, Sallam A, Choudhury S, Thachil J. Iron deficiency without anaemia: a diagnosis that matters. Clin Med (Lond). 2021;21:107–13.

Figure Legends

Figure 1. Anaemia prevalence by (A) ethnicity, and (B) quintile of Index of Multiple Deprivation (IMD). Anaemia prevalence was calculated for each five-year age group as the number of people with haemoglobin below the age and gender specific threshold in the category, divided by the total in the population for that category. Values are plotted at the lower end of each five-year age group category and interpolated by straight lines. People with missing IMD were excluded from panel (B).

Figure 2. Classification of anaemia by category of mean corpuscular volume (MCV). Percentages in each MCV category were calculated separately by age group and gender. Age groups are 1-14 years, and then 5-year age groups from age 15 years. Values are plotted at the lower end of each five-year age group category and interpolated by straight lines.

Table 1. Characteristics of the study population and frequency of haemoglobin (Hb) testing in 2019. Statistics are n (%).

	Gender	
	Female	Male
N	7,121,614 (100%)	7,086,227 (100%)
Age category		
1 - 4 years	331,318 (4.7%)	346,202 (4.9%)
5 – 11 years	586,881 (8.2%)	615,077 (8.7%)
12 – 14 years	234,626 (3.3%)	243,913 (3.4%)
15 – 49 years	3,523,355 (49.5%)	3,570,156 (50.4%)
50 – 65 years	1,293,689 (18.2%)	1,344,887 (19.0%)
>65 years	1,151,745 (16.2%)	965,992 (13.6%)
Ethnicity category		
Asian	607,897 (8.5%)	621,011 (8.8%)
Black	303,876 (4.3%)	297,025 (4.2%)
Mixed	141,484 (2.0%)	132,185 (1.9%)
Other	116,708 (1.6%)	124,376 (1.8%)
White	4,831,857 (67.8%)	4,513,732 (63.7%)
Missing	1,119,792 (15.7%)	1,397,898 (19.7%)
Quintile of Index of Multiple Deprivation		
1 (Least deprived)	1,420,788 (20.0%)	1,380,397 (19.5%)
2	1,425,495 (20.0%)	1,401,778 (19.8%)
3	1,398,949 (19.6%)	1,385,188 (19.5%)
4	1,501,449 (21.1%)	1,513,539 (21.4%)
5 (Most deprived)	1,368,704 (19.2%)	1,398,898 (19.7%)
Missing	6,229 (0.1%)	6,427 (0.1%)
Pregnancy in 2019		
No pregnancy	6,806,745 (95.6%)	7,086,227 (100.0%)
Pregnancy	314,869 (4.4%)	0 (0.0%)
Number of Hb tests in 2019		
0	5,051,013 (70.9%)	5,627,588 (79.4%)
1	1,441,976 (20.2%)	1,053,253 (14.9%)
2	406,591 (5.7%)	261,590 (3.7%)
3	124,600 (1.7%)	78,807 (1.1%)
4	46,167 (0.6%)	30,841 (0.4%)
≥5	51,267 (0.7%)	34,148 (0.5%)

Table 2. Prevalence of haemoglobin (Hb) testing in the study population in 2019 and of test results below the threshold for anaemia

	N	At least one Hb test n (%)	At least one Hb test below anaemia threshold n (%)	Prevalence of anaemia (%)[a]
Female				
All	7,121,614	2,070,601 (29.1)	363,438 (17.6)	(5.1)
Age category				
1 - 4 years	331,318	7,640 (2.3)	992 (13.0)	(0.3)
5 – 11 years	586,881	24,088 (4.1)	1,949 (8.1)	(0.3)
12 – 14 years	234,626	25,327 (10.8)	3,790 (15.0)	(1.6)
15 – 49 years	3,523,355	882,444 (25.0)	138,216 (15.7)	(3.9)
50 – 65 years	1,293,689	503,741 (38.9)	59,863 (11.9)	(4.6)
>65 years	1,151,745	627,361 (54.5)	158,628 (25.3)	(13.8)
Ethnicity category				
Asian	607,897	186,723 (30.7)	56,835 (30.4)	(9.3)
Black	303,876	89,069 (29.3)	30,422 (34.2)	(10.0)
Mixed	141,484	30,825 (21.8)	6,760 (21.9)	(4.8)
Other	116,708	27,879 (23.9)	5,806 (20.8)	(5.0)
White	4,831,857	1,513,065 (31.3)	225,222 (14.9)	(4.7)
Missing	1,119,792	223,040 (19.9)	38,393 (17.2)	(3.4)
Quintile of IMD[b]				
1 (Least deprived)	1,420,788	407,477 (28.7)	60,677 (14.9)	(4.3)
2	1,425,495	414,915 (29.1)	65,182 (15.7)	(4.6)
3	1,398,949	405,608 (29.0)	69,666 (17.2)	(5.0)
4	1,501,449	427,443 (28.5)	81,879 (19.2)	(5.5)
5 (Most deprived)	1,368,704	413,672 (30.2)	85,816 (20.7)	(6.3)
Male				
All	7,086,227	1,458,639 (20.6)	220,409 (15.1)	(3.1)
Age category				
1 - 4 years	346,202	9,384 (2.7)	1,409 (15.0)	(0.4)
5 – 11 years	615,077	22,206 (3.6)	1,644 (7.4)	(0.3)
12 – 14 years	243,913	14,112 (5.8)	674 (4.8)	(0.3)
15 – 49 years	3,570,156	447,557 (12.5)	19,224 (4.3)	(0.5)
50 – 65 years	1,344,887	440,583 (32.8)	42,179 (9.6)	(3.1)
>65 years	965,992	524,797 (54.3)	155,279 (29.6)	(16.1)
Ethnicity category				
Asian	621,011	128,058 (20.6)	18,983 (14.8)	(3.1)
Black	297,025	55,979 (18.8)	10,792 (19.3)	(3.6)
Mixed	132,185	17,212 (13.0)	2,164 (12.6)	(1.6)
Other	124,376	18,522 (14.9)	1,853 (10.0)	(1.5)
White	4,513,732	1,069,031 (23.7)	161,823 (15.1)	(3.6)
Missing	1,397,898	169,837 (12.1)	24,794 (14.6)	(1.8)
Quintile of IMD[b]				
1 (Least deprived)	1,380,397	291,709 (21.1)	43,237 (14.8)	(3.1)
2	1,401,778	298,671 (21.3)	45,066 (15.1)	(3.2)
3	1,385,188	286,461 (20.7)	43,296 (15.1)	(3.1)
4	1,513,539	296,128 (19.6)	44,656 (15.1)	(3.0)
5 (Most deprived)	1,398,898	284,603 (20.3)	44,010 (15.5)	(3.1)

a Anaemia prevalence is the number of people with Hb below the threshold for anaemia divided by total number of people in the stratum (N)

b Excludes people with missing IMD (Index of Multiple Deprivation)

Table 3. Ferritin testing in people with anaemia by category of mean corpuscular volume (MCV)[a]

Age category	N in MCV category	Tested for ferritin n (%)	Ferritin below WHO age-specific cut-offs n (%)	Ferritin <30 µg/L n (%)
Female				
MCV<80 fL				
All ages	78,648	52,936 (67.3)	33,611 (63.5)	41,687 (78.7)
1 - 14 years	3,691	2,594 (70.3)	1,518 (58.5)	2,013 (77.6)
15 – 49 years	46,401	32,954 (71.0)	23,250 (70.6)	27,777 (84.3)
50 – 65 years	11,957	7,376 (61.7)	3,997 (54.2)	4,989 (67.6)
>65 years	16,599	10,012 (60.3)	4,846 (48.4)	6,908 (69.0)
MCV 80-100 fL				
All ages	256,576	117,706 (45.9)	32,705 (27.8)	57,791 (49.1)
1 - 14 years	2,688	1,642 (61.1)	762 (46.4)	1,193 (72.7)
15 – 49 years	84,523	45,976 (54.4)	21,175 (46.1)	32,872 (71.5)
50 – 65 years	43,358	19,085 (44.0)	4,202 (22.0)	7,621 (39.9)
>65 years	126,007	51,003 (40.5)	6,566 (12.9)	16,105 (31.6)
MCV >100 fL				
All ages	17,343	6,904 (39.8)	185 (2.7)	790 (11.4)
Male				
MCV<80 fL				
All ages	23,762	13,666 (57.5)	5,341 (39.1)	7,872 (57.6)
1 - 14 years	2,498	1,572 (62.9)	611 (38.9)	1,046 (66.5)
15 – 49 years	5,227	2,972 (56.9)	1,063 (35.8)	1,322 (44.5)
50 – 65 years	6,087	3,395 (55.8)	1,467 (43.2)	1,981 (58.4)
>65 years	9,950	5,727 (57.6)	2,200 (38.4)	3,523 (61.5)
MCV 80-100 fL				
All ages	169,585	67,823 (40.0)	4,608 (6.8)	13,279 (19.6)
1 - 14 years	883	453 (51.3)	44 (9.7)	189 (41.7)
15 – 49 years	11,909	4,786 (40.2)	517 (10.8)	1,027 (21.5)
50 – 65 years	31,178	12,708 (40.8)	1,207 (9.5)	2,893 (22.8)
>65 years	125,615	49,876 (39.7)	2,840 (5.7)	9,170 (18.4)
MCV >100 fL				
All ages	19,184	7,630 (39.8)	50 (0.7)	314 (4.1)

a 10,871 females and 7,878 males had anaemia but missing MCV and so are not included in the table

Table 4. Retesting of haemoglobin (Hb) in people with an Hb below the threshold for anaemia in January to March 2019. Time periods 3-6 months and 6-12 months after the initial low Hb were considered.

	Anaemia (N)	Retested (n)	Retested % (95% CI)	Hb still below anaemia threshold (n)	Hb still below anaemia threshold (%) (95% CI)
Female					
3-6 months from initial test[a]					
All ages	116,990	40,659	34.8 (34.5 to 35.0)	28,354	69.7 (69.5 to 70.0)
1 - 14 years	1,867	332	17.8 (16.0 to 19.5)	168	50.6 (48.3 to 52.9)
15 – 49 years	40,922	10,310	25.2 (24.8 to 25.6)	5,648	54.8 (54.3 to 55.3)
50 – 65 years	19,451	7,417	38.1 (37.4 to 38.8)	5,079	68.5 (67.8 to 69.1)
>65 years	54,750	22,600	41.3 (40.9 to 41.7)	17,459	77.3 (76.9 to 77.6)
6-12 months from initial test[b]					
All ages	112,686	56,358	50.0 (49.7 to 50.3)	37,684	66.9 (66.6 to 67.1)
1 - 14 years	1,834	428	23.3 (21.4 to 25.3)	209	48.8 (46.5 to 51.1)
15 – 49 years	39,895	14,923	37.4 (36.9 to 37.9)	8,162	54.7 (54.2 to 55.2)
50 – 65 years	19,011	10,324	54.3 (53.6 to 55.0)	6,622	64.1 (63.5 to 64.8)
>65 years	51,946	30,683	59.1 (58.6 to 59.5)	22,691	74.0 (73.6 to 74.3)
Male					
3-6 months from initial test[a]					
All ages	74,005	27,976	37.8 (37.5 to 38.2)	22,555	80.6 (80.3 to 80.9)
1 - 14 years	1,220	171	14.0 (12.1 to 16.0)	79	46.2 (43.4 to 49.0)
15 – 49 years	5,759	1,544	26.8 (25.7 to 28.0)	989	64.1 (62.8 to 65.3)
50 – 65 years	13,298	4,691	35.3 (34.5 to 36.1)	3,294	70.2 (69.4 to 71.0)
>65 years	53,728	21,570	40.1 (39.7 to 40.6)	18,193	84.3 (84.0 to 84.7)
6-12 months from initial test[b]					
All ages	70,294	39,136	55.7 (55.3 to 56.0)	30,163	77.1 (76.8 to 77.4)
1 - 14 years	1,189	227	19.1 (16.9 to 21.3)	96	42.3 (39.5 to 45.1)
15 – 49 years	5,612	2,154	38.4 (37.1 to 39.7)	1,266	58.8 (57.5 to 60.1)
50 – 65 years	12,895	6,821	52.9 (52.0 to 53.8)	4,525	66.3 (65.5 to 67.2)
>65 years	50,598	29,934	59.2 (58.7 to 59.6)	24,276	81.1 (80.8 to 81.4)

a Excludes people who were no longer in the cohort 3 months after the initial low Hb result
b Excludes people who were no longer in the cohort 6 months after the initial low Hb result