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DOI: https://doi.org/10.3399/BJGPO.2022.0139

To access the most recent version of this article, please click the DOI URL in the line above.

Received 04 November 2022
Revised 04 November 2022
Accepted 05 December 2022

Variation in laboratory testing for patients with long-term conditions: longitudinal cohort study in UK primary care

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Word Count: 2,734

Abstract

Background: Use of laboratory testing has increased in the UK over the last few decades, with considerable geographical variation.

Aim: To evaluate what laboratory tests are used to monitor people with hypertension, type 2 diabetes, or chronic kidney disease and assess variation in test use in UK primary care.

Design and setting: Longitudinal cohort study of people registered with UK general practices between June 2013 and May 2018 and previously diagnosed with hypertension, type 2 diabetes, or chronic kidney disease (CKD).

Methods: CPRD primary care data linked to ethnicity and deprivation was used to examine testing rates over time, by GP practice, age, sex, ethnicity, and socioeconomic deprivation, with age-sex standardisation.

Results: Nearly 1 million patients were included, and over 27 million tests. The most ordered tests were for renal function (1,463 per 1,000 person-years), liver function (1,063 per 1,00 person-years), and full blood count (996 per 1,000 person-years). There was evidence of under-testing (compared to current guidelines) for HbA1c and ACR/microalbumin, and potential over-testing of lipids, full blood count, liver function, and thyroid function. Some GP practices had up to 27 times higher testing rates than others (HbA1c testing amongst CKD patients).

Conclusions: Testing rates are no longer increasing, but they are not always within the guidelines for monitoring long-term conditions. There was considerable variation by GP practice, indicating uncertainty over the most appropriate testing frequencies for different conditions. Standardising the monitoring of long-term conditions based on the latest evidence would provide greater consistency of access to monitoring tests.

Key words: general practice; primary health care; hypertension; diabetes mellitus; renal insufficiency, chronic; healthcare disparities

How this fits in

Rates of laboratory testing in UK GP practices have been increasing over the last few decades, with considerable geographical variation. This study showed that testing rates to monitor hypertension, type 2 diabetes, and chronic kidney disease have mostly stopped increasing in recent years, but there is still considerable variation by GP practice. We found evidence of potential under-testing of HbA1c and microalbuminuria levels, and potential over-testing of lipids, full blood count, liver function, and thyroid function compared to a review of guidelines. Standardising the monitoring of long-term conditions based on the latest evidence would provide greater consistency of access to monitoring tests and optimal care for patients.

Introduction

Rates of laboratory testing have been rising in the UK,[1, 2] with significant geographical variability.[1] A large proportion of general practice laboratory testing is thought to represent monitoring for long-term conditions (LTC), e.g. type 2 (T2) diabetes, hypertension and chronic kidney disease (CKD).[3] By convention, patients with LTC receive regular laboratory tests to monitor disease progression, response to treatment, detect complications and side effects of medications. Whilst some of this testing is supported by evidence and guidelines, this is not universally the case[4]; for example when testing patterns of 20 primary care practices in North Devon were reviewed, no two practices had the same testing algorithms for monitoring LTC.[3] In the context of an increasingly risk-averse society, and with a lack of clear, easy to follow guidelines, clinicians may add additional tests for disease monitoring 'just in case'.[5, 6] There is increasing recognition that some of this testing may be wasteful; the Carter report in 2008 estimated that around 25% of pathology testing overall may be unneccesary;[7] and more recently the Organisation for Economic Co-operation and Development (OECD) estimated that one fifth of healthcare expenditure is wasted.[8] In addition, there is increasing strain on the National Health Service (NHS) as highlighted by the Care Quality Commission report, 2016/17,[9] which has been further exacerbated by the COVID-19 pandemic. An Academy of Medical Sciences Report has called on doctors to take responsibility for cutting waste, with overuse of laboratory tests being one of three core areas of focus.[10]

As well as being a potential source of waste, overuse of laboratory tests may be a source of harm, potentially causing patient anxiety, unnecessary downstream tests,[11] referrals, and overdiagnosis. It also has a significant impact on GP workload and costs through reviewing

test results and further investigations following abnormal tests.[6] On the other hand, failure to test may lead to delayed diagnoses, complications, patient harm and litigation.

Previous studies found an increase in testing in primary care between 2000 and 2015,[1, 2] and wide variation in testing by region of the UK for some tests.[1] Our objectives were to find out what tests are ordered for patients with common LTC (hypertension, T2 diabetes, or CKD), describe variation in their use over time, by GP practice and patient characteristics, and compare this to current evidence-based guidelines where available.[4]

Methods

This is a longitudinal observational study using prospectively-collected routine administrative information about patients registered with UK GP practices from June 2013 to May 2018. It is reported according to the RECORD[12] extension to STROBE guidelines for observational studies.

Data Sources

Data were from the Clinical Practice Research Datalink (CPRD Gold), anonymised health records from ~16 million patients at 758 UK general practices over the last 30 years.[13] CPRD Gold is representative of the UK general population in terms of age, sex and ethnicity.[13] Around 55% of patients were eligible for linkage (by CPRD) to other datasets, and were linked to death certificate information (for accurate dates of death), indices of multiple deprivation, and hospital admissions records (for ethnicity). Linkage is only available for GP practices in England that don't opt out. Missingness in deprivation and ethnicity was largely due to linkage ineligibility and coded as 'missing' without excluding people. Where death

certificate information was available, we used the date of death from the certificate, otherwise we used the CPRD-derived date of death. The CPRD pregnancy register was used to determine if women were pregnant during the study period.

Identifying people with long-term conditions

We identified people with a code indicating any of three common LTC in their GP record prior to 31st May 2018: hypertension (Supplementary Table S1), T2 diabetes (Supplementary Table S2) or CKD (Supplementary Table S3); who had active registration at a contributing GP practice during the study period (n=1,196,879). Exclusions incorporated people providing less than one year of follow-up (n=226,953, 20% of the cohort) to ascertain robust individual testing rates, leaving 933,907 people for analysis (see Figure 1). Demographics for excluded people were like the included cohort (Supplementary Table S4) with less missing information - mostly due to a smaller proportion of people from Scotland, Wales, and Northern Ireland, who are ineligible for linkage and tend to have longer follow-up at the same GP practice.

Testing Rates

Crude testing rates were calculated by dividing the number of tests ordered by the person-years of follow-up. Age-sex standardised testing rates were estimated using direct standardisation[14] (see Supplementary Box S1 for detailed methods). We explored testing rates by sex, age (0-49, 50-59, 60-69, 70-79, 80-89, 90+), practice, region, year of testing (2013/14 – 2017/18), deprivation quintile, ethnic group (white, black, Asian, other), time since diagnosis (<1 year and >=1 year), and number of LTC (1-3). To explore variation in standardised testing rates across GP practices, we ordered all of the GP practices by

standardised testing rate from smallest to largest and divided the rate at the 90th percentile by the 10th percentile rate. This provides a robust indication of variation whilst ignoring extreme outliers.

Comparison to testing guidelines

Some of the authors previously conducted a review of laboratory testing guidelines for monitoring hypertension, T2 diabetes, and CKD within the National Institute for Health and Care Excellence; Scottish Intercollegiate Guidelines Network; Royal Colleges of Pathologists, Physicians, and General Practitioners; and the Quality Outcomes Framework.[4] The findings are summarised in their Figures 1-3, to which we compared our testing rates.

Tables use colour lightness as a guide to the eye to communicate higher/lower rates.[15 16] All analysis used STATA version 16.1.[17] Code lists and Stata code are available at: https://github.com/jonestim2002/primary_care_testing

Results

Patient and practice characteristics

Figure 1 shows a Venn diagram of our cohort: 87% (n=810,492) had hypertension; 67% (n=629,049) had only one of the conditions; 27% (n=255,185) had two conditions; and 5% (n=49,753) had all three. Table 1 describes the population demographics stratified by LTC. 61% of people with only CKD were women, whilst 40% of people with only T2 diabetes were women. Those with only T2 diabetes were younger on average (median age group: 50-59

years), whilst for people with only CKD the median age group was 70-79 years. There was a deprivation gradient for people with hypertension or CKD (25% least deprived to 13% most deprived for both), but not for T2 diabetes (~20% in each quintile). 9.1% of people with only T2 diabetes were Asian, compared to 1.4% of people with only CKD.

Testing Rates

For clarity, we have focussed on testing rates for people with only hypertension, only T2 diabetes, or only CKD (Figure 2, Supplementary Table S6); information for people with multiple conditions is presented in the supplementary tables (S11-S13). The most ordered tests were for renal function (1,463 per 1,000 person-years), liver function (1,063 per 1,000 person-years), and FBC (996 per 1,000 person-years).

Figure 2 shows the number of tests ordered per person per year for each type of test and each LTC. There was some evidence for under-testing compared to recommendations and guidelines.[4] Albumin creatinine ratio testing is recommended 1-4 times per year for T2 diabetes and CKD, whereas we observed testing rates lower than once per year for most people, and testing decreased during the study period (by -24% for hypertension to -69% for CKD, Supplementary Tables S7-S9). HbA1c monitoring is recommended every 2 to 6 months for people with T2 diabetes; whilst HbA1c testing was highest amongst the diabetes cohort, most people were tested less than twice per year. HbA1c tests were ordered less than once per year for people with hypertension; annual testing is only recommended for people at high risk of developing diabetes, so this may be appropriate. We found evidence that eGFR (kidney function) testing roughly fit with recommendations of 1-4 times per year, although was less frequent for over half of people with hypertension, nearly half of people with CKD, and around a quarter of people with T2 diabetes (Figure 2).

There was some evidence for potential over-testing compared to guidelines. Lipid profile testing isn't recommended amongst people with hypertension (except with high risk of diabetes) or CKD. However, these tests were recorded around once every 2 years per person, and roughly annually for people with T2 diabetes, presumably to monitor cardiovascular risk.[18] Liver function testing is not recommended for any of our LTC, so the observed testing rates (median around once per year for T2 diabetes and CKD) may represent over-testing. Additionally, FBC and thyroid function testing rates appear high as these are not routinely recommended except for annual haemoglobin checks (part of FBC) for people with combined T2 diabetes and stage 3+ CKD.

Supplementary Table S6 shows age and sex standardised testing rates (per 1,000 person years) by patient characteristics for the five most common tests, stratified by LTC. Supplementary Tables S7-S9 show the same information for all 12 included tests. The top two rows of each table (number and % tested) show that not everyone with an LTC is receiving tests. Testing increased with age up to the oldest age group (90+) where there was a slight drop off. There were higher testing rates in Scotland and Northern Ireland compared to other regions for most tests. Testing rates were stable over the study period (decreasing overall by 2%), although there was an increase in the use of HbA1c testing in the non-diabetic cohorts (31% for hypertension and 23% for CKD), an increase in haematinics testing (between 36% and 44% increase), and a decrease in the use of blood glucose (between -36% and -38%) and ACR tests (between -30% to -52%). Testing appeared higher amongst Asian people and lower amongst black people compared to white people; and higher for people with more LTC (i.e. sicker people).

Variation in Testing Rates

There was considerable variation in testing rates between different people (Figure 2). The percentage of people being tested varied from 13% of the hypertension cohort for ACR/microalbumin testing, to 96% of the diabetes cohort having renal function or HbA1c tests (Supplementary Tables S6-S9). Higher testing practices had up to 27 times higher rates than lower testing practices (i.e. HbA1c testing in the CKD cohort; Supplementary Table S6), and even more extreme for ESR tests (Supplementary Tables S7-S9) which were hardly recorded at some practices (<1 test per 1,000 person years).

Discussion

Summary

The most common tests for hypertension, T2 diabetes, and CKD were renal function, liver function, FBC, lipid profile, and HbA1c. There was evidence of under-testing of HbA1c and ACR/microalbumin, and potential over-testing of lipids, FBC, liver function, and thyroid function. Some practices had 27 times higher testing rates than others. Overall testing rates were relatively stable between 2013/14 to 2017/18, but increased substantially for some tests (e.g. HbA1c amongst non-diabetic cohorts), and decreased for others (e.g. blood glucose and ACR/microalbumin tests). Testing increased with age and comorbidity, and appeared higher amongst Asian people and lower amongst black people compared to white people.

Strengths and limitations

The size and geographical spread of the cohort should make results generalisable to primary care populations in the UK. We investigated primary care testing for three common LTC

which should have relevance to many people. Our results were unaffected by recent changes (e.g. equipment shortages) due to the COVID-19 pandemic as our study period ends before the pandemic began, although this means it reflects older testing rates.

CPRD does not record the reason for ordering a test; we excluded tests used primarily for screening and diagnosis, but some of the observed 'over-testing' of thyroid function, liver function and FBC may reflect appropriate diagnostic testing of symptoms, rather than monitoring. Given that liver function tests were the second most frequent this seems unlikely to account for all testing observed. There is some variation between labs in grouping tests, which may add some noise. There may be differences in practice test recording; we sampled 'acceptable' patient records at 'up-to-standard' practices to minimise reporting bias. CPRD records some tests initiated in secondary care; we attempted to exclude tests unlikely to be requested by GPs. We standardised testing rates on age and sex, but other factors may contribute to variation in rates (e.g. disease severity). We have focussed on three long-term conditions, which excludes others such as non-alcoholic fatty liver disease. People with LTC were identified based on recorded diagnostic codes, which may under-estimate the full cohort; however, we assume most people with LTC would have the condition recorded in their medical record. Our examination of the impact of comorbidity is limited to the three conditions that were the focus of the study.

There was a lot of missingness in deprivation and ethnicity, largely due to ineligibility of people for linkage. This is a largely descriptive study, and we included people with missing deprivation or ethnicity labelled as 'missing' for completeness. As testing rates were not adjusted for variables other than age and sex, there could still be confounding of rates by other factors.

Comparison with existing literature

Busby et al. (2013)[1] found that general practice laboratory test use increased by 24% between 2005 and 2009, whilst O'Sullivan et al. (2018)[2] found an 8.5% increase each year on average between 2000/1 and 2015/16 – this was slowing over time to 2.6% increase between 2008/9 and 2015/16. Our results indicate further slowing to near zero growth between 2013/14 and 2017/18, with a large increase (over 100%) of HbA1c testing amongst hypertension and CKD cohorts, and substantial decreases in blood glucose and ACR/microalbumin testing. The likely intention of increased HbA1c testing is to diagnose and treat diabetes early, which can prevent disease progression and complications.[19] Reduced blood glucose testing may represent a shift to HbA1c testing for diabetes, and reductions in ACR/microalbumin may be partly due to their removal from the Quality Outcomes Framework (QOF),[20] although testing is lower than NICE recommendations.[4] We found considerable variation for certain tests (e.g. HbA1c in non-diabetic cohorts), particularly at practice level. We agree with Busby et al.[1] that this may reflect uncertainty about indications for laboratory tests due to limited clear, evidence-based guidance.[4] Liver function tests were the second most common in our dataset, despite not being recommended for monitoring any of the LTC. This may reflect monitoring following prescription of common medications for people with these conditions (e.g. statins); liver function tests are recommended at 3 months and 12 months after beginning statin treatment.[21] The same may be true for lipid profile testing; some evidence suggests natural variation in cholesterol levels makes regular testing less informative,[22, 23] but regular cholesterol checks were encouraged by NICE[18] and QOF (DM004)[20] for people with diabetes throughout the study period. The recent NHS Evidence Based Interventions programme recommended reducing lipid and liver function testing following initiation of lipid lowering

therapies.[24] Thyroid disease monitoring is recommended for people with T1 diabetes; perhaps some observed thyroid testing represents extension of this advice to T2 diabetes. Health regulation is devolved and testing guidance can be different in England, Wales, Scotland, and Northern Ireland, which could account for higher testing rates in Scotland and Northern Ireland. Higher testing rates amongst Asian people may relate to the prevalence of LTC (e.g. cardiovascular disease) and multimorbidity in this community.[25] It is unclear why there should be slightly lower testing rates amongst black people; a concern is that this could reflect different access to testing, but more detailed analysis is required to rule out other potential factors.

Implications for research and practice

Testing in primary care is not increasing as rapidly as it was over the last couple of decades and may reflect increasing awareness about the appropriateness of testing. However, there is still variation in testing rates after adjustment for age and sex, particularly at the level of GP practices. Some practices had more than 27 times higher testing rates than others for particular tests (e.g. HbA1c in CKD cohort). Some tests were ordered less often than recommended by current evidence-based guidelines (e.g. HbA1c, ACR/microalbumin), whilst others were ordered more often than recommended (e.g. liver function tests, FBC, thyroid function) for people with hypertension, T2 diabetes, or CKD. This reflects a lack of clarity or clear communication of the latest evidence-based guidelines for monitoring long-term conditions. More evidence is needed in terms of patient outcomes and costs to determine the optimum testing levels to maximise population health. The acceptability of testing frequencies to patients and health professionals should be considered. We also need to ascertain the best way to communicate these recommendations. Standardising the

monitoring of LTC based on the latest evidence would provide greater consistency in access to monitoring tests.

Author Statement

This publication is the work of the authors, who serve as guarantors for the contents of this paper. TJ and RP contributed to study design, data cleaning, data analysis, interpretation of results and writing the manuscript. ME, JW, EM, KA, and PW contributed to study design, interpretation of results and writing the manuscript. TJ had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Funding

This research was funded by the National Institute for Health Research Applied Research Collaboration West (NIHR ARC West). The views expressed in this article are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

Ethnical Approval

We were provided with routinely-collected, pseudonymised Clinical Practice Research Datalink (CPRD) data under licence from the MHRA and NIHR. The protocol (18_188RMnA2R) for this study was approved on 1 June 2020 by the Independent Scientific Advisory Committee (ISAC), the independent body that approves use of CPRD data.

Data Sharing

This study is based on data from the Clinical Practice Research Datalink (CPRD) obtained under licence from the MHRA and NIHR. The data are provided by patients and collected by the NHS as part of their care and support. CPRD data can be accessed via the MHRA: https://www.cprd.com/

Transparency

The manuscript's guarantor (TJ) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned have been explained.

Competing Interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf. All authors declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Table 1. Patient demographics by long-term condition (n=933,907)

Cohort	All hypertension	Hypertension only	All diabetes	Diabetes only	All CKD	CKD only
N (% of cohort)	810,412 (86.8%)	514,757 (55.1%)	266,169 (28.5%)	76,707 (8.2%)	211,937 (22.7%)	37,585 (4%)
Avg follow-up, years (sd)	3.39 (1.42)	3.33 (1.42)	3.39 (1.43)	3.11 (1.41)	3.40 (1.42)	3.12 (1.4)
Women (%)	417,137 (51.5%)	263,882 (51.3%)	116,323 (43.7%)	30,423 (39.7%)	125,737 (59.3%)	22,970 (61.1%)
Age						
0-49	69,253 (8.5%)	56,515 (11%)	30,688 (11.5%)	19,652 (25.6%)	5,214 (2.5%)	2,305 (6.1%)
50-59	132,564 (16.4%)	100,697 (19.6%)	47,622 (17.9%)	20,006 (26.1%)	11,909 (5.6%)	4,131 (11%)
60-69	198,668 (24.5%)	138,543 (26.9%)	66,105 (24.8%)	18,593 (24.2%)	30,110 (14.2%)	6,929 (18.4%)
70-79	210,480 (26%)	126,887 (24.6%)	67,268 (25.3%)	12,465 (16.3%)	61,187 (28.9%)	9,966 (26.5%)
80-89	150,878 (18.6%)	71,719 (13.9%)	44,291 (16.6%)	5,049 (6.6%)	73,170 (34.5%)	9,646 (25.7%)
90+	48,569 (6%)	20,396 (4%)	10,195 (3.8%)	942 (1.2%)	30,347 (14.3%)	4,608 (12.3%)
Region						
North East	5,423 (0.7%)	3,380 (0.7%)	1,756 (0.7%)	524 (0.7%)	1,439 (0.7%)	238 (0.6%)
North West	79,662 (9.8%)	50,351 (9.8%)	27,423 (10.3%)	7,857 (10.2%)	20,998 (9.9%)	3,679 (9.8%)
Yorkshire & the Humber	7,216 (0.9%)	4,511 (0.9%)	2,560 (1%)	767 (1%)	1,872 (0.9%)	317 (0.8%)
East Midlands	1,353 (0.2%)	873 (0.2%)	504 (0.2%)	157 (0.2%)	267 (0.1%)	025 (0.1%)
West Midlands	70,046 (8.6%)	42,454 (8.2%)	23,134 (8.7%)	6,383 (8.3%)	21,165 (10%)	3,605 (9.6%)
East of England	44,093 (5.4%)	29,540 (5.7%)	12,911 (4.9%)	3,466 (4.5%)	9,424 (4.4%)	1,406 (3.7%)
South West	56,990 (7%)	34,583 (6.7%)	18,891 (7.1%)	5,250 (6.8%)	18,018 (8.5%)	3,629 (9.7%)
South Central	86,190 (10.6%)	57,568 (11.2%)	25,465 (9.6%)	7,845 (10.2%)	20,362 (9.6%)	3,372 (9%)
London	82,620 (10.2%)	53,350 (10.4%)	30,412 (11.4%)	9,389 (12.2%)	16,867 (8%)	2,821 (7.5%)
South East Coast	90,307 (11.1%)	55,868 (10.9%)	28,052 (10.5%)	7,886 (10.3%)	27,992 (13.2%)	5,640 (15%)
Northern Ireland	34,257 (4.2%)	21,322 (4.1%)	11,146 (4.2%)	3,361 (4.4%)	10,883 (5.1%)	2,418 (6.4%)
Scotland	116,790 (14.4%)	74,728 (14.5%)	38,497 (14.5%)	11,904 (15.5%)	30,185 (14.2%)	5,054 (13.4%)
Wales	135,465 (16.7%)	86,229 (16.8%)	45,418 (17.1%)	11,918 (15.5%)	32,465 (15.3%)	5,381 (14.3%)
Deprivation Quintile						
1 - Least	98,840 (24%)	66,295 (25.4%)	26,489 (19.7%)	7,474 (19.3%)	25,006 (23.3%)	4,697 (24.7%)
2	91,231 (22.2%)	58,934 (22.6%)	27,388 (20.4%)	7,560 (19.5%)	23,815 (22.2%)	4,280 (22.5%)
3	88,676 (21.6%)	56,040 (21.5%)	28,559 (21.2%)	7,896 (20.4%)	23,384 (21.8%)	4,100 (21.6%)
4	74,759 (18.2%)	45,819 (17.5%)	27,634 (20.5%)	8,222 (21.2%)	19,801 (18.4%)	3,398 (17.9%)
5 - Most	57,819 (14.1%)	34,001 (13%)	24,430 (18.2%)	7,585 (19.6%)	15,499 (14.4%)	2,532 (13.3%)
Missing	399,087 (49.2%)	253,668 (49.3%)	131,669 (49.5%)	37,970 (49.5%)	104,432 (49.3%)	18,578 (49.4%)
Ethnicity						
White	313,676 (92.5%)	192,426 (93.2%)	99,936 (87.1%)	26,297 (84.2%)	93,235 (95%)	16,392 (96.5%)
Black	8,371 (2.5%)	5,068 (2.5%)	3,694 (3.2%)	1,039 (3.3%)	1,597 (1.6%)	176 (1%)
Asian	10,706 (3.2%)	5,007 (2.4%)	7,946 (6.9%)	2,842 (9.1%)	2,164 (2.2%)	244 (1.4%)
Other	6,453 (1.9%)	3,958 (1.9%)	3,102 (2.7%)	1,068 (3.4%)	1,136 (1.2%)	167 (1%)
Missing	471,206 (58.1%)	308,298 (59.9%)	151,491 (56.9%)	45,461 (59.3%)	113,805 (53.7%)	20,606 (54.8%)

Figure Captions

Figure 1. Inclusion/exclusion of people to the cohort with long-term conditions

Figure 2. Venn diagram for numbers with each of the three long-term conditions and the overlap between them (933,907 individuals)

Figure 3. Tests ordered per person per year for people with only hypertension (left), only T2 diabetes (middle), or only CKD (right)
Note: Box plot shows median, interquartile range (25th and 75th percentiles), and whiskers are 10th and 90th percentiles

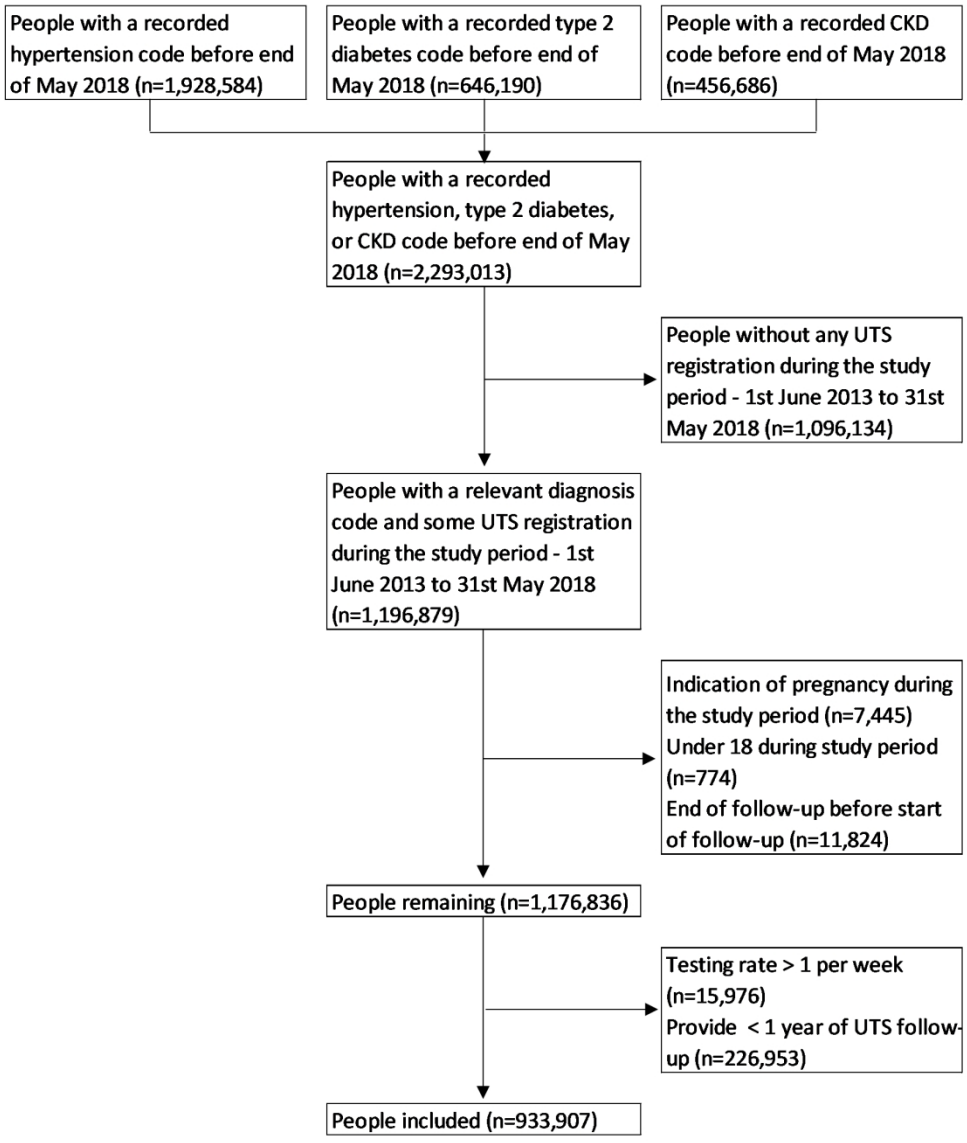

Figure 1. Inclusions/exclusion of people to the cohort

162x194mm (300 x 300 DPI)

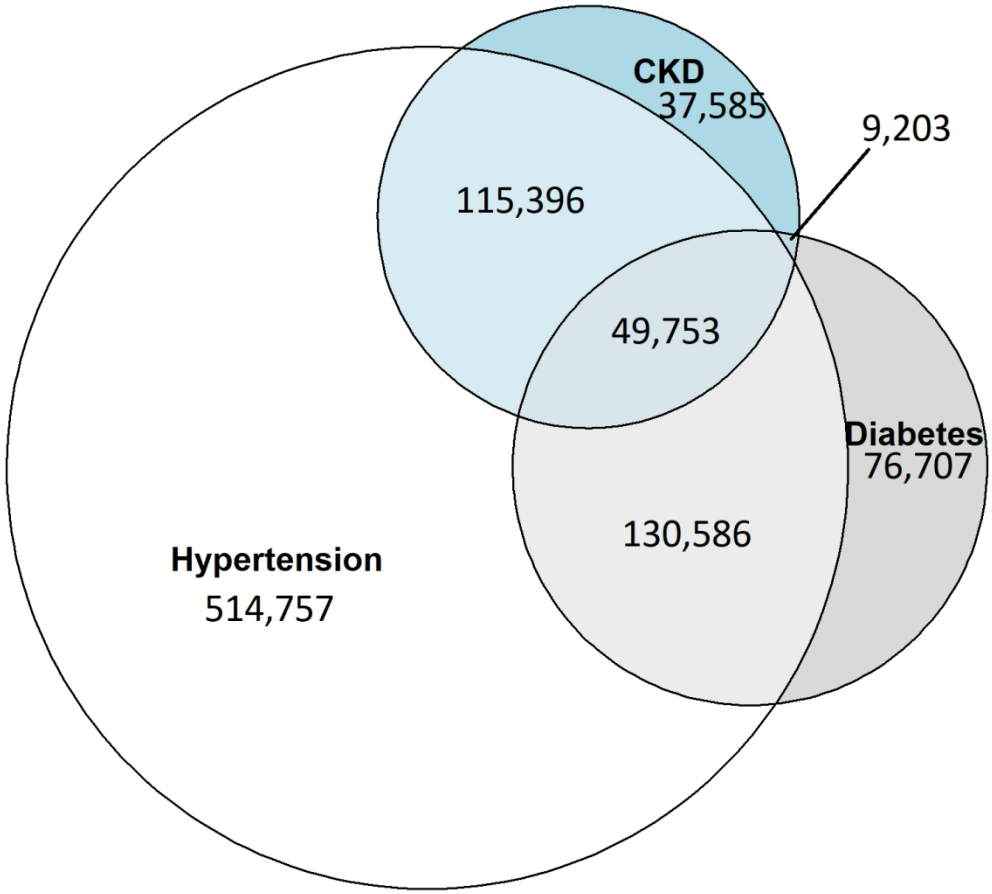

Figure 2. Venn diagram for numbers with each of the three long-term conditions of interest and the overlap between them (933,907 individuals)

127x127mm (300 x 300 DPI)

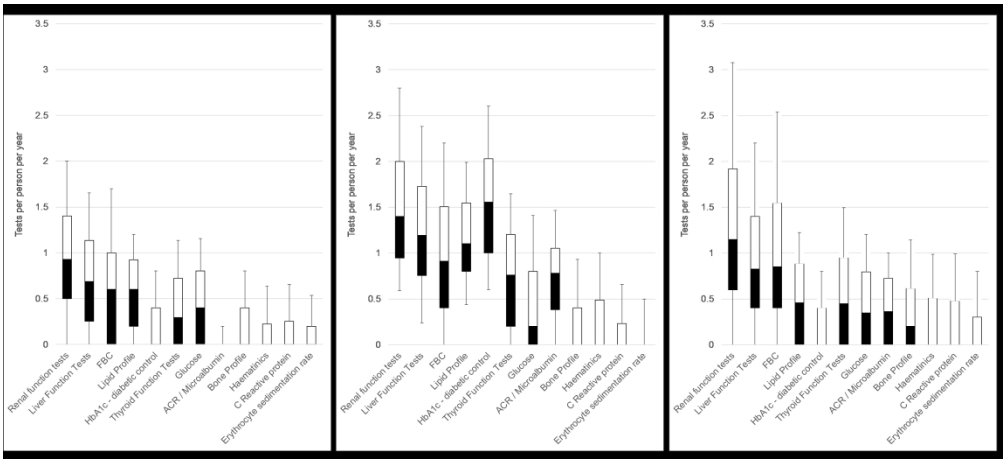

Figure 3. Tests ordered per person per year for people with only hypertension (left), only T2 diabetes (middle), or only CKD (right)

Notes: Note: Box plot shows median, interquartile range (25th and 75th percentiles), and whiskers are 10th and 90th percentiles

457x208mm (300 x 300 DPI)