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Prevalence and predictors of delayed clinical diagnosis of Type 2 diabetes: a longitudinal cohort study

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Abstract

Aims—To examine the prevalence and person-level predictors of undiagnosed Type 2 diabetes among adults with elevated HbA_{1c} values.

Methods—We identified adults without diabetes who had a first elevated HbA_{1c} (index $HbA_{1c} \geq$ 48 mmol/mol; ≥ 6.5%) between January 2014 and December 2015, and classified them by Type 2 diabetes diagnosis status at 1 year following this result. Multilevel modelling techniques were used to examine the association of individual demographic, clinical and utilization characteristics with remaining undiagnosed. We quantified differences in early Type 2 diabetes care between diagnosed and undiagnosed individuals.

Results—Of the 18 356 adults with a first elevated index HbA_{1c}, 30.2% remained undiagnosed with Type 2 diabetes 1 year later. Individuals with lower index HbA_{1c} values [adjusted odds ratio (aOR) 5.95, 95% confidence interval (CI) 5.21–6.78 for 48 to < 53 mmol/mol (6.5% to 7.0%); referent 53 to < 64 mmol/mol (7.0% to <8.0%)], who were ≥ 70 years old (aOR 1.40, 95% CI 1.24–1.59; referent 50–59 years), and who had a prior prediabetes diagnosis (aOR 1.35, 95% CI 1.24–1.47; referent no prediabetes) had increased odds of remaining undiagnosed. After adjusting for age, race and index HbA_{1c}, remaining undiagnosed was associated with lower odds of initiating metformin (aOR 0.06, 95% CI 0.05–0.07).

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Author contributions

All listed authors have met the requirements for authorship. AG oversaw the study design, data analysis, and result interpretation, and wrote the manuscript. PM contributed to the study design, performed all programming and data analysis, and contributed to the writing/reviewing of the manuscript. SEA planned and directed the statistical analysis and interpretation of the results and contributed to the writing/reviewing of the manuscript. MAB reviewed the manuscript and contributed to the construction of tables and figures. EK and AM contributed clinical expertise and reviewed the manuscript. RWG contributed to study design and reviewed/edited the manuscript. AG is the guarantor of this study and manuscript.

Early results from this work were presented as posters at the 2017 American Diabetes Association Scientific Sessions and the 2017 Academy Health Annual Research Meeting.

Competing interests

None declared.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Conclusions—Almost one-third of adults with an elevated HbA_{1c} value were not diagnosed with Type 2 diabetes within 1 year. Undiagnosed Type 2 diabetes, in turn, was associated with differences in early care. Strategies that leverage the electronic health record to facilitate earlier diagnosis may help reduce delays and allow for early intervention towards the goal of improved outcomes.

Introduction

Most people with Type 2 diabetes experience delays in clinical diagnosis of 4–7 years following the onset of hyperglycaemia [1,2]. Although the undiagnosed period is often asymptomatic, it is a missed opportunity for early intervention to treat hyperglycaemia, implement lifestyle changes, and address cardiovascular risk factors. In fact, up to one-quarter of people already have diabetes-related microvascular changes by the time a clinical diagnosis is made [1,3,4]. Achieving early glycaemic control is particularly critical in preventing such disease-related complications [5]. The United Kingdom Prospective Diabetes Study (UKPDS) demonstrated that better early glycaemic control conveyed a substantially lower risk of microvascular complications and myocardial infarctions, a risk reduction that persisted for decades after diagnosis compared with people without initial tight control [5]. Understanding the current prevalence and person-level correlates of a delayed Type 2 diabetes diagnosis is crucial to decreasing such diagnostic delays and optimizing early care.

Inadequate care access and under-screening contribute to the prevalence of undiagnosed diabetes [6–8]. However, missed or delayed Type 2 diabetes diagnoses still occur among insured individuals, even when evidence of hyperglycaemia is available in the electronic health record (EHR) [9,10]. For example, in a 2002 cross-sectional analysis of 1426 adults with EHR-documented evidence of hyperglycaemia, only 79% had diagnostic codes indicating a diagnosis of diabetes [9]. Furthermore, a 2010 chart review of people seen at a Veterans Affairs Medical Center (a system with a well-established EHR) revealed an average delay of 3.7 years between initial EHR evidence of hyperglycaemia and clinical diagnosis [10]. Our work provides an updated look at the prevalence of delayed diagnoses and builds on these two small studies by examining the person-level characteristics and early care differences that are associated with delayed Type 2 diabetes diagnoses.

In this study, we assessed the prevalence of undiagnosed Type 2 diabetes 1 year following an elevated HbA_{1c}, examined factors associated with remaining undiagnosed, and examined differences in receipt of three diabetes-specific care activities based on diagnosis status.

Research design and methods

Study design and setting

We conducted a retrospective, longitudinal cohort analysis of Kaiser Permanente Northern California (KPNC) EHR data to examine the prevalence of undiagnosed Type 2 diabetes 1 year following EHR-documented hyperglycaemia (defined as $HbA_{1c} \geq 48$ mmol/mol; ≥ 6.5%) among adult KPNC members. We examined person-level correlates of remaining

undiagnosed during this year, as well as differences in receipt of American Diabetes Association (ADA)-recommended care between undiagnosed and diagnosed individuals.

Study population

KPNC is an integrated healthcare system that serves 4.2 million members and has a well-established, Epic®-based EHR. KPNC EHR data were used to identify adults (age ≥ 21 years) with no evidence of prior diabetes who had a first diabetes-consistent HbA_{1c} (index HbA_{1c} ≥ 48mmol/mol; ≥ 6.5%) between 1 January 2014 and 31 December 2015. For KPNC members, all HbA_{1c} testing is performed within KPNC and available in the EHR. We defined a prior diabetes diagnosis as any encounter before the index HbA_{1c} with an ICD-9/10 [11] diagnostic code for diabetes, the presence of diabetes on the EHR-based problem list, or a prior prescription for a diabetes-related medication (other than metformin). We excluded members with any ICD-9/10 codes specific to Type 1 or gestational diabetes. To identify newly diagnosed Type 2 diabetes (rather than new KPNC members with prevalent Type 2 diabetes), we required continuous KPNC membership and at least one outpatient visit in the year before the index HbA_{1c}. We also excluded individuals who did not remain KPNC members during the year following their index HbA_{1c}.

Examined outcomes

The primary study outcome was individuals' diagnosis status 1 year after their index HbA_{1c} value (Fig. 1). Individuals were designated as having undiagnosed Type 2 diabetes if they had no encounters (outpatient, inpatient, telephone or secure electronic message) with an associated ICD-9/10 diagnostic code for diabetes and did not have diabetes added to their EHR-based problem list during the year following their index HbA_{1c} date.

We defined two HbA_{1c} measures to capture subsequent testing: (i) 'confirmatory HbA_{1c}', defined as at least one repeated value within 3 months of the index value; and (ii) 'any follow-up HbA_{1c}', defined as at least one repeat HbA_{1c} value within 3–12 months following the index value.

We examined differences in three types of ADA-recommended care during the year following the index HbA_{1c}: (i) diabetes-related health education (including both weight management and diabetes self-management), (ii) a retinal exam, and (iii) initiation of metformin. Each of these outcomes was defined as a dichotomous variable. Metformin initiation was defined as an individual filling a prescription at a KPNC pharmacy (nearly all medications are filled internally).

Person-level predictors

Demographic covariates included age, gender, ethnicity/race, English proficiency and neighbourhood socio-economic status. Clinical characteristics included index HbA_{1c} value, BMI, prior prediabetes ICD-9/10 codes, and the presence of comorbid conditions, specifically hypertension, hyperlipidaemia, chronic renal disease, cardiovascular disease and depression (defined using ICD-9/10 codes during the 2 years prior to the index HbA_{1c}). Because use of oral corticosteroids could contribute to hyperglycaemia, use of these agents during the year prior to the index HbA_{1c} was noted. Finally, we examined individuals'

primary care provider (PCP) contact in the year prior to their index HbA_{1c} value (defined as any vs. none). We also examined whether the index HbA_{1c} value was ordered by the PCP or another provider, as well as the PCPs' years of practice (defined as years since medical school graduation). Since individual-level data on educational attainment and income were not available, we quantified each person's neighbourhood socio-economic status using the Neighbourhood Deprivation Index (NDI) [12]. Specifically, each person's geocoded address was linked with census data from the American Community Survey (ACS) and the NDI was computed from census tract-level variables representing income, education, employment, and housing using a previously validated algorithm [13,14].

Statistical analysis

To estimate the adjusted prevalence of undiagnosed Type 2 diabetes in the population, we performed mixed-effects logistic regression with PCP and KPNC medical facility as random effects to account for clustering of individuals by PCP and medical facility. Chi-square and *t*-tests were performed to determine whether clinically diagnosed and undiagnosed groups differed with respect to their demographic factors, clinical characteristics and prior PCP contact at baseline. Chi-square tests were also used to compare differences in confirmatory and follow-up HbA_{1c} tests between groups.

Mixed-effects logistic regression [15] with PCP and KPNC medical facility included as random effects was used to identify independent predictors of remaining undiagnosed at 1 year following the index HbA_{1c}. The random effects were included to account for clustering of individuals by PCP and medical facility. The covariates included as fixed effects in this model were selected based on research team discussions and the existing literature [16–19] and included: age (categorical variable), index HbA_{1c} (a categorical variable), gender, ethnicity/race, NDI, comorbidities, (including depression), recent oral corticosteroid prescription, prior prediabetes diagnosis, BMI (categorical variable), the provider who ordered the index HbA_{1c} and the PCP's years of practice.

To estimate the adjusted odds of receiving the examinined diabetes care during the year following the index HbA_{1c}, we employed mixed-effects logistic regression models with PCP and medical facility included as random effects. Based on existing literature and care guidelines, index HbA_{1c}, age, and ethnicity/race were included as fixed effects in these models [19–21].

Additional analyses—We repeated all the aforementioned analyses in two subpopulations. First, we excluded undiagnosed individuals who had a confirmatory HbA_{1c} < 48 mmol/mol (<6.5%) (i.e. 'unconfirmed Type 2 diabetes'). Second, we limited the population to individuals with 'milder' hyperglycaemia (index HbA_{1c} 48 to < 53 mmol/mol; 6.5% to < 7.0%), to better assess the association between initial disease severity and differences in early care.

We also examined how the predictors of remaining undiagnosed differed by age (< 50, 50–70 and ≥ 70 years). All analyses were conducted using SAS Enterprise Guide 4.3.

Results

A total of 18 356 people had an index HbA_{1c} ≥ 48 mmol/mol (≥ 6.5%) (Fig. 1). Of this group, 30.2% (N = 5552) remained undiagnosed in the 12 months following their index HbA_{1c}. Accounting for correlation in individuals' outcomes within PCP and within KPNC facility, the estimated prevalence of undiagnosed diabetes in this population was 28% (95% confidence interval 26%–31%).

Undiagnosed individuals were older [61 (SD 13) years for undiagnosed vs. 57 (13) years for diagnosed; P < 0.001] and differed significantly from diagnosed individuals by gender, ethnicity/race and NDI (P < 0.001 for all comparisons) (Table 1).

Undiagnosed people had lower mean index HbA_{1c} values [50 mmol/mol, 6.7% (SD 0.5) for undiagnosed vs. 62 mmol/mol, 7.8% (1.9) for diagnosed; P < 0.001], with 92.2% of undiagnosed individuals having an index HbA_{1c} < 53 mmol/mol (< 7.0%) (compared with 53% of diagnosed individuals; P < 0.001). Fewer undiagnosed individuals had no in-person PCP contact during the year prior to the index HbA_{1c} (15.7% for undiagnosed vs. 19.6% for diagnosed; P < 0.001).

Overall, few individuals had a confirmatory HbA_{1c} value (12.1% for undiagnosed vs. 27.6% for diagnosed; P < 0.001). Of the 5552 undiagnosed individuals, only 10.2% (n = 565) had a confirmatory HbA_{1c} < 48 mmol/mol (6.5%) (compared with 21.6% for diagnosed individuals; P < 0.001), and only 40.5% of undiagnosed individuals had any follow-up HbA_{1c} testing (compared with 76.6% of diagnosed individuals; P < 0.001). The mean number of follow-up HbA_{1c} tests was 0.5 (SD 0.7) for undiagnosed individuals and 1.1 (0.9) for diagnosed individuals (P < 0.001).

For the results of adjusted analyses, we report adjusted odds ratios (aORs) followed by the 95% confidence interval (95% CI). People in the oldest age group (≥ 70 years) were most likely to remain undiagnosed (aOR 1.40, 95% CI 1.24–1.59; referent 50–59 years) (Table 2). Black individuals were also more likely to remain undiagnosed compared with white individuals (aOR 1.26, 95% CI 1.10–1.45). Individuals with with an index HbA_{1c} < 53 mmol/mol (< 7.0%) [aOR 5.95, 95% CI 5.21–6.78; referent 53 to < 64 mmol/mol (7.0% to < 8.0%)] or prior prediabetes (aOR 1.35, 95% CI 1.24–1.47; referent no prior prediabetes) were also more likely to remain undiagnosed. Those with recent oral corticosteroid use had higher odds of remaining undiagnosed compared with those without (aOR 1.27, 95% CI 1.12–1.43). Individuals with previously diagnosed hyperlipidaemia (aOR 0.72, 95% CI 0.66–0.78) or hypertension (aOR 0.90, 95% CI 0.82–0.98), and those with a BMI in the obese range (aOR 0.71, 95% CI 0.62–0.80; referent BMI < 25 kg/m^2) were less likely to remain undiagnosed. Also, individuals with PCPs who had < 10 years' experience were less likely to remain undiagnosed compared with those with PCPs with ≥ 20 years of experience (aOR 0.90, 95% CI 0.81–1.01).

Repeating the analysis after the exclusion of undiagnosed individiduals with a confirmatory HbA_{1c} < 48 mmol/mol (<6.5%) did not significantly change any of the identified predictors of remaining undiagnosed.

In each of the examined age strata, people with index HbA_{1c} values < 53 mmol/mol (< 7%) had increased odds of remaining undiagnosed compared with those with index HbA_{1c} values between 53 and < 64 mmol/mol (7% and < 8%) (Tables S1–S3). For people aged < 50 years and 50 to < 70 years, being black and having a prior prediabetes diagnosis still increased the likelihood of remaining undiagnosed (Tables S1 and S2). However, for people ≥ 70 years, the likelihood of being undiagnosed was no longer associated with being black or prior prediabetes (Table S3).

Undiagnosed individuals were less likely to receive diabetes-related education, a retinal exam, and be started on metformin during the year following their index HbA_{1c} values (Fig. 2). After adjustment for age, index HbA_{1c} and ethnicity/race, undiagnosed people were less likely to receive each examined type of care: diabetes-related education (aOR 0.08, 95% CI 0.06–0.09), retinal exam (aOR 0.02, 95% CI 0.02–0.03) and metformin initiation (aOR 0.06, 95% CI 0.05–0.07).

Among the subpopulation of individuals with index HbA_{1c} values < 53 mmol/mol (< 7.0%), we observed similar significant differences in the receipt of the examined care activities during the year following the index HbA_{1c}, including lower odds of metformin initiation (aOR 0.06, 95% CI 0.05–0.07) for undiagnosed individuals (Fig. S1 and Table S4).

Conclusions

In this longitudinal analysis of data from a large, integrated healthcare system, 30.2% of people with an EHR-documented elevated HbA_{1c} were not clinically diagnosed in the 12 months following this index value. Lower index HbA_{1c}, older age and a prior prediabetes diagnosis were associated with greater odds of remaining undiagnosed. We also quantified the expected association between undiagnosed diabetes and less subsequent recommended diabetes-related care, including diabetes-related education, retinal exams and metformin therapy.

The high prevalence of undiagnosed diabetes suggests the existence of explanations beyond missed or unreviewed lab results [22]. Several provider behaviours may contribute to these delayed diagnoses. First, providers may not formally document a diagnosis unless they are initiating pharmacological treatment, because ordering a prescription medication requires an associated ICD-9/10 code. If this is the case, then people with lower index HbA_{1c} values, who may be less likely to be prescribed medications, would be less likely to have a documented diagnosis. This documentation practice may also explain the observed associations between undiagnosed diabetes with older age and prior prediabetes diagnoses. Given the less-stringent HbA_{1c} targets recommended for older adults, providers may be less likely to start pharmacological treatment and, therefore, would be less likely to document a new clinical diagnosis [21]. Based on recommendations for regular follow-up testing, people with established prediabetes diagnoses may have diabetes detected earlier and have lower index HbA_{1c} values, and, therefore, may be less likely to start pharmacological treatment and have a formal diagnosis documented [22]. Second, some providers may place higher priority on a confirmatory diagnostic test, particularly in the setting of lower levels of hyperglycaemia (e.g. lower index HbA_{1c}). Although this makes theoretical sense, it may

contribute to the observed diagnostic delays given the low rates of repeat testing. Only 12.1% of undiagnosed individuals had a confirmatory HbA_{1c} and only 40.5% had any follow-up HbA_{1c} testing at all during the 12 months following their index HbA_{1c}. Finally, the association between lower index HbA_{1c} values and remaining undiagnosed may be further explained by provider disagreement or misinterpretation of guidelines that define an HbA_{1c} value ≥ 48 mmol/mol (≥ 6.5%) as diagnostic, but an HbA_{1c} < 53 mmol/mol (< 7.0%) as the therapeutic goal. Providers' familiarity with guidelines may also explain the lower likelihood of remaining undiagnosed for people with less-experienced PCPs, as the addition of HbA_{1c} as a diagnostic test was relatively recent.

The increased chance of remaining undiagnosed among black adults is consistent with past work that has demonstrated that non-white populations are more likely to experience diagnostic delays [19,20]. These ethnicity/race-based disparities are often attributed to differential access to care and screening, both barriers that should be minimized for insured KPNC members with already-documented hyperglycaemia. Still, these differences in diagnosis might reflect different levels of interaction and engagement with the healthcare system. Further work is needed to explore this possibility, as well as other potential drivers of these disparities in clinical diagnosis, including differences in Type 2 diabetes clinical presentation and initial treatment preferences [7]. Regardless of the cause, healthcare system-level strategies are needed to improve the timeliness of clinical diagnosis among black individuals.

The differences we observed in receipt of ADA-recommended care by diagnosis status, although expected, help to quantify the early intervention opportunities that may be missed when diagnoses are delayed. Regardless of formal Type 2 diabetes diagnosis status, all the examined individuals arguably have some level of impaired glucose tolerance and could benefit from health education and the initiation of metformin therapy [5,23,24]. For any of these individuals who may technically have prediabetes, support for behaviour change and metformin therapy could help to prevent or delay the onset of Type 2 diabetes. For many of these individuals who do have Type 2 diabetes, the HbA_{1c} reduction achieved with metformin therapy could be enough to achieve the level of early glycaemic control that is associated with decreased long-term micro- and macrovascular complication risks [5,23,24]. Further, initiation of metformin soon after diagnosis and while the HbA_{1c} is low may help to preserve β-cell function, prolonging the effectiveness of metformin and decreasing the risk of future disease-related complications [25]. We plan to follow this cohort over time to assess what happens to those who remained undiagnosed at 1 year and to explore the relationships between diagnosis timing and early care with longer-term health outcomes. Finally, the persistence of these care differences within a subpopulation of people with 'milder' initial hyperglycaemia (index HbA_{1c} < 53 mmol/mol; < 7.0%) suggests that these practice differences are not just driven by disease severity, but reflect healthcare-, provider- or person-level variations in care.

Our results must be interpreted within the context of the study design. Eligible people were all members of a single healthcare system, potentially limiting the generalizability of the findings to other populations. Still, past work has demonstrated that the demographic characteristics and diabetes prevalence among KPNC members are representative of the

general population and insured populations in Northern California, except at the extremes of incomes [26]. Second, we relied solely on HbA_{1c} values to identify the cohort and may have missed some individuals with diagnostic fasting or random glucose values. However, the use of the HbA_{1c} provided a reliable marker of hyperglycaemia (does not require verification of fasting state or the presence of symptoms) and reflects current diabetes screening practices [27]. Third, providers may have documented diabetes diagnoses in ways we did not capture (e.g. within the text of encounter notes). Similarly, we were not able to capture diabetes-attributable symptoms that may have influenced providers' diagnostic decisions. Finally, this study cannot address causation. We can only comment on observed associations between person-level characteristics and remaining undiagnosed.

One proposed solution to the high prevalence of undiagnosed diabetes in the USA has been to increase screening in high-risk adults, resulting in national-level changes in screening recommendations [28]. Our findings demonstrate that delays exist even after screening occurs. In this study, almost one-third of adults with EHR-documented hyperglycaemia were not clinically diagnosed within 1 year. Although a better understanding of provider decision-making regarding the diagnosis and documentation of new diabetes is needed, the prevalence of undiagnosed diabetes raises questions regarding our current use of the EHR [29,30]. Although EHRs provide easy access to available HbA_{1c} data, this may not be sufficient to trigger the documentation and subsequent care processes for people with newly diagnosed Type 2 diabetes. Ensuring timely Type 2 diabetes diagnoses may require EHR advances that more explicitly and automatically connect available test results to diabetes diagnoses and prompt early intervention towards the goal of improved Type 2 diabetes outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What's new?

- Although undiagnosed Type 2 diabetes is usually asymptomatic, diagnostic delays result in missed opportunities for early interventions that may improve peoples' long-term health.
- In this study, we examine the prevalence and predictors of undiagnosed Type 2 diabetes among adults with documented hyperglycaemia.
- In a population of 18 356 adults with a first elevated HbA_{1c}, individuals with milder hyperglycaemia, prior prediabetes and those of older age or of black race had higher odds of remaining undiagnosed at 1 year.
- After accounting for HbA_{1c} and age at diagnosis, remaining undiagnosed was associated with missed early interventions, including metformin initiation and formal diabetes-related education to support behaviour change.

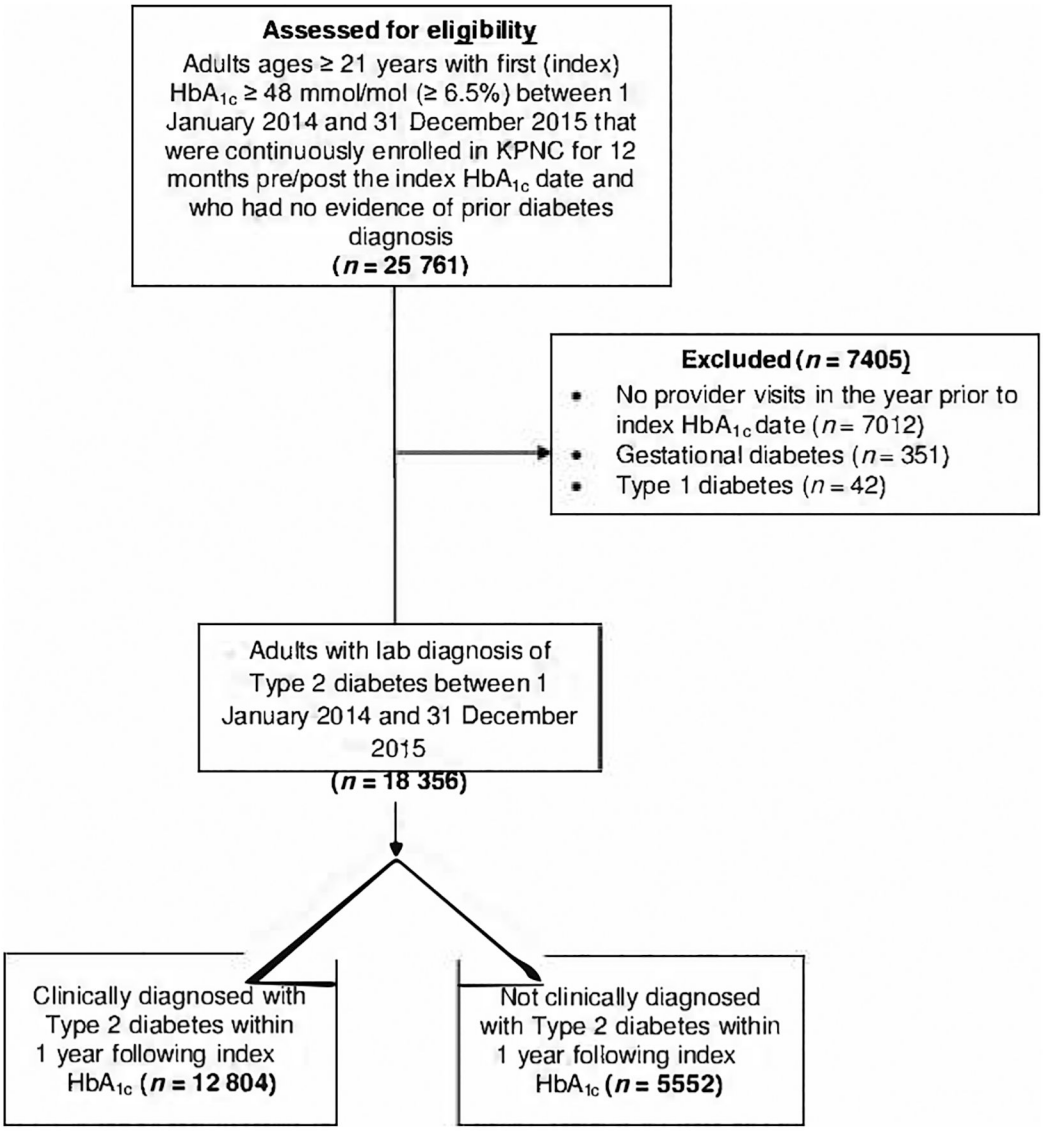

FIGURE 1.

Identifying adults with undiagnosed Type 2 diabetes during the year following Electronic Health Record-documented hyperglycaemia

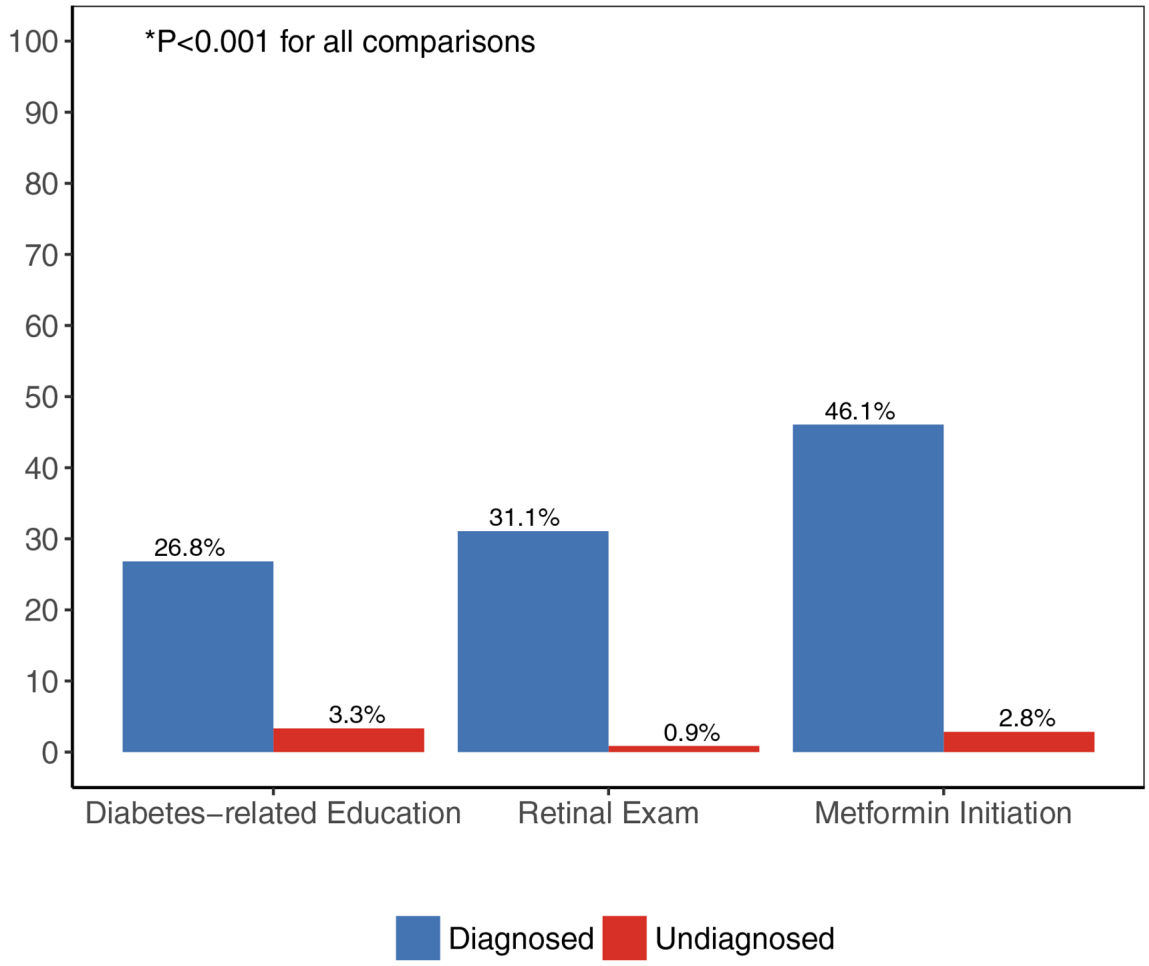

FIGURE 2.

Proportion of people who received select diabetes-related care during the year following their index HbA_{1c} value by clinical diagnosis status.

Table 1.

Population characteristics at baseline by clinical diagnosis status

	Diagnosed *N* =12 804 (69.8%)		Undiagnosed *N* = 5552 (30.2%)		*P*-value
Characteristics	***n***	**%**	***n***	**%**	
Age; years					< 0.001
21–29	216	1.7	51	0.9	
30–39	1027	8.0	291	5.2	
40–49	2516	19.7	779	14.0	
50–59	3894	30.4	1475	26.6	
60–69	3094	24.2	1513	27.3	
≥ 70	2057	16.1	1443	26.0	
Male	6465	50.5	2585	46.6	< 0.001
Race*					< 0.001
White	4804	37.5	1867	33.6	
Asian	2881	22.5	1470	26.5	
Latino	2760	21.6	991	17.8	
Black	1289	10.1	734	13.2	
Other	1070	8.4	490	8.8	
Neighborhood Deprivation Index					< 0.001
Least deprived	2718	21.5	1312	23.8	
Most deprived	2636	20.8	1114	20.2	
English proficiency (yes)	11 223	88.0	4878	88.1	0.838
Index HbA_{1c} value (%)					< 0.001
48 to < 53 mmol/mol (6.5 to < 7%)	6781	53.0	5121	92.2	
53 to < 64 mmol/mol (7 to < 8%)	2639	20.6	337	6.1	
64 to < 75 mmol/mol (8 to < 9%)	870	6.8	35	0.6	
75 to < 86 mmol/mol (9 to < 10%)	582	4.5	21	0.4	
≥ 86 mmol/mol (≥ 10%)	1932	15.1	38	0.7	
Preceding diagnoses (yes)					
Hypertension	7058	55.1	3231	58.2	< 0.001
Hyperlipidaemia	7344	57.4	3178	57.2	0.884
Cardiovascular disease	3480	27.2	2009	36.2	< 0.001
Chronic renal disease	1080	8.4	555	10.0	< 0.001
Prediabetes	6432	50.2	3618	65.2	< 0.001
Depression	1550	12.1	624	11.2	0.095
Recent corticosteroid (yes)	1215	9.5	648	11.7	< 0.001
BMI; kg/m^2					< 0.001
Normal (18.5–24.9)	1201	9.8	833	15.5	
Overweight (25.0–29.9)	3230	26.3	1653	30.8	
Obese (≥ 30.0)	7861	64.0	2885	53.7	
In-person PCP encounters during year prior to index HbA_{1c}					

Characteristics	Diagnosed *N* =12 804 (69.8%)		Undiagnosed *N* = 5552 (30.2%)		*P*-value
	n	**%**	***n***	**%**	
At least one encounter	10 299	80.4	4683	84.4	< 0.001
Any PCP encounters during year prior to index HbA_{1c} (%)					
At least one encounter	11 240	87.8	5028	90.6	< 0.001
HbA_{1c} ordered by PCP	10 482	81.9	4443	80.1	0.005
PCP years of practice					
< 10	1816	14.5	660	12.2	< 0.001
10 to < 20	5081	40.7	2119	39.1	
≥ 20	5589	44.8	2639	48.7	

White, non-Hispanic white; Black, non-Hispanic black; Asian, non-Hispanic Asian; Hispanic, Latino.

Table 2.

Predictors remaining undiagnosed with Type 2 diabetes at one-year following index HbA_{1c} *

Variable	aOR (95% CI)	*P*-value
Index age; years (referent: 50–59)		
21–29	0.98 (0.66–1.47)	0.927
30–39	1.14 (0.95–1.37)	0.167
40–49	0.99 (0.87–1.12)	0.819
60–69	1.12 (1.01–1.25)	0.036
70+	1.40 (1.24–1.59)	< 0.001
Index HbA_{1c} (referent: 53 to < 64 mmol/mol; 7 to < 8%)		
48 to < 53 mmol/mol (6.5 to < 7%)	5.95 (5.21–6.78)	< 0.001
64 to < 75 mmol/mol (8 to < 9%)	0.33 (0.22–0.48)	< 0.001
75 to < 86 mmol/mol (9 to < 10%)	0.27 (0.17–0.44)	< 0.001
≥ 86 mmol/mol (≥ 10%)	0.15 (0.10–0.21)	< 0.001
Gender (referent: male)	0.93 (0.86–1.01)	0.167
Race (referent: white)		
Black	1.26 (1.10–1.45)	0.001
Asian	1.07 (0.95–1.20)	0.282
Latino	1.03 (0.92–1.16)	0.624
Other	1.17 (1.01–1.36)	0.034
Neighborhood Deprivation Index (referent: 1st quartile)		
2nd quartile	1.01 (0.91–1.13)	0.800
3rd quartile	0.91(0.82–1.02)	0.117
4th quartile	1.01 (0.89–1.14)	0.882
Preceding diagnoses (referent: no)		
Chronic renal disease	0.93 (0.81–1.07)	0.097
Cardiovascular disease	1.05 (0.95–1.15)	0.358
Hyperlipidaemia	0.72 (0.66–0.78)	< 0.001
Hypertension	0.90 (0.82–0.98)	0.014
Prediabetes	1.35 (1.24–1.47)	< 0.001
Depression	0.90 (0.80–1.01)	0.082
Recent corticosteroid (referent: no)	1.27 (1.12–1.43)	< 0.001
BMI (referent: normal)		
Overweight	0.81 (0.71–0.92)	0.001
Obese	0.71 (0.62–0.80)	< 0.001
HbA_{1c} ordering provider (referent: PCP)		
Non-PCP	1.46 (1.32–1.62)	< 0.001
PCP years practice (referent: ≥ 20 years)		
< 10	0.90 (0.81–1.01)	< 0.001
10 to < 20	0.74 (0.63–0.87)	0.069

* Model included random effects for PCP and medical facility.