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ORIGINAL RESEARCH

Sociodemographic differences in diabetic retinopathy screening; using patient-level primary care data for health equity audit

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Background: The prevalence of diabetes is increasing worldwide and there is inequality in the distribution of diabetic complications. Diabetic retinopathy is the leading cause of blindness in adults of working age in the UK, and certain risk factors are recognized. Retinopathy screening in the UK involves annual digital retinal photography and image grading. Auditing equity in retinopathy screening poses unique challenges, and screening program data are often incomplete for variables relevant to equity. Using two sources of patient-level primary care data, we conducted a health equity audit comparing the access and uptake of screening between groups of people with diabetes in each of three screening programs covering this area of southern England.

Methods: A patient-level dataset using data from general practices and a combined health record was used to compare dimensions of equity (gender, age, length of time since diabetes diagnosis, type of diabetes, presence of hypertension, socioeconomic deprivation, ethnicity, and screening program) between people with and without a record of retinopathy screening within three years in Hampshire and the Isle of Wight, UK.

Results: Anonymized data for 70,004 people with diabetes were obtained from 205 (88%) general practices. In total, 62,836 people (89.8%) had a record of screening within three years and 7168 (10.2%) did not. Lower uptake of screening was independently associated with the youngest and oldest age groups (compared with 50–79-year-olds), recent diabetes diagnosis, and deprived areas. Diagnosed hypertension was positively associated with screening.

Conclusion: Evaluating equity in screening programs is important to help reduce inequalities. We found evidence of inequity in access and uptake of retinopathy screening. Primary care data contained more information than screening program data. Using a combined health record was more efficient than obtaining data directly from general practices, but data were incomplete for deprivation measures at the time of this audit. Our audit informed subsequent efforts to improve equity in local diabetic retinopathy screening services.

Keywords: inequality, diabetes, eye, complications, screening

Background

Diabetic retinopathy is the leading cause of blindness in adults under the age of 65 years in the UK.[1] The prevalence of diabetes is increasing in many countries, and inequalities in the prevalence of diabetic retinopathy are recognized, with men and certain ethnic groups at greater risk.[2–4] Risk factors for developing diabetic retinopathy include poor diabetic control, hypertension, hyperlipidemia, prolonged duration of diabetes, and being of South Asian origin.[5–8]

Diabetic retinopathy screening in England is provided by local programs with guidance and quality assurance oversight from the English National Screening

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Programme for Diabetic Retinopathy. Diabetic retinopathy screening is offered annually to all people with diabetes over the age of 12 years using digital retinal photography followed by protocol-defined grading of images.[9] People with diabetes are identified in primary care from general practice diabetes registers and referred to the local screening program, which organizes call and recall procedures. People with existing diabetic retinopathy under the care of an ophthalmologist are excluded from recall until discharged back to the care of the general practitioner. There are unique challenges in evaluating diabetic retinopathy screening programs, such as the need for annual recall of a large population of people, changing diabetic populations, variability of screening pathways among regional screening programs, and lack of clarity in defining the important clinical outcome measures. There is evidence from ecological studies that diabetic retinopathy screening programs are prone to inequity; a health equity audit of the diabetic retinopathy screening program in NHS Wirral, UK, using a diabetes register identified that uptake of retinopathy screening was inversely related to general practice deprivation score.[10] Data from the Bradford Low Vision Register showed that diabetes formed a higher proportion of cause of blindness among Asians than among Caucasians (26.1% versus 7.8%).[11] Cross-sectional studies using diabetes registers have shown lower attendance rates among younger patients, people with type 1 diabetes, and those from more deprived areas, and that older patients, people with type 1 diabetes, immigrants, and people from deprived areas are more likely to present with diabetic retinopathy.[12,13] However, there is some conflicting evidence about the relationship between deprivation and presentation with diabetic retinopathy at first screening.[14]

Various barriers to diabetic retinopathy screening have been identified, including patient factors, (lack of education about retinopathy, noncompliance with screening, language issues, and low health literacy), provider factors, (poor awareness of screening guidelines, communication issues, time limitations, and referral patterns), and system factors (understaffing, diagnostic imaging issues, and waiting times).[13] Recommendations have included education of patients and primary care, electronic record prompts, and mobile screening.[13] Some programs have altered service provision, used marketing techniques, and targeted particular groups, to improve access.[15]

Choice of data source for health equity audit of diabetic retinopathy screening is challenging. Diabetes registers are not uniformly available across the UK, and compared with general practice records, retinopathy screening program records contain fewer details of important risk factors for retinopathy, and other variables relevant to health equity, such as deprivation, comorbidities, and length of time with diabetes. As part of the UK Quality and Outcomes Framework (QOF), general practitioners are incentivized to ensure a high proportion of their diabetic population is screened annually (which increases likelihood of recording screening), but studies in the UK using QOF data to audit health care equity have identified major limitations of these data as a research tool, particularly the lack of individual patient data.[16] Health equity audits using bespoke surveys have encountered problems acquiring accurate and timely data.[10,11,17] Patient-level primary care data are potentially much more informative, but directly accessing general practice data requires individual practice consent and cooperation, careful communication to ensure completeness and data security, and adequate technical expertise (given the diversity of clinical systems in general practice, the need for bespoke data searches, and the complexity of interpretation and analysis). We aimed to conduct a health equity audit using two methods of obtaining anonymized patient-level data from general practices referring people to diabetic retinopathy screening services in our area (direct data from general practices, and via the Hampshire Health Record) in order to compare the ability of different populations of people with diabetes to access and take up screening in each of the three screening programs that cover this area of southern England.

Methods

We used UK Department of Health and Health Development Agency guidelines for health equity audit.[18,19] Retinopathy screening in Hampshire and the Isle of Wight is provided by three screening programs (denoted as A, B, and C) with differing care pathways, and the area incorporates four primary care trusts. The three screening programs are not described in detail in order to maintain anonymity, but they operate slightly differing methods of delivery of screening, ie, either cameras in fixed locations, such as a hospital, or cameras in mobile screening units that visit general practice premises on a regular basis. Following national guidance, between the primary care trusts we agreed dimensions of equity which included gender, age, length of time since diabetes diagnosis, type of diabetes, presence of another chronic condition (hypertension), deprivation, ethnicity, and screening program (including geographical location and aspects of service delivery).[18]

Data available from the screening programs themselves were only complete for age and gender, and did not contain additional clinical data, such as comorbidities. Therefore, they were not used for these comparisons. Instead, we used data from general practice databases for our analyses. We took a pragmatic approach to obtaining data, requesting data directly from general practice databases where there was sufficient individual practice expertise (judged by a data specialist), and from a local combined electronic health record where there was not. Our data sources were chosen to maximize completeness of data while testing the feasibility of using the combined health record. We obtained agreement from the Local Medical Committee (a body representing the views of general practitioners) for data requests.

At the time of this audit, the Hampshire Health Record (HHR) received data from approximately two thirds of general practices in the region, and from secondary care. It is used by clinicians to share information between primary and secondary care, and provides a rich source of contemporaneous data with potential for public health use. HHR data are accessible from a central hub, precluding the need to request data directly from general practices, and therefore potentially providing much more timely data for audit. In the analytical database, patient records are pseudonymized so individuals cannot be identified, and access to the database is controlled by an advisory group with information governance and Local Medical Committee representation.[20,21]

Data were extracted from general practice clinical computer systems using "Miquest" (a methodology for extracting data from different general practice computer systems using a common query language).[22] This was combined with the HHR data to create the final anonymized dataset of people with diabetes. Data requested included the general practice, registered practice population, number of people with diabetes, diabetes type, age, gender, ethnicity and language (if recorded), lower super output area (LSOA, ie, the standard geography used to report small area data in England and Wales, derived from postcode for this study), diabetes diagnosis date, last retinal screening date, and diagnosis of hypertension. Multiple diabetes diagnosis codes were used in order to capture all registered people with diabetes. Hypertension was chosen because it is a risk factor for diabetic retinopathy and likely to be recorded in general practice records. A measure of deprivation was added to each record using the Index of Multiple Deprivation (IMD) LSOA level scores, and categorizing them into national quintiles (1 being the most deprived 20% in England; 5 being the least deprived 20% in England). The IMD is made up of seven domains, ie, income, employment, health deprivation and disability, education skills and training, barriers to housing and services, crime, and living environment. Unfortunately, LSOA data were not available from the HHR at the time of this audit which meant that we were unable to extract an IMD score for the HHR data. Due to wide variation in recording, and to simplify analysis, ethnicity was summarized into four categories (white British, white other, Asian, and black). Screening program databases were interrogated for the same variables, and information was obtained from the program managers on practical issues, such as call/recall procedures, care pathways, camera locations, appointment times, and disabled access.

Statistical analysis

Two groups were identified from the general practice dataset, ie, people with a record of screening within three years (from July 2010), and people with no record of screening within three years. These groups were chosen to compare those people who are "true" nonattenders compared with recent attenders (to distinguish a clear group of people who are at risk from not being screened for a significant period of time from those who might usually attend screening, but had just missed one screening episode). To assess the validity of this assumption, we conducted sensitivity analyses with a cutoff of those screened within two years. Age was divided into ten-year bands (except the 12–19-year age group, because diabetic retinopathy screening begins at age 12 years). Where type of diabetes was not recorded, we imputed type based on age and date of diagnosis (those with a new diagnosis after the age of 30 years were categorized as type 2 diabetics). This assumption was checked by repeating the analyses using the original data without imputation of type. Basic demographic details were presented with frequencies and percentages for both the screened and the nonscreened groups. Comparisons were made for the dimensions of equity using logistic regression. Three models were constructed to adjust by sociodemographic, clinical, and service factors using SPSS version 18 (SPSS Inc, Chicago, IL). The final model included deprivation based on the IMD at the LSOA level. We conducted a sensitivity analysis to consider the effect of the missing deprivation data by repeating the main model using only those data that contained a deprivation record, because the number with a deprivation score was considerably less than the total database. A further model used the limited proportion of records that included ethnicity. Odds ratios (OR) and 95% confidence intervals (CI) were

presented with the outcome of interest as having a record of screening in the last three years.

Results

Data were obtained from 205 (88%) of the 234 general practices referring people with diabetes to the three diabetic retinopathy screening programs (131 [56%] using Miquest searches, and 74 [32%] using the HHR). Twenty-nine practices (12%) did not return Miquest data and were also not contributors to the HHR (Figure 1). These practices therefore represent missing data from which we were able to get practice level (QOF) data but no individual patient data.

Characteristics of the population

The total population of people of screening age identified from these sources was 70,004 people (35,119 [50%] from practices referring to screening program A, 20,858 [30%] from practices referring to program B, and 14,027 [20%] from practices referring to program C, see Table 1).

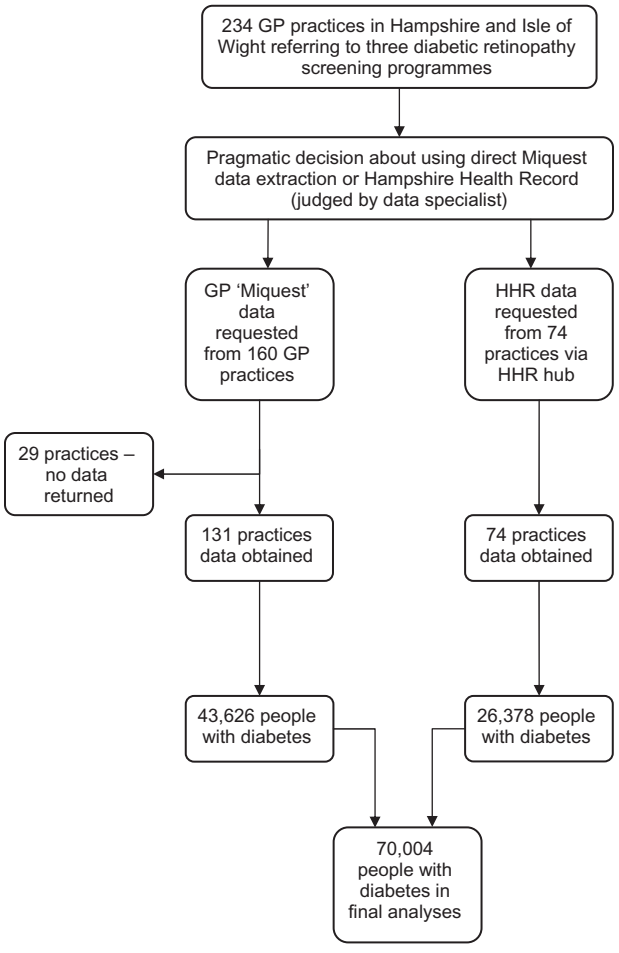

Figure 1 Data sources for the combined general practice dataset.

Table 1 Characteristics of people with and without a record of diabetic retinopathy screening in the previous three years

Variable	Screened n (%)	Not screened n (%)	Total n (%)
Gender			
Male	34,790 (89.7)	3994 (10.3)	38,784 (100)
Female	28,046 (89.8)	3174 (10.2)	31,220 (100)
Age group (years)			
12–19	515 (71.3)	207 (28.7)	722 (100)
20–29	962 (80.6)	231 (19.4)	1193 (100)
30–39	2078 (79.8)	527 (20.2)	2605 (100)
40–49	5897 (85.6)	992 (14.4)	6889 (100)
50–59	10,229 (88.7)	1299 (11.3)	11,528 (100)
60–69	16,409 (92.0)	1430 (8.0)	17,839 (100)
70–79	16,468 (93.0)	1234 (7.0)	17,702 (100)
80–89	8997 (90.2)	974 (9.8)	9971 (100)
90+	1281 (82.4)	274 (17.6)	1555 (100)
Screening program			
A	31,790 (90.5)	3329 (9.5)	35,119 (100)
B	18,610 (89.2)	2248 (10.8)	20,858 (100)
C	12,436 (88.7)	1591 (11.3)	14,027 (100)
Hypertension			
No hypertension	28,862 (87.2)	4250 (12.8)	33,112 (100)
Hypertension	33,974 (92.1)	2918 (7.9)	36,892 (100)
Time with diabetes, years			
≤5	23,566 (84.5)	4327 (15.5)	27,893 (100)
6–10	19,390 (93.9)	1252 (6.1)	20,642 (100)
11–15	9110 (93.9)	587 (6.1)	9697 (100)
16–20	4605 (94.7)	257 (5.3)	4862 (100)
>20	4816 (92.7)	380 (7.3)	5196 (100)
Missing	1349 (78.7)	365 (21.3)	1714 (100)
Diabetes type			
Type 1	8438 (87.6)	1199 (12.4)	9637 (100)
Type 2 (including imputed values)	53,520 (90.3)	5765 (9.7)	59,285 (100)
Missing	878 (81.1)	204 (18.9)	1082 (100)
Deprivation			
IMD quintile 1	5353 (88.1)	722 (11.9)	6075 (100)
IMD quintile 2	7750 (88.9)	968 (11.1)	8718 (100)
IMD quintile 3	9030 (89.8)	1028 (10.2)	10,058 (100)
IMD quintile 4	7465 (90.6)	777 (9.4)	8242 (100)
IMD quintile 5	9656 (91.9)	852 (8.1)	10,508 (100)
Missing (HHR data)	23,582 (89.3)	2821 (10.7)	26,403 (100)

Abbreviations: IMD, Index of Multiple Deprivation; HHR, Hampshire Health Record.

In total, 9637 (13.8%) had type 1 diabetes and 59,285 (84.7%) had type 2 diabetes (53,029 [75.8%] recorded in records, 6256 [8.9%] imputed from age and date of diagnosis), and 1082 (1.5%) remained with no diabetes type identified.

There were 62,836 people (89.8%) who had a record of screening within three years and 7168 (10.2%) who had either a record of screening prior to three years ago or no record of screening at all (see Figure 2). Characteristics of people with and without a record of screening within three years are shown in Table 1. Data were missing for deprivation in 26,403

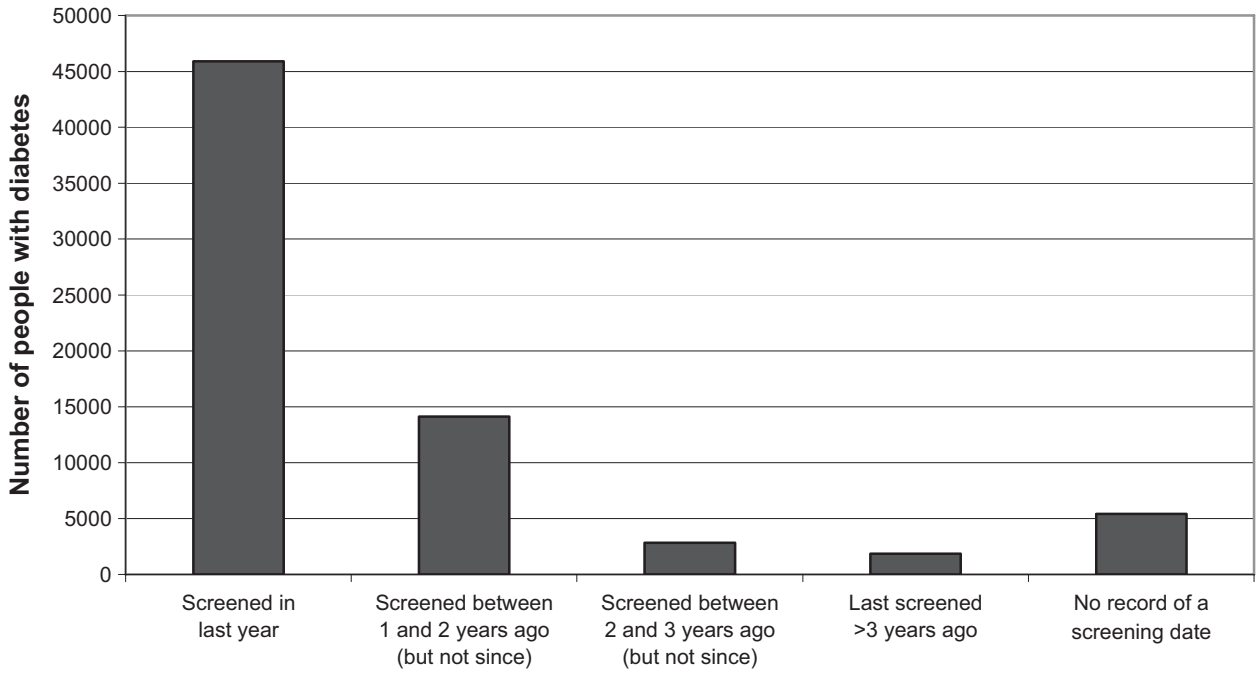

Figure 2 Timing of last record of retinopathy screening.

people (38% of the total), 1714 (2.4%) for time with diabetes, and 1082 (1.5%) for diabetes type. Univariate analyses showed no association between screening and gender, but statistically significant associations with age group, screening program, time with diabetes, type of diabetes, hypertension, and deprivation (χ^2 for each <0.001).

Independent associations with screening uptake

No difference was shown in odds of screening by gender (Table 2). There was strong evidence of association between screening in the 50–79-year age groups compared with younger and older groups after adjusting for gender. Gender, age, and hypertension patterns were consistent across models. There was no significant difference in odds of screening by type of diabetes after adjusting for gender and age (OR 1.07, 95% CI 1.0–1.16) for type 2 compared with type 1 diabetes. The odds of screening among type 2 diabetics increased after adjusting for time with diabetes, suggesting that the association with type of diabetes is confounded by duration of diabetes (OR 1.34, 95% CI 1.22–1.47) for type 2 compared with type 1 diabetes. Repeating the analyses using the original data without imputation of type of diabetes (ie, excluding imputed values) altered the association, but this increase in odds was still present (OR 1.11 for type 2 diabetes [excluding imputed values] compared with type 1 diabetes, 95% CI 1.02–1.2, $P = 0.01$).

In models 2 and 3, people with shorter duration of diabetes had a lower odds of screening (model 2, OR 0.39, 95% CI 0.35–0.44) for 5 years or less compared with more than 20 years and people with hypertension had greater odds of screening after adjusting for gender, age, and type of diabetes (model 2, OR 1.35, 95% CI 1.27–1.42).

In model 2, people in screening programs B and C had lower odds of screening than program A after adjustment (OR 0.84, 95% CI 0.78–0.90 and 0.86, 95% CI 0.80–0.91, respectively). Screening program A used mobile screening units.

People from areas of higher deprivation had a lower odds of screening than people from less deprived areas after adjusting for all other variables. However, there was evidence of the associations with type of diabetes, duration of diabetes, and screening programs being confounded by deprivation. Data were available for 43,601 people (62.3%) for the deprivation quintile (Table 2). Evidence for this confounding was supported by sensitivity analyses. Sensitivity analyses using a "screened within two years" cutoff showed no significant differences in any variable from using the "screened in last three years" cutoff (data not shown).

Of the 27,040 people (39% of total) in whom ethnicity was recorded, 25,237 (93%) were classified as "White British", 1033 (3.8%) were "Asian", 567 (2.1%) were "White other", and 203 (0.75%) were "Black". Incorporating ethnic group into the multivariable model (data not shown in Table 2

Table 2 Logistic regression models of record of screening by equity parameters

Variable	Model 1 OR (95% CI) n = 70,004 (100%)	Model 2 OR (95% CI) n = 68,922 (98%)	Model 3 OR (95% CI) n = 43,601 (62%)
Gender			
Male	1.00	1.00	1.00
Female	1.04 (0.99–1.09)	1.01 (0.96–1.06)	1.05 (0.98–1.12)
Age group, years			
12–19	0.32 (0.27–0.37)**	0.37 (0.30–0.44)**	0.40 (0.31–0.50)**
20–29	0.53 (0.45–0.62)**	0.54 (0.46–0.64)**	0.54 (0.44–0.66)**
30–39	0.50 (0.45–0.56)**	0.56 (0.50–0.63)**	0.55 (0.48–0.63)**
40–49	0.75 (0.69–0.82)**	0.81 (0.74–0.89)**	0.77 (0.69–0.86)**
50–59	1.00	1.00	1.00
60–69	1.46 (1.35–1.58)**	1.33 (1.22–1.44)**	1.37 (1.24–1.52)**
70–79	1.69 (1.56–1.84)**	1.39 (1.28–1.52)**	1.43 (1.28–1.59)**
80–89	1.17 (1.07–1.27)	0.91 (0.83–0.99)	0.91 (0.81–1.03)
90+	0.59 (0.51–0.68)	0.43 (0.37–0.50)**	0.39 (0.32–0.47)**
Diabetes type			
Type 1		1.00	1.00
Type 2		1.07 (1.00–1.16)	1.34 (1.22–1.47)**
Time with diabetes, years			
≤5		0.39 (0.35–0.44)**	0.30 (0.27–0.35)**
6–10		1.08 (0.96–1.23)	0.86 (0.72–1.01)
11–15		1.11 (0.97–1.28)	0.90 (0.75–1.09)
16–20		1.30 (1.10–1.53)*	1.05 (0.84–1.31)
>20		1.00	1.00
Hypertension			
No hypertension		1.00	1.00
Hypertension		1.35 (1.27–1.42)**	1.33 (1.24–1.43)**
Screening program			
A		1.00	1.00
B		0.84 (0.78–0.90)**	0.91 (0.85–0.98)*
C		0.86 (0.80–0.91)**	1.02 (0.92–1.13)
Deprivation			
IMD quintile 1			1.00
IMD quintile 2			1.04 (0.93–1.15)
IMD quintile 3			1.12 (1.01–1.24)
IMD quintile 4			1.21 (1.08–1.35)*
IMD quintile 5			1.42 (1.27–1.60)**

Notes: *$P < 0.01$; **$P < 0.001$.
Abbreviations: CI, confidence interval; IMD, Index of Multiple Deprivation; OR, odds ratio.

because of incompleteness) showed two groups with lower odds of screening ("White other" OR 0.68, 95% CI 0.54–0.89, $P = 0.05$; and "Asian" OR 0.70, 95% CI 0.58–0.84, $P < 0.001$ compared with "White British"), adjusting for all other variables. However, there were changes in parameter estimation with screening program, type of diabetes, and deprivation, suggesting that these results were affected by data incompleteness. Conclusions from this reduced population group should therefore be treated with caution.

Discussion

In this pragmatic, service-based health equity audit, we showed that approximately 90% of people with diabetes had a record of retinopathy screening within three years in this area of southern England. However, we found evidence of inequity for some groups. Younger people and the elderly, people with a recent diabetes diagnosis, and those from more deprived areas had lower independent odds of screening within three years. There was some evidence that this was also true for people with type 1 diabetes and possibly certain ethnic groups. This raises concern that some people at greater risk of retinopathy are less likely to be screened. In the model with the most complete data, we identified a greater odds of screening associated with the program using mobile screening units rather than fixed location cameras, suggesting that access was better for this program. It was

reassuring that people with a diagnosis of hypertension were more likely to have a record of screening, possibly reflecting a perception of being at greater risk of retinopathy. Using primary care data allowed better assessment of equity than data from screening services by including relevant variables such as comorbidities, time since diabetes diagnosis, and type of diabetes. This is the first use of the HHR for this kind of audit, and we found that using such a combined health record has potential for providing data for future similar audits in a more timely fashion than accessing data from multiple individual general practices. Record linkage has been shown to improve understanding of disease behavior in populations, and combined health records offer potential for data to be obtained expediently and to provide secondary care data.[23]

What is already known on this topic?

The findings of this audit are consistent with the findings of many previous studies reporting inequality and inequity in screening programs, such as variation in uptake of cervical cancer screening by age and deprivation.[24–28] Previous health equity audits of diabetic retinopathy screening have showed inequity by deprivation, age, and type of diabetes.[10,12,13] Suitable data sources for equity audit vary between screening programs, and accurate data are difficult to obtain for this purpose in diabetic retinopathy screening.[23] Previous audits have relied on diabetic registers or screening program databases. General practice data is sourced for many public health purposes, but many current systems for accessing general practice databases are complicated and time-consuming. The Department of Health advises that timely provision of data for health equity audit is vital, and recommends "where possible using information that is already there".[18]

Diabetic retinopathy is the leading cause of blindness in people of working age in the UK, certain risk factors are recognized (poor diabetic control, hypertension, hyperlipidemia, prolonged duration of diabetes, and South Asian origin), and barriers to access and uptake of screening can be identified at patient, provider, and system levels, all of which need to be considered to reduce inequity.[5] A recent systematic review of the rate of progression to retinopathy showed a pooled incidence of retinopathy of 11% at 4 years.[29] We used a three-year cutoff to define attendance at screening. There is debate about optimum screening frequency, with evidence that there may be little marginal benefit to annual as opposed to biennial screening, but concerns that changing screening frequency would adversely affect patient compliance.[30]

What this study adds

This study adds to the evidence demonstrating inequity in various aspects of diabetic retinopathy screening. Using patient-level data from primary care, we identified some groups at greater risk of developing sight-threatening retinopathy in our area who are less likely to have a record of screening. Our methodology allowed some comparison between neighboring screening programs. We demonstrated benefits of general practice data over screening program data in allowing additional variables to be considered, such as presence of hypertension, a risk factor for retinopathy. To identify high-risk groups, this could include diabetic and lipid control measures in future studies. We identified that extracting data from multiple general practices is time-consuming and requires high levels of expertise, whereas using a local combined health record was feasible, gave a usable data set for analysis, and was considerably easier to access.

Limitations

Despite the methodology used, the main limitation remained incompleteness of data. We were not able to obtain any data for 15% of practices referring to the screening programs because they did not respond to our requests to return data and were not contributors to the HHR. We also recognize that routine general practice data may not be complete with regard to recording the "screened/not screened" status of patients for a number of reasons. There may also be inaccuracy in recording diabetes data in general practice records, for example, date of diagnosis (with potential to equate "recent recording" of diabetes with "recent diagnosis"), and for incorrect/incomplete type of diabetes recording. A major limitation was incompleteness with respect to deprivation (only 62% complete) because the HHR was unable to access LSOA data at the time of this audit (this has now changed). This impacts our analysis by limiting the interpretation of model 3 and, therefore, in addition to considering the cross-sectional nature of these data, firm conclusions cannot be drawn about the effects of deprivation. Ethnicity is incompletely and inconsistently recorded in many clinical contexts, and our findings proved no exception. There are potential flaws in our method of imputation of type of diabetes, and results concerning diabetes type should be treated with caution.

We recognize the problems associated with making comparisons of equity based on incomplete data and the need to improve recording of type of diabetes and ethnicity to facilitate future equity audit and improve services. We are

also aware that this study may not be generalizable to other health systems. However, screening for diabetic retinopathy remains an important part of diabetes care, and these findings of inequity in the UK highlight the importance of including strategies to conduct equity audit in the establishment and quality assurance of diabetic retinopathy screening programs.

Conclusion

Evaluating equity in screening programs is important to help reduce inequalities. This health equity audit using primary care data demonstrated inequity in several aspects of diabetic retinopathy screening. Overall, uptake of retinopathy screening was very good (approximately 90%), but several groups were identified which appeared to have no record of screening. It is of particular concern that younger age groups and those with recently diagnosed diabetes may not be engaging with screening. There was a slightly greater odds of screening among people referred to a program that used mobile screening units rather than fixed camera locations. The results of this audit were used to improve screening services locally by considering the location of screening cameras in relation to the prevalent diabetes population, timing of appointments, and targeting at risk groups. The detailed description of these program changes and subsequent re-audit was beyond the scope of this paper. However, it is important to repeat equity audit to assess the impact of service improvement measures, and the inclusion of deprivation data within the HHR and the increasing proportion of the population now included in the HHR database will make this process more straightforward locally.

There are implications for retinopathy screening across the UK, and possibly further afield, because most dimensions of inequity identified in this audit are not geographically determined. Retinopathy screening is delivered in a variety of ways in the UK, and clinical outcomes for patients referred to ophthalmology services from screening programs are often not recorded in an easily retrievable form, making full assessment of the success of screening difficult. Further research, to include the assessment of outcomes, is needed to identify the most effective and cost-effective organizational structures and care pathways. Use of primary care data, and accurate surveillance data on new retinopathy and visual impairment could have great potential to improve quality, efficiency, consistency, and equity in retinopathy screening.

Disclosure

The authors report no conflicts of interest in this work.

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