RESEARCH: COMPLICATIONS

DIABETIC
Medicine

Characteristics of repeat non-attenders at Diabetes Eye Screening Wales, a national community-based diabetes-related retinopathy screening service, during 2003-2018

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Abstract

Aims: To understand factors associated with repeat non-attendance at screening for diabetes-related retinopathy.

Methods: Retrospective observational study using anonymised data from Diabetic Eye Screening Wales for people with a full history of screening invitations and attendances was linked with primary and secondary care records held in the Secure Anonymised Information Linkage Databank. Repeat non-attendance was defined as no record of attendance during any 36-month period despite three cycles of annual screening invitations. The associations between repeat non-attendance and potential risk factors were examined using multivariable logistic regression analysis, stratified according to type 1 and type 2 diabetes.

Results: A total of 18% with type 1 diabetes (1146/6513) and 8% with type 2 diabetes (12,475/156,525) were repeat non-attenders. Participants attending their very first appointment were least likely to become repeat non-attenders [odds ratio (95% confidence interval)]: type 1 diabetes: 0.12 (0.09, 0.17) and type 2 diabetes: 0.08 (0.07, 0.09). For both types of diabetes, those of a younger age, living in areas of higher deprivation and subject to multiple house moves were at greater risk of becoming repeat non-attenders.

Conclusion/interpretation: A more tailored approach is needed for the younger population, those living in areas of higher deprivation and/or undergoing multiple residential relocation and to ensure attendance at their initial appointment to minimise future repeat non-attendance.

KEYWORDS
diabetes-related retinopathy, screening, repeated non-attendance

1 | INTRODUCTION

Diabetes-related retinopathy is acknowledged to be one of the leading causes of blindness in the working age population in most countries with devastating personal and socio-economic consequences, despite being largely avoidable.[1-3] Since systematic screening was introduction in the early 2000s, it is no longer the primary cause of blindness in this population

group in England and Wales.[4] A 50% reduction in the incidence of new certification for visual impairment and blindness has been observed in Wales from 2007 to 2015.[5]

Despite the clinical and cost effectiveness benefits of retinal screening, a substantial number of people invited fail to attend.[6] A high coverage is vital to reduce unnecessary visual loss and blindness due to diabetes; the current uptake rates in England and Wales are relatively stable at approximately 80%.[6,7] Factors known to inhibit attendance at diabetic retinopathy screening include younger age, a lower socio-economic status, type of diabetes, age, ethnicity and poor glycaemic control.[6-14] In addition, confusion between screening and standard eye tests, relevance of screening despite no visual symptoms, fear of screening (e.g. mydriasis), plus practical obstacles (e.g. cost, time, access), have also been identified as person-related barriers.[12,13,15,16]

2 | METHODS

This retrospective observational study involved analysing anonymised linked electronic health records held in the Secure Anonymised Information Linkage Databank (Swansea University) from Diabetic Eye Screening Wales, primary care (Welsh Longitudinal General Practice) and secondary care (Patient Episode Database for Wales).

2.1 | Screening procedure in Wales

Within 3 months of diagnosis of diabetes, people aged 12 years and over and registered with a general practitioner located in Wales are referred to Diabetes Eye Screening Wales (previously known as the Diabetic Retinopathy Screening Service for Wales), a community-based national screening programme commissioned by the Welsh Government in 2003.[17,18] Since 2018 Public Health Wales have become responsible for the screening service. A small number of individuals are excluded from screening on medical grounds, as well as those currently under the care of hospital eye services for a diabetes-related reason, until they are discharged. A first appointment letter is dispatched which allows dates and venues to be altered for the person's convenience. For those who fail to respond to the initial closed invitation, another open invitation is sent automatically within 3 months, requesting them to contact the screening centre to make an appointment. A text messaging or e-mail reminder service is also used where possible. Failure to attend and no contact with Diabetic Eye Screening Wales results in a letter to the relevant general practice. Each cycle of screening appointments occurs on an annual basis.

Novelty statement

- **What is already known?**
  Age, socio-economic status, type of diabetes, ethnicity and diabetes glycaemic control influence attendance at diabetic retinopathy screening.
- **What this study has found?**
  Risk of repeat non-attendance at screening events related to: Non-attendance at the first screening appointment; Younger age <35 years; Social deprivation; Frequent house moves.
- **What are the clinical implications?**
  As non-attendance at the initial diabetic retinopathy screening appointment lessens subsequent attendance, a more tailored education programme aimed at younger people with diabetes, those living in higher deprivation areas and/or subject to changes in residence is needed.

2.2 | Data acquisition, transfer and storage

Our data encompassed the entire screening history and changes in socio-demographic profile from the date people with diabetes were added to the Diabetic Eye Screening Wales register, until study end date, 1 January 2018.

From Diabetic Eye Screening Wales records, we extracted: age, sex, type of diabetes, duration of diabetes and date of registration at baseline and date of screening attendance and retinopathy grade, at each appointment. The Welsh Longitudinal General Practice database for primary care (which covers approximately 75% of the Welsh population), provided information on diagnoses, medications prescribed, laboratory test results[19] as well as house moves and changes of general practice n. For secondary care, the Patient Episode Database for Wales, include inpatient and outpatient hospital records covering the whole of Wales since 1998[20]; type of diabetes was extracted from this database. The type of diabetes was confirmed using all three databases. The data were anonymised by the National Health Service Wales Informatics Service and then transferred to the Secure Anonymised Information Linkage databank for storage and processing as described elsewhere[20] (Figure S1). In the databank, there is a unique person-based linkage of data across several data files.

2.3 | Statistical analysis

We present descriptive data as mean $\pm$ SD or n (%). SPSS v26 was used to conduct the statistical analysis.

We adhered to the 'Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis' guidelines in the design of this study and reporting of the findings.[21] People with known diabetes, aged 12 years and over, registered with Diabetic Eye Screening Wales for 3 or more years were included in the analysis. The primary outcome was repeat non-attendance, defined as no record of attendance at Diabetic Eye Screening Wales following three consecutive annual invitations (closed and open invitations) during a 36-month period.[22]

People with type 1 and type 2 diabetes were analysed separately due to differences identified during our initial analysis, and the potential differences in risk factors for non-attendance for those with type 1 diabetes being skewed by the higher numbers of people with type 2 diabetes in the dataset.

Potential risk factors (covariates) for repeat non-attendance studied were: sex, age, attendance at first screening appointment, retinopathy status at first screening, socio-economic status (Welsh Index Multiple Deprivation, version 2011), smoking status, number of house moves (defined as a change in lower layer output area between screening invitations), number of changes in general practices and HbA_{1c}. We also adjusted on the number of years since 2003 when participants were added to the Diabetic Eye Screening Wales registry, to control for changes in service delivery. Duration of follow-up was added as a covariate to adjust for a potential impact of unequal lengths of follow-up between participants.

2.3.1 | Initial data analysis

Characteristics of repeat non-attenders and attenders were compared using χ^2 tests for categorical variables and t-tests for numeric variables. The percentages of repeat non-attendance between people with type 1 and type 2 diabetes were compared with a χ^2 test.

2.3.2 | Model development

Multivariable logistic regression analysis was performed to study associations between non-attendance and potential causative factors. We used a stratified temporal 80:20 split sample for model development and validation, according to the date of registration with the screening programme. Dates of registration with Diabetic Eye Screening Wales were sorted chronologically; the development dataset included people before the 80th percentile split; the remaining 20% of data becoming the validation dataset. We aimed to see if the model developed on older data was appropriate for more recent data. The data were stratified by repeat non-attendance before splitting to ensure similar percentages of repeat non-attenders in the development and validation datasets.

We used a combination of variable selection processes, including forward and backward stepwise selection, and comparison of goodness of fit statistics (Snell R^2 and Nagelkerke R^2) of candidate models to build the development model (Table S1).

Age was categorised according to a combination of literature review[6,23] and clinical judgement. People with type 1 diabetes older than 34 were combined into one group because there were too few people in the older age group. The youngest age group (10–17 years) was used as the reference for type 1 diabetes whereas for type 2 diabetes, the cut-off points chosen were 54 and 84 years, considered to be when changes in people's daily lives (employment pattern, availability of free time, prioritisation of health and social care needs) become more observable, with the oldest age group (≥85 years) serving as the reference group.

The fifth quintile of the Welsh Index Multiple Deprivation (least deprived areas) was used as the reference group for both type 1 and type 2 diabetes. HbA_{1c} values were categorised into 10 mmol/mol or 1% bands before analysis. Calendar year is when individual participants were added to the Diabetic Eye Screening Wales registry; in the models we used years after the index year, 2003.

The continuous covariates: number of house moves per year, number of general practice changes per year, number of years from the time when screening service started and duration of eye screening follow-up were assessed for non-linearity by comparing models fitting them as linear term, quadratic or cubic terms. The combination of terms with best fit was chosen. If the model fit was similar, then the simplest model was chosen.

2.3.3 | Model performance on validation data

The model created in the development dataset was then applied to the validation dataset to test its performance. In the validation dataset, the predicted probability of repeat non-attendance was calculated using the coefficients from the development model. We examined every possible cut-off value along the whole range of the model's estimated risk of becoming a repeat non-attender using area under the receiver operating characteristic curve. Model discrimination was considered acceptable if area under the receiver operating characteristic curve was >0.7, [24] indicating that the ratio of the time when a repeat non-attender had a higher predicted probability than an attender to be >0.7.

People in the validation dataset were grouped into risk strata, based on the predicted probability of repeat non-attendance. Expected and observed rates of repeat non-attendance in each risk strata were compared to assess model calibration through the use of the Hosmer–Lemeshow test. A $p > 0.05$ indicates that a model is not significantly mis calibrated.

3 | RESULTS

People aged 12 years or more were invited for screening between 1 January 2003 and 1 January 2018. The mean ± SD follow-up time since registration for type 1 diabetes ($n = 6513$) was 6.3 ± 2.0 years and 6.2 ± 2.0 years for type 2 diabetes ($n = 156,525$). Only those on the register for more than 3 years with a confirmed type of diabetes and who survived till the end of the follow-up period were included in the analysis (Figure S2). Failure to attend three consecutive annual screening appointments over a period of 36 months was more frequent in type 1 than type 2 diabetes 18% versus 8.0% ($p < 0.0001$).

Characteristics of repeat non-attenders and attenders with type 1 and type 2 diabetes and the level of missing data are shown in Tables 1 and 2. In type 1 diabetes repeat non-attenders were more likely to be aged 18–34 years, less likely to have attended their first screening invitation, live in more deprived areas and move house more frequently and have a higher HbA_{1c} (81 vs. 73 mmol/mol [9.6 vs. 8.9%]) compared to attendees (Table 1). In type 2 diabetes repeat non-attenders were more likely to be aged 35–54 years, and also less likely to attend the first screening invitation, live in more deprived areas and to have a higher HbA_{1c} levels (65 mmol/mol [8.1%] vs. 58 mmol/mol [7.5%]) (Table 2).

We reviewed potential covariates for inclusion in the final model using the development dataset. For type 1 diabetes, the development model explained a modest amount of variability between repeat non-attenders and attenders (Cox and Snell R^2 were 0.18; Nagelkerke R^2 0.30). The regression equation derived from the development dataset was applied to the validation dataset for model validation, and the corresponding area under the curve was 0.87 (95% CI 0.84–0.90). The Hosmer–Lemeshow statistic was 31.30, $p = 0.0001$.

Similarly, for type 2 diabetes, the development model explained a modest amount of variability between repeat non-attenders and attenders (Cox and Snell R^2 0.13; Nagelkerke R^2 0.29). The regression equation derived from the development dataset was applied to the validation dataset for model validation, and the corresponding area under the curve was 0.91 (95% CI 0.90–0.91). The Hosmer–Lemeshow statistic was 977.29, $p < 0.0001$. Table 3 shows the odds ratios of the potential risk factors for both type 1 and type 2 diabetes with HbA_{1c} in mmol/mol; HbA_{1c} results in % units are shown in Table S3.

Based on the multivariable model, people with type 1 diabetes aged 18–34 years were 37% more likely to miss three consecutive annual screening appointments compared to the reference group, aged 12–17 years (Table 3). The most deprived (Welsh Index of Multiple Deprivation quintiles 1 and 2) were 84% and 50%, respectively, more likely to be repeat non-attenders compared to those living in the least deprived area (Welsh Index of Multiple Deprivation 5). Every additional house move per year would lead to 2.59 times increased risk of repeat non-attendance. A major predictor of repeat non-attendance was failure to attend the first screening appointment whereas those attending were 88% less likely to become repeat non-attenders.

Women with type 2 diabetes were more likely than men to miss all three consecutive annual screening appointments (Table 3). Also, those who were younger were more likely to become repeat non-attenders with those aged 12–17, 18–34 and 35–54 years at 5.2, 2.3 and 1.4-fold increased risk of non-attendance, respectively when compared to those aged >84 years. In contrast, people with type 2 diabetes aged 55–84 years were 22% more likely to attend all three annual appointments. Those living in more deprived areas were significantly more likely to be repeat non-attenders and for every additional house move per year, the risk of becoming a repeat non-attender increased fourfold. The most significant predictor of being a repeat non-attender was failure to attend the first screening appointment: those attending their initial appointment were 92% more likely to attend all three consecutive annual screening appointments.

Unfortunately, the level of missing data was high for smoking status and HbA_{1c}, for both type 1 and type 2 diabetes. Current smokers with type 1 and type 2 diabetes were 1.5 and 1.6 times, respectively, more likely to be repeat non-attenders compared to those who provided no information on smoking (Table 3). When compared with those for whom no HbA_{1c} information were available, those with type 1 diabetes with lower HbA_{1c} (48–78 mmol/mol, 6.5–9.5%) were significantly less likely to be repeat non-attenders, although there was no significant difference for those with higher HbA_{1c} levels. In people with type 2 diabetes when compared with those for whom no HbA_{1c} information was available, those with HbA_{1c} lower than 79 mmol/mol (9.5%) were significantly less likely to be repeat non-attenders and those with HbA_{1c} higher than 98 mmol/mol (10.5%) were 1.6 times more likely to be repeat non-attenders (Table 3; Table S2). Supplementary analysis was carried out excluding these two risk factors with similar results (Table S3).

4 | DISCUSSION

Previous studies have demonstrated that the risk of developing sight-threatening diabetic retinopathy increases with increasing numbers of missed screening appointments.[6,8] In our population, young age (18–34 years), increasing deprivation and social mobility (house/residence) and especially non-attendance at first screening appointment were all predictors for repeated non-attendance for both type 1 and type 2 diabetes. We observed for the first time, the very significant negative impact of missing the first screening appointment

TABLE 1 For people with type 1 diabetes, demographic differences between those who attended (attenders) screening for diabetic retinopathy ($n = 5367$) and those who repeatedly did not (non-attenders) ($n = 1146$) over a 36-month period

	Type 1 diabetes attenders $n = 5367$	Type 1 diabetes non-attenders $n = 1146$	p value
Sex, men	2993 (56%)	671 (59%)	0.09
Age (years)			<0.0001
12–17	1413 (26%)	207 (18%)	
18–34	1868 (35%)	575 (50%)	
>34	2085 (39%)	364 (32%)	
Missing	1	0	
Attendance at first screening invitation	4409 (82%)	382(33%)	<0.0001
Retinopathy status at first screening			0.51
No	2568 (48%)	212 (19%)	
Background	1268 (24%)	103 (9.0%)	
Maculopathy	83 (1.5%)	11 (1.0%)	
Referable diabetic retinopathy	199 (3.7%)	18 (1.6%)	
Missing	1249 (23%)	802 (70%)	
Deprivation			<0.0001
WIMD1 (most)	1173 (22%)	358 (31%)	
WIMD2	1121 (21%)	288 (25%)	
WIMD3	1150 (21%)	222 (19%)	
WIMD4	969 (18%)	150 (13%)	
WIMD5 (least)	933 (17%)	125 (11%)	
Missing	21 (0.4%)	3 (0.3%)	
Smoking status			<0.0001
Non-smoker	2234 (42%)	153 (13%)	
Smoker	1148 (21%)	148 (13%)	
Missing	1985 (37%)	845 (74%)	
Number of house moves/year	0.13 ± 0.18	0.20 ± 0.22	<0.0001
Number of general practice changes/year	0.15 ± 0.16	0.18 ± 0.18	<0.0001
HbA$_{1c}$ within 12 months of screening invitation			<0.0001
mmol/mol	73 ± 20	81 ± 22	
%	8.9 ± 1.8	9.6 ± 2.0	
Missing	2340 (44%)	607 (53%)	
Calendar year when added to diabetic eye screening register			<0.0001
2003	117 (2.2%)	14 (1.2%)	
2004	271 (5.0%)	36 (3.1%)	
2005	508 (9.5%)	78 (6.8%)	
2006	670 (12%)	126 (11%)	
2007	685 (13%)	106 (9.3%)	
2008	1322 (25%)	527 (46%)	
2009	314 (5.9%)	71 (6.2%)	
2010	354 (6.6%)	66 (5.8%)	
2011	259 (4.8%)	46 (4.0%)	
2012	244 (4.5%)	29 (2.5%)	
2013	268 (5.0%)	23 (2.0%)	
2014	202 (3.8%)	13 (1.1%)	
2015	153 (2.9%)	9 (0.8%)	
Duration of diabetic eye screening Wales follow-up (years)	6.30 ± 2.05	6.49 ± 1.82	0.002

Note: Data are presented as n (%) or mean ± SD.

Variables with missing data are shown, along with the number of missing values.

Abbreviations: WIMD, Welsh Index Multiple Deprivation (version 2011).

TABLE 2 For people with type 2 diabetes, demographic differences between those who attended (attenders) screening for diabetic retinopathy ($n = 144,050$) and those repeatedly who did not (non-attenders) ($n = 12,475$) over a 36-month period

	Type 2 diabetes attenders $n = 144,050$	Type 2 diabetes non-attenders $n = 12,475$	p value
Sex, men	81,651 (57%)	6461 (52%)	<0.0001
Age (years)			<0.0001
12–17	46 (0.0%)	19 (0.2%)	
18–34	2311 (1.6%)	747 (6.0%)	
35–54	32,307 (22%)	4868 (39%)	
55–84	105,558 (73%)	6465 (52%)	
>84	3798 (2.6%)	369 (3.0%)	
Missing	30 (0.0%)	7 (0.1%)	
Attendance at first screening invitation	131,370 (91%)	4931 (40%)	<0.0001
Retinopathy status at first screening			0.12
No	93,220 (65%)	3422 (27%)	
Background	28,167 (20%)	1054 (8.4%)	
Maculopathy	702 (0.5%)	31 (0.2%)	
Referable diabetic retinopathy	1691 (1.2%)	80 (0.6%)	
Missing	20,270 (14%)	7888 (63%)	
Deprivation			<0.0001
WIMD1 (most)	31,407 (22%)	3915 (31%)	
WIMD2	30,795 (21%)	3013 (24%)	
WIMD3	30,225 (21%)	2382 (19%)	
WIMD4	27,460 (19%)	1870 (15%)	
WIMD5 (least)	23,903 (17%)	1274 (10%)	
Missing	290 (0.2%)	21 (0.2%)	
Smoking status			<0.0001
Non-smoker	73,078 (51%)	2194 (18%)	
Smoker	34,578 (24%)	1948 (16%)	
Missing	36,394 (25%)	8363 (67%)	
Number of house moves/year	0.05 ± 0.12	0.11 ± 0.16	<0.0001
Number of general practice changes/year	0.12 ± 0.14	0.15 ± 0.16	<0.0001
HbA$_{1c}$ within 12 months of screening invitation			<0.0001
mmol/mol	58 ± 17	65 ± 23	
%	7.5 ± 1.6	8.1 ± 2.2	
Missing	55,795 (39%)	5941 (48%)	
Calendar year when added to diabetic eye screening Wales register			<0.0001
2003	2201 (1.5%)	136 (1.1%)	
2004	6364 (4.4%)	421 (3.4%)	
2005	12,567 (8.7%)	763 (6.1%)	
2006	18,597 (13%)	1149 (9.2%)	
2007	19,540 (14%)	1182 (9.5%)	
2008	21,723 (15%)	4292 (34%)	
2009	10,403 (7.2%)	1014 (8.1%)	
2010	10,381 (7.2%)	889 (7.1%)	
2011	9819 (6.8%)	808 (6.5%)	
2012	9350 (6.5%)	688 (5.5%)	
2013	9309 (6.5%)	568 (4.6%)	
2014	8208 (5.7%)	369 (3.0%)	
2015 and 6[a]	5588 (3.9%)	196 (1.6%)	

(Continues)

TABLE 2 (Continued)

	Type 2 diabetes attenders n = 144,050	Type 2 diabetes non-attenders n = 12,475	p value
Duration of diabetic eye screening Wales follow-up (years)	6.24 ± 2.09	6.01 ± 1.91	<0.0001

Note: Data are presented as n (%) or mean ± SD.

Variables with missing data are shown, along with the number of missing values.

WIMD, Welsh Index Multiple Deprivation (version 2011).

[a]Cell count in 2016 < 5, reported together with 2015.

TABLE 3 Odds ratios (95% confidence intervals) from multivariable logistic regression models for the risk of repeated non-attendance at retinopathy screening, in type 1 and type 2 diabetes, using the 80% development dataset

		Type 1 diabetes n = 5197	Type 2 diabetes n = 124,961
Sex		Removed from model	
Men			Reference
Women			1.25 (1.19, 1.31)
Age (years)			
Type 1	Type 2		
12–17	12–17	Reference	5.16 (2.34,11.34)
18–34	18–34	1.37 (1.07, 1.74)	2.35 (1.97,2.81)
>34	35–54	0.91 (0.71, 1.17)	1.41 (1.23, 1.61)
	55–84		0.78 (0.68, 0.89)
	>84		Reference
Attendance at first screening invitation		0.12 (0.09, 0.17)	0.08 (0.07, 0.09)
Deprivation			
WIMD 1 (most)		1.84 (1.40, 2.42)	1.76 (1.63, 1.91)
WIMD 2		1.50 (1.13, 1.98)	1.52 (1.40, 1.65)
WIMD 3		1.23 (0.92, 1.64)	1.29 (1.18, 1.40)
WIMD 4		1.00 (0.73, 1.37)	1.19 (1.09, 1.30)
WIMD 5 (least)		Reference	Reference
Smoking status			
Missing		Reference	Reference
Non smoker		0.90 (0.63, 1.27)	0.97 (0.88, 1.06)
Smoker		1.53 (1.07, 2.20)	1.56 (1.42, 1.72)
Number of house moves/year		2.59 (1.70, 3.96)	4.15 (3.53, 4.88)
HbA$_{1c}$ (mmol/mol) within 12 months of screening invitation			
Missing		Reference	Reference
≤48		0.92 (0.56, 1.53)	0.87 (0.81, 0.94)
49−58		0.67 (0.45, 0.99)	0.64 (0.59, 0.69)
59–68		0.54 (0.40, 0.74)	0.63 (0.58, 0.69)
69–78		0.63 (0.48, 0.84)	0.80 (0.73, 0.89)
79–88		1.04 (0.77, 1.40)	0.99 (0.88, 1.11)
89–98		1.27 (0.89, 1.79)	1.02 (0.89, 1.16)
99–108		1.26 (0.82, 1.94)	1.50 (1.28, 1.75)
≥109		1.12 (0.74, 1.71)	1.64 (1.40, 1.91)
Number of years since 2003 when added to screening registry		3.53 (2.59, 4.82)	2.56 (2.40, 2.74)
[Number of years since 2003 when added to screening registry]^2		0.88 (0.85, 0.91)	0.92 (0.91, 0.92)
Duration of diabetic eye screening Wales follow-up (years)		2.34 (1.74, 3.14)	1.94 (1.78, 2.11)
[Duration of diabetic eye screening Wales follow-up (years)]^2		0.94 (0.92, 0.96)	0.92 (0.91, 0.92)

Abbreviation: WIMD, Welsh Index Multiple Deprivation (version 2011).

and frequent changes in residence. Additionally, women with type 2 diabetes were more likely to be repeat non-attenders.

The strength of this study is that it is derived from a national community-based diabetic retinopathy screening programme with a high coverage (~80%) of people with diabetes who are eligible for screening. The study benefits from its longitudinal nature and the ability to link Diabetic Eye Screening Wales and other electronic health record data from primary and secondary care. We adopted a logistic model to understand the relationship between repeat non-attendance and potential risk factors; we checked the performance of our models with temporal validation and found that though they showed some miscalibration, model discrimination was excellent. This study was retrospective, the current analytical models developed may not apply to future data and therefore will require further recalibration to improve the model fit. Whereas logistic models provide a good understanding of the underlying relationships between repeat non-attendance and potential risk factors it may be possible in the future to externally validate the model with a different population. The use of routine data also has its limitations due to missing information which here was especially true for smoking status and HbA_{1c}. We tried to limit the bias of missing data[23] which can cause an overestimation of the precision of the prediction, although the magnitude of the coefficients in our models showed this to be unlikely. In addition, further analysis without HbA_{1c} or smoking status, found a similar pattern of risk factors, again making the possibility of overestimation unlikely. Another limitation of the study was that only approximately 75% of the Welsh population (Welsh Longitudinal General Practice) was available for inclusion in the analysis.

Younger age and living in higher deprivation areas have previously been identified as risk factors for non-attendance at eye screening in people with diabetes.[6,8,14,25] A diabetic retinopathy screening programme in England is currently evaluating an education programme delivered in paediatric diabetes clinics to address this problem.[26] Other methods such as inviting children and young people with diabetes to visit a screening clinic prior to receiving their first appointment could also be employed. However, further enhancement in the education of parents/carers of children and young people with diabetes to better understand the importance and need for screening is required.[27] Leaflets to promote screening in young adults with type 2 diabetes developed by Lake et al[28] could easily be made available to general practice, paediatric and adult secondary care clinics.

The finding of increasing deprivation having a negative impact on attendance is not a new observation for diabetic retinopathy screening programmes.[7,9] However, it is acknowledged that tackling health inequalities is complex and extends beyond health care.[29]

In summary, we confirm the sub-optimal screening uptake in the younger population with diabetes. However, our findings that non-attendance at the first screening event and a higher level of house moves may offer in part an explanation for the pattern of repeat non-attendance. The importance of attending the first screening appointment should not be underestimated. Also changing residence is particularly relevant to the younger and more mobile population with diabetes who are leaving home to pursue further education or employment in new areas.

It is therefore vital that health care professionals and policy-makers continue the quest to better understand the barriers to screening and adjust future management procedures to ensure attendance at future screening invitations in an attempt to prevent the development of sight-threatening diabetic retinopathy and blindness in our vulnerable population with diabetes.

CONFLICT OF INTEREST
There is no conflict of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.