Research Article

Characteristics of Smoking Quitters in Type 1 and Type 2 Diabetes: A Five-Year Cohort Study

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Abstract

Aims: Smoking is one of the biggest causes of preventable death in diabetes and non-diabetes populations. The aim of this study was to investigate the characteristics of patients with type 1 and type 2 diabetes in Ayrshire and Arran, UK, who quit smoking in the five-year period 2009 to 2014.

Methods: Data were collected from 46 General Practice databases in 2009 and 2014. Statistical analysis was performed using SPSS V21.

Results: In 2009 there were 12,121 patients with diabetes (type 1 n=1,442; type 2 n=10,679). Smoking was more prevalent among type 1 diabetes (23.3% *vs*.19.8%; p< 0.002) but was associated with deprivation in both type 1 and type 2 diabetes (p<0.01). There was no significant difference in mean HbA_{1c} between those who smoked and those who quit. In type 2 diabetes those who quit had significantly higher mean HbA_{1c} (2.13 mmoml/mol; p<0.01). Smoking was associated negatively with duration of type 2 diabetes (p<0.001). In type 2 diabetes, ischaemic heart disease was associated with an increased level of quitting while hypertension, retinopathy, neuropathy or foot ulcers were not. Survival was best for non- or ex-smokers (median survival 10,053 days) and worst for those who continued to smoke (median survival 7948 days; p=0.01).

Conclusion: Why patients with IHD but not other complications of diabetes quit is not clear. More work needs to be undertaken to encourage all patients to quit smoking.

What is new?

•   Smoking is more prevalent in type 1 diabetes than type 2 diabetes

•   Smoking in both type 1 and 2 diabetes is associated with deprivation

•   In type 2 diabetes increased likelihood of quitting smoking was associated with ischaemic heart disease but not retinopathy, neuropathy or foot ulcers

•   Quitting smoking in type 2 diabetes led to a small (0.1%; 2.13 mmol/mol) increase in mean HbA_{1c}

Keywords: Smoking; Glycaemic control; Weight; Complications; Ischaemic heart disease

Introduction

Smoking is one of the biggest causes of preventable death in type 1 and type 2 diabetes plus the non-diabetes populations [1,2]. Cigarette smoking increases the risk of diabetic complications, such as coronary heart disease, stroke, peripheral vascular disease and diabetic nephropathy [3-8]. Furthermore, smokers with diabetes have an 80% higher risk of mortality [9], more depressive symptoms and are less actively involved in their diabetes care than non-smokers [10]. Epidemiological evidence also suggests that cigarette smoking is associated with the development of type 2 diabetes, with a 30-40% higher risk of type 2 diabetes in smokers than non-smokers [11]. The adverse effects of cigarette smoking on the action of insulin and function of pancreatic β-cells play fundamental roles in the pathogenesis of type 2 diabetes [4]. The risk of developing type 2 diabetes increases with cigarette consumption and is reduced by smoking cessation [5]. It is estimated that smoking accounts for more than half of the difference in male mortality between the lowest and highest social strata [12]. As a result, encouraging smoking cessation is one of the main goals in the management of diabetes [13,14].

Given the increasing prevalence of diabetes mellitus [15] and the relatively high prevalence of smoking [16], the observed associations between smoking and disease outcomes among patients with diabetes has significant clinical public health importance [3,6-9]. The aim of this study was to investigate in type 1 and type 2 diabetes the prevalence of smoking plus the association of the socioeconomic status and glycaemic control in individuals who quit smoking in the five-year period 2009 to 2014 in Ayrshire and Arran, UK. In type 2 diabetes we also investigated the association with gender, age, duration of diabetes, diabetes complications and lipid levels plus mortality and survival in individuals who quit smoking compared

Table 1: Smokers, non-smokers and quitters in relation to social deprivation.

	Deprivation Quintile 2009						p*
	1	2	3	4	5	total	
Type 1 Smokers 2009	16.20% (40/247)	16.40% (45/275)	22.40% (64/286)	19.80% (56/283)	38.40% (127/331)	23.30% (332/1422)	<0.01
Type 2 Smokers 2009	11.70% (190/1621)	16.50% (335/2031)	18.30% (371/2022)	23.00% (558/2427)	25.80% (639/2475)	19.80% (2093/10576)	<0.01
Type 1 Smokers 2014	11.70% (29/247)	12.00% (33/275)	16.80% (48/286)	15.20% (43/283)	28.70% (95/331)	17.70% (248/1422)	<0.01
Type 2 Smokers 2014	8.80% (142/1621)	12.6% (255/2031)	14.40% (291/2022)	18.00% (436/2427)	20.40% (504/2475)	15.40% (1628/10576)	<0.01
Type 1 Quitters 2009 to 2014 (as % of smokers)	27.50% (11/40)	26.70% (12/45)	25.00% (16/64)	23.20% (13/56)	25.20% (32/127)	25.30% (84/332)	0.735
Type 2 Quitters 2009 to 2014 (as % of smokers)	25.30% (48/190)	23.90% (80/335)	21.60% (80/371)	21.90% (122/558)	21.10% (135/639)	22.20% 465/2093	0.186

˙linear chi square test.

with those who continued to smoke in this five-year period.

Methods

Forty-six out of fifty-five General Practices in NHS Ayrshire & Arran, covering 85% of the total patient population (above 18 yrs) of Ayrshire & Arran contributed data from their practice computer systems. Data were provided both in 2009 and in 2014. There was no significant difference in the prevalence of diabetes between practices that did and did not provide data (5.5% *vs.* 5.7% χ^2=3.3; p=0.07). Survival was measured in days from a 'start date' of 1/10/2009 to an 'end date' of 30/09/2014. The number of days between the start and end date (survival time) was calculated for each subject. Duration of DM was calculated as the time between diagnosis and the start date. Data on age, gender, deprivation, smoking status, ischaemic heart disease and hypertension, were collected for all subjects. Ischaemic heart disease was defined as per the Quality Outcome Framework document [17]. Hypertension was defined as BP > 140/90 or on anti-hypertensive medication. Data on glycaemic control and lipid levels were only routinely collected for those patients with diabetes. Abnormal lipids were defined as total cholesterol > 5mmo/l (or on statin therapy), low HDL-cholesterol [men < 1mmol/l; women < 1.3mmol/l (or on statin therapy)] or non-fasting triglycerides > 1.7mmol/l (or on statin therapy).

Socioeconomic groups based on the Scottish Index of Multiple Deprivation (SIMD) 2012 were derived using patient postcodes. SIMD quintiles ranged from 1 (least deprived) to 5 (most deprived) [18]. As Ayrshire and Arran is more deprived than the rest of Scotland, deprivation weighted quintiles were used [19]. The audit was registered with the Clinical Governance Department, NHS Ayrshire and Arran, UK and Caldicott Guardian approval was obtained from each General Practice.

Statistics

Inferential analysis of categorical variables was by chi-square test or chi square linear test for gender, deprivation, BMI and complications. For interval level variables age, glycaemic control and lipid levels analysis was by ANOVA with Bonferroni post hoc tests or else t-tests. Survival analysis of survival in days between diagnosis and either death or end date was by Kaplan-Meier with Mantel-Cox log rank comparison test. Statistical analysis was performed using SPSS V21.

Table 2: Change in HbA_{1c} (mmol/mol and %) in smokers and quitters at the beginning and the end of the five-year follow-up.

Type 1 HbA_{1c}	Smoker (n= 240)	Quitter (n=82)	p*
2009 (Mean ± SD) mmol/mol; %	78.4±20.9 9.3±0.9	74.7±22.3 9.0±2.0	0.17 NS
2014 (Mean ± SD) mmol/mol; %	73.6±17.9 8.9±1.6	73.6±17.1 8.9±1.6	0.98 NS
Change (Mean ± SD) mmol/mol; %	-4.8±18.5 -0.4±1.7	-1.0±22.9 -0.1±2.1	0.14 NS
Type 2 HbA_{1c}	Smoker (n= 1613)	Quitter (n=457)	
2009 (Mean ± SD)	57.5±18.0 7.4±1.6	58.7±19.5 7.5±1.8	0.22 NS
2014 (Mean ± SD)	57.2±18.6 7.4±1.6	60.8±19.1 7.7±1.8	<0.001
Change (Mean ± SD)	-0.3±17.8 -0.0±1.6	2.1±21.04 0.2±1.9	0.024

˙Independent t-test

Results

Quitting smoking

In 2009 in the Ayrshire Diabetes follow-up Cohort study (ADOC) cohort there were 12,121 patients with diabetes of which 1,442 had type 1 diabetes and 10,679 had type 2 diabetes. 20.2% (2444) were smokers with a significantly higher prevalence among type 1 diabetes (23.3% vs.19.8%; p< 0.002). By 2014, prevalence was still significantly higher among patients with type 1 diabetes (17.4% vs. 15.4%) but the difference had reduced from 3.5% to 2% (p=0.196). Overall 25.4% (85/335) of patients with type 1 diabetes had quit compared with 22.6% (468/2109) of patients with type 2 diabetes.

Socioeconomic status

In 2009 there was a clear relationship between deprivation and smoking for both type 1 and type 2 diabetes (Table 1). Prevalence for smoking in type 1 diabetes was 38.4% in the most deprived quintile falling to 16.2% in the least deprived quintile while for type 2 diabetes the prevalence fell from 25.8% to 11.7% (p< 0.001 for both). Despite the overall fall in smoking, this relationship was maintained in 2014. Prevalence for smoking in type 1 diabetes was 28.7% in the most deprived quintile falling to 11.7% in the least deprived while for type 2 diabetes it fell from 20.4% to 8.8% (p< 0.001 for both). In addition, despite the higher prevalence in more deprived areas, between 2009 and 2014 there was no significant difference in the proportion of quitters by deprivation quintile for either type 1 or type 2 (p > 0.05 for both). There was also no significant difference in quitters between type 1 and type 2 for any deprivation quintile.

Table 3: Smoking prevalence and duration of type 2 diabetes.

	Duration of diabetes at start date				Total (n=10663)
	< 5 yrs (n= 5275)	5-10yrs (n=3481)	>10 yrs (n=1907)	p*	
Smokers in 2009	21.6% (1141)	18.8% (656)	16.4% (312)	<0.01	19.8% (2109)
Smokers in 2014	17.2% (905)	14.4% (501)	12.3% (235)	<0.01	15.4% (1641)
Quitters between 2009 and 2014†	20.7% (236)	23.6% (155)	24.7% (77)	0.07	22.2% (468)

†Percentage baseline for quitters is smokers in 2009
*p value based on chi-square test of linear association

Table 4: Change in BMI plus development of hypertension, IHD, retinopathy, neuropathy and foot ulcers.

	Smoker (n= 1641)	Quitter (n=468)	Total (n=2109)	p*
BMI improved	11.5% (182)	8.6% (39)	10.8% (221)	<0.05
BMI became at risk	3.9% (62)	6.4% (29)	4.5% (91)	
New hypertension	7.5% (123)	8.8% (41)	7.8% (164)	0.37 NS
New IHD	3.7% (61)	9.8% (46)	5.1% (107)	<0.01
New retinopathy	38.4% (630)	38.7% (181)	38.5% (811)	0.91 NS
New Neuropathy	2.3% (37)	1.5% (7)	2.1% (44)	0.31 NS
New Foot Ulcer	2.2% (36)	2.4% (11)	2.2% (47)	0.84 NS

*p value based on chi-square test

Glycaemic control

Mean HbA_{1c} was significantly higher for type 1 diabetes than type 2 diabetes both for smokers and those who quit in both 2009 and 2014 (Table 2). However, the fall in mean HbA_{1c} among quitters while larger for type 1 was not statistically significant.

For type 1 diabetes there was no significant difference in mean HbA_{1c} in 2009 between those who smoked and those who would quit. There was a fall in mean HbA_{1c} between 2009 and 2014 for both smokers and quitters and while the fall was greater for smokers the difference was not significant.

For type 2 diabetes there was no significant difference in 2009 in mean HbA_{1c} between those who smoked and those who would quit. In 2014, however, those who quit had significantly higher mean HbA_{1c}. Those who quit had a mean increase in HbA_{1c} of 2.13 mmoml/mol, while those who did not quit had a marginal fall.

Gender, age and duration for type 2 diabetes

55% were male and 45% female with no difference by group (non-smokers, smokers or quitters, p=0.91). Overall mean (±SD) age in 2009 was 65.1yrs (±12.2). Non-smokers were older (66.1yrs±12.2) than the other groups (p<0.01) but there was no significant difference between smokers (61.2yrs±11.6) and quitters (62.1yrs±10.9) (p=0.44)

In 2009 there was a clear relationship between duration of type 2 diabetes and smoking, with prevalence at 21.6% in those with the shortest duration falling to 16.4% in the longest (p<0.001) (Table 3). Despite a general fall in smoking prevalence during the study period, the difference in relation to duration was maintained in 2014 (p<0.001). Between 2009 and 2014 there was a slightly greater proportion of quitters in those with longest duration of type 2 diabetes, 24.7% compared to 20.7% in those most recently diagnosed with type 2 diabetes although the difference only approached statistical significance (p<0.07).

Table 5: Type 2 diabetes patients on statin therapy plus total-cholesterol, triglyceride and HDL-cholesterol levels in smokers and quitters at the beginning and the end of the five-year follow-up.

Lipid levels	Smoker (n= 1641)	Quitter (n=468)	Total (n=2109)	p*
On statin therapy in 2009	87.6% (1437)	85.5% (400)	87.1% (1837)	0.23 NS
On statin therapy in 2014	78.2% (1284)	82.3% (385)	79.1% (1669)	0.06 NS
Decrease in total-cholesterol 2009 to 2014 (mean ± SD)	0.17±1.07	0.36±1.13	0.21±1.09	<0.01
Decrease in triglyceride 2009 to 2014 (mean ± SD)	0.37±1.62	0.37±1.99	0.37±1.71	0.96 NS
Increase in HDL-cholesterol 2009 to 2014 (mean ± SD)	0.09±0.31	0.04±0.35	0.78±0.32	<0.01

*p value based on chi-square test for statin therapy and t- test for lipid levels

Body Mass Index (BMI), hypertension, ischaemic heart disease, retinopathy, neuropathy and foot ulcer

Overall around 85% of patients with type 2 diabetes did not change BMI risk categories (BMI > 30kg/m²). We know that the mean BMI of patients with type 2 diabetes in Ayrshire and Arran, UK is around 32kg/m² [19]. There was, however, a significant difference between quitters and smokers in those who changed BMI category between 2009 and 2014; more smokers improved BMI while more quitters increased their BMI to greater than 30 kg/m² (p < 0.05). Although there was no significant difference between smokers and quitters in terms of hypertension, retinopathy, and neuropathy or foot ulcer, there were significantly more quitters in patients with Ischaemic Heart Disease (IHD) (p<0.01) (Table 4).

Lipid levels

87% of the smokers in 2009 were on statin therapy (Table 5). By 2014 this had fallen to 79%. The reduction was slightly larger among those who remained smokers, but the difference did not quite attain statistical significance. There were decreases in total-cholesterol and triglyceride levels between 2009 and 2014 for both groups but the decrease in total-cholesterol was significantly larger for those who quit. There were increases in HDL-cholesterol for both groups, but the increase was significantly larger for those who remained smokers.

Mortality and survival

16.5% of the patients with type 2 diabetes died between 2009 and 2014 (1762/10664). Mortality was slightly higher among smokers (18%, 296/1641) compared to those who quit (16%, 75/468) but the difference was not significant (p=0.31, chi-square test). Survival from diagnosis was best for non or ex-smokers at the start of the study (median survival 10,053 days) followed by those who quit smoking between 2009 & 2014 (median 9199 days) and worst for those who continued to smoke (median survival 7948 days) The differences were significant (p=0.01).

Discussion

In this observational study we found that the prevalence of smoking was higher in type 1 diabetes than in type 2 diabetes. This probably reflects the age difference between the two diabetes groups and reflects the prevalence by age seen in the general population [20]. Smoking prevalence was associated with deprivation in both type 1 and type 2 diabetes again reflecting the general population [21]. Previously we have shown that the prevalence of type 1 diabetes is not associated with socioeconomic status, but the prevalence of type 2 diabetes is clearly associated with deprivation [22].

In this observational study in type 2 diabetes, we found that just over 20% of smokers with type 2 diabetes quit smoking between 2009 and 2014, which is similar to other studies [16]. Smokers were slightly younger but there was no significant difference in age between smokers and quitters. Our study confirmed the clear relationship between smoking and social deprivation [23]. Despite starting from a lower baseline, a greater percentage of smokers with type 2 diabetes in the least deprived quintile quit smoking during the study period although this did not achieve statistical significance. Previous literature suggests potential explanations for the link between smoking cessation behaviours and poverty. Individuals of a lower income and education are less knowledgeable of the hazards of smoking, the benefits of smoking cessation aids and smoking cessation programs [16,23-26]. Interestingly, in the USA it has been reported that tobacco use declined between 1999 and 2010 in people without diabetes but not with diabetes [27]. Cost is a potential barrier to accessing smoking cessation medications and lower-income groups utilize smoking cessation aids less frequently than higher-income groups. For the economically disadvantaged, there is more financial stress and less respite from life's demands. The preoccupation with meeting the needs of daily living may discourage taking on the additional demands of quitting smoking [24,25]. Furthermore, when smokers from poorer socioeconomic groups do try to quit, they are less likely to be successful than other smokers [24-26].

We demonstrated that there was a clear relationship between the prevalence of smoking and duration of type 2 diabetes, which probably reflects increased mortality risk with duration. Quitting may also reflect patient concern about mortality risk with increasing duration of diabetes. There was no difference in the mean ages between the groups therefore age was not a factor [21].

The change in glycaemic control with quitting smoking is of interest because patients often believe that smoking cessation will lead to a large and significant deterioration in glycaemic control. In type 1 diabetes there was no significant change while in type 2 diabetes there was a small (0.1%; 2.13 mmo/mol) increase in HbA_{1c}. More smokers improved their BMI while more quitters increased their BMI to greater than $30 kg/m^2$. Previous studies have suggested that the overall mortality risk benefit of stopping smoking outweighed the mortality risks of weight gain and poorer glycaemic control [29]. Presumably some of the benefit of quitting smoking in type 2 diabetes is secondary to the reduction of the adverse effects of smoking on the action of insulin and function of pancreatic β-cells [4]. There needs to be greater understanding that the potential weight gain and minimal deterioration in glycaemic control, particularly in type 2 diabetes, is associated with less morbidity and mortality than continued smoking

[25,29]. Unfortunately, we did not have information on individual weight changes.

In our study there was evidence to suggest that smokers with type 2 diabetes in the five-year follow-up period had a higher mortality risk, and that quitting smoking reduced mortality. Recently published data from the Framingham Heart Study indicated that among heavy smokers in a non-diabetic population, smoking cessation was associated with a significantly lower risk of cardiovascular disease within five years relative to current smokers [28].

Our study demonstrated that the presence of IHD was associated with an increased level of stopping smoking. There was no association between quitting smoking and hypertension, retinopathy, neuropathy or foot ulcers. The level of quitting with IHD may reflect peoples' greater awareness of the association of IHD with smoking, particularly in patients with diabetes. It may also reflect targeted smoking cessation in this group such as cardiac rehabilitation classes.

The changes in the patients taking statin therapy and the changes in lipid levels are more difficult to explain. The increased number of smokers stopping their statin therapy may reflect their reduced concern about their general well-being and health including their diabetes [11]. The decrease in the total-cholesterol in the quitters may reflect the greater number staying on statin therapy plus possible changes in diet. The small but significant increase in HDL-cholesterol is much more difficult to explain.

There are several possible limitations in our observational study. The motivations behind patients quitting smoking were unknown, as were the length of time which people had quit smoking for within the 5-year period examined, the smoking relapse rate and how patient gender affected quitting smoking. In addition, data was self-reported by patients and does not specify the amount of tobacco smoked. However, we can be certain that the data that we collected from the General Practice databases were accurate, as it was based on Quality Outcome Framework data [17].

Smoking cessation is a process initiated by the intention to quit. Intention to quit is affected by individual (perceived susceptibility and benefits, severity of harms), social (social group norms, cultural acceptability), and environmental factors (barriers and accessibility to support) [23,29-30]. Using data from retrospective reports of ex-smokers, health reasons, including both smoking related symptoms (present health) and the desire to avoid future illness (future health), were by far the most frequently mentioned motives reported by the successful quitters, followed by social reasons and, less frequently, economic cost [28,29-30]. Tobacco dependency often requires multiple quit attempts and patients may relapse after several years of cessation [23,29-30].

There is a great deal of work that needs to be undertaken to reduce the prevalence of smoking in Scotland and the UK to the lower levels seen in other parts of western Europe. There needs to be a greater knowledge and understanding in the non-diabetes and diabetes populations of the deleterious effects of smoking on health. In addition, there needs to be a greater understanding that the possible weight gain in both groups and the deterioration in glycaemic control observed in type 2 diabetes is associated with less morbidity and mortality risk than continued smoking [28]. People with diabetes

are faced with the challenge of making extensive changes to their lifestyle, a burden that may be increased by attempts to stop smoking. Tailoring smoking cessation programmes to the needs of people with diabetes may lead to improved outcomes, compared with the usual care, but possibly increases the burden of self-management.

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