Smoking cessation in adults with diabetes: a systematic review and meta-analysis of data from randomised controlled trials

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ABSTRACT

Objectives: To evaluate the effects of more intensive smoking cessation interventions compared to less intensive interventions on smoking cessation in people with type 1 or type 2 diabetes.

Design: A systematic review and meta-analysis of randomised trials of smoking cessation interventions was conducted. Electronic searches were carried out on the following databases: MEDLINE, EMBASE, CINAHL and PsycINFO to September 2013. Searches were supplemented by review of trial registries and references from identified trials. Citations and full-text articles were screened by two reviewers. A random-effect Mantel-Haenszel model was used to pool data.

Setting: Primary, secondary and tertiary care.

Participants: Adults with type 1 or type 2 diabetes.

Interventions: Smoking cessation interventions or medication (more intensive interventions) compared to usual care, counselling or optional medication (less intensive interventions).

Outcome measures: Biochemically verified smoking cessation was the primary outcome. Secondary outcomes were adverse events and effects on glycaemic control. We also carried out a pooled analysis of self-reported smoking cessation outcomes.

Results: We screened 1783 citations and reviewed seven articles reporting eight trials in 872 participants. All trials were of 6 months duration. Three trials included pharmacotherapy for smoking cessation. The risk ratio of biochemically verified smoking cessation was 1.32 (95% CI 0.23 to 7.43) for the more intensive interventions compared to less intensive interventions with significant heterogeneity (I²=76%). Only one trial reported measures of glycaemic control.

Conclusions: There is an absence of evidence of efficacy for more intensive smoking cessation interventions in people with diabetes. The more intensive strategies tested in trials to date include interventions used in the general population, adding diabetes-specific education about increased risk. Future research should focus on multicomponent smoking cessation interventions carried out over a period of at least 1 year, and also assess impact on glycaemic control.

Strengths and limitations of this study

- It is the first systematic review of randomised trials of smoking cessation interventions in diabetes.
- The statistical power of our attempts to pool data is limited by the small number of trials published to date and a relatively small number of participants in the published trials.
- Interventions offered and groups studied are heterogeneous.
- Available evidence to inform treatment strategies for smoking cessation in type 2 diabetes is limited.

INTRODUCTION

For adults with diabetes, as in the wider population, smoking is associated with an increased risk of cardiovascular events and death. A recent systematic review and meta-analysis of prospective studies on diabetes reported that smoking increased the risk of death by 48%, coronary heart disease by 54%, stroke by 44% and myocardial infarction by 52%.1 The risk for coronary heart disease, stroke and proteinuria is directly related to the number of cigarettes smoked per day.2 3 Patients with diabetes who smoke have higher glycated haemoglobin (HbA1c) levels4 and are more likely to experience severe hypoglycaemia.5

People with diabetes who stop smoking are likely to have a lower risk of death and cardiovascular events compared with those who continue to smoke.1 Smoking cessation is also associated with a reduction in levels of albuminuria, improvement of glycaemic control and lipid profile.6 Smoking cessation has been recommended as a routine component of the treatment of diabetes by the American Diabetes Association,7 although evidence to guide best practice is limited.8
People with diabetes are faced with the challenge of extensive changes in their lifestyle, a burden that may be increased by attempts to stop smoking.9 10 Tailoring smoking cessation programmes to the needs of people with diabetes may lead to improved outcomes compared with usual care, but may also further increase the burden of self-management. Concerns have also been expressed regarding weight gain associated with smoking cessation.11

We, therefore, carried out a systematic review of randomised controlled trials reporting the effects of smoking cessation interventions in diabetes to inform clinical practice and identify potential for further research to improve patient outcomes.

METHODS

Eligibility criteria
We carried out this systematic review in accordance with the study protocol (see online supplementary appendix 1).12 Peer-reviewed journal articles and conference abstracts that reported the results of a randomised controlled trial and met the following eligibility criteria were eligible for inclusion: trials recruiting non-pregnant adults with type 1 or type 2 diabetes who smoked at baseline, evaluating pharmacological or non-pharmacological interventions intended to support smoking cessation (more intensive interventions) compared to usual care, counselling or optional medication (less intensive interventions). We included trials reporting at least one of the following outcomes: (1) smoking cessation, (2) glycaemic control, (3) weight. There were no restrictions on length of follow-up or language of publication. We included trials that did not report biochemically verified smoking cessation to fully capture the available evidence, characterise smoking status as reported in these trials and to add to the available data from which we could analyse effects of interventions on glycaemic control and weight where such additional data were available.

Search strategy
We based our search strategy on that used by the Cochrane Tobacco Addiction Group13 for identifying randomised controlled trials of smoking cessation together with the Cochrane Metabolic and Endocrine Disorders Group14’s search strategy for interventions in type 1 or type 2 diabetes using the high sensitivity options (see online supplementary appendix 2).

We searched the following online databases: Cochrane Central Register of Controlled Trials [The Cochrane Library, Wiley] (Issue 9, 2013), MEDLINE [OvidSP] (1946—present), EMBASE [OvidSP] (1974—present), CINAHL [EbscoHOST] (1980—present), PsycINFO [OvidSP] (1967—present) and Science Citation Index, Social Sciences Citation Index, Conference Proceedings Citation Index—Science & Conference Proceedings Citation Index—Social Science & Humanities [Web of Knowledge] (1945—present). The most recent search date was 3 September 2013. We also searched clinicaltrials.gov, isrctn.org, anzctr.org.au and International Clinical Trials Registry Platform for ongoing trials. References from bibliographies of included trial reports and results of a search on Web of Science Citation Index for those reports were also reviewed. We contacted authors of potentially eligible conference abstracts.

Study selection and data extraction
Two reviewers (AN and RB) independently screened the titles and abstracts of identified citations to select those requiring full-text assessment. Where there was disagreement, a third reviewer (AF) assessed the records to reach a consensus. Full-text articles were further assessed and data were entered into a prespecified table including 12 entry fields (see online supplementary appendix 3). The data extraction table included information on: (1) trial methodology, setting and duration of follow-up; (2) population characteristics; (3) type of intervention and (4) analyses and outcomes.

Data reported for intention-to-treat analyses were selected at the longest follow-up point. We assumed a diagnosis of type 1 diabetes in insulin-treated participants if the type of diabetes was not otherwise specified.

Data analysis
We used the Cochrane Collaboration’s tool to assess risk of bias at the outcome level.15 Bias was assessed in duplicate with disagreements resolved by a third reviewer. The assessed domains were random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment and completeness of outcome data. Trials deemed to have a high risk of detection bias due to assessing only self-reported smoking cessation were not included in the primary analysis of objectively measured cessation data.

The risk ratio (RR) for biochemically verified smoking cessation with 95% CI was the primary outcome measure in this analysis. We made an a priori decision to use the random effect model to take into account the variability of studied populations and intervention types. The meta-analysis was carried out in Review Manager V.5.2.3 (The Nordic Cochrane Centre, Copenhagen, Denmark) using Mantel-Haenszel method, Cochran’s $\chi^2$ test and the I² statistic to assess heterogeneity. The main meta-analysis included all measures of biochemically verified smoking cessation outcomes. We also pooled data on self-reported smoking cessation: (1) in all eligible trials and (2) in trials with biochemically verified smoking cessation. We calculated pooled means and SDs and obtained SDs from SEs of the mean using formulas recommended by the Cochrane Collaboration.

RESULTS
A total of 2914 citations were identified (figure 1) from electronic searches. A further 15 relevant publications
were identified as citing or cited by included trial reports. After removing duplicates we screened 1783 citations. Based on the title and abstract, 1669 were assessed as ineligible. The full text of the remaining 114 articles was assessed for eligibility. Most were excluded as not reporting a randomised controlled trial (n=43), or included patients who did not have diabetes (n=29) or did not smoke (n=26). One potentially eligible conference abstract could not be retrieved. We contacted the first author, but received no reply. We selected seven articles reporting eight trials for inclusion.

Duration and settings
All eight trials were reported in English and had a 6-month maximum duration of follow-up. Two were reported in a single article. Three trials were carried out in Europe, two in Asia, and one in North America.

Population
In total, 872 smokers with type 1 or type 2 diabetes participated in the reviewed trials (table 1). Three trials reported in two publications did not include information on the type of diabetes. Two trials included only men.

Intervention
Five trials assessed either non-pharmacological interventions to support smoking cessation or referral to a smoking cessation clinic. Interventions reported in three other trials included optional nicotine replacement therapy (NRT) without bupropion or with bupropion.

The intervention was delivered by nursing staff or allied health professionals in three trials and by both doctors and nursing staff or allied health professionals in two trials. In one trial, the intervention included advice from a doctor and referral to cessation clinic. In two other trials, intervention delivery was not specified. The interventions were not specifically tailored for people with diabetes apart from the inclusion of educational components focusing on the effects of smoking on the complications of diabetes and glycaemic control.

We did not identify any trials that specifically assessed pharmacological interventions, although among the three identified ongoing trials not included in this

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**Figure 1** Flow diagram of literature search, screening and selection for analysis.
Table 1 Characteristics of trials included in the analysis

| Source          | Setting                                      | Duration, months | Sample size | Mean (SD)age, years | Men, n (%) | T1D, n (%) | T2D, n (%) | More intensive intervention                                                                 | Less intensive intervention                                                                 | Percentage followed up | Primary or efficacy outcome*               |
|-----------------|----------------------------------------------|------------------|-------------|---------------------|------------|------------|------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------|------------------------------------------|
| Ardron et al    | Diabetes clinic, UK                          | 6                | 60          | 29 (7)              | 29 (48)    | 50 (83)    | 10 (17)    | Doctor’s advice and information pack followed by a home visit by health visitor               | Routine doctor’s advice                                                                   | 100                    | Breath CO and urinary cotinine           |
| Canga et al     | 12 primary care practices and 2 hospitals, Spain | 6                | 280         | 55 (15)             | 240 (86)   | 85 (30)    | 195 (70)   | Research nurse interview with follow-up by telephone, post and visits; optional NRT       | Usual care including advice to stop smoking                                                 | 99                     | Smoking cessation assessed by urinary cotinine |
| Fowler et al    | University hospital, Australia               | 6                | 18          | 47 (9)              | Not reported | 3 (17)    | 15 (83)    | In newly diagnosed diabetes; counselling (smokescreen programme) at diagnosis                | Counselling (smokescreen programme) 2 months after diagnosis                              | 83                     | Plasma cotinine                          |
| Fowler et al    | University hospital, Australia               | 6                | 16          | 53 (13)             | Not reported | 9 (56)    | 7 (44)     | In pre-existing diabetes; counselling (smokescreen programme)                              | Diabetes-specific counselling                                                              | 88                     | Plasma cotinine                          |
| Hokanson et al  | Large diabetes centre, USA                   | 6                | 114         | 54 (9)              | 65 (57)    | –          | 114 (100)  | Face-to-face counselling followed by repeated telephone counselling and optional NRT or bupropion | Standard care including referral to cessation programmes                                   | 63                     | Self-reported 7-day point prevalence of smoking cessation confirmed by saliva cotinine |
| Ng et al        | 2 diabetes clinics, Indonesia                | 6                | 71          | 56 (9)              | 71 (100)   | –          | 71 (100)   | Doctor’s advice and visual materials with referral to cessation clinic                      | Doctor’s advice and visual materials                                                     | 79                     | Self-reported 7-day point prevalence abstinence |
| Sawicki et al   | Diabetes clinic, Germany                     | 6                | 89          | 38 (12)             | 54 (61)    | 72 (81)    | 17 (19)    | 10 weekly behavioural sessions by a therapist with optional NRT                              | A single unstructured session by a physician with optional NRT                             | 100                    | Smoking cessation assessed by urine cotinine |
| Thankappan et al| 2 diabetes clinics, India                    | 6                | 224         | 53 (9)              | 224 (100)  | Not reported| Not reported| Doctor’s advice, educational materials and three 30 min non-doctor counselling sessions   | Doctor’s advice and educational materials                                                | 88                     | Self-reported 7-day smoking abstinence    |

* Primary outcome unless it was not specified in the article.
† Assumption on the type of diabetes was made on the basis of reported treatment with insulin.
CO, carbon monoxide; NRT, nicotine replacement therapy; T1D, type 1 diabetes; T2D, type 2 diabetes.
review, one European trial assesses the efficacy and safety of smoking cessation with varenicline tartrate in patients with diabetes. The two other ongoing trials carried out in North America and Asia assess the effectiveness of behavioural interventions.

The less intensive intervention comparator groups received usual care, involving advice to stop smoking in three trials, counselling about general health risks of smoking in another three trials and diabetes-specific counselling in one trial. In one trial, optional NRT was reported as used in addition to counselling in the comparator group.

Outcomes

Four of eight trials included a definition of the primary outcome (table 2). In four trials, smoking cessation was biochemically verified using concentration of breath carbon monoxide (CO), urinary cotinine or salivary cotinine. Two trials assessed only self-reported cessation, and two trials reported only a total number of people with biochemically verified cessation in the study population. All trials measured smoking cessation as point prevalence abstinence.

Risk of bias

All trials were deemed to have low risk of attrition bias and most trials were assessed as having low risk of detection bias (figure 2, see online supplementary appendix 4). Most trials provided incomplete information on random sequence generation, allocation concealment and blinding of participants and personnel.

Primary outcome

Trial findings are summarised in table 2. One article reporting two trials included only the overall number of patients who stopped smoking in both trials. Two trials were excluded from pooled analysis due to high risk of detection bias as a consequence of self-reported cessation outcomes.

Pooled data from the four trials that reported point prevalence of biochemically verified smoking cessation in both trial arms are summarised in figure 3. For 543 participants, 44 smoking cessation events are

| Type of outcome                          | Study          | More intensive intervention | Less intensive intervention | Comparison                        | Effect                  |
|------------------------------------------|----------------|-----------------------------|------------------------------|-----------------------------------|-------------------------|
| Objective measures                       |                |                             |                              |                                   |                         |
| Biochemically verified smoking cessation | Ardron et al   | 0                           | 1 (3%)                       | Incidence ratio (95% CI)          | 7.5 (2.3 to 24.4)       |
|                                          | Canga et al    | 25 (17%)                    | 3 (2%)                       | χ² test for difference in abstinence rate | p=0.077                |
|                                          | Hokanson et al | 4 (7%)                      | 2 (4%)                       | Difference in point prevalence of cessation | Reported as not significant |                         |
|                                          | Sawicki et al  | 2 (5%)                      | 7 (16%)                      |                                   |                         |
| Urinary cotinine-creatinine ratio, µg/mg | Ardron et al   | 7.6 (4.5)                   | 6.7 (4.4)                    |                                   |                         |
|                                          | Hokanson et al | 18.2 (10.0)                | 19.4 (8.9)                   |                                   |                         |
|                                          |                | 35 (61%)                    | 43 (75%)                     |                                   |                         |
| HbA1c <7% (53 mmol/mol)                 | Ardron et al   | 18.2 (10.0)                | 19.4 (8.9)                   | Difference in proportion of patients achieving HbA1c <7% | Reported as not significant |                         |
|                                          | Hokanson et al | 35 (61%)                    | 43 (75%)                     |                                   |                         |
| Breath CO (µL/L)                         | Ardron et al   | 18.2 (10.0)                | 19.4 (8.9)                   |                                   |                         |
| HbA1c <7% (53 mmol/mol)                 | Hokanson et al | 35 (61%)                    | 43 (75%)                     |                                   |                         |
| Self-reported measures                   |                |                             |                              |                                   |                         |
| 7-day abstinence                         | Ng et al       | 14 (37%)                    | 10 (30%)                     | Allocation effect in logistic regression model | Reported as not significant | 8.4 (4.1 to 17.1)     |
|                                          | Thankappan et al | 58 (52%)                   | 14 (13%)                     | Adjusted OR (95% CI)              |                         |
| Number of cigarettes smoked daily        | Canga et al    | 15.5†                       | 18.1†                        | Difference in change in mean cigarettes per day from baseline (95% CI) | −3.0 (−1.1 to −4.9)   |
|                                          | Thankappan et al | 20 (18%)                   | 25 (22%)                     | Adjusted OR (95% CI)              | 1.9 (0.8 to 4.1)       |
| >50% reduction in number of cigarettes smoked daily | Thankappan et al | 20 (18%)                   | 25 (22%)                     | Allocation effect in logistic regression model | Reported as not significant | 22.8 (13.6 to 32.0) |
| Attempts to quit or reduce smoking      | Ng et al       | 21 (55%)                    | 16 (48%)                     | Allocation effect in logistic regression model | Reported as not significant |                         |
| Incidence of smoking relapse            | Canga et al    | 49 (33%)                    | 14 (11%)                     | Difference (95% CI) in incidence of relapse | Reported as not significant |                         |

Data presented as number of events (%) or mean (SD).
*Reported as a primary outcome.
†SDs not reported.
CO, carbon monoxide; HbA1c, glycated haemoglobin.
reported. The likelihood of biochemically verified smoking cessation was 32% higher in patients who received more intensive intervention compared with less intensive intervention, although this effect was not significant (RR 1.32, 95% CI 0.23 to 7.43).

There was substantial heterogeneity between the results of trials included in the pooled analysis of the primary outcome (χ² test for heterogeneity, p=0.006; I²=76%). Two trials, 18 19 jointly accounting for 44% of the weight of these results, reported point estimates of effects that suggested a greater likelihood of smoking cessation in the less intensive intervention group compared with the more intensive intervention group. In one trial, 19 the only biochemically verified incident of smoking cessation was recorded in a less intensive intervention group patient who stopped smoking after sustaining a myocardial infarction.

In the pooled analyses of self-reported smoking cessation outcomes in (1) all eligible trials and (2) in trials also reporting biochemically verified smoking cessation, participants allocated to more intensive intervention had, respectively, 1.85 times (RR 1.85, 95% CI 0.81 to 4.22) or 1.39 times (RR 1.39, 95% CI 0.28 to 6.92) greater likelihood of cessation compared with patients allocated to the less intensive intervention.

Secondary outcomes

Other outcomes reported related to smoking outcomes and metabolic outcomes (table 2). Continuous measures of urinary cotinine–creatinine ratio and breath CO were reported for one trial, 19 but the results were not compared between allocated trial groups. In one trial, 23 proportions of patients with HbA1c <7% (53 mmol/mol) in more intensive and less intensive intervention groups were reported at 6 months (61% vs 75%), but were not significantly different (p=0.16). No trials reported other objectively measured short-term or long-term cardiovascular risk or safety data.

DISCUSSION

Despite an excess cardiovascular risk in people with diabetes, we have identified only a small number of trials evaluating the effect of smoking cessation interventions in this group. Interventions tested in the trials were similar to those used in the general population and included counselling, referral and advice, with, for some, the addition of diabetes-specific education. Interventions and comparator groups were heterogeneous and the pooled results did not provide evidence of efficacy for smoking cessation interventions in people with diabetes. Only one trial reported data on glycaemic outcomes, which were not significantly different between intervention groups.

Figure 2 Summary of authors’ judgements on the risk of bias in reviewed trials.

Figure 3 Forest plot showing pooled analysis of trials reporting biochemically verified point prevalence of smoking cessation.
This is, to our knowledge, the first systematic review of randomised trials of smoking cessation interventions in diabetes. Our analysis includes equal numbers of studies reporting positive and negative effect estimates, which reduces the likelihood of publication bias. The statistical power of the meta-analysis is limited by the small number of trials published to date and a relatively small number of participants in the published trials. Limited statistical power may partially explain the lack of significant findings in the pooled analysis. There are too few trials to draw conclusions about the types of intervention, and differences between type 1 and type 2 diabetes.

The extent of heterogeneity in interventions, and intervention and comparator groups, also limited our ability to draw conclusions based on our findings. Most of the included trials provided incomplete information on randomisation, allocation concealment and blinding of participants and personnel which may potentially introduce bias at the level of individual trials.

This review does not include trials in which smoking cessation was a part of a more extensive complex intervention and in which only a proportion of patients had diabetes and smoked at baseline. This limited the number of trials to be reviewed and the size of the reviewed population, but allowed us to measure specifically the effect of smoking cessation by reducing the extent of performance bias and detection bias arising from multiple interventions and multiple measurements.

Some studies suggest that smokers with diabetes may be more motivated to stop smoking, than the general smoker population and more likely to stop smoking after hospitalisation compared with patients without diabetes. There is no evidence from our review that, if such motivation is present, it translates into improved outcomes. In other high-risk patient groups, for example, chronic obstructive pulmonary disease and cardiovascular disease, higher point estimates of the effect of intervention on smoking cessation are reported with most trials extending to 12-month follow-up.

An earlier, narrative review has examined the issues associated with smoking cessation in diabetes and identified some of the reasons why evaluation of smoking cessation interventions in this group may have been dealt with cautiously. The datasheets for most recommended first-line smoking cessation medications, caution against their use in diabetes. Moreover, studies report that smoking cessation may worsen metabolic profile and glycemic control and lead to weight gain. We have identified four trials not included in the narrative review, two predating the narrative review.

Further data from randomised trials of interventions evaluating smoking outcomes, weight change and glycemic control would inform treatment strategies in a population in which smoking cessation is likely to have high absolute benefits. The issue of safety of such treatments is partly addressed in an ongoing trial of varenicline for smoking cessation in diabetes, but the follow-up period of 6 months is likely to be too short to identify sustained effects. Trials assessing combinations of NRT with varenicline or bupropion in addition to non-pharmacological interventions may, in any case, better reflect clinical practice.

Despite the potential health benefits of smoking cessation in diabetes, there has been limited work on developing and evaluating tailored interventions to support smoking cessation in these patients. From a health services perspective, it would be important to know whether a tailored intervention is more effective in this patient group than providing the same management as for the general population. Given the high burden of self-management required of people with diabetes, it is possible that integrating an intervention with routine care may be more effective than managing the problem separately. Further work is needed to explore the role of this approach in clinical care using trial designs with follow-up extending to at least 1 year.

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