

Burden of Diabetes on the Ability to Work

A systematic review

MARIE-CLAUDE BRETON, PHD^{1,2}
LINE GUÉNETTE, PHD^{1,2,3}
MOHAMED AMINE AMICHE, DPHARM^{1,2,3}

JEANNE-FRANÇOISE KAYIBANDA, PHD^{1,2,3}
JEAN-PIERRE GRÉGOIRE, PHD^{1,2,3}
JOCELYNE MOISAN, PHD^{1,2,3}

Type 2 diabetes is an increasingly common disease (1) that places a considerable economic burden on society. An estimated 171 million people were suffering from diabetes in 2000, and this number could total 366 million by 2030 (1). Type 2 diabetes accounts for more than 90% of all diabetes cases, and it often appears in middle age (2). In 2010, the prevalence of diabetes in the U.S. was 11.3 and 26.9% among individuals aged 20 years or over and 65 years or older (2), respectively.

In 2007, costs related to diabetes in the U.S. were an estimated \$174 billion; \$116 billion in direct costs and \$58 billion in indirect costs (3). Direct costs include the cost of personal expenditures, drugs, and health care services, whereas indirect costs include lost productivity at work. Lost productivity at work may be measured through absenteeism (time lost from work due to illness), presenteeism (time at work impaired due to illness), productivity (time lost from work due to illness plus time at work impaired due to illness), or early retirement (retirement before the official retirement age due to illness).

Lost productivity at work is an important concern for employees, employers, and society. Moreover, the complications related to diabetes are a major cause of disability, reduced quality of life, and death (4). Employees with diabetes may stop working prematurely (5–8) and may experience unemployment (7,9–12), which

could translate into a reduction in earned income and savings (13) and loss of self-esteem (14). For employers too, lost productivity due to absenteeism (6,8,13,15–23), presenteeism (17), and early retirement (5–7) is an important economic issue.

To the best of our knowledge, there are no published systematic reviews answering the following question: Do individuals with diabetes have more time lost from work or more impaired time at work, and do they retire earlier than individuals without diabetes? Knowledge synthesis is needed regarding the effect of type 2 diabetes on a person's ability to work so as to improve our understanding of the indirect impact of this chronic disease, to provide evidence for the importance of addressing its effects on the workforce, and to develop and implement sound interventions specifically designed for workers with diabetes. The aim of this study was to perform a systematic review in order to describe the risk and magnitude of lost productivity due to absenteeism, presenteeism, and early retirement among individuals with type 2 diabetes in the workforce compared with those without the disease.

RESEARCH DESIGN AND METHODS

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (24,25).

Eligibility criteria

Type of participants. All studies that focused on individuals in the workforce aged 18 years or over were included. Individuals at work and those not working but actively seeking work were both regarded as being in the workforce. Studies that included students, retirees, stay-at-home individuals, or incarcerated individuals were excluded.

Type of exposure. Since our review focus was on an etiological question, the exposure corresponds here to the target condition, type 2 diabetes. We included studies focusing on individuals with type 2 diabetes, those on patients with diagnoses associated with a diabetes diagnosis (hypoglycemia or hyperglycemia), and those involving mixed populations with type 2 and type 1 diabetes. Studies on women with gestational diabetes mellitus were excluded, given the difficulty of separating the effects of the diabetes from those of pregnancy itself.

Type of comparison. Individuals with type 2 diabetes were compared with those without type 2 diabetes.

Types of outcomes. The main outcome was ability to work. This included absenteeism, presenteeism, productivity loss, and early retirement.

Study designs. Cohort, case-control, and cross-sectional (with control subjects) studies were used. Systematic reviews, meta-analysis, case series, editorials, focus groups, and economic modeling studies were all excluded.

Electronic search

The literature search of studies was conducted using Medline (via PubMed), Embase, PsychINFO, ProQuest, and the Occupational Health and Safety reference collection. The database search was performed with a combination of Medical Subject Heading (MeSH) terms and/or keywords (see Supplementary Data for the search strategy of the major databases used). An adapted search strategy was used to search all the databases from their start date to 1 November 2011, when we began to draft the manuscript. Search results were downloaded and imported

From the ¹Chair on Adherence to Treatments, Laval University, Quebec City, Quebec, Canada; ²URES, Centre de recherche du CHU de Québec, Quebec City, Quebec, Canada; and the ³Faculty of Pharmacy, Laval University, Quebec City, Quebec, Canada.

Corresponding author: Marie-Claude Breton, marie-claude.breton@uresp.ulaval.ca.

Received 7 March 2012 and accepted 26 September 2012.

DOI: 10.2337/dc12-0354

This article contains Supplementary Data online at <http://care.diabetesjournals.org/lookup/suppl/doi:10.2337/dc12-0354/-DC1>.

© 2013 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. See <http://creativecommons.org/licenses/by-nc-nd/3.0/> for details.

directly into EndNote, version X4. To reduce language bias, no language restrictions were applied. An information scientist helped us develop and conduct an optimal search strategy. To identify other relevant studies, we manually searched the bibliographic reference lists of the included studies.

Study selection

We used a three-step process to select the studies. First, using EndNote, we eliminated exact duplicate articles. Second, to discard irrelevant studies, two authors (L.G. and M.-C.B.) screened all titles identified through the electronic databases search. Third, to select studies that met our inclusion criteria from the remaining articles, L.G. and M.-C.B. read abstracts and full texts using a study selection form built specifically for this purpose. If the results of a study were reported in more than one publication, only the publication with the most complete results was retained. Only if publications on the same study focused on different outcomes or different populations did we include them. To avoid double counting data from multiple publications, we juxtaposed author names, sample sizes, and outcomes. Using κ statistics, we assessed interreviewer agreement on the selection process steps: for title evaluation (step 2) and abstract and full-text evaluation (step 3). Lastly, to identify other potentially relevant articles, M.-C.B. examined the reference lists of selected articles. Disagreements between L.G. and M.-C.B. were resolved by consensus. Whenever consensus could not be reached, another author (J.M.) made the final decision.

Data extraction and management

We developed a standardized data extraction form based on the Cochrane Consumers and Communication Review Group's data template (26). M.A.A. and M.-C.B. used this form and independently extracted and compared the data from the selected studies. Another author (J.-F.K.) reviewed all extracted data. Disagreements between M.A.A., M.-C.B., and J.-F.K. were resolved by consensus. If consensus could not be reached, L.G. made the final decision. The following information was extracted from each study article: author names, year of publication, study design, country, period of data collection, description of participants, age, and data on diabetes assessment (type of diabetes, data collection, and method). In addition, we extracted the following

details for each study article: number of individuals with and without diabetes, type of outcome (definition and data collection and assessment methods), statistical analysis, number of days lost per year, percentage of individuals with the outcome, number of years retired earlier, and summary measure of dependent variable effect with 95% CI or *P* value. In the included studies different units of time (week, month, or year) were used to report data on the productivity outcomes. In consequence we calculated, when necessary, the number of days lost per year to allow comparison between studies. When data on the number of hours worked per week and the number of weeks worked per year were missing, we assumed that individuals were working 40 h per week and 50 weeks a year. Whenever more than one summary measure was reported for an outcome, the most adjusted (summary measure from the model including highest number of variables) was considered. Crude relative risks were calculated each time the effect size was not reported, provided the article supplied sufficient information. Missing information was obtained by contacting corresponding authors and consulting survey web sites. We did not impute missing data.

Quality assessment

M.A.A. and M.-C.B. independently evaluated the quality of cohort studies included in the review using the Newcastle-Ottawa Scale (NOS) for cohort studies. They also assessed the quality of case-control studies using the NOS for case-control studies (27). Both scales address three domains: 1) selection of study groups (four items for case-control studies and three items for cohort studies [we removed one item for cohort studies—"demonstration that outcome of interest was not present at start of study"—because it was irrelevant to our outcomes]), 2) comparability of these groups (one item), and 3) ascertainment of either exposure or outcome of interest (three items). A study could be awarded a maximum of one star for each item within the selection and outcome categories and a maximum of two stars for comparability. The overall quality rating was the sum of the stars (maximum of eight stars for cohort and nine for case-control studies, respectively). To evaluate the quality of cross-sectional studies, we modified the NOS for cohort studies. In the selection and outcome sections, three of the nine items—"demonstration that outcome of interest was not present at start

of study," "was follow-up long enough for outcomes to occur?" and "adequacy of follow-up"—were removed since they are not applicable to cross-sectional studies. Thus a maximum of six stars could be awarded. We regarded a study as having a low risk of bias if it was allocated the maximum number of stars for its design. M.A.A. and M.-C.B. evaluated the quality of each study using a quality standardized table form. Disagreements between M.A.A. and M.-C.B. were resolved by consensus after discussion or, if necessary, by another author (L.G.). J.-F.K. reviewed the quality of data rating.

Data synthesis and analysis

Since substantial heterogeneity exists between the studies for almost all methodological parameters and in the methodological quality, undertaking a meta-analysis was not appropriate. Therefore, our synthesis focuses on the description of study characteristics, the relationship between diabetes and ability to work (quantification of direction of effect, size of effect, and consistency of effect), the quality of the included studies, and on the search for factors that may explain differences in results between studies. Ability-to-work measures, statistical analyses, and adjustment variables varied considerably across studies assessing the same outcome. Consequently, our synthesis focuses on effect direction on the range of the effect size.

As systematic reviews can be misleading if their results are substantially influenced by studies with a high risk of bias, we performed sensitivity analyses to evaluate the impact of excluding studies with lower methodological quality (≤ 4 stars for cohort studies, ≤ 4 stars for case-control studies, and ≤ 3 stars for cross-sectional studies). In these analyses, we found that the results for absenteeism and presenteeism were somewhat influenced by studies with a high risk of bias.

RESULTS

Search results and study characteristics

A total of 23 studies met all inclusion criteria and were included in the systematic review (Fig. 1). Characteristics of the included studies are displayed in Supplementary Table 1. Of the 23 selected studies, 17 were conducted in North America (6,7,11,13,15–18,20,23,28–34), 5 in Europe (5,8,19,22,35), and 1 in Australia

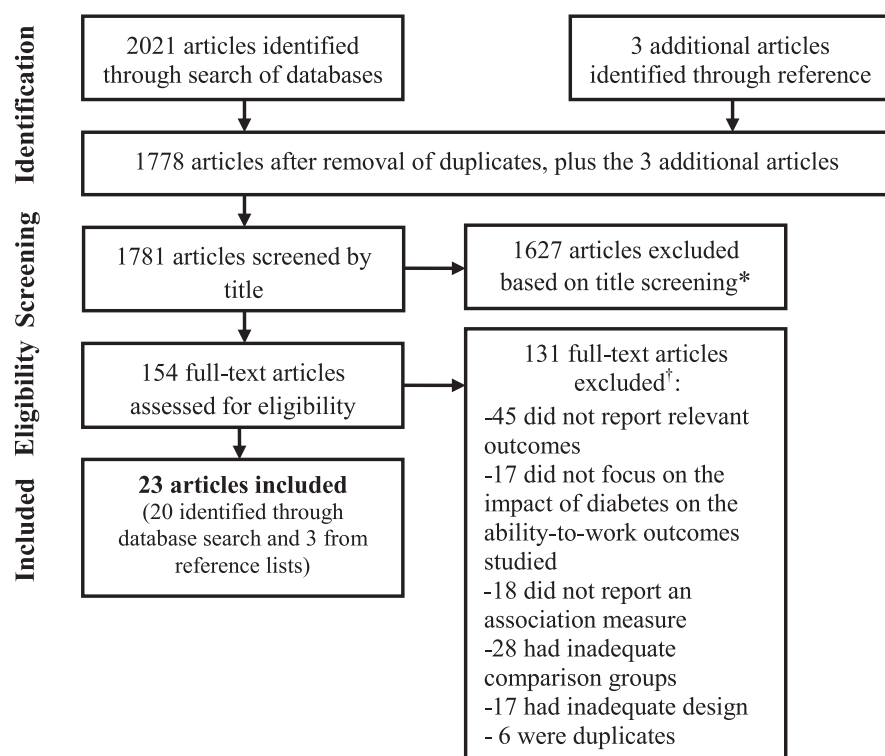


Figure 1—Flowchart of methodology for identifying studies included in the systematic review. Based on PRISMA guidelines, 2009 (24,25). *Agreement between reviewers for title screening was high ($\kappa=0.70$). †Agreement between reviewers for abstract and full-text evaluation was almost perfect ($\kappa=0.89$).

(21). Seventeen studies were cross-sectional (5,7,11,13,15,16,18,20–22,28–34), 4 were cohort studies (8,17,19,23), 1 was a case-control study (35), and 1 study included cross-sectional and longitudinal analyses (6). Data collection periods occurred between 1985 and 2009, but most data collection took place in the last decade. Twenty studies were published after the year 2000. All the studies were published in English and performed in different populations, including general population, employees of companies, or patients from diabetes clinics. Participant age ranges varied across studies. However, all studies were restricted to a population of working-age individuals. Diabetes status was self-reported in 18 studies (5–8,11,13,15–17,19,21–23,28,30,31,33,34) where different questionnaires were used. A total of 20 studies included individuals with both type 1 and type 2 diabetes (5–8,13,15–23,28,29,31,33–35), and 3 were composed of individuals with type 2 diabetes only (11,30,32).

Absenteeism, studied in 17 studies, was the ability-to-work outcome most frequently considered (6,8,11,13,15–23,29,31,32,35). Presenteeism (15,17,21,32)

and productivity (17,28,30,32–34) data were available in four and six studies, respectively. Four studies focusing on early retirement were identified for inclusion in the review (5–8).

Quality of studies

The methodological quality of the included studies varies a great deal. None received the maximum number of stars. Quality scores ranged from one to five stars (out of a possible six) for cross-sectional studies (Supplementary Table 2) and from four to six stars (out of a possible eight stars) for cohort studies (Supplementary Table 3). The case-control study was allocated four out of a possible nine stars (Supplementary Table 4).

With regard to selection, the first quality assessment domain of the NOS, nine cross-sectional studies were deemed subject to bias due to the nonrepresentativeness of the population (individuals with type 2 diabetes in the workforce; 6,15,16,21,28–32), as were eight cross-sectional studies due to use of an inadequate method for ascertaining diabetes (15,16,21,28–31,33). Selection was more adequately assessed in cohort and case-control studies.

Concerning comparability, the second domain of quality assessment, a total of 21 studies lacked adjustment for demographic, lifestyle, or illness factors, such as the presence of comorbidity (5–8,11,13,15–19,21,23,28–35). Finally, the last domain of the NOS (outcome or exposure) was also vulnerable to bias in all but 2 studies (8,19) due to the use of self-reported measures of ability-to-work outcomes in those studies.

Sensitivity analysis

When we excluded studies with lower methodological quality scores, 8 studies (out of 17) remained for absenteeism (Table 1) (8,11,13,18–20,22,23), 1 for productivity (Table 2) (34), and 3 for early retirement (Table 3) (5,7,8). No studies focusing on presenteeism were considered to have a low risk of bias. Results of included studies with high risk of bias are displayed in Supplementary Tables 5–8.

Absenteeism

Among the eight studies on absenteeism with a low risk of bias (Table 1), five were cross-sectional studies (11,13,18,20,22) and three were cohort studies (8,19,23). In two of those studies, individuals with diabetes had significantly more absences from work than those without diabetes (odds ratio ranged between 1.51 and 3.3 [19,22]). In four studies, individuals with diabetes had between 0.90 and 5.7 more days lost in the previous year than individuals without diabetes (13,18,20,23), and in two studies (8,11) no statistically significant differences were observed between individuals with and those without diabetes. Results of all eight studies were adjusted for potential confounders and three for comorbidities (20,22,23).

Individuals with diabetes had between 5.4 and 18.1 days of absenteeism per year compared with 3.4 to 8.7 days for individuals without diabetes. However, it is important to note that the number of days lost from work due to illness among individuals with diabetes and depression was much higher (78.5 days per year) (22).

Productivity

The only study that remained for the productivity outcome was a cross-sectional study including individuals with diabetes with and without neuropathic symptoms (Table 2) (34). Following adjustment for potential confounders, including the number of health conditions, individuals

Table 1—Results of included studies on the impact of type 2 diabetes on absenteeism with a low risk of bias

| Authors | Study population | | Outcome | | | | Results | | | | | |
|-----------------------------|------------------|--------|-----------|--|----------------------------|--------------------|---|--|------------------------|---|---------------------------|---------------|
| | Sex | DM (N) | No DM (N) | Definition | Data collection instrument | Statistical method | Adjustment variables | Summary measure | 95% CI | % of people with the outcome (DM/no DM) | Days lost/year (DM/no DM) | Quality score |
| Herquelot et al., 2011 (8) | | 506 | 2,530 | Pension for disability or longstanding illness or if they had sick leave of more than 365 days | Administrative records | Cox reg. | B (matched for A, Q ₁₅ , W) | HR 1.4 | 0.8–2.4 | 7.9/2.7 (IR per 1,000 years) | — | 5 |
| De Backer et al., 2006 (19) | F | 109 | 4,802 | Days of work lost due to illness in the previous year (M/F: $\geq 12/\geq 15$ days) | Records of sick leave | Logistic reg. | A, B, E, H, O, P, T | F: OR 1.38 | 0.89–2.14 | 33.9/25.1 | — | 5 |
| | M | 447 | 15,293 | Days of work lost (≥ 7 consecutive days) | | | | M: OR 1.51 F: OR 1.45 | 1.22–1.88 0.94–2.23 | 36.9/25.3 33.9/25.2 | — | |
| | | | | ≥ 3 repetitive sick leave periods in the previous year | | | | M: OR 1.11 F: OR 1.71 | 0.87–1.41 1.12–2.62 | 25.3/19.3 36.7/24.0 | — | |
| Tunceli et al., 2005 (23) | F | 231 | 3,453 | Days of work lost due to illness in the previous year | Questionnaire* | OLS | A, B, B ² , C, E, I, M, O, U | M: OR 1.54 F: 2.05 more days lost in the previous year† | 1.20–1.98 — | 21.2/14.5 — | 6.7/4.2 | 5 |

Continued on p. 744

Table 1—Continued

| Authors | Study population | | Outcome | | | Results | | | | | | |
|--------------------------|------------------|--------------------|--------------------|---|----------------------------|------------------------|---|--|------------|---|---------------------------|---------------|
| | Sex | DM (N) | No DM (N) | Definition | Data collection instrument | Statistical method | Adjustment variables | Summary measure | 95% CI | % of people with the outcome (DM/no DM) | Days lost/year (DM/no DM) | Quality score |
| | M | 259 | 3,112 | | | | | M: 0.90 more days lost in the previous year | — | — | — | |
| Cross-sectional | | | | | | | | | | | | |
| Fu et al., 2009 (20) | F/M | 4,233 | 42,384 | Days of work lost due to illness or injury in the previous year | CAPI* | Negative binomial reg. | A, C, E, I, J, R, S, T, Q, X ₂ | 0.90 more days lost in the previous year† | — | — | 6.7/NA | 5 |
| Vamos et al., 2009 (22) | F/M | 127‡ | 5,625§ | Lost work days | Questionnaire | — | — | — | — | — | 18.1‡/78.5 8.7§ | 5 |
| 16 | | | | | | | | | | | | |
| | | | | ≥10 days of work lost due to illness in the previous year | Questionnaire | Logistic reg. | A, B, C, E, S, P, T | OR 1.8‡† | 1.19–2.69 | — | — | |
| Cawley et al., 2008 (18) | | | | | | | | | | | | |
| | F | Obese: NA | Healthy weight: NA | Days of work lost due to illness in the previous year | CAPI* | OLS | A, E, F, O, R | OR 3.3† F: 2.2 more days lost in the previous year† | 1.10–10.74 | — | — | 4 |
| | F | Morbidly obese: NA | | | | | | F: 3.0 more days lost in the previous year† | — | — | 77.0/64.0 | |

Continued on p. 745

Table 1—Continued

| Authors | Study population | | Outcome | | | Results | | | | | | |
|-------------------------------|------------------|--------------------------|--------------------------|--|----------------------------|--------------------|---|--|--------|---|---------------------------|---------------|
| | Sex | DM (N) | No DM (N) | Definition | Data collection instrument | Statistical method | Adjustment variables | Summary measure | 95% CI | % of people with the outcome (DM/no DM) | Days lost/year (DM/no DM) | Quality score |
| | M | Obese: NA | Healthy weight: NA | | | | | M: 2.6 more days lost in the previous year† | — | 55.0/42.0 | — | |
| | M | Morbidly obese: NA | | | | | | M: 5.7 more days lost in the previous year† | — | 65.0/48.0 | — | |
| Ng et al., 2001 (11) | F/M | 715 | 52,117 | Days of work lost in the past 2 weeks | Questionnaire* | Tobit reg. | A, C ₂₂ , E, N, O, S | 0.87 more days lost in the past 2 weeks | — | — | 11.8/5.3 | 4 |
| Mayfield et al., 1999 (13) | F/M | 1,502 | 20,405 | Days of work lost due to illness per year | Questionnaire* | Linear reg. | A, A ² , E, I, R, S, (A*, C ₁₅) (S*, C ₁₅) | ~2 more days lost per year† | — | NA | F: 5.4/3.8 M: 5.9/3.4 | 4 |

A, age; A², age²; B, BMI; B², BMI²; C, comorbidities; C₁₅, diabetes; C₂₂, health status; CAPI, computer-assisted personal interview; DM, diabetes; E, education; F, region of residence; H, alcohol use; HR, hazard ratio; I, income; IR, incidence rate; J, diabetes severity; M, marital status; N, medical cost; NA, not available; O, occupation; OLS, ordinary least squares model; OR, odds ratio; P, physical activity/inactivity; Q, employment; Q₁₅, occupational grade at the hiring; R, race; reg, regression; S, sex; T, tobacco use; U, children; W, calendar year; X₂, health insurance. *Information obtained from the official survey website. †P < 0.05. ‡Without depression. §Without diabetes and depression. ¶With depression.

Table 3—Results of included studies on the impact of type 2 diabetes on retirement with a low risk of bias

| Authors | Study population | | Retirement | | | Results | | | | | | |
|----------------------------|------------------|--------|------------|--|----------------------------|--------------------|---|-----------------|-----------|--|----------------------------------|---------------|
| | Sex | DM (N) | No DM (N) | Definition | Data collection instrument | Statistical method | Adjustment variables | Summary measure | 95% CI | % of people with the outcome (DM/no DM) (IR per 1,000 years) | Years retired earlier (DM/no DM) | Quality score |
| Cohort | | | | | | | | | | | | |
| Herquelot et al., 2011 (8) | F/M | 506 | 2,530 | NA | Administrative records | Cox reg. | B (matched for A, Q ₁₅ , W) | HR 1.6 | 1.5–1.8 | 209.1/37.6 (IR per 1,000 years) | 0.7 years earlier* | 5 |
| Cross-sectional | | | | | | | | | | | | |
| Alavinia et al., 2008 (5) | F/M | 799 | 10,663 | Cannot work due to illness and benefit from sickness or disability insurance | CAP† | Logistic reg. | A, B, C ₂₅ , E, H, M, P, S, T | OR 1.3 | 1.05–1.68 | NA | NA | 4 |
| Yassin et al., 2002 (7) | F | NA | NA | Cannot work due to illness now | Questionnaire† | Logistic reg. | (A*, Y) E, I, M, N, T, R (C ₁₅ *, Y ₁) | OR 2.9 | 1.0–8.8 | 12.8/3.3 | NA | 4 |
| | M | NA | NA | | | | | OR 3.1 | 1.2–8.0 | 7.2/2.2 | NA | |

A, age; B, BMI; C₁₅, diabetes; C₂₅, self-perceived health; CAP†, computer-assisted personal interview; DM, diabetes; E, education; H, alcohol use; HR, hazard ratio; I, income; IR, incidence rate; M, marital status; N, medical cost; NA, not available; OR, odds ratio; P, physical activity/inactivity; Q₁₅, occupational grade at the hiring; R, race; reg, regression; S, sex; T, tobacco use; W, calendar year; Y, interaction term; Y₁, error term. *P < 0.05. †Information obtained from the official survey website.

2 diabetes, diabetes with obesity, diabetes with morbid obesity, painful diabetic peripheral neuropathy, diabetes with depression, diabetes in men, and diabetes in women). In addition, outcomes definitions, productivity measures, recall periods, statistical analyses and the variables used for adjustment differed considerably across those studies that assessed the same outcomes. Since the results of the review are somewhat influenced by the high risk of bias in the included studies we have based our discussion on only the 11 studies with high methodological quality scores (5,7,8,11,13,18–20,22,23,34).

On the other hand, the effects of diabetes on absenteeism, productivity loss, and early retirement are generally consistent across studies with high methodological quality ($n = 11$). In 9 studies, diabetes was found to have a significant negative impact on the ability-to-work outcomes considered (5,7,13,18–20,22,23,34). Associations between diabetes and increased absenteeism were statistically nonsignificant in only two studies (8,11). No studies focusing on presenteeism (defined as perceived impairment, performance, or efficiency lost while at work in the included studies) were considered to have low risk of bias.

The number of days lost annually from work (absenteeism) per employee that was reported in the included studies with high methodological quality, ranged between 5.4 and 18.1 days for employees with diabetes and between 3.4 and 8.7 for those without diabetes and was 78.5 days for employees with diabetes and depression. Individuals with diabetes have between 2 and 10 days of absenteeism per year more than those without diabetes. This result suggests that the associated economic burden could be high for employers. Moreover, the equivalent number of days lost from work per employee annually, as a result of productivity loss, was 26.3 in the group with diabetes with neuropathic symptoms compared with 11.9 days for those with diabetes without neuropathic symptoms and 12.0 for those without diabetes. Finally, individuals with diabetes retired 0.7 years earlier compared with individuals without diabetes.

Differences in absenteeism could be attributed to differences in social security coverage modalities that vary across countries in terms of granting sick leave or other employment benefits (36). However, despite differences between social

security models, results are generally consistent and attest to the negative consequences of diabetes on ability to work. Individuals with diabetes and depression or complications related to diabetes had more absenteeism and productivity loss than individuals with diabetes but without those comorbidities and than those individuals without diabetes (22,34).

Our review has some limitations. Certain limiting factors were inherent in the studies we included. First, evidence gathered on the effect of diabetes on ability to work is based largely on cross-sectional data. More longitudinal data are needed to provide a better assessment of the causes and effects of diabetes on ability-to-work outcomes. Second, diabetes status and ability-to-work data were generally self-reported, and, as such, are subject to errors related to misreporting or memory, especially when recall periods are long (37). Psychometric properties of a majority of self-reported instruments used in the included studies have not been published in peer-reviewed articles. Diabetes status might be inaccurate in some cases given that more than one third of individuals with diabetes in the general population are undiagnosed (2). Thus, the magnitude of the association between diabetes and ability-to-work outcomes may also be underestimated since some individuals with diabetes may have been included among the individuals without diabetes group. Third, only two studies used objective measures—sick leave database (19) and company administrative records (8)—to measure outcomes. Lastly, conclusions are based on the evidence reported in seven studies performed in the U.S. (7,11,13,18,20,23,34) and four conducted in Europe (5,8,19,22). It is therefore not clear whether the same conclusions would apply to individuals working in other countries.

Furthermore, the way we conducted this review could also have led to some limitations. Some relevant articles may not have been captured. However, we did use an exhaustive search strategy developed with the expertise of a librarian, and we applied it without date limits or language restriction across several databases, two of which included gray literature (theses, research reports, conference proceedings, and textbooks). Moreover, although only 3 of the 12 authors contacted responded positively to our request for missing data, it is unlikely that this missing data have an impact on our findings. Most missing data were related

to the number of individuals with and without diabetes included in the analysis according to each outcome and to the number of days lost.

Finally, we were unable to assess whether our review is subject to potential publication bias as we could not perform a funnel plot. Such a procedure requires a minimum of 10 studies for a given outcome (38), and standard errors associated with those studies are needed (39). Unfortunately, in our systematic review, there was only one outcome (absenteeism) for which there were at least 10 studies, and standard errors were reported in only 3 of these. However, it should be noted that the risk of publication bias tends to be greater for clinical trials than for observational studies (40) and for studies sponsored by entities that may have a commercial or financial interest in achieving favorable results. In our review, we included only observational studies and only 3 of these had sponsors with commercial or financial interest.

Our results provide comprehensive evidence of the burden of type 2 diabetes on the workforce. In fact, they suggest that employers, insurers, and decision makers should pay attention to ability to work because of diabetes. This review could help employers better manage services overseen by various managers of human resources and employee benefits programs, such as paid sick days, medical insurance, and education or intervention programs. Insurers, employers, medical personnel, and employees could also use this information as a collaborative basis for creating adequate insurance programs to protect employers and employees against work productivity loss. Our results could also assist health care professionals in motivating their patients in the workforce to improve management of their diabetes by providing them with more clear-cut information on the impact their disease has on the ability to work and loss of earned income and savings.

In conclusion, the results of this review support the development, assessment, and implementation of effective interventions targeting all workers with type 2 diabetes. Indeed, efficient employer-implemented intervention programs to improve the physical health and well-being of their workers with type 2 diabetes could be a good strategy for controlling productivity-related costs. Studies have shown that such programs can reduce work absenteeism among individuals with type 2 diabetes (41,42).

Taken overall, diabetes appears to reduce an individual's ability to work. There is a need for setting up diabetes prevention programs and to develop and implement effective targeted intervention to help workers better manage their disease. Otherwise this diabetes-related burden could worsen as the prevalence of type 2 diabetes in the working-age population continues to rise.

Acknowledgments—This study was funded by the Chair on Adherence to Treatments. This chair is supported by nonrestricted grants from AstraZeneca, Merck Canada, Sanofi Canada, Pfizer, and from the “Prends soin de toi program” (a Quebec provincial program for the improvement of public health, focused on mental health disorders). The authors wrote the entire article themselves. No forms of sponsorship or honoraria for the material have been received. No other potential conflicts of interest relevant to this article were reported.

M.-C.B. and L.G. researched data, contributed to the discussion, wrote the manuscript, and reviewed and edited the manuscript. M.A.A. researched data. J.-F.K., J.-P.G., and J.M. contributed to the discussion and reviewed and edited the manuscript.

Parts of this study were presented in abstract form at the Canadian Association for Population Therapeutics 2012 Annual Conference, Montréal, Quebec, Canada, 6–8 May 2012; at the 2012 Canadian Agency for Drugs and Technologies in Health Symposium, Montréal, Canada, 15–17 April 2012; at the 28th International Conference on Pharmacoepidemiology and Therapeutic Risk Management, Barcelona, Spain, 23–26 August 2012; and at the 15th CDA/CSEM Professional Conference and Annual Meetings, Vancouver, British Columbia, 10–13 October 2012.

The authors would like to thank Frédéric Bergeron, from Laval University library, for help in the development of search strategies and Mélanie Drolet from the Unité de recherche en santé des populations, Centre de recherche du CHU de Québec and Laval University for reviewing this article.

References

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004;27:1047–1053
2. Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2011. Available from http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf. Accessed 3 October 2011

3. Dall T, Mann SE, Zhang Y, et al.; American Diabetes Association. Economic costs of diabetes in the U.S. in 2007. *Diabetes Care* 2008;31:596–615
4. International Diabetes Federation. *Diabetes Atlas*. 5th ed. Brussels, Belgium, International Diabetes Federation, 2011. Available from <http://www.idf.org/diabetesatlas>. Accessed 12 October 2011
5. Alavinia SM, Burdorf A. Unemployment and retirement and ill-health: a cross-sectional analysis across European countries. *Int Arch Occup Environ Health* 2008;82:39–45
6. Vijan S, Hayward RA, Langa KM. The impact of diabetes on workforce participation: results from a national household sample. *Health Serv Res* 2004;39:1653–1669
7. Yassin AS, Beckles GL, Messonnier ML. Disability and its economic impact among adults with diabetes. *J Occup Environ Med* 2002;44:136–142
8. Herquelot E, Guéguen A, Bonenfant S, Dray-Spira R. Impact of diabetes on work cessation: data from the GAZEL cohort study. *Diabetes Care* 2011;34:1344–1349
9. Bastida E, Pagán JA. The impact of diabetes on adult employment and earnings of Mexican Americans: findings from a community based study. *Health Econ* 2002;11:403–413
10. Latif E. The impact of diabetes on employment in Canada. *Health Econ* 2009;18:577–589
11. Ng YC, Jacobs P, Johnson JA. Productivity losses associated with diabetes in the U.S. *Diabetes Care* 2001;24:257–261
12. Robinson N, Yateman NA, Protopapa LE, Bush L. Unemployment and diabetes. *Diabet Med* 1989;6:797–803
13. Mayfield JA, Deb P, Whitecotton L. Work disability and diabetes. *Diabetes Care* 1999;22:1105–1109
14. Smith R. “Gissa job”: the experience of unemployment. *Br Med J (Clin Res Ed)* 1985;291:1263–1266
15. Boles M, Pelletier B, Lynch W. The relationship between health risks and work productivity. *J Occup Environ Med* 2004;46:737–745
16. Burton WN, Conti DJ, Chen CY, Schultz AB, Edington DW. The role of health risk factors and disease on worker productivity. *J Occup Environ Med* 1999;41:863–877
17. daCosta DiBonaventura M, Cappelleri JC, Joshi AV. A longitudinal assessment of painful diabetic peripheral neuropathy on health status, productivity, and health care utilization and cost. *Pain Med* 2011;12:118–126
18. Cawley J, Rizzo JA, Haas K. The association of diabetes with job absenteeism costs among obese and morbidly obese workers. *J Occup Environ Med* 2008;50:527–534
19. De Backer G, Leynen F, De Bacquer D, Clays E, Moreau M, Kornitzer M. Diabetes mellitus in middle-aged people is associated with increased sick leave: the BEL-STRESS study. *Int J Occup Environ Health* 2006;12:28–34
20. Fu AZ, Qiu Y, Radican L, Wells BJ. Health care and productivity costs associated with diabetic patients with macrovascular comorbid conditions. *Diabetes Care* 2009;32:2187–2192
21. Holden L, Scuffham PA, Hilton MF, Ware RS, Vecchio N, Whiteford HA. Which health conditions impact on productivity in working Australians? *J Occup Environ Med* 2011;53:253–257
22. Vamos EP, Mucsi I, Keszei A, Kopp MS, Novak M. Comorbid depression is associated with increased healthcare utilization and lost productivity in persons with diabetes: a large nationally representative Hungarian population survey. *Psychosom Med* 2009;71:501–507
23. Tunceli K, Bradley CJ, Nerenz D, Williams LK, Pladevall M, Elston Lafata J. The impact of diabetes on employment and work productivity. *Diabetes Care* 2005;28:2662–2667
24. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol* 2009;62:e1–e34
25. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg* 2010;8:336–341
26. Cochrane Consumers and Communication Review Group. Data extraction template, 2011. Available from <http://www.latrobe.edu.au/chcp/cochrane/>. Accessed 11 July 2011
27. Wells GS, O’Connell B, Peterson D, Welch J, Losos V, Tugwell M. P. The Newcastle-Ottawa score for non-randomized studies, 2010. Available from http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed 28 June 2011
28. Burton WN, Pransky G, Conti DJ, Chen CY, Edington DW. The association of medical conditions and presenteeism. *J Occup Environ Med* 2004;46(Suppl.):S38–S45
29. Collins JJ, Baase CM, Sharda CE, et al. The assessment of chronic health conditions on work performance, absence, and total economic impact for employers. *J Occup Environ Med* 2005;47:547–557
30. Kannan H, Thompson S, Bolge SC. Economic and humanistic outcomes associated with comorbid type-2 diabetes, high cholesterol, and hypertension among individuals who are overweight or obese. *J Occup Environ Med* 2008;50:542–549
31. Kessler RC, Greenberg PE, Mickelson KD, Meneades LM, Wang PS. The effects of chronic medical conditions on work loss and work cutback. *J Occup Environ Med* 2001;43:218–225
32. Lavigne JE, Phelps CE, Mushlin A, Lednar WM. Reductions in individual work productivity associated with type 2 diabetes mellitus. *Pharmacoeconomics* 2003;21:1123–1134
33. Lenneman J, Schwartz S, Giuseffi DL, Wang C. Productivity and health: an application of three perspectives to measuring productivity. *J Occup Environ Med* 2011;53:55–61
34. Stewart WF, Ricci JA, Chee E, Hirsch AG, Brandenburg NA. Lost productive time and costs due to diabetes and diabetic neuropathic pain in the US workforce. *J Occup Environ Med* 2007;49:672–679
35. Robinson N, Yateman NA, Protopapa LE, Bush L. Employment problems and diabetes. *Diabet Med* 1990;7:16–22
36. Osterkamp R, Röhn O. Being on sick leave: possible explanations for differences of sick-leave days across countries. *CESifo Economic Studies* 2007;53:97–114
37. Stewart WF, Ricci JA, Leotta C. Health-related lost productive time (LPT): recall interval and bias in LPT estimates. *J Occup Environ Med* 2004;46(Suppl.):S12–S22
38. Sterne JAC, Egger M, Moher D; On behalf of the Cochrane Bias Methods Group. Addressing reporting biases. In *Cochrane Handbook of Systematic Reviews of Interventions*. Higgins JPT, Green S, Eds. Version 5.0.2 [updated September 2009]. The Cochrane Collaboration, 2009
39. Sterne JAC, Egger M. Funnel plots for detecting bias in meta-analysis: guidelines on choice of axis. *J Clin Epidemiol* 2001;54:1046–1055
40. Stern JM, Simes RJ. Publication bias: evidence of delayed publication in a cohort study of clinical research projects. *BMJ* 1997;315:640–645
41. Julius U, Gross P, Hanefeld M. Work absenteeism in type 2 diabetes mellitus: results of the prospective Diabetes Intervention Study. *Diabete Metab* 1993;19:202–206
42. Wolf AM, Siadaty MS, Crowther JQ, et al. Impact of lifestyle intervention on lost productivity and disability: improving control with activity and nutrition. *J Occup Environ Med* 2009;51:139–145