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 [1]Chair on Adherence to Treatments, Laval University, Quebec City, Quebec, Canada; [2]URESP, Centre de recherche du CHU de Québec, Quebec City, Quebec, Canada; and the [3]Faculty of Pharmacy, Laval University, Quebec City, Quebec, Canada.
Corresponding author: Marie-Claude Breton, marie-claude.breton@uresp.ulaval.ca.
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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

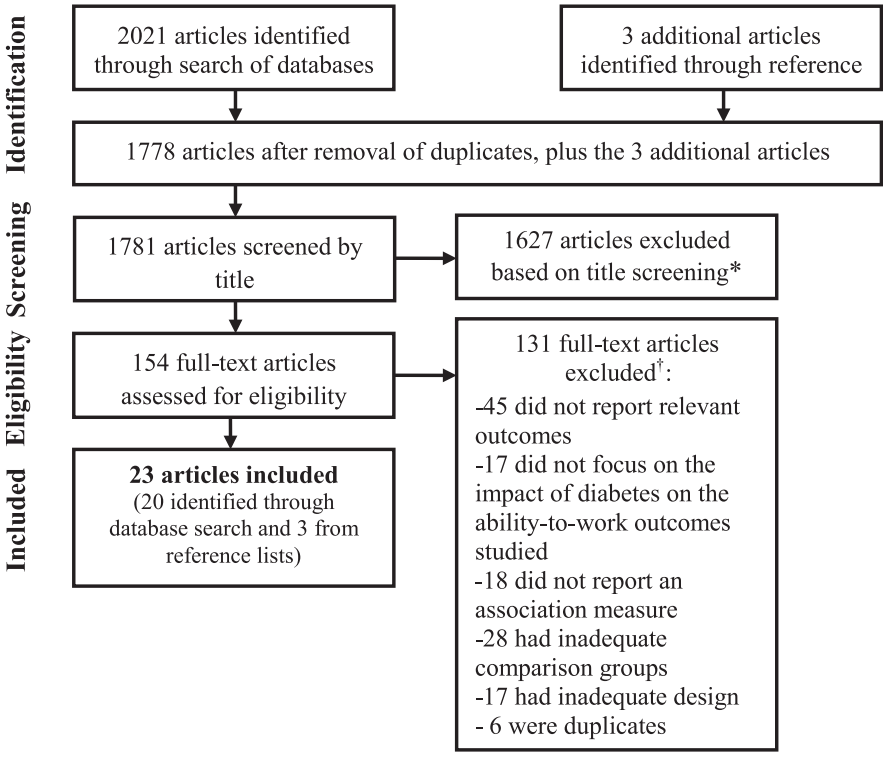

Figure 1—*Flowchart of methodology for identifying studies included in the systematic review. Based on PRISMA guidelines, 2009 (24,25). *Agreement between reviewers for title screening was high (κ=0.70). †Agreement between reviewers for abstract and full-text evaluation was almost perfect (κ=0.89).*

(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*

		Study population		Outcome				Results				
Authors	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
Cohort												
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: ≥12/≥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					M: OR 1.51	1.22–1.88	36.9/25.3	—	
				Days of work lost (≥7 consecutive days)				F: OR 1.45	0.94–2.23	33.9/25.2	—	
								M: OR 1.11	0.87–1.41	25.3/19.3	—	
				≥3 repetitive sick leave periods in the previous year				F: OR 1.71	1.12–2.62	36.7/24.0	—	
								M: OR 1.54	1.20–1.98	21.2/14.5	—	
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	F: 2.05 more days lost in the previous year†	—	—	6.7/4.2	5

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Table 1—*Continued*

Authors	Sex	Study population: DM (*N*)	Study population: No DM (*N*)	Outcome: Definition	Outcome: Data collection instrument	Statistical method	Adjustment variables	Results: Summary measure	Results: 95% CI	Results: % of people with the outcome (DM/no DM)	Results: 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	—	—	
								OR 3.3†‖	1.10–10.74	—	—	
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	F: 2.2 more days lost in the previous year†	—	66.0/59.0	—	4
	F	Morbidly obese: NA						F: 3.0 more days lost in the previous year†	—	77.0/64.0	—	

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Table 1—*Continued*

		Study population		Outcome				Results				
Authors	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	4
											M: 5.9/3.4	

A, age; A^2, age^2; B, BMI; B^2, BMI^2; C, comorbidities; C_{15}, diabetes; C_{22}, 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; Q_{15}, occupational grade at the hiring; R, race; reg, regression; S, sex; T, tobacco use; U, children; W, calendar year; X_2, health insurance. *Information obtained from the official survey website. †$P < 0.05$. ‡Without depression. §Without diabetes and depression. ‖With depression.

with diabetes and neuropathic symptoms were found to be 18% more likely to lose ≥2 h of work per week due to illness when compared with individuals without diabetes. In fact, 52.0% of individuals with diabetes and neuropathic symptoms lost ≥2 h per week from work due to illness or reduced performance compared with 28.0% of individuals without diabetes. However, no significant difference was found between individuals with diabetes and without neuropathic symptoms and those without diabetes.

The total number of days of productivity lost due to illness annually was 26.3 in the group of individuals with diabetes with neuropathic symptoms compared with 11.9 for those with diabetes without neuropathic symptoms and 12.0 for those without diabetes.

Early retirement

Three studies reporting data on early retirement were scored at low risk of bias (Table 3): two were cross-sectional (5,7), and one was a cohort study (8). In all of these studies, individuals with diabetes were significantly more likely to retire early than those without diabetes (odds ratios ranged between 1.3 and 3.1; hazard ratio 1.6). Results of all studies were adjusted for a different set of potentially confounding variables but not for comorbidities.

Proportions of individuals who stop work because of illness were presented in one study in which 7.2% of men and 12.8% of women with diabetes reported stopping work because of illness compared with 2.2% of men and 3.3% of women without diabetes (7). Number of years retired earlier was also reported in only one study (8). Individuals with diabetes in this last study retired 0.7 years earlier than those without diabetes (8).

CONCLUSIONS—This review included 23 studies investigating the impact of diabetes on ability-to-work outcomes (5–8,11,13,15–23,28–35). Methods used in the included studies varied widely and so limited comparability. Studies were conducted in many countries using different study designs and involving different settings (general population or specific population of workers) and age-groups. Moreover, assessment of diabetes varied greatly across studies, not to mention different mixes of diabetes or diabetes subpopulations that were included (type 1 and type 2 diabetes, type

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

	Study population			Outcome				Results					
Authors	Sex	DM (*N*)	No DM (*N*)	Definition	Data collection instrument	Statistical method	Adjustment variable	Summary measure	95% CI	% of people with the outcome (DM/no DM)	Days lost/year (DM/no DM)	Quality score
Cross-sectional												
Stewart et al., 2007 (34)	F/M	642*	18,042	≥2 h per week lost from work due to illness plus hour-equivalent per week of health-related reduced performance at work during the 2 weeks before interview	CAPI	GLM	A, C_{20}, E, F, I, S, R, Q_{14}	PR 1.05*	0.96–1.16	34.0*/28.0	—	4
		391†						PR 1.18†‡	1.09–1.28	52.0†/28.0	—	
				Mean hours per week lost from work due to illness plus hour-equivalent per week of health-related reduced performance at work during the 2 weeks before interview							11.9*/26.3†/12.0§	

A, age; C_{20}, number of health conditions; CAPI, computer-assisted personal interview; DM, diabetes; E, education; F, region of residence; GLM, generalized linear model; I, income; PR, prevalence ratio; Q_{14}, type of work; R, race; S, sex. *Without neuropathic symptoms. †With neuropathic symptoms. ‡$P < 0.05$. §Days lost per year were calculated by assuming that individuals were working 40 h per week and 50 weeks a year.

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

Authors	Sex	Study population		Retirement				Results				Quality score
		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)	Years retired earlier (DM/no DM)	
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	CAPI†	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; C_{15}, diabetes; C_{25}, self-perceived health; CAPI, 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; Q_{15}, occupational grade at the hiring; R, race; reg, regression; S, sex; T, tobacco use; W, calendar year; Y, interaction term; Y_1, 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.

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