

Factors of occurrence and improvement methods of presenteeism attributed to diabetes: A systematic review

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Abstract

Objective: A systematic review was performed to study factors of occurrence and improvement methods of presenteeism attributed to diabetes.

Methods: We set 2 clinical questions; (a) how comorbidities and complications of diabetes induce presenteeism and (b) what interventions or conditions effectively improve presenteeism. Then, we conducted a comprehensive search with MEDLINE/PubMed and Scopus databases and extracted those that met the clinical questions.

Results: Eighteen papers studied occurrence of presenteeism by comorbidities and complications of diabetes. Most studies were cross-sectional and had a low quality of evidence. However, the associations of hypoglycemia, diabetic neuropathy, and mood disorders with presenteeism were relatively well studied. The papers that discussed effective interventions or conditions for improving presenteeism were very limited.

Conclusions: Our review suggests that presenteeism attributed to diabetes is mainly caused by hypoglycemia, diabetic neuropathy, and mood disorders. There are very limited evidences, but available information suggests that improving glycemic control, adjusting treatment regimen by evaluating the impact on work, providing psychological support, and developing suitable work accommodations may effectively reduce presenteeism.

KEYWORDS

comorbidity, complication, diabetes mellitus, presenteeism, work productivity

1 | INTRODUCTION

Diabetes is one of the most common chronic diseases in nearly all countries and has been increasing globally.^{1,2} The increase in diabetes is a considerable economic burden for patients/employees, employers, and society. The American Diabetes Association (ADA) has estimated economic costs of diabetes in the United States (US) every 5 years since 1997.³⁻⁷ The costs of diabetes have also been estimated in several European

countries (Norway,⁸ Sweden,⁹ The Netherlands,¹⁰ Spain,¹¹ and Poland¹²) and others (Argentina¹³ and Mali¹⁴). The costs usually consist of direct medical costs and indirect costs attributed to diabetes. Although direct costs are substantial, indirect costs occupy a significant part of total costs in the entire population. Goetzel et al have continued to estimate the costs of common chronic conditions from employers' aspects in the US since 1996.¹⁵⁻¹⁷ Considering that it was effective for employers to understand total work productivity costs for

better decision making, they added presenteeism attributed to chronic diseases, such as diabetes, hypertension, depression, and arthritis, to the estimation.¹⁸ In the study, like other diseases, presenteeism accounts for a large proportion of total costs of diabetes, reaching 62% of total costs and 87% of indirect costs among a database of employees in large US corporations. The trend was reflected in ADA's estimation, and the organization added presenteeism as an indicator of reduced performance at work to indirect costs in its 2007⁵, 2012⁶ and 2017⁷ estimations, which comprised 34%, 30%, and 30% of indirect costs, respectively.

Work productivity loss often consists of absenteeism and presenteeism. While absenteeism is to be absent from work due to health problems, presenteeism is defined as the health-related productivity loss at paid work.¹⁹ Presenteeism can also be said as difficulty in doing work due to illness or symptoms, and is measured with various self-reported instruments.²⁰ In many industrialized countries including Japan, the working population is aging, and it is expected that more workers will continue to work while undergoing treatment for diseases. Diabetes is one such disease. When considering the significant burden of presenteeism attributed to diabetes, counteractive measures are necessary in the workplace as well as for disease prevention. In order to provide support for such workers to demonstrate their performance in the workplace, it is considered effective to clarify factors that create difficulty in doing work due to disease itself or its treatment. Breton et al²¹ conducted a systematic review on burden of diabetes on the ability to work in 2011 and identified only one research on the occurrence of presenteeism by comorbidities of diabetes that is a cross-sectional study observing that individuals with diabetes and neuropathic symptoms were found to have more work performance loss than those without diabetes.²² However, we expected that most of targeted studies had been published after the review.

Therefore, we conducted a systematic review on the occurrence of presenteeism by comorbidities and complications of diabetes and interventions for improving presenteeism.

2 | MATERIALS AND METHODS

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-analyses Protocols (PRISM-P).^{23,24}

We set the following two clinical questions to achieve our research objectives: (a) how comorbidities and complications of diabetes induce presenteeism and (b) what interventions or conditions effectively improve presenteeism attributed to diabetes.

On August 15, 2018, we searched MEDLINE/PubMed and Scopus databases for studies published from their start date to August 15, 2018. In some studies, absenteeism and

presenteeism were not separated, and are expressed as work productivity loss. The loss from presenteeism attributed to chronic conditions were usually much bigger than absenteeism.¹⁵⁻¹⁷ Therefore, studies were included if they described an observational and intervention study where presenteeism or health-related productivity loss including presenteeism was evaluated among workers with diabetes. In addition, as some tools measuring work productivity loss use terms such as work impairment as synonyms with presenteeism,²⁵⁻²⁷ we decided to take them together. The database search was performed with the following search term and limited to "Human" ("diabetes"[MeSH Terms] OR "diabetes" [All Fields] OR "hypoglycemia"[MeSH Terms] OR "hypoglycemia" [All Fields] OR "hyperglycemia"[MeSH Terms] OR "hyperglycemia" [All Fields]) AND ("presenteeism"[MeSH Terms] OR "presenteeism" [All Fields] OR "productivity"[MeSH Terms] OR "productivity" [All Fields] OR "work ability" [All Fields] OR "work impairment" [All Fields] OR "work performance" [All Fields] OR "work limitation" [All Fields] OR "work loss" [All Fields]).

First, two researchers (TM and TN) independently collected studies from those identified by the above literature search that evaluated the association between diabetes and productivity loss by the titles. When the opinions of the two researchers differed, the paper was included. Second, two researchers (KM and TM) independently selected studies that met inclusion and exclusion criteria from the abstracts. The inclusion criterion was any study that evaluated the association between diabetes and labor productivity or work ability in peer-review journals. Exclusion criteria included papers examining medical costs (direct costs) only and papers written in languages other than English. Papers were also excluded when we could not judge the inclusion/exclusion criteria from the abstract only. When the opinions of the two researchers differed, the paper was also included. After including possible papers identified from references of the related papers in our search, one of researchers read the full text of the screened studies and we discussed when the assigned researcher judged it did not meet criteria at researchers' conference. Finally, we selected papers that studied the occurrence of productivity loss including presenteeism by comorbidities and complications of diabetes and those that discussed effective interventions or conditions for improving presenteeism attributed to diabetes. Study selection was performed as shown in Figure 1.

We assessed the quality of selected papers on the occurrence of productivity loss including presenteeism by comorbidities and complications of diabetes using the Newcastle Ottawa Scale (NOS)²⁸ for cohort studies. However, as the NOS was originally developed for cohort studies and case-control studies, we used the modified NOS by Breton et al²² for cross-sectional studies. These scales address three domains: (a) selection of study groups (four items for cohort

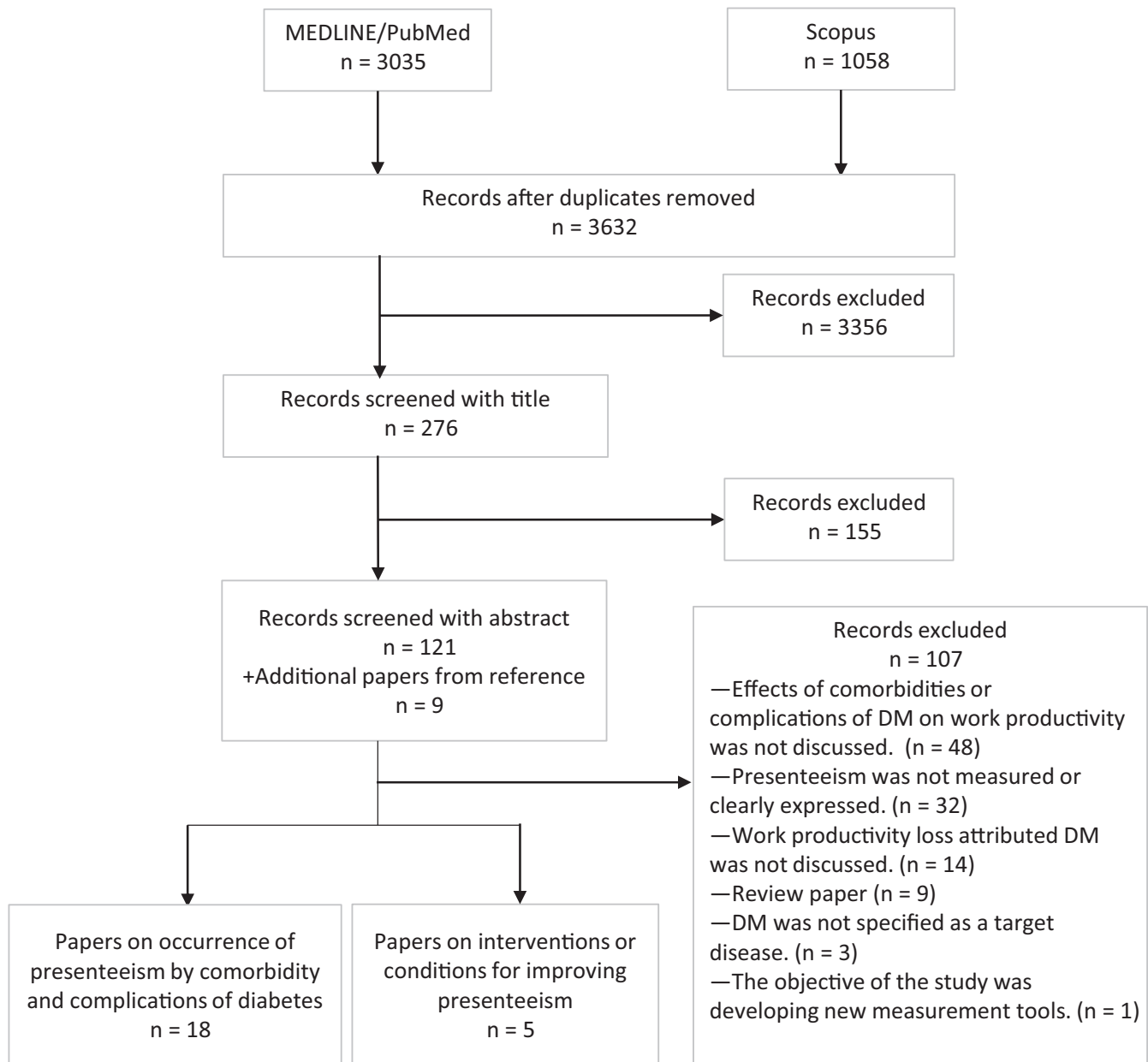


FIGURE 1 Flowchart of methodology for identifying papers included in the systematic review

studies and three items for cross-sectional studies), (b) comparability of these groups (one item for both studies), and (c) ascertainment of either exposure or outcome of interest (three items for cohort studies and one item for cross-sectional studies). A study could be awarded a maximum of 1 star for each item within the selection and outcome categories and a maximum of 2 stars for comparability. The overall quality rating was calculated as the sum of stars (maximum of 9 stars for cohort studies and 6 stars for cross-sectional studies). Interventions and conditions differed among papers on effective interventions or conditions for improving presenteeism attributed to diabetes. Thus, we judged quality of evidence was judged with NOS for a cohort study and a cross-sectional study and the risk of bias was judged with the

Cochrane Handbook for Systematic Reviews, Version 5.1.0 for interventions.²⁹

3 | RESULTS

We found 18 papers that studied the occurrence of productivity loss including presenteeism by comorbidities and complications of diabetes (Table 1). Sixteen papers were cross-sectional studies and 7 of them did not mention the control group. Two were cohort studies. Most of the papers had relatively low qualities of evidence which were evaluated by NOS as shown in Table 1. We also identified 5 papers that discussed effective interventions or conditions for improving presenteeism

attributed to diabetes (Table 2). Of them, there were a cross-sectional study and a cohort study, and their qualities of evidence evaluated by NOS were shown in Table 2. Three were interventions, and they were a randomized control trial, a non-randomized control trial, and a pre-post intervention comparison study. Their risks of bias were high.

Also, among the 23 papers, 12 papers were focused on type 2. However, type 1 and type 2 were combined in 5 papers and the type with diabetes was not clarified in 5 papers. Therefore, we decided not to be conscious of the type of diabetes mellitus.

3.1 | Occurrence of productivity loss

DiBonaventura et al³⁰ studied loss of work productivity of type 2 diabetes associated with tolerability issues of oral anti-diabetic agents. As the number of tolerability issues increased, presenteeism worsened after adjusting for demographics, comorbidities of diabetes, and disease characteristics. Patients with 1, 2, 3, and 4 or more issues were projected to have presenteeism costs that were \$1583, \$3662, \$5940, and \$6190 or greater, respectively, and these costs were much higher than absenteeism costs. Although not specific for presenteeism, hypoglycemia, headache, water retention (edema), and weight gain were the only tolerability issues significantly associated with greater total work impairment.

Comorbidities and complications whose effects on presenteeism were relatively well studied included hypoglycemia, neuropathy, and mental disorders, mainly depression. Nine papers evaluated effects of hypoglycemia on work productivity including presenteeism. Brod et al³¹ reported that among individuals reporting a non-severe hypoglycemia event (NSHE) at work, 23.8% reported missing a meeting or work appointment or not finishing a work task on time. Among respondents experiencing an NSHE outside working hours (including nocturnal NSHE), 31.8% reported that they missed a meeting or work appointment or did not finish a work task on time due to the nocturnal NSHE. Brod et al³²⁻³⁴ also reported that the impact of non-severe nocturnal hypoglycemia events (NSNHE) was apparent for those who worked the next day in the US, Canada, and European Union countries. When compared with respondents with type 1 diabetes, those with type 2 appeared to experience more presenteeism associated with an NSNHE. Also, US respondents were least likely to report presenteeism, and respondents from French had the highest rate of presenteeism when comparing 4 countries, ie, USA, UK, Germany, and France.³² The impact of the NSNHE on presenteeism was higher than that for groups defined as normal controls in two recent studies when evaluated with Endicott Work Productivity Scale scores.^{33,34} Moreover, 25.0% of the subjects reported that the NSNHE had a high impact on productivity at work the following day, 32.1% reported a moderate impact, 18.9% reported a little

impact, and 24.0% reported no impact with Likert scale assessment.³³ However, Ohashi et al³⁵ evaluated the impact last NSHE on presenteeism by a question on missing a meeting/work appointment or failing to finish a task in Japanese population, and observed 25% of respondents with last daytime were missing a meeting/work appointment or failing to finish a task, but only 2% with last night-time NSHE were reported the impact. Meneghini et al³⁶ categorized type 2 diabetes patients in the US based upon self-reported experience in the past 3 months, and reported that patients with severe hypoglycemia had significantly greater presenteeism compared with patients with non-severe or no hypoglycemia, but there was no significant difference in presenteeism between non-severe and no hypoglycemia. Pawaskar et al³⁷ also reported similar results from US population. Mitchell et al³⁸ analyzed self-reported hypoglycemic episode at 6 follow-up assessments separated by 4 weeks in the United Kingdom. At the baseline survey, about 35.3% of employed respondents who experienced at least 1 hypoglycemia experience (HE) in the month had work impairment in the prior 7 days, which was approximately double of those without HE. However, there was no significant difference in work impairment between those with HE and without HE during the follow-up period, although the analysis included only a small number of samples who completing all surveys. Lopez et al³⁹ compared presenteeism attributed to diabetes among those who had experienced hypoglycemia in the previous 3 months (recent), in the past but not in the previous 3 months (non-recent), and those who had never experienced hypoglycemia (never). The recent group had significantly higher presenteeism (21.3%) compared with those in non-recent (15.1%) or never (14.0%) groups.

Five papers assessed the effects of diabetic neuropathy on work productivity including presenteeism attributed to diabetes. Stewart et al²² reported that those with neuropathic symptoms were substantially more likely to report the need to change the number of hours worked or their jobs and that there was a moderate-to-severe impact on their job performance in 1 US population-based study. DiBonaventura et al⁴⁰ compared presenteeism among the healthy control group, diabetes without painful peripheral neuropathy (pDPN) group, and pDPN group across 3 years and reported that both the control and diabetes without pDPN groups reported significantly lower levels of presenteeism than the pDPN group. The other papers were clinic-based studies. Gore et al⁴¹ observed 64.4% patients with pDPN among those who worked reported work productivity loss due to the symptom and accomplished less at work an average of 15.2 days in the preceding 3 months. Taylor-Stokes et al⁴² analyzed self-reported data from employed individuals diagnosed as pDPN and reported impairment while working increased as pDPN severity levels worsened. Estimated loss productivity and annual related costs were 21.0% and \$8266, 33.7% and \$15 449, and 60.5% and \$24 300 for mild,

TABLE 1 Summary of papers on presenteeism in patients with comorbidities or complications of diabetes

Comorbidities or complications	Authors	Year published	Country of study	DM type	Data source/sample recruitment
Tolerability issues					
Tolerability issues with oral antidiabetic agents (eg, constipation or diarrhea, headache, loss of appetite, nausea or vomiting, upper respiratory tract infection, genitourinary tract infections, water retention or edema, unintended weight loss/gain, yeast infections, hypoglycemia, and cardiovascular events)	DiBonaventura et al ³⁰	2011	USA	Type 2	Invited T2DM patients identified from 3 other surveys via e-mail
Hypoglycemia					
Self-reported non-severe hypoglycemia event (NSHE): a hypoglycemic situation in which the patient had low blood glucose but did not require help from anyone else to manage the episode	Brod et al ³¹	2011	USA, UK, Germany, France	Types 1 and 2	Recruited subjects online via a wide range of permission, e-mail recruitment, affiliate networks, and website advertising
Self-reported NSNHE: a night-time hypoglycemic episode that occurred while sleeping and did not require medical attention or did not require help from anyone else to manage the hypoglycemia	Brod et al ³²	2012	USA, UK, Germany, France	Types 1 and 2	Recruited respondents from a variety of online venues, including website advertising, affiliate networks and email recruitment, and via face-to-face or telephone interview
Self-reported non-severe nocturnal hypoglycemia event (NSNHE): a night-time hypoglycemic episode that occurred while sleeping and did not require medical attention or did not require help from anyone else to manage the episode	Brod et al ³³	2013	USA, Canada, UK, Germany, France, Italy, Spain, The Netherlands, Sweden	Types 1 and 2	Recruited subjects from more than 100 websites as well as from face-to-face and telephone surveys.

Sample size	Measure of presenteeism	Key conclusions on presenteeism	Research design	Quality of evidence ^a
2074 eligible patients among 4316 respondents from 10374 contacted	Work productivity and activity impairment questionnaire (WPAI)	As the number of tolerability issues increased, presenteeism worsened by 8.65%, 14.99%, 20.08%, and 21.96% for those with 1, 2, 3, and 4 or more issues, respectively, after adjusting for demographics, comorbidities, and disease characteristics. When monetizing, total annual adjusted presenteeism costs were \$1585, \$3662, \$5940, and \$6190 or greater for patients, respectively.	Cross-sectional study	4/6
A total of 6756 respondents with self-reported diabetes were screened. Of these, 2669 reported an NSHE during the last month, 1431 reported working for pay; 1404 respondents were finally analyzed after excluding those who did not remember.	Evaluated impact on work productivity by reports of missing a meeting or work appointment or not finishing a work task on time.	Lost productivity was estimated to range from \$15.26 to \$93.47 per NSHE, representing 8.3–15.9 h of lost work time per mo. Among individuals reporting an NSHE at work (n = 972), 23.8% (n = 231) reported missing a meeting or work appointment or not finishing a work task on time. Among respondents experiencing an NSHE outside working hours (including nocturnal; n = 612), 31.8% (n = 197) reported that they missed a meeting or work appointment or did not finish a work task on time due to the nocturnal NSHE.	Cross-sectional study	1/6
A total of 6756 respondents with diabetes were screened. Of these 2600 (1280 type 1 and 1320 type 2) had experienced one or more NSHE at any time in the past month. Of these respondents, 1086 (676 type 1 and 410 type 2) indicated that they had experience one or more NSNHE while asleep at night.	Evaluated the impact by a question on missing a meeting/work appointment or failing to finish a task.	Compared with respondents with type 1 diabetes, those with type 2 appeared to experience more presenteeism associated with an NSNHE (8.7% vs 14.4%). US respondents were least likely to report presenteeism, and respondents from French had the highest rate of presenteeism.	Cross-sectional study	1/6
A total of 20 212 respondents with self-reported diabetes were screened. Of these 2673 respondents who reported an NSNHE during the last month, 2108 patients completed the survey; 1100 reported working for pay.	Endicott Workplace Productivity Scale (EWPS) and Likert scale assessment with the question “How much has this NSNHE impacted productivity at work?”	For those who worked the next day, the impact of the previous night event was apparent, with 42.6% reporting that they had trouble focusing or concentrating at work the next day, 20.1% reporting they could not complete work tasks on time, and 15.6% reporting they needed to reschedule their work time. Additionally, 25% of the respondents reported that the NSNHE had a high impact on work productivity the following day, 32.1% reported a moderate impact, 18.9% reported a low impact, and 24.0% reported no impact. Based on EWPS scores, the impact on presenteeism had a mean score of 21.3 (SD = 21.0), which was significantly higher than those for groups defined as normal controls [ranging from mean 3.54 and mean 15.6 (SD = 11.7) to 18.2 (SD = 10.7)].	Cross-sectional study	1/6

(Continues)

TABLE 1 (Continued)

Comorbidities or complications	Authors	Year published year	Country of study	DM type	Data source/sample recruitment
Self-reported NSNHE: a nighttime hypoglycemic episode that occurred while sleeping and did not require medical attention or did not require help from anyone else to manage the hypoglycemia	Brod et al ³⁴	2013	Canada	Types 1 and 2	Recruited subjects from more than 100 websites as well as from face-to-face and telephone surveys
Self-reported hypoglycemia episode	Mitchell et al ³⁸	2013	UK	Type 2	Identified potential respondents through the 2011 5EU National Health and Wellness Survey (NHWS) and the diabetes chronic ailment panel of Light Speed Research in the UK. Invitation emails were sent to 7144 panelists who indicated that they had diabetes
Self-reported hypoglycemia episode	Lopez et al ³⁹	2014	USA	Type 2	Used data from the 2012 US NHWS. In the survey, participants were recruited through opt-in emails, co-registration with other panels, e-newsletter campaigns, and online banner placements
Self-reported NSHE	Ohashi et al ³⁵	2017	Japan	Types 1 and 2	Recruited respondents through multiple online channels, such as website advertising, permission emailing, and affiliate networks
Self-reported hypoglycemia event	Meneghini et al ³⁶	2017	USA	Type 2	Used data from the 2011, 2012, and 2013 US NHWS. Potential respondents were identified through the general panel of Lightspeed Research

Sample size	Measure of presenteeism	Key conclusions on presenteeism	Research design	Quality of evidence ^a
A total of 2279 respondents with self-reported diabetes were screened, of which 239 reported an NSNHE during the previous month. Of the 239 respondents, 200 completed the survey and 87 reported working for pay	EWPS and Likert scale assessment with the question “How much has this NSNHE impacted work productivity?”	For those who worked the next day, the impact of the previous night’s event was apparent, with 44.8% reporting they had trouble focusing or concentrating the next day at work, 24.1% reporting they could not complete work tasks on time, and 18.4% reporting they needed to reschedule their work day. Additionally, 33.3% reported that NSNHEs had a high impact on work productivity the following day, 33.3% reported a moderate impact, 17.2% reported a low impact, and 16.1% reported no impact. Based on EWPS scores, the impact on presenteeism had a mean score of 24.1 (SD = 21.6), which was significantly higher than those for groups defined as normal controls in two recent studies [ranging from mean 3.54 and 15.6 (SD = 11.7) to 18.2 (SD = 10.7)]	Cross-sectional study	1/6
Those who gave consent were screened for a physician diagnosis and current use of prescription medications. Respondents who used only oral medicine were excluded. The remaining participants were directed to the baseline questionnaire. Among 1329 respondents who completed the baseline survey, 448 were employed. Five follow-up assessments separated by 4 weeks were completed by 836, 759, 765, 511, and 451 respondents	WPAI	At the baseline survey, about 35.5% of employed respondents experienced ≥ 1 hypoglycemia experience (HE) in the month prior to the survey, which was approximately double the work impairment in the prior 7 d experienced by those without ≥ 1 HE (16.6%). However, there was no significant difference in work impairment between those with ≥ 1 HE (n = 83) and without HE (n = 72) during the study among those completing all study surveys. Baseline comparisons showed that worse HbA1c and greater healthcare resource use was associated with HE	Cohort study	3/9
Among 71 157 participants, a total of 7239 participants reported a diagnosis of type 2 DM, and 6065 were treated with antihyperglycemic agents. Additionally, 5756 knew their hypoglycemia status; 1688 had experienced hypoglycemia within the previous 3 mo (recent), whereas 1516 had experienced hypoglycemia in the past but not in the previous 3 mo (non-recent) and 2552 had never experienced hypoglycemia (never)	Presenteeism was defined as the percentage of overall work impaired by hypoglycemia-related health issues	Those with recent hypoglycemia had significantly higher presenteeism (21.3%) compared with those with non-recent hypoglycemia (15.1%) or never (14.0%). Compared with those who never experienced hypoglycemia, those who experienced hypoglycemia tended to be more aware of their HbA1c levels, have higher HbA1c levels, and were less adherent to their antihyperglycemic medications	Cross-sectional study	2/6
A total of 411 respondents among 3145 screened met inclusion criteria that were treatment with insulin aged 20 y old and above and completed the survey	Evaluated the impact by a question on missing a meeting/work appointment or failing to finish a task	As for last daytime NSHE, 25% of respondents were missing a meeting/work appointment or failing to finish a task. As for last night-time NSHE, only 2% were reported the impact	Cross-sectional study	2/6
A total of 17 676 unique respondents were identified, and of whom 2423 met inclusion criteria. Patients were categorized into “no hypoglycemia in the past 3 mo (n = 938), non-severe hypoglycemia (n = 1335), and severe hypoglycemia (n = 150)	Work Productivity and Activity Impairment questionnaire (WPAI)	Patients with severe hypoglycemia (adjusted mean 33.7%) had significantly greater presenteeism compared with patients with non-severe (18.6%) or no hypoglycemia (15.5%), but there was no significant different in presenteeism between non-severe and no hypoglycemia	Cross-sectional	4/6

(Continues)

TABLE 1 (Continued)

Comorbidities or complications	Authors	Year published year	Country of study	DM type	Data source/sample recruitment
Self-reported hypoglycemia event (Severe hypoglycemia was based on the need for external assistance)	Pawaskar et al ³⁷	2018	USA	Type 2	Used data from the 2013 US NHWS. Patients with Type 2 diabetes were identified by their answers
Peripheral neuropathy					
Painful diabetic distal symmetrical sensorimotor polyneuropathy (DPN) (Community-based practitioners diagnosed)	Gore et al ⁴¹	2006	USA	Not Specific	Recruited by 17 community-based practitioners from settings across the US
Self-reported diabetes-related neuropathy (respondents reported in the affirmative to the question on sensory symptoms)	Stewart et al ²²	2007	USA	Not specific	Used data of American Productive Audit, which was a national random-digit-dial telephone survey of US population. A total of 42 107 interviews were completed. Of these, 36 634 were eligible based on occupation
Painful diabetic peripheral neuropathy (self-administered questionnaire)	DiBonaventura et al ⁴⁰	2011	USA	Type 2	Obtained data through an annual cross-sectional study across the US. The sample was identified through a web-based consumer panel. Participants who completed 3 consecutive waves were included
Painful diabetic peripheral neuropathy (pDPN) (with a confirmed diagnosis by physicians)	Taylor-Stokes et al ⁴²	2011	France, Germany, Italy, UK	Not specific	Collected data in clinical practice settings by physicians. Patients were invited to participate by completing questionnaires

Sample size	Measure of presenteeism	Key conclusions on presenteeism	Research design	Quality of evidence ^a
The analysis included 3630 participants—1729 of whom reported having non-severe hypoglycemia and 172 of whom had severe hypoglycemia in the previous 3 mo. Among survey participants, 1130 (31.3%) were employed	Work Productivity and Activity Impairment questionnaire (WPAI)	Presenteeism were significantly associated with severity of hypoglycemia event (no hypoglycemia 17.7%, non-severe hypoglycemia 18.7%, and severe hypoglycemia 31.2%). Mean annualized costs due to presenteeism also increased with increasing severity of hypoglycemia (no hypoglycemia \$5600.70, non-severe hypoglycemia \$6263.30, and severe hypoglycemia \$9090.00)	Cross-sectional	4/6
Among 265 patients who met all study eligibility criteria, 255 returned completed surveys. In the preceding 3 mo, 73 of patients worked either part-time or full-time	Evaluated by the question, days accomplished less at work	Among patients who worked, 64.4% reported work productivity loss due to painful DPN and accomplished less at work an average of 15.2 (SD = 18.5) d in the preceding 3 mo	Cross-sectional	2/6
The study included 19 075 occupation-eligible individuals 40-65 y of age. All analyses compared those without self-reported diabetes (n = 18 042), individuals with diabetes but without neuropathic symptoms (n = 642), and individuals who reported both diabetes and neuropathic symptoms (n = 391)	Hour-equivalent per week of health-related reduced performance on days at work was determined. Presenteeism was quantified by the occurrence of 5 specific work behaviors (losing concentration, repeating a job, working more slowly than usual, feeling fatigued at work, and doing nothing at work) and the average amount of time between arriving at work and starting to work on days not feeling well	Among the respondents with diabetes who remained in the workforce, those with neuropathic symptoms were substantially more likely to report the need to change the number of hours worked (11.5% vs 4.4%) or their jobs (10.7% vs 4.4%) and that there was a moderate-to-severe impact on their job performance (11.6% vs 3.9%) compared with those without neuropathic symptoms	Cross-sectional study	5/6
Participants were categorized into 1 of 3 groups: those with pDPN (n = 290), those with type 2 diabetes but without pDPN (n = 1037), and those not diagnosed with type 2 diabetes (control group; n = 8162). Among them, only employed patients were measured for work productivity loss	WPAI	Across the 3 y, both the control and diabetes without pDPN groups reported significantly lower levels of presenteeism (12.8% and 13.5%, respectively) than the pDPN group (17.8%)	Cohort study	5/9
In this study, 634 individuals identified as having a confirmed diagnosis of pDPN, 124 of whom were employed individuals and had available WPAI data	WPAI	Employed individuals reported greater impairment while working at increasing pDPN severity levels. Estimated loss productivity and annual related costs among employed individuals were 21.0% and \$8266, 33.7% and \$15449, and 60.5% and \$24300 for mild, moderate, and severe pDPN, respectively. These costs appeared to be primarily driven by presenteeism	Cross-sectional study	3/6

(Continues)

TABLE 1 (Continued)

Comorbidities or complications	Authors	Year published year	Country of study	DM type	Data source/sample recruitment
Peripheral diabetic neuropathy (diagnosed with pDPN at least 6 mo earlier)	Sadosky et al ⁴³	2013	USA	Not specific	Recruited subjects during routine visits from general practitioner and specialists sites
Mental conditions					
Mood disorders including depression, bipolar disorder, mania, or dysthymia (self-reported through interview)	Bielecky et al ⁴⁴	2016	Canada	Not specific	Used cross-sectional secondary data from the 2003, 2005, 2007, 2009, and 2010 cycles of the Canadian Community Health Survey in which data were collected through interview
Poor and very poor mental well-being (evaluated using the mental component summary)	Bolge et al ⁴⁵	2016	USA	Type 2	Used data from the 2013 US NHWS, an annual, cross-sectional study of the US adult population. Data were collected through a self-administered internet-based questionnaire
Cognitive impairment					
Cognitive impairment self-reported with perceived defects questionnaire	Lee et al ⁴⁶	2017	Canada	Type 2	Selected individuals as a part of a motivation study through employers' third-party health insurance providers and/or directly by the project team

^aQuality of evidence was evaluated with the Newcastle Ottawa Scale and is expressed as number of stars gained/maximum number of stars for each study type.

moderate, and severe pDPN, respectively. The authors also mentioned that costs appeared to be primarily driven by presenteeism. Sadosky et al⁴³ also observed mean overall work impairment as pain severity increased but did not note a significant difference, likely due to the small number of subjects employed for pay.

Two papers studied effects of mental conditions on presenteeism attributed to diabetes. Bielecky et al⁴⁴ reported that respondents with both diabetes and mood disorder including depression, bipolar disorder, mania, or dysthymia have higher presenteeism and fully adjusted prevalence ratio than those with either diabetes or mood disorder only. However, a significant negative interaction was observed with the combination of the two conditions. Bolge et al⁴⁵ reported that those with very poor mental well-being evaluated by the mental component summary had higher presenteeism than those with poor and good mental well-being, and those with poor

mental well-being had higher presenteeism than those with good mental well-being.

Lee et al⁴⁶ evaluated the mediational effect of depressive symptoms and cognitive impairment on work productivity to understand the mechanistic link between diabetes and work productivity loss. Self-rated depressive and cognitive symptoms were positively correlated with work impairment among subjects with or at risk for diabetes and cognitive impairment severity partially but significantly mediated the association between depressive symptom severity and work impairment.

3.2 | Effective interventions or conditions

There are two main approaches that improve productivity loss including presenteeism, ie, approaches to individuals and those to work accommodations. Among 5 papers, 4 were

Sample size	Measure of presenteeism	Key conclusions on presenteeism	Research design	Quality of evidence ^a
Among 112 subjects, 20 were employed for pay	WPAI-Specific Health Problem	Mean overall work impairment among subjects employed for pay was 43.6%, which worsened as pain severity increased. However, this difference was not significant due to the small number of subjects	Cross-sectional study	3/6
Among 132 072 eligible respondents, 120 005 respondents who met inclusion criteria were used in the analysis	Evaluated by the question, “Does a long-term physical condition, mental condition, or health problem reduce the amount or kind of activity you can do at work?” “Sometimes” or “often” were classified into presenteeism, and “never” was classified into no presenteeism	About 37.6% of respondents with both diabetes and a mood disorder have presenteeism. The fully adjusted prevalence ratio of the group was 1.78, which was significantly higher than those with either diabetes or diabetes. However, a significant negative interaction was observed between the 2 conditions	Repeated cross-sectional study	5/6
Among 7852 respondents, 1701 experienced very poor mental well-being, 1781 poor mental well-being, and 4370 good mental well-being	WPAI-General Health questionnaire	Respondents with very poor mental well-being had higher presenteeism than those with poor and good mental well-being. Additionally, respondents with poor mental well-being had higher presenteeism than those with good mental well-being	Cross-sectional study	4/6
A total of 3627 individuals were screened, 1738 met eligibility criteria, and 724 consented. Among them, 205 subjects with pre/diabetes were included in the study	EWPS	Self-rated depressive and cognitive symptoms were positively correlated with work impairment among subjects with or at risk for diabetes. Self-rated measures of cognitive impairment mediated the association between depressive symptom severity and workplace impairment	Cross-sectional study	3/6

related to individual approaches and the other was related to work accommodations.

Loeppke et al⁴⁷ analyzed medical pharmacy claims data from large corporations including health risk appraisal and reported medication adherence is a significant predictor of job performance for the type 2 diabetes with insulin, oral hypoglycemic agent, or metformin group. Katcher et al⁴⁸ studied the effects of a vegan nutrition program for individuals with body mass index ≥ 25 kg/m² and/or previous diagnosis of type 2 diabetes at a large corporate site on work productivity, and participants in the vegan diet group reported a 40% decrease in the number of health problems affecting work productivity. Adepoju et al⁴⁹ compared presenteeism among subjects aged ≥ 18 years with type 2 diabetes randomized into 4 study arms: 1 usual care arm and 3 self-management program arms. There were no statistically significant differences among the groups, although presenteeism was calculated with a multiplication

factor obtained from prior literature. Bevis et al⁵⁰ provided 12 months wellness programs including screening and measurement of baseline indices, educational sessions, telephonic support, quarterly laboratory monitoring, and provision of glucometers and test stripes to employees with diabetes at a major employer in the US. There was significant improvement in both HbA1c levels and presenteeism scoring between pre- and postintervention. They reported that improved stress management and perceived improvement in health were the major contributors to improved presenteeism scoring.

As for work accommodations, Gifford et al⁵¹ observed 5.11 times greater odds that an employee who did not receive a needed accommodation experienced a higher level of lost productivity than an employee who received a needed accommodation. However, they found no interactions between chronic health problems including metabolic condition and accommodations.

TABLE 2 Summary of papers on effective interventions or conditions for improving presenteeism attributed to diabetes

Conditions or interventions	Authors	Year published	Country of study	DM type and other conditions	Data source/sample recruitment
Medical adherence (medical possession ratio)	Loeppke et al ⁴⁷	2011	USA	Type 2	Employee medical pharmacy claims data from five large corporations including health risk appraisal (HPA)
Nutrition program	Katcher et al ⁴⁸	2010	USA	BMI \geq 25 and/or Type 2 diabetes	Recruited from 2 large corporate sites of an insurance company
Self-management program	Adepoju et al ⁴⁹	2014	USA	Type 2	Recruited potential subjects selected with electronic medical records from a large university-affiliated healthcare system
Employer-supporting combination programs involved screening and measurement of baseline indices, education sessions, telephonic support, quarterly laboratory monitoring, and provision of glucometers	Bevis et al ⁵⁰	2014	USA	Type 2 (Type 1 diabetes was excluded)	Recruited by multimedia publicity on the employer campus and home mailings. Simultaneously sequestered review by the single payer on the basis of previously diagnosed and/or treated diabetes
Needed work accommodation	Gifford et al ⁵¹	2017	USA	Not specific Evaluate as a metabolic condition with hypertension and high cholesterol	RANS's Corporation's American Life Panel with several existing surveys and a representative sample of US consumers. The panel includes about 6000 respondents from over 5000 US households

^aQuality of evidence was evaluated with the Newcastle Ottawa Scale and is expressed as number of stars gained/maximum number of stars for each study type.^bQuality of evidence was evaluated with the Cochrane Handbook for Systematic Reviews, Version 5.1.0, and is expressed as risk of bias.

Sample size	Measure of presenteeism	Key conclusions on work productivity including presenteeism	Research design	Quality of evidence ^a
A total of 115 991 HPA surveys were completed and 64 422 unique employees were included in the survey. A total of 1312 employees had Type 2 diabetes and required insulin, oral hypoglycemic agent, or metformin	Work Performance Questionnaire (HPQ)	Medication adherence (categorical MPR) is a significant predictor of job performance (absenteeism, presenteeism) for type 2 diabetes with insulin or oral hypoglycemic agent or metformin group. Those with an MPR $\geq 80\%$ have 2.34 h more work performance over a 28-d period than those with an MPR $< 80\%$. However, no significant relationship with absenteeism was observed	Cohort study (retrospective)	6/9 ^a
Of 170 who met criteria, 68 participated in the intervention group and 45 participated in the control group	Work Productivity and Activity Impairment questionnaire, general health version (WPAI-GH)	Participants in the vegan diet group reported a 40% decrease in the amount that health problems affected their work productivity (absenteeism + presenteeism)	Non-randomized control trial	High ^b
A total of 1897 potential subjects were contacted, 922 of whom voiced their interest in the study. Of these, 376 individuals met the study criteria and agreed to participate in the study	Any impairments or health problems that limited the kind or amount of paid work subjects could perform and multiplied the factors obtained from prior literature	Interventions were personal digital assistant (PDA), chronic disease self-management program (CDSMP), and PDA and CDSMP combined. Presenteeism comprised 44% of total productivity loss, but there were no statistically significant differences among persons undergoing any of the 3 diabetes management interventions compared with subjects in the usual care group	Randomized control trial	High ^b
Of the employees with diabetes, 175 participants in the full 12 mo of the program. Of these, 151 of the 175 employees attended at least 2 educational sessions and met all inclusion criteria	Total 6-item Stanford Presenteeism Scale (SPS-6)	SPS-6 scores for employees with diabetes were compared at the beginning and the end of the program. There was a highly significant increase in SPS-6 scoring (improvement). Improved stress management and perceived improvement in health were the major contributors to improved scoring. From HbA1c values of $8.02\% \pm 1.90\%$ at 0 mo, there was significant improvement in HbA1c levels at 6 mo ($7.13\% \pm 1.43\%$), but the HbA1c improvement slipped to a more modest outcome by 12 mo ($7.48\% \pm 1.52\%$)	Pre-post intervention comparison	High ^b
Of 1396 invited participants, 1174 respondents were followed up. Of these respondents, 7.7% of them had diabetes	Measured the extent by which health problems affect participants' work productivity	The odds that an employee who did not receive a needed accommodation reported a higher level of lost productivity are 5.1 times the odds for an employee who received a needed accommodation. However, there were no interactions between chronic health problems, including metabolic problems and accommodations. This suggests that the association between accommodations and productivity loss are similar on average for employees with and without any of the reported problems	Cross-sectional study	4/6 ^a

4 | DISCUSSION

Diabetes has steadily increased globally, and it is expected that not only direct costs but also indirect costs will also continue to increase.¹ Among them, losses of presenteeism occupy a substantial part of indirect costs of workers; thus, it is considered that countermeasures against presenteeism are more important than the burden of medical expenses from the standpoint of the employer. Also, in supporting workers trying to continue their work while receiving treatment for diabetes, presenteeism, defined as the health-related productivity loss while paid work,¹⁹ is the difficulty of work itself that needs the support. To develop and implement effective measures against presenteeism, it is necessary to clarify the mechanism of its occurrence and consider improvement measures. Therefore, we conducted a systematic review to identify factors that induce presenteeism and methods to improve presenteeism attributed to diabetes.

4.1 | Comorbidities and complications of diabetes which induce presenteeism

Papers on occurrence factors of presenteeism attributed to diabetes were limited and most of them were published after 2011. We adopted NOS to evaluate the quality of evidences for cohort studies and the modified NOS by Breton et al²¹ for cross-sectional studies. As a result of the evaluation, they had a low quality of evidence. However, it was found that the associations of hypoglycemia,³¹⁻³⁹ diabetic neuropathy,^{22,40-43} and mood disorders with presenteeism^{44,45} had been relatively well studied in this review. This is probably because these comorbidities and complications occur relatively frequently, and reasonably high presenteeism may occur due to accompanying symptoms. However, these comorbidities and complications result from different causes. That is, hypoglycemia is associated with inappropriate treatment and poor adherence. A few papers reported that it caused productivity loss even when the symptoms were not severe³¹ or occurred at night,^{33,34} although there are conflicting reports that there was no significant difference in presenteeism between non-severe and no hypoglycemia.^{36,37} Diabetic neuropathy is 1 of the 3 major complications arising from long-term poor glycemic control, and it is observed that when the pain becomes stronger, larger productivity loss occurs.⁴² Although the exact cause remains unclear, diabetes has a high incidence of mood disorders as with other chronic diseases.⁴⁴ Presenteeism increases with both diabetes and mood disorders, although the interaction is not recognized. It is also thought that mood disorders affect diabetes control.⁵² In addition, presenteeism worsens with worsening of diabetes complications.⁵³

4.2 | Possible interventions or conditions which improve presenteeism effectively

Although there is limited information on causes of presenteeism attributed to diabetes, based on the findings obtained in this systematic review, improving diabetes control, evaluating the effect of treatment on work productivity and adjusting treatment, and providing psychological support are expected to be important methods to improve presenteeism. However, intervention studies based on these possibilities have been hardly investigated, as we found out only 4 related studies including randomized control trials (RCTs) with the negative result. As for reduction in presenteeism by glycemic control, Loeppke et al⁴⁷ observed medication adherence was a significant predictor of job performance, and the results indirectly suggested the effectiveness of improving glycemic control on presenteeism. Although presenteeism was not evaluated, Testa et al⁴² compared changes in glycemic control and absenteeism between an active therapy group and a placebo group in a double-blinded RCT and observed that good glycemic control for patients in the active therapy group was associated with greater improvement in absenteeism. They also observed that symptoms of distress and cognitive function improved in the active therapy group. The result suggests the possible reduction in presenteeism by glycemic control. To our knowledge, however, only 2 intervention studies with presenteeism as an outcome have been published: a retrospective observational study that examined the effect of a nutrition program⁴⁴ and an RCT of a self-management program.⁴⁹

As for presenteeism due to treatment, inappropriate treatment content and poor adherence increase the likelihood of the occurrence of hypoglycemia. Although we could not find evidence in the relevant literature, it is considered that an increase in urine volume by sodium glucose co-transporter 2 inhibitor may affect job performance. Nakajima et al⁵⁴ asked 1300 Japanese patients with diabetes, what diabetes-related issues affected their work and reported 10.5% of respondents answered that they had to frequently use the restroom. The increase in urine volume is considered to have a substantial impact on work productivity for workers who operate in an environment where they cannot freely go to the restroom. Therefore, it is necessary to select treatment regimens according to symptoms and work conditions. Collaboration between diabetes physicians and occupational physicians would be effective.

As diabetes frequently accompanies mood disorders, especially depression, diagnosis and treatment of mood disorders should be considered in the treatment of diabetes. Bogner et al⁵⁵ reported the results of an RCT that integrated diabetes management and depression treatment to improve medication adherence and conditions of both diseases. It was also reported that psychological support improves self-efficacy, resulting in improved medication adherence and health behavior, which might lead to improved glycemic

control.^{56,57} Bevis et al⁵⁰ reported that improved stress management and perceived improvement in health were the major contributors to improved presenteeism scoring by diabetes wellness care at the workplace. Safren et al⁵⁸ reported that cognitive behavioral therapy was an effective intervention for adherence, depression, and glycemic control in patients with uncontrolled type 2 diabetes and depression. Therefore, psychological support is also considered to be important for patients without mood disorders. In addition, as it was suggested that presenteeism was alleviated by work accommodations required by workers with diabetes,⁵¹ approaches to improve the work environment and work are also important, as well as those to individuals. Work accommodations should be considered with the understanding of specific issues of individual workers.

4.3 | Limitations

The main limitation is the quantity and quality of papers identified. Most studies were cross-sectional studies and control setting was sometimes insufficient. In addition, in spite that factors associated with each type of diabetes, such as age, duration, and insulin dependency, are different, we analyzed type 1 and type 2 together as they were combined or type was not specified in about half of papers.

Because presenteeism occupies a substantial part of diabetes-associated costs, especially for persons of working age, active investigation is needed.

5 | CONCLUSIONS

Presenteeism attributed to diabetes is caused by hypoglycemia, diabetic neuropathy, and mood disorders. Our systematic review suggested that improving glycemic control, adjusting treatment regimen by evaluating the impact on work productivity, providing psychological support, and developing suitable work accommodations for individual issues can effectively reduce presenteeism. However, further study is necessary considering the significant costs associated with presenteeism attributed to diabetes.

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DISCLOSURE

Approval of the research protocol: N/A. Informed consent: N/A. Registry and the registration no. of the study/trial: N/A. Animal studies: N/A.

CONFLICTS OF INTEREST

None declared.

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