Research Article

The Cost of Diabetes-Related Complications: Registry-Based Analysis of Days Absent from Work

Jan Sørensen¹ and Uffe Jon Ploug²

¹ University of Southern Denmark, J. B. Winsløvs Vej 9B, 5000 Odense, Denmark

² Novo Nordisk A/S, Vandtårnsvej 114, 2860 Søborg, Denmark

Correspondence should be addressed to Jan Sørensen; jas@cast.sdu.dk

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The aim of this study was to estimate the annual number of days absent from work associated with diabetes-related complications. Registry data were obtained for 34,882 individuals aged 18–70 years with hospital-diagnosed diabetes (ICD-10 codes: E10–E14) identified from a large national sample (40% of the Danish population) with 6 years of hospital utilisation data. The occurrence of a complication was defined as a hospital admission with a specified diagnosis or procedure code. Data on sickness episodes with municipal subsidy were retrieved for each individual. Days absent from work attributable to complications were defined as the estimated difference in absence days between individuals with and without the specified complication and were estimated for the first and subsequent years after the initial episode of the recorded complication. Angina pectoris, ischaemic stroke, and heart failure were the three most frequent complications in the population. Heart failure, amputation, renal disease, and peripheral vascular disease were on average associated with more than three-month additional absence from work during the first and subsequent years. Leg ulcers and neuropathy were associated with more days absent from work during the first year than in subsequent years. Diabetes complications are associated with a substantial number of additional days absent from work. The avoidance of these complications would benefit both patients and society.

1. Introduction

Diabetes is a chronic disease that has a serious impact on health status, duration of life, cost of health care, and social production [1]. Diabetes is associated with a number of long-term health complications, many of which impose additional costs above those associated with the disease itself and thus can be a considerable burden on health care systems [2]. Such complications are likely to incur additional indirect costs to patients, employers, and society due to absence from work caused by sickness days and early retirement.

A US-based analysis of the cost attributable to diabetes estimated an annual cost of 174 billion \$ in 2007. Two-thirds of this cost was related to health care of patients with diabetes and one-third to lost production. The cost of lost production included costs associated with “work day absence” (4%), “reduced performance at work” (34%), “permanent disability” (14%), and “premature mortality” (46%) [3]. Although

the analysis suggested that the production cost related to premature deaths was substantial, the production loss of individuals living with diabetes was also considerable, both for those in employment and those outside the labour market.

Similar findings are likely in Scandinavian countries. A recent Norwegian study found that the health care cost of diabetes accounted for three-quarters of the cost associated with diabetes, while labour market consequences accounted for one-quarter. The latter is possibly a low estimate as the analysis did not include cost related to premature mortality which may be considerable in diabetes [4]. A recent Danish cohort study found that individuals with diabetes have a 1.5–2.5 times higher mortality in comparison with the general population [5]. Similar increased mortality has also been reported in studies from Sweden and the UK [6, 7].

The health care cost of diabetic complications has been investigated in a number of studies. A Swedish study used hospital records of individuals diagnosed with diabetes to

estimate the annual hospitalisation cost of treating diabetes-related complications [8]. Complications were recorded according to ICD-10 diagnostic information, and panel data regression models were used to estimate hospital treatment costs during the year of the first complication episode, the year of the second complication episode, and subsequent years. They found that hospital-treated complications in patients with diabetes significantly elevated the treatment cost both in the year the complication occurred and in subsequent years, compared to the cost for people without diabetes. This finding is consistent with other studies (see, e.g., [9–11]).

Labour market consequences of illness include days absent from work and reduced job performance due to poor health, reduced labour force participation and reduced earnings capacity due to permanent disabilities, and lost productivity due to premature mortality [3].

The likelihood of being employed was estimated to be 10% less for men with diabetes in a US cross-sectional study of individuals aged 45+ years residing in a poor border area of South Texas [12]. Analysis of data from a nationally representative Australian sample showed that diabetes might reduce labour market participation by nearly 4% for men aged 18–49 years and 12% for men aged 50–65 years [9]. A US study focusing on women's labour force participation found that women with diabetes had a 23% lower probability of working [13], while a Canadian study showed that the likelihood of being in the labour market was 19% and 17% lower for men and women with diabetes, respectively [14]. Although these studies provide different assessments of the size of impact, they all indicate that diabetes is associated with substantial negative effects on labour market attachment.

Besides being associated with a lower probability of employment, diabetes may also be associated with lower earnings. A Swedish study using longitudinal data from 1983–2005 matched individuals with type 1 diabetes with controls of similar age, gender, and municipality at the time of diabetes diagnosis [15]. The study showed that individuals with type 1 diabetes had a considerable decline in future earnings compared with the general population.

Loss of work productivity has been studied using US longitudinal cohort data. Men and women with diabetes were 5% and 6%, respectively, more likely to have work limitations compared to those without diabetes, and individuals with diabetes had more days off work than those without diabetes [16].

Diabetes thus appears to have a significant impact on labour market attachment and social production. While several studies have assessed loss of production associated with diabetes per se, only few studies have investigated the labour market consequences of diabetic complications although the loss of production associated with diabetes most likely come from complications. In a study of macrovascular comorbidity, the number of work days missed due to illness or injury and the number of days spent in bed due to illness or injury were analysed [17]. After adjustment for a wide range of covariates, the annual work force absence related to macrovascular conditions in individuals with diabetes was estimated at 20 days. A second study looking at peripheral

neuropathy complications [18] analysed data on work productivity collected with the Work Productivity and Activity Impairment Questionnaire [19]. Individuals with peripheral neuropathy reported a 13% higher rate of work impairment than individuals with diabetes without peripheral neuropathy and even higher impairment related to general activities.

Our search of the literature revealed no studies that used health registers to identify individuals with complications or administrative registers to measure labour force absence as a consequence of diabetes-related complications.

The aim of the current study was to assess the potential impact of a range of diabetes-related complications on work production. We used registry data to identify a nationally representative sample of individuals with diabetes and to estimate the annual number of days absent from work due to complications in individuals with diabetes.

2. Methods

2.1. Identification of Individuals with Diabetes. The unique Danish person identification number enables researchers to combine individual-level data from different administrative registries, including national hospital records and the municipal sickness benefit register that contains data on absence from work [20]. Several Danish studies have used national registries to identify individuals with diabetes and estimate the prevalence of diabetes (see, e.g., [21, 22]).

The basis for the current analysis was a database of 2.2 million randomly selected Danes representing approximately 40% of the adult population aged 18–70 years. From the National Patient Registry (NPR), we obtained data about these individuals' use of hospital care during 1997–2002. From social service statistics, we obtained data on labour market attachment, registered sickness periods, and municipal reimbursement of sickness benefit payments.

In the analysis, we defined diabetes according to the ICD-10 codes E10–E14, that is, the full spectrum of diabetes including the subgroups of insulin-dependent diabetes (E10), non-insulin dependent diabetes (E11), and unspecified diabetes (E14). We included all individuals who had a hospital contact during 1997–2002 either as an outpatient or an inpatient, where diabetes was included in the registry of diagnostic codes. As this part of the analysis was concerned with identifying people with diabetes, we imposed no restrictions on the type of diabetes code and included all types of diagnoses—principal/first-line diagnosis, secondary diagnoses, and referral diagnoses. If an individual was registered by a hospital doctor as having diabetes at any time during the observation period, then we considered that individual to be diagnosed with diabetes.

The onset of diabetes was registered as the date of the earliest hospital contact for diabetes. Although many patients are initially diagnosed with diabetes by a primary care physician, such diagnosis are not registered in the administrative primary care registries. However, the NPR records the date of the first diabetes-related hospital contact in a treatment series; this variable was used to indicate the date of the first diagnosis. This meant that some individuals were diagnosed

TABLE 1: Definitions of diabetes-related complications and number of individuals identified.

Category	ICD-10 codes	Individuals identified 1997–2002	Occurred in 2001		Occurred in 2002	
(1) Myocardial infarction	I21	4503	825	18%	999	22%
(2) Angina pectoris	I20	8382	1235	15%	1186	14%
(3) Peripheral vascular disease	I700, I701, I701, I702, I708, I709, I739	4916	792	16%	761	15%
(4) Ischaemic stroke	G450, G458, G459, I678, I61, I63, I64	6715	1096	16%	1130	17%
(5) Heart failure	I46, I50	6672	1156	17%	1338	20%
(6) Renal disease	I12, I13, N18, N019, N052, N055, N058, N059, N170, N171, N172, N178, N179	1573	274	17%	427	27%
(7) Uninfected ulcer	L97	1893	362	19%	400	21%
(8) Infected ulcer	L00, L03, L08	1317	208	16%	228	17%
(9) Neuropathy	G560, G561, G562, G563, G564, G565, G566, G567, G568, G589, G990, G632, G733, M146, K318H	1869	228	12%	207	11%
(10) Amputation	Procedure codes: KNHQ14, KNHQ17, KNFQ19, KNGQ19, KNHQ11	1448	286	20%	387	27%

with diabetes before the observation period (i.e., earlier than 1997).

Only individuals who had (at least once) been hospital diagnosed with diabetes and were alive as of 1 January, 2002 were included. This strategy provided data on 34,882 individuals with diabetes aged 18–70 years. Using a four-year wash-out period (1997–2000), we identified 7860 individuals who were hospitalised and diagnosed with diabetes for the first time in 2002 (newly diagnosed patients).

2.2. Definition of Complications. Diabetes-related complications were defined according to the diagnostic or operative procedures codes provided in the NPR. Table 1 shows the ICD-10 diagnostic codes and procedure codes used. These definitions were derived from discussion with clinical experts, previous experience with analysis of complications, and inspection of the number of cases in each diagnosis. We omitted rare complications that occurred in less than 200 individuals per year. Table 1 also shows the number of individuals with diabetes who were hospitalised with complications during the whole observation period (1997–2002) and those hospitalised for complications in 2001 and 2002.

2.3. Absence from Labour Market. Data on socioeconomic status were available for 2002 and included a variable that showed the most frequent labour market status during that year. The codes included retirement due to old age (code 322), early retirement due to sickness (code 321), and early voluntary retirement (an arrangement aimed at people aged 60 years and over; code 323). Other codes indicated employed, unemployed, and under education. We excluded 185 individuals in education (code 310) and 978

outside the work force for other reasons (code 410 and missing). Of the remaining individuals, 28% were coded as early retirement due to sickness (code 321), 17% as old-age retirement (aged 66–70 years; code 322), 10% as early voluntary retirement (code 323), and 4% on social benefit (code 330). We assumed that the labour market status of these individuals was constant over the whole year and thus assigned these individuals with 365 absence/sickness days. We assumed that the remaining 42% of the sample was attached to the labour market and had absence/sickness days as recorded by their local municipality.

At the time of observation, the Danish municipalities were responsible for funding the reimbursement of sickness benefit beyond the first 14 days (later this has been changed to the first 21 days). Each illness episode that satisfies the criteria for reimbursement is recorded in a registry containing information about the type of sickness/absence and the outcome (return to work, continued rehabilitation, or departure from labour market). There is also information on the amount of reimbursement paid to the employer and employee (subsidies), the number of days that subsidies were paid for, and the full number of sickness days (i.e., including the first 14 days of the sickness period where no subsidies are paid). We obtained individual data from this registry for the year 2002.

In the event that an individual is recorded as having several sickness episodes in one year, these might represent real separate periods of illness but may also be due to the individual having more than one employer (e.g., two part-time jobs) and that subsidies have been paid to all employers for the one illness episode. The data set obtained did not include dates of illness. In the preparation of the data, we aggregated the number of days absent from work for each individual. If the same person had two records with an identical number

of sickness days, it was assumed that this person had two employers and that subsidies were paid to both. In these cases, the days of sickness were counted only once.

Only absence due to personal illness was included in the analysis (codes 11, 12, 13, 14, 17, and 22). Subsidies and absence relating to pregnancy/childbirth and sabbatical leave were excluded. All observations of days absent from work were truncated at 365 days.

2.4. Analysis. We wanted to obtain estimates of days absent from the labour market due to complications in the first and subsequent years. We used the principle of “attributable cost” [23], which proposes that by comparing the mean cost of exposed individuals (i.e., individuals with a complication) with the mean cost of nonexposed individuals (i.e., individuals without a complication), the observed difference in mean cost can be interpreted as the mean cost attributable to the exposure (i.e., the complication). This principle has been used in many registry-based analyses [20] and was used here to estimate the absence period attributable to particular complications.

For the actual estimation, we used an ordinary regression model where the estimated parameter for the dummy variable for the presence of complication was interpreted as the attributable cost of the complication.

The observed days of absence in 2002 were used as the dependent variable. The interaction variables for dummy variables for periods of 12 months after the first diagnosis (first and subsequent years) and dummy variables for the different complications (present or not) were used as independent variables. We interpreted the estimated period parameter as the average absence period (in days) associated to the particular complication.

We initially undertook the analysis for the whole sample of individuals with diabetes aged 18–70 years. Subsequent analysis included only the sample of individuals who were in the labour market, through the exclusion of individuals registered with early retirement, old age pension, and early voluntary retirement.

We report the number of individuals with and without complications and the average period of sickness for the two groups. From the regression models, we report the estimated mean absence period (days) and 95% confidence intervals.

3. Results

The estimated mean absence periods attributable to different complications are presented in Tables 2 and 3. Table 2 includes the whole sample of people with diabetes alive as of 1 January, 2002 ($n = 34,882$), while Table 3 includes mean absence periods calculated for those in the workforce only ($n = 14,746$).

The average individual with diabetes was absent from the labour market about 226 calendar days, corresponding to 61% of a year (Table 2). This figure includes both individuals in the labour market and those outside due to sickness or retirement. Individuals with one of the defined complications were absent for longer periods.

In the whole sample, 839 individuals (2.4%) were identified with new myocardial infarction in 2002. The average labour market absence attributable to the incidence of myocardial infarction was on average 62 days (95% CI: 51–74).

Of the remaining 34,043 individuals, 1,419 (4.2%) had been hospitalised with a myocardial infarction between 1997 and 2001. The average labour market absence attributable to complications in these subsequent years was 65 days (95% CI: 56–74).

Amputation, heart failure, and renal disease are complications that were associated with the longest period of labour market absence in the first year (and subsequent years) after the event, while ulcers and neuropathy were associated with shorter absence. Ischaemic stroke and peripheral vascular disease were associated with longer absence periods in years subsequent to the event.

The prevalence of complications was lower when only individuals still in the labour market were included in the analysis (Table 3). Individuals with diabetes without complications had an average 38 days of absence from work, but this figure increased considerably in the event of diabetes-related complications (e.g., 143 days after amputation). In subsequent years, individuals in the workforce had shorter periods of absence for all complications compared to the sample as a whole.

4. Discussion

In this study, we estimated the number of days absent from the labour market associated with serious health complications in individuals with diabetes. The underlying analytical principle of attributable cost was used in a regression model, in which the estimated parameters for complication dummies were interpreted as the mean absence from work due to complications. The difference in absence days was assumed to reflect the additional period of absence related to the complication. We used two samples—one with all individuals aged 18–70 diagnosed with diabetes and one including only individuals attached to the labour market. It is interesting to note that the absence period in the years after the complications was considerably lower in the analysis that includes only individuals in the labour market.

The identification of individuals with diabetes was based on hospital registration of diagnosis (inpatients and outpatients). Individuals who were diagnosed prior to 1997 and had not had a hospital contact coded for diabetes (e.g., where all diabetic management was provided by the general practitioner) would not be identified through this method. However, the six-year washout period should be long enough to capture most individuals with diabetes. Other studies have used different criteria for identifying individuals with diabetes. A previous Danish study used data from both the hospital registry (inpatient and outpatient) and the primary care registry (specific codes for chiropody services and glucose tests provided in the primary care sector) [22]. Other studies have also extracted data from laboratory and prescription databases [21, 24]. Patients with diabetes could also

TABLE 2: Estimation of additional days absent from work due to diabetes-related complications ($n = 34, 882$).

ID		First year of complication					Subsequent years of complications						
		Proportion with specific complication		Average number of days absent from work		Additional absence days (95% CI)	Proportion with Specific complication		Average number of days absent from work		Additional absence days (96% CI)		
		Without compl.	With compl.	Without compl.	With compl.		Without compl.	With compl.	Without compl.	With compl.			
1	Myocardial infarction	34043	839	226	288	62.4 (51–74)	32624	1419	223	288	64.9 (56–74)		
2	Angina pectoris	33479	1403	225	281	56.0 (47–65)	29979	3500	217	289	71.6 (66–78)		
3	Peripheral vascular disease	34159	723	225	311	86.1 (73–99)	32467	1692	221	312	91.6 (83–100)		
4	Ischaemic stroke	33963	919	225	307	81.6 (70–93)	32058	1905	220	314	94.7 (87–103)		
5	Heart failure	33986	896	225	320	95.0 (84–106)	32429	1557	220	323	102.5 (94–111)		
6	Renal disease	34541	341	226	320	93.7 (75–112)	33966	575	225	318	93.1 (79–107)		
7	Uninfected ulcer	34522	360	226	309	82.6 (65–100)	33944	578	225	300	74.7 (61–89)		
8	Infected ulcer	34593	289	227	266	39.2 (19–59)	33917	676	227	242	16.0 (3–29)		
9	Neuropathy	34565	317	227	266	38.7 (20–58)	33482	1083	226	245	19.1 (9–30)		
10	Amputation	34557	325	226	325	99.2 (80–118)	34135	422	225	315	90.2 (74–107)		

TABLE 3: Estimation of additional days absent from work due to diabetes-related complications for individuals in the workforce ($n = 14,746$).

ID	First year of complication					Subsequent years of complications				
	Proportion with specific complication		Average number of days absent from work		Additional absence days (95% CI)	Proportion with specific complication		Average number of days absent from work		Additional absence days (95% CI)
	Without compl.	With compl.	Without compl.	With compl.		Without compl.	With compl.	Without compl.	With compl.	
Myocardial infarction	14509	237	38	92	54.4 (43–66)	14154	355	38	56	18.9 (9–29)
Angina pectoris	14314	432	37	92	54.7 (46–63)	13466	848	36	51	14.9 (9–21)
Peripheral vascular disease	14598	148	38	103	65.2 (50–80)	14309	289	38	57	19.5 (9–30)
Ischaemic stroke	14522	224	38	125	87.9 (76–100)	14194	328	37	71	34.1 (24–44)
Heart failure	14586	160	38	111	73.0 (59–87)	14380	206	38	44	6.1 (–6–19)
Renal disease	14684	62	39	117	78.6 (56–102)	14595	89	38	60	21.0 (2–41)
Uninfected ulcer	14663	83	38	122	83.1 (63–103)	14529	134	38	84	45.6 (30–61)
Infected ulcer	14644	102	39	85	46.2 (28–64)	14382	262	38	49	10.4 (–1–21)
Neuropathy	14634	112	39	83	44.9 (28–62)	14216	418	38	55	16.8 (8–26)
Amputation	14688	58	38	143	104.4 (81–128)	14616	72	38	74	35.5 (14–57)

be identified from general practitioner records using the international classification of primary care [25] if access to such data could be established. However, the best approach for future studies is likely to be the national diabetes registry [26].

In defining individuals with diabetes, we did not differentiate between type 1 and type 2 diabetes. This is the result of coding in ICD-10. Diabetes is defined only according to the need for insulin, which would group all type 1 cases with those type 2 cases who required insulin. There are differences in the age distribution of complications between the two types, however, such that people with type 1 diabetes are more likely to experience complications before age 70. It would thus be useful to analyse the types of diabetes separately in future studies.

In the analysis of work absence, we have included absence for all adults aged 18–70. We assumed that the absence attributable to the diabetes complication would not have arisen if the individual had not experienced the complication, on the assumption that the labour market allowed full employment. That would be the case in situations with staff shortages, but might not be appropriate in times of high unemployment.

We did not have data on type of employment, and this might be expected to influence the opportunities to continue working after the onset of a diabetes-related complication. Also, various social characteristics variables, for example, immigration from nonwestern countries, could have been relevant for the analysis. The need for subsequent analyses to differentiate between individuals who may have a weak or strong labour market attachment is clearly evident, and the lack of such considerations in this analysis may provide a biased impression of the labour market consequences of diabetes-related complications.

The Danish pension age in year 2002 was 67 years (it was later reduced to 65 years in 2004). In our first analysis, we assumed that individuals aged 67–70 years potentially could work, as retirement age is nonmandatory and a longer working life leads to higher annual retirement benefits in subsequent years. In the public sector, however, there is a mandatory retirement age of 70 years. Only individuals in employment were considered in our second analysis.

In contrast to many other studies of production loss due to health problems, we used administrative data on absence from work. The majority of these data are registered in connection with some form of money transfer either to the employer as subsidies or direct payment as sickness pay or social pension. We have thus avoided imprecision in reporting and recalling bias that can affect the quality of survey studies. Earlier studies of sickness periods using these administrative registers were biased, as public employers were not required to register their employees' absences, as no subsidies were paid to them. This has now been changed, however, so also absences of public sector employees are included in the registry. There may be some systematic omissions in the registry data, however. According to the regulations at the time of data collection (2002), employers had to finance sickness absence of less than 14 consecutive days. That means that short absences due to minor illnesses were not included in the registry. The influence of this underreporting of work

absence is difficult to assess, as we do not know its extent, the causative health problem, or whether the rate of short-term illness differs for those in or out of the workforce.

We have focused exclusively on absence from the labour market. Other production costs associated with diabetes-related complications could include lower productivity due to presenteeism and premature death [27]. Presenteeism arises when sick individuals attend work and have lower than normal productivity. Presenteeism is usually assessed in studies based on surveys and cannot be assessed using registry data. Production loss associated with premature death is usually estimated using either the human capital method or the friction method, which assess the value of production that would have occurred if the individual had not died. Such estimations are reasonably straightforward using registry-based data on mortality and value of production (gross salary).

People with diabetes have an elevated mortality risk. Current national data suggest that individuals with diabetes have a relative risk ratio of 1.5–2.5, indicating a 60–150% increased risk of premature death [5, 26]. We have not taken mortality into account, and thus the estimates of labour market absence may be underestimated.

In the current study, absence from work has been estimated for each of the defined complications separately, thus in effect assuming independency of complications. That is a simplification in the analysis that might either under- or overestimate the duration of absence. We have not found any evidence to determine whether the effect of diabetes complications should be treated as additive or multiplicative.

Treatment of renal failure includes dialysis, but the data codes for this activity were not available from the hospital registration system. Psychiatric complications were not included as our data material only related to the somatic hospital service. A psychiatric hospital registry does exist, however, that records health services provided by the psychiatric health care sector. Other complications not requiring hospital admission or outpatient care were also disregarded, including minor complications that are usually managed within the family or by the general practitioner or other primary care providers, such as most hypoglycaemic episodes.

5. Conclusion

Existing studies have established that diabetes leads to significant indirect costs in the form of production loss, sick days, and earlier departure from the workforce. The aim of this study was to use individual-level data from national registries to assess the potential impact of diabetes-related complications on work absence.

Cardiovascular problems were the most common complications registered (the three most frequent being angina pectoris, ischaemic stroke, and heart failure). Several of the complications investigated were found to lead to an average work absenteeism of over three months.

These results indicate that a reduction in the incidence of diabetes-related complications has the potential not only to improve patient morbidity and quality of life, but also to reduce workforce absenteeism.

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