ORIGINAL ARTICLE

Polymorbidity in diabetes in older people: consequences for care and vocational training

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Objective: To investigate the prevalence of complicating and concurrent morbidities in older diabetic patients and to evaluate to what extent their occurrence affects the burden of disease and use of medical healthcare.
Study design: Cross-sectional analysis of retrospectively obtained data on comorbidities and use of medical healthcare. Healthcare registration systems were used to retrieve data on 300 patients with diabetes aged ⩾60 years who, according to the severity of their disease and intensity of care required, were treated in a regional general practitioner (GP), diabetes nurse specialist (DNS) or medical specialist (MS) practice.
Results: Complicating and concurrent morbidities were often found irrespective of the type of practice involved. After adjustments for differences in sex, age and glycosylated haemoglobin (HbA1c), the extent of complicating comorbidities showed sequential increases in patients managed by GP, DNS and MS (mean number of 3.6, 4.7 and 6.7, respectively; $p_{trend}<0.001$). However, the mean number of concurrent comorbidities was similar across all three settings (2.1, 1.8 and 2.0, respectively). Both complicating and concurrent comorbidities were similarly associated with the extent of drug use ($\beta=0.49$ (95% CI 0.40 to 0.58) and $\beta=0.57$ (95% CI 0.52 to 0.72), respectively) and the number of consultations with specialists other than the main care giver ($\beta=1.19$ (95% CI 1.15 to 1.24) and $\beta=1.21$ (95% CI 1.14 to 1.28), respectively). However, the mean number of different specialists involved in a patient's care per additional concurrent comorbidity was twice as high as per any additional complicating comorbidity ($\beta=0.60$ (95% CI 0.48 to 0.71) vs $\beta=0.31$ (95% CI 0.24 to 0.39)).
Conclusions: The use of healthcare facilities by older patients with diabetes is substantial, irrespective of the complexity of the disease and the kind of practice involved. The common manifestation of complicating and concurrent comorbidities and their varying complexity in individual patients requires a patient-oriented rather than a disease-oriented approach and vocational training programmes for care givers that are tailored to the complexity of multiple chronic diseases.

Chronic diseases are becoming a major health problem in the ageing population. As a single occurrence of a chronic disease in older people is rare, an increasing number of people with a chronic disease will have comorbidities.[1] These comorbidities can be differentiated into complicating (ie, those that occur as a complication of an index disease) and concurrent (ie, the co-occurrence of multiple chronic diseases in one patient).[2 3]

Because of the multiple aspects involved in the care of patients with a chronic disease, there is a trend to manage them by multidisciplinary teams following a disease-centred or disease-management approach, in which disease-specific guidelines are applied. Although such an approach will certainly improve management of the disease, the consequence may be that concurrent comorbidities that are not part of the disease-specific protocol or the competency of the multidisciplinary management team are not sufficiently addressed in the management of the patient.[4] Consequently, patients with concurrent comorbidities are treated by different disease-oriented management teams. This may contribute to fragmentation of care, loss of individual responsibility of the care givers involved, and confusion for the patient with multiple chronic conditions.

Diabetes mellitus is one of the most prevalent chronic diseases.[5] Patients with diabetes mellitus of long duration often have complicating comorbidities, in particular cardiovascular. In addition, because of the age-related manifestation of multiple chronic diseases, older diabetic patients in particular often have non-diabetes-related or concurrent comorbidities as well. Diabetes is therefore a good model for studying the effect of complicating and/or concurrent comorbidities on the burden of disease and consequent use of healthcare resources. However, this has not been addressed across different care settings—that is, general practitioner, diabetes nurse specialist and medical specialist practices. Therefore, we investigated, in an older population of diabetic patients currently receiving care in three settings articulated in a regional disease management model for diabetes care:

(1) the prevalence of both complicating and concurrent comorbidities and its effect on the burden of disease;
(2) the extent to which complicating and concurrent comorbidities explain the amount of medication used and the type and volume of medical care use.

METHODS

Study population and design

The study population consisted of 300 patients with diabetes, receiving care at a general practitioner (GP), diabetes nurse specialist (DNS) or medical specialist (MS) practice (100 per practice; see sample size considerations below). These three care settings are part of the disease management model for diabetes care implemented in the region of Maastricht (The Netherlands) and described previously by Vrijhoef *et al*.[6] Briefly, on the basis of disease severity, the intensity of care required (defined according to national and international guidelines),[7 8] and the patient's preference, diabetic patients are assigned to

Abbreviations: DNS, diabetes nurse specialist; GP, general practitioner; HbA1c, glycosylated haemoglobin; MS, medical specialist

one of three paths: low, medium or high intensity care. Accordingly, patients who require low-intensity care are under the primary care of the GP. The DNS is the main care giver for patients requiring medium-intensity care, and patients requiring high-intensity care are the prime responsibility of the MS (endocrinologist). This disease management model—''diabetes care Maastricht''—was fully implemented on 1 January 2003.

Inclusion criteria used were patients aged ⩾60 years on 1 January 2003 and having diabetes mellitus diagnosed before that date. Enrolment in any other healthcare study was an exclusion criterion.

The study was designed as a retrospective record review of patients' medical files (paper and electronic). It was approved by the ethics committee of the University Hospital Maastricht.

Data collection

Patients' demographic and clinical data were collected through retrospective review and cross-check of three different healthcare registration systems. Firstly, the patients' medical files were reviewed. These files were selected on the basis of lists of eligible patients made available by the administrative services within each practice; a random selection of 100 patients per practice (on the basis of patients' numbers or day of birth registered on those lists) was made by a medical student who had no previous knowledge of patients' characteristics. These files were then linked, through a unique number (for those under DNS and MS care) or date of birth (for those under GP care), to the regional University Hospital computer system, where all patients are registered. Secondly, this hospital computer system (Mirador) was reviewed. Finally, and if available, the patient's electronic file (implemented more recently within the diabetes care Maastricht model) was cross-checked to confirm the data retrieved from the other two sources. Data on healthcare use could only be assessed with the use of the Mirador system.

The data collection period was 1 January 2003 (the date the model was fully implemented) to 31 August 2006 (closing date of the study).

Glycaemic control

Glycaemic control is one of the major objectives in the clinical management of diabetes. We therefore recorded the most recent concentrations of glycosylated haemoglobin (HbA1c) and glucose control regimens used—that is, the use of insulin and/or oral glucose-lowering drugs.

Lifetime polymorbidity

Lifetime-encountered diseases other than diabetes were classified and arranged using the criteria of the International Statistical Classification of Disease and Related Health Problems (ICD-10).[9] The total polymorbidity data were then subdivided into three groups of polymorbidities. Firstly, concurrent comorbidities containing all chronic non-diabetes-related diseases were extracted. These concurrent diseases were defined as non-reversible diseases, with no chance of total rehabilitation and of long duration—for example, musculoskeletal, otolaryngological, lung, neurological and psychological diseases. Secondly, complicating comorbidities, comprising all diseases causally related (in either direction) to diabetes mellitus, were extracted. These included dyslipidaemia, obesity, neuropathy, eye disease such as retinopathy and cataract, nephropathy such as proteinuria in combination with loss of renal function assessed by serum creatinine and an estimated glomerular filtration rate <60 ml/min according to the Cockroft–Gault formula, diabetic foot disease, diabetes-related connective tissue disease and cardiovascular disease. Finally, complicating infectious diseases were classified as intercurrent diseases, as were all chronic diseases not considered to be complicating or concurrent.[3]

Mortality risk

To evaluate the burden of polymorbidities on the 1-year mortality risk, we calculated the combined Charlson Comorbidity Index. This index includes 19 weighted categories of comorbidity selected and scored on the basis of the strength of their associations with 1-year mortality and combined with age by adding an extra point for every decade starting at 50 years of age.[10 11] Diabetes, the primary (or index) disease under investigation, was not included in the score.[12] The overall score reflects the cumulative increased likelihood of 1-year mortality (the higher the score, the more severe the burden of comorbidity).

Use of drugs

The data on different types of drug used was classified and organised using the Dutch Pharmaceutical Compass 2007.[13] All chronic disease-related drugs used at the patient's last visit to the care giver or previous consultation with a specialist were counted. For analysis, these data were further specified as diabetes-related drugs.

Use of medical healthcare

The use of medical healthcare was expressed in terms of the amount of different types of medical specialties (other than the main care giver) and volume of consultations attended over the course of the previous 3.7 years—that is, from 1 January 2003 until 31 August 2006.

Sample size

On the basis of a previously observed[14] SD for the main determinant (ie, number of complicating or concurrent comorbidities) of 2.5 and an estimated SD for the main outcomes of interest (ie, number of different drugs used or number of different medical specialists consulted or number of consultations with specialists other than the main care giver) of 2.0, when the α level was set at 5% and power at 90%, a sample size of 99 subjects would be required to detect a meaningful effect size (ie, a linear regression coefficient, β) of 0.25 (expressed in units of outcome of interest per unit increase in main determinant).[15] Because we intended to investigate the

Table 1 General and clinical characteristics of study population

Characteristic	All	GP (n = 100)	DNS (n = 100)	MS (n = 100)
Female (%)	54	56	47	58
Age (years)	72.3 (7.4)	74.7 (7.7)	71.3 (7.2)	70.9 (6.7)
Type 2 diabetes (%)	98	100	100	94
HbA1c (%)	7.6 (1.3)	7.1 (1.0)	7.3 (1.1)	8.3 (1.2)
Insulin use (%)	45	22	25	87
Oral glucose-lowering drug (%)	50	66	72	11

Data are mean (SD) or percentages.
GP, general practice; DNS, diabetes nurse specialist practice; HbA1c, glycosylated haemoglobin; MS medical specialist.

Table 2 Levels of comorbidities, mortality risk (Charlson score), and use of medication and medical healthcare in the whole study population and in patients across the three practices studied

Characteristic	All (n = 300)	GP (n = 100)	DNS (n = 100)	MS (n = 100)	p Value for trend
Lifetime comorbidities per person (No)					
Total	7.0 (0.2)	5.7 (0.3)	6.5 (0.3)	8.7 (0.4)	<0.001
Complicating	5.0 (0.2)	3.6 (0.3)	4.7 (0.3)	6.7 (0.3)	<0.001
Concurrent	2.0 (0.1)	2.1 (0.2)	1.8 (0.2)	2.0 (0.2)	0.799
Mortality risk (Charlson Index score)	4.5 (0.1)	3.9 (0.2)	4.4 (0.2)	5.3 (0.2)	<0.001
Medication use (No)					
Total	6.6 (0.2)	6.3 (0.3)	6.6 (0.3)	7.0 (0.3)	0.125
Diabetes-related	5.0 (0.1)	4.6 (0.2)	5.1 (0.2)	5.5 (0.3)	0.017
Medical healthcare use (No)					
Specialties involved	4.0 (0.1)	3.3 (0.2)	3.8 (0.2)	4.9 (0.2)	<0.001
Consultations	17.1 (1.1)	9.8 (1.3)	13.2 (1.1)	38.4 (1.1)	<0.001

GP, general practice; DNS, diabetes nurse specialist practice; MS medical specialist practice
Data are mean (SE); all analyses were adjusted for age, sex and HbA1c.

associations between complicating or concurrent comorbidity, on the one hand, and the outcome variables mentioned above, on the other, in patients under care in three different settings, 297 (ie, 3×99) subjects would be needed. We therefore included a total of 300 subjects (100 per care setting) in the study.

Statistical analysis

All analyses were carried out with the Statistical Package of Social Sciences, V12.0 for Windows (SPSS Inc, Chicago, Illinois, USA). Data were first described as mean (SD) or percentage, as appropriate. Variables with skewed distribution (eg, volume of consultations) were log-transformed to meet the assumption of normal distribution required by the data analysis technique used for comparisons and associations (see below).

Analysis of covariance was then used to compare data, adjusted for age, sex and HbA1c, on comorbidities, 1-year mortality risk, medication use and healthcare use between groups of patients under GP, DNS and MS care. Linear regression models were used to investigate the associations between complicating and concurrent comorbidities (mutually adjusted), on the one hand, and drug use and medical healthcare use, on the other. Results obtained for variables that were initially log-transformed were reversed (by exponentiation) and presented in the original scale of measurement. Statistical significance was set at the 5% level—that is, $p<0.05$.

RESULTS

Table 1 summarises the general characteristics of the whole study population and patients under the primary care of a GP, DNS or MS practice.

No statistically significant differences in gender distribution between groups were found (despite fewer women in the DNS group). Patients under GP care were older than those under DNS or MS care ($\beta = 3.4$ years (95% CI 1.4 to 5.5), $p<0.01$, and $\beta = 3.8$ years (95% CI 1.8 to 5.8), $p<0.001$, respectively). Patients under MS care had higher HbA1c concentrations than those under GP and DNS care ($\beta = 1.2\%$ (95% CI 0.9 to1.5), $p<0.001$, and $\beta = 1.0\%$ (95% CI 0.7 to 1.3), $p<0.001$, respectively). Most of these patients were receiving insulin (87% vs 22% and 25%; $p<0.001$), whereas most patients under GP and DNS care were receiving glucose-lowering medication only (66% and 72% vs 11%, respectively; $p<0.001$). To account for differences between groups in sex, age and HbA1c, all the following analyses were performed with adjustments for these variables.

Table 2 shows the sex-, age- and HbA1c-adjusted levels of comorbidities, burden of disease (Charlson score), and use of medication and medical healthcare in the whole study population and in patients across the three practices studied.

All patients had at least one comorbidity. One patient had concurrent comorbidity only (0.3%), 60 patients (20%) had complicating comorbidities only, whereas the remaining 239 patients (79.7%) had both complicating and concurrent comorbidities. The mean number of complicating comorbidities increased according to patients' level of required intensity of care—that is, low (GP), medium (DNS) and high (MS). The mean number of concurrent comorbidities was similar across the three groups. The burden of polymorbidities on the 1-year mortality risk (as assessed by the Charlson Index) increased consecutively in patients under GP, DNS and MS care.

Drug use was similar in all groups; 87% of the patients used four or more drugs. The mean number of diabetes-related drugs and the mean number of different specialists involved in patient care increased gradually across GP, DNS and MS diabetes care settings. However, the total number of consultations with specialists other than the main care giver was considerably higher in patients under MS than GP or DNS care.

Table 3 shows the associations of both complicating and concurrent comorbidities with drug use and use of medical healthcare adjusted for age, sex and HbA1c. In the whole population, any additional complicating or concurrent comorbidity was similarly associated with a larger number of drugs used (0.49 (95% CI 0.40 to 0.58) and 0.57 (95% CI 0.42 to 0.72), respectively) and a greater total number of consultations with specialists (1.19 (95% CI 1.15 to 1.24) and 1.21 (95% CI 1.14 to 1.28), respectively). The increase in the number of different types of specialists involved per additional concurrent comorbidity was twice as high as per additional complicating comorbidity (0.60 (95% CI 0.48 to 0.71) vs 0.31 (95% CI 0.24 to 0.39), respectively). This pattern of association was similar across the three patient care settings.

DISCUSSION

In this study, we show that complicating and concurrent comorbidities are often found in older patients with diabetes, irrespective of the type of healthcare practice involved. We found an increasing number of complicating comorbidities in patients under GP, DNS and MS care (in this order). In contrast, the extent of concurrent comorbidities was similar between patients managed across these three different settings. Patients managed by the MS, in particular, had more complications of diabetes, a higher mortality risk, more use of medication, more specialties involved, more specialist consultations and worse metabolic control despite the more common use of insulin. In other words, patients managed by the MS were clearly more complex and therefore more difficult to control. This complexity should be taken into consideration when quality of care between different types of healthcare services are compared and when substitution of care between

Table 3 Association of complicating and concurrent comorbidities with the number of drugs used and type and volume of medical healthcare use

Outcome variable	Main determinant	All		GP		DNS		MS	
		β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value
Total drugs used	Complicating*	0.49 (0.40 to 0.58)	<0.001	0.63 (0.41 to 0.85)	<0.001	0.60 (0.42 to 0.79)	<0.001	0.47 (0.32 to 0.63)	<0.001
	Concurrent†	0.57 (0.42 to 0.72)	<0.001	0.56 (0.25 to 0.86)	<0.001	0.55 (0.30 to 0.79)	<0.001	0.55 (0.29 to 0.80)	<0.001
Specialties involved	Complicating*	0.31 (0.24 to 0.39)	<0.001	0.30 (0.12 to 0.47)	0.001	0.33 (0.18 to 0.49)	<0.001	0.22 (0.18 to 0.49)	<0.001
	Concurrent†	0.60 (0.48 to 0.71)	<0.001	0.52 (0.28 to 0.76)	<0.001	0.62 (0.40 to 0.84)	<0.001	0.60 (0.40 to 0.80)	<0.001
Total consultations	Complicating*	1.19 (1.15 to 1.24)	<0.001	1.23 (1.11 to 1.35)	<0.001	1.17 (1.08 to 1.26)	<0.001	1.06 (1.03 to 1.10)	<0.001
	Concurrent†	1.21 (1.14 to 1.28)	<0.001	1.20 (1.05 to 1.37)	0.008	1.23 (1.10 to 1.36)	<0.001	1.16 (1.10 to 1.22)	<0.001

β indicates increase in outcome variables per unit increase in complicating or concurrent comorbidity (main determinants); CI, confidence interval.
All analyses are adjusted for age, sex and HbA1c.
*Also adjusted for concurrent comorbidities;
†Also adjusted for complicating comorbidities.
GP, general practice; DNS, diabetes nurse specialist practice; MS medical specialist practice.

different types of care givers is considered. Ideally, this requires a flexible management model for the different care givers and disciplines involved. Our findings suggest that the diabetes care management model developed in our region fulfils this requirement for the most part.[6]

The Charlson Index was used firstly to associate polymorbidity with current patient management, and secondly, to estimate the complexity of disease across settings. This index, originally developed to predict relative mortality risk,[10 11] is more than a simple count of chronic conditions in one patient; it is also of value in assessing the effects of polymorbidity and predicting the use of healthcare facilities.[16] This is supported by our findings of more specialties involved and more hospital consultations for patients who were considered to have increased mortality risk on the basis of the Charlson Index.

Most studies on the occurrence of multiple chronic diseases are performed in general practices.[14 17 18] Our findings of the common occurrence of polymorbidity are in accordance with these studies, and extend the previous findings to DNS and MS practices. Similar studies have been carried out for other chronic diseases such as chronic obstructive pulmonary disease, cancer and rheumatoid arthritis.[19–21] This emphasises the view that polymorbidity should not only be primarily the concern of GPs.

The findings of our study have made us question the relevance of a disease management model in the care of patients with more than one chronic disease. Several authors have discussed the conflicting relevance of multiple conditions in one patient and disease-specific guidelines.[22 23] Although disease-specific guidelines are usually evidence-based, this does not mean that they are applicable in all situations. In studies on which disease-specific guidelines are based, patients with multiple conditions are usually excluded. In addition, disease-specific guidelines often do not take into consideration the simultaneous occurrence of other diseases. Therefore the value of disease-specific guidelines decreases in proportion to the increase in multiple morbidities. Polymorbidity requires an integrated patient-oriented approach rather than a fragmented disease-oriented approach. Such an approach is needed not only in healthcare services, but also in studies investigating optimal treatment strategies for patients with chronic illnesses. As, at present, chronic illness contributes 60% of the global burden of disease, which by the year 2020 will increase to 80%, such a focus in healthcare research and services is of ultimate importance.[24]

We, like Struijs and co-workers,[14] found substantial use of healthcare facilities by patients with diabetes. In particular, in patients managed by MS practices, the burden of this disease in terms of hospital visits appeared to be high. These patients visited the hospital for a specialist consultation on average once a month (excluding visits for laboratory investigations and to the GP). Patients managed by the GP or DNS also showed a high use of healthcare facilities. The higher number of

Main messages

- Older patients with a chronic disease usually have other chronic diseases as well.
- Polymorbidity in older patients requires a patient-oriented rather than a disease-centred approach to the provision of care.
- Vocational training programmes for carers of older patients should focus on the consequences of the complexity of multiple chronic diseases.

consultations for patients managed by the MS may be due, at least in part, to the greater complexity of their disease, but are also probably due to the focus on the treatment of diabetes in this practice. To treat and manage complicating and concurrent comorbidities, consultation of other specialties is therefore often needed and prescribed. Again, this suggests that, to better address the deleterious consequences of multiple morbidities, a more holistic approach to the treatment of chronic diseases may be warranted. Such an approach will require that the care giver or management team is able to cover the various aspects of multiple concomitant diseases.[25 26] This implies that vocational training programmes for care givers, working in both general and specialist practices, should focus on these requirements.[27] For specialist training programmes, in particular, this is far from the present situation, as these focus more and more on subspecialist expertise at the cost of general expertise, partly because of preference of trainees to become a subspecialist rather than a general physician.[28]

There are limitations to our study (intrinsic to its retrospective design) that warrant a mention. The validity of the data obtained rely on the accuracy with which patients' medical files were recorded by the main care givers, throughout the whole period of interest. We therefore cannot exclude the possibility that some bias—for example, underestimation of complicating or concurrent diseases—may have occurred. However, review of medical charts as described here is thought to yield more complete and accurate data than other methods, such as interviews or questionnaires.[29] The present findings are for patients under the disease management model implemented in the region of Maastricht, and inferences to other models should be made with caution. Finally, these findings do not allow us to draw conclusions in terms of causality, but may be relevant for the generation of hypotheses in future (prospective) studies.

CONCLUSIONS

We found that the use of healthcare facilities by older patients with diabetes is substantial, irrespective of the complexity of the disease and the kind of practice involved. Therefore, we believe that the common manifestation of concurrent comorbidities in such patients requires a patient-oriented rather than a disease-oriented approach and vocational training programmes for care givers involved that are tailored to the complexity of multiple chronic diseases.

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