BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049487
Article Type:	Original research
Date Submitted by the Author:	26-Jan-2021
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Keywords:	General diabetes < DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, HEALTH ECONOMICS

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Identifying and delineating the type 2 diabetes population in the Netherlands using an all-payer claims database: Characteristics, healthcare utilization, and expenditures

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Word count main text: 3950

ABSTRACT

Objective We aimed to identify and delineate the Dutch type 2 diabetes population and the distribution of healthcare utilization and expenditures across the health system from 2016 to 2018 using an all-payer claims database.

Research Design and Methods This retrospective observational study was based on an all-payer claims database of the Dutch population. The type 2 diabetes population (n=900,522 in 2018) was determined based on bundled payment codes for integrated diabetes care and medication use indicating type 2 diabetes. Comprehensive data on healthcare utilization and expenditures were drawn from the database and analyzed descriptively.

Results In 2018, 900,522 people (6.5% of the adult population) were identified as having type 2 diabetes. The most common comorbidity in the population was heart disease (12.1%). Additionally, 16.2% and 5.6% of patients received specialized care for microvascular and macrovascular diabetes-related complications, respectively. Almost all type 2 diabetes patients received pharmaceutical care (99.1%), medical specialist care (97.0%), and general practitioner consultations (90.5%). In total, €8,173 million was reimbursed. Medical specialist care accounted for the largest share of spending (38.1%).

Conclusions All-payer claims databases can be used to delineate healthcare use: this insight can inform health policy and practice and, thereby, support better decisions to promote long-term sustainability of healthcare systems. The healthcare utilization of the Dutch type 2 diabetes population is distributed across the health system and utilization of medical specialist care is high. This is likely to be due to presence of concurrent morbidities and complications. Therefore, a shift from a disease-specific approach to a person-centered and integrated care approach could be beneficial in the treatment of type 2 diabetes.

Strengths and limitations of this study

- The use of an all-payer claims database enables an overview of the complete Dutch type 2 diabetes population
- Due to the economic function of claims data, the data is accurate and complete enabling a reliable estimation of healthcare utilization and expenditures
- Internationally, the generalizability of findings could be limited because of the differences in the organization of healthcare
- Real- or near-time data use of claims data is hampered by a two-year time lag

INTRODUCTION

Internationally, there are rising concerns regarding the financial sustainability of healthcare systems. This financial strain is caused by increasing costs associated with ageing populations, rising life expectancy, expensive technological advances, and higher patient expectations.[1–3] In particular, the burden caused by chronic diseases is rapidly increasing.[4] Diabetes mellitus is currently one of the most prevalent chronic diseases affecting an estimated 463 million people in the age group 20 - 79 years, or 9.3% of adults worldwide.[4,5] This number is expected to rise to 700 million by 2045.[5] Within the diabetes population, 90% of patients suffer from type 2 diabetes.[5,6] Many develop at least one diabetes-related macro- or microvascular complication during the course of their disease.[7,8] The presence of these complications substantially increases healthcare utilization and expenditures.[7–12] For instance, the presence of both micro- and macrovascular complications increases patients' care expenditures by up to 250%.[7] In total, expenditures on diabetes–related complications are estimated to amount to more than half of all diabetes care expenditures.[13,14]

However, to date, knowledge on healthcare utilization and expenditures of type 2 diabetes patients remains limited due to scarcity of data or use of incomplete data.[8,9,11,15,16] National diabetes registries are rare and studies on diabetes care costs are often based on data from smaller subgroups of patients, such as veterans, diabetes patients who suffered a specific event, geographically defined groups, insurance defined groups, or patients of specific care organizations.[9–11,16–20] Thus, knowledge of the characteristics of nationwide type 2 diabetes populations is rare and generalizability of research findings is limited. Additionally, prior studies are often based on self-reported cost data which may lead to recall bias.[8,9,12,16] Existing insights into expenditures on type 2 diabetes-related complications are similarly fragmented and unclear.[11,14,16] This is caused by the limited number of papers covering this topic, difficulties in separating diabetes-related expenditures, as well as poor transparency regarding cost sources in existing studies.[11,15] In addition, previous studies in this area have often focused on hospital care or analyzed only one specific diabetes-related complication.[8] Accordingly, estimates of expenditures on complications vary widely.[15]

Because of the increasing concerns about the financial sustainability of healthcare systems and the rising prevalence of type 2 diabetes, a more exact insight into the healthcare utilization and expenditures of type 2 diabetes populations is needed. Such insight would enhance understanding of where and how much diabetes care is provided in the health system and support better decisions to promote long-term sustainability.[21] Therefore, we use an all-payer claims database (APCD) that covers 99% of the Dutch population to identify the Dutch type 2 diabetes population and present a detailed and complete overview of population characteristics, healthcare utilization, and expenditures. APCDs are becoming increasingly important in facing health care challenges as these enable analysis of whole populations across the health system, as well as over time.[22–24] Accordingly, the aim of this study is twofold. The first aim is to specify the size and characteristics of the Dutch type 2 diabetes population, including the annual prevalence of comorbidities and type 2 diabetes-related complications, over the years 2016 to 2018. The second aim is to determine the total healthcare utilization and expenditures of this population and the distribution of use and expenditures (a) across healthcare sectors (e.g. primary care, specialized care); (b) related to specific service types (e.g. mental health care, pharmaceutical care), and; (c) for type 2 diabetes-related complications (e.g. heart failure, diabetic foot) over the same time period.

METHODS

Data source

This retrospective observational study was based on an APCD from the national health insurance registry managed by the Vektis Healthcare Information Center. Vektis was set up by Dutch health insurers in 2006 to support claims reimbursement and enable the main players in the Dutch healthcare market to base their decision-making and policy execution on reliable, essential and timely data. For this purpose, the Vektis databases contain information on all procedures covered by Dutch statutory health insurance, as well as a set of data on patients, providers, care products, and prices. Before integration into the Vektis databases, health insurers' data undergo rigorous inspection and validation. Vektis' coverage rate has gradually expanded since 2006: the information center now receives data from all Dutch health insurers and covers over 99% of the Dutch population. For this study, comprehensive claims data on the type 2 diabetes population spanning across healthcare sectors and service types for the timeframe 2016-2018 were drawn from the Vektis registry. The timeframe 2016-2018 was chosen to examine most recent data and because no major policy changes regarding diabetes care were made during this period.

Study population

In the Netherlands, the vast majority of type 2 diabetes patients (83% in 2018) receive integrated diabetes care within a primary care setting organized by care groups,[25] i.e. regionally organized health care provider groups comprising general practitioners (GPs) and affiliated personnel. These integrated diabetes care programs are funded by health insurers on the basis of a bundled payment per patient per year.[26] We used existing bundled payment claim codes to identify type 2 diabetes patients in the APCD. The remaining type 2 diabetes patients were identified by medication use (based on ATC-codes) indicating type 2 diabetes. Thus, to be as accurate and inclusive as possible, we identified individuals as type 2 diabetes patients if they met one or more of the following criteria: (a) received integrated diabetes care or (b) were treated for their type 2 diabetes with (b.1.) only oral medication (A10B blood glucose lowering drugs excl. insulins); (b.2.) a combination of insulin (A10A insulins and analogues for injection) and oral medication (A10B blood glucose lowering drugs excl. insulins), or (b.3.) a combination medication (A10AE54 or A10AE56:

mix of insulins and GLP-1 for injection, long-acting). The type 2 diabetes population was determined separately for each year within the timeframe 2016 to 2018. Individuals were included in the annual population prevalence if one or more of the inclusion criteria applied at any time during that year. Accordingly, the study population had the nature of an open and dynamic cohort, to which individuals could be added or excluded from each year. No exclusion criteria were applied.

Patient and population characteristics

To describe the study population, we included age and gender as demographic variables. Moreover, the presence of comorbidities and type 2 diabetes-related complications were assessed using 'pharmaceutical costs groups' (In Dutch: *Farmaceutische KostenGroepen*, FKGs) and reimbursement codes, respectively. FKGs indicate the presence of specific chronic conditions based on patients' medication use and are used for risk equalization between health insurers in the Dutch health insurance system.[27] In this study, the FKGs present in over 1% of the type 2 diabetes population were displayed. Additionally, presence of type 2 diabetes-related complications was assessed based on reimbursement codes. The type 2 diabetes-related complications included were largely based on the most common complications listed by Nathanson et al.[28] For macrovascular type 2 diabetes-related complications, we included acute coronary syndrome, stroke, and heart failure. Microvascular type 2 diabetes-related complications included were diabetic mono-/polyneuropathy, diabetic eye complications, diabetic foot/peripheral angiopathy, and diabetic kidney disease. One of the authors, who is an internist (HB), matched the associated reimbursement codes to the type 2 diabetes-related complications (Supplementary Table 1).

Healthcare utilization and expenditures

This study considered total healthcare expenditures of the type 2 diabetes population under the Dutch Health Insurance Act (In Dutch: *Zorgverzekeringswet*, Zvw), as well as under the Long-term Care Act (In Dutch: *Wet Langdurige Zorg,* Wlz). Together, these two Acts account for the bulk of the available health care budget in the Netherlands. For the Dutch Health Insurance Act, utilization and expenditures of the type 2 diabetes population related to a number of healthcare sectors and service types were extracted from the Vektis databases. Data on the primary care and specialized care (care provided in hospitals and Independent

Specialized Treatment Centers) sectors were studied in detail. Utilization of primary care covered patients registered with a GP, whereas utilization of GP consultations included patients that utilized regular consultations (excluding integrated diabetes care consultations), home visits, and consultations via e-mail and by phone. Moreover, we distinguished data regarding service types: pharmaceutical care, assistive devices, mental health care, district nursing, paramedical care, and other care. Other care included maternity care, obstetrics, oral care, patient transport, care abroad, geriatric rehabilitation, primary care support, and inpatient primary care. Expenditures within these specified healthcare sectors and services were also considered at the individual patient level. Utilization and expenditures both directly related to diabetes care as well as other (non-diabetes related) services were included. The expenditures considered under the Dutch Health Insurance Act include mandatory deductibles paid by patients; other (co)payments are not included.[29] Indirect costs were not considered in this study, since no information on this aspect is available in the Vektis database.

Utilization and expenditures of type 2 diabetes-related complications

We studied utilization of and expenditures on specialized care for type 2 diabetes-related macro- and microvascular complications in more detail. In the Netherlands, specialized care is reimbursed via 'diagnosis-treatment combinations' (in Dutch: *diagnose-behandelcombinaties*, DBCs), a concept similar to diagnosis-related groups (DRGs). DBCs consider complete episodes of care and thus contain information on specialism or responsible specialized physician, patient diagnosis, and provided treatment.[30] Moreover, one DBC may contain a number of healthcare consultations, tests, or treatments. DBCs were used to assess both utilization of and expenditures on specialized care.

Total expenditures on medical specialist care services were determined using the total reimbursed costs for this service type per study year, drawn from the APCD. However, in determining expenditures per type 2 diabetes-related complication, a median Dutch price per DBC was calculated. This is because the prices for specific DBCs can differ to some extent between hospitals due to variations in contractual agreements made between individual hospitals and health insurers.[31] Moreover, hospitals are known to raise or reduce the prices of specific DBCs for administrative purposes, e.g. to meet a hospital-wide turnover

constraint. As a consequence, DBC prices do not necessarily reflect the true cost of the correlated care episode.[32] Thus, to mitigate the variation in expenditures introduced by administrative DBC pricing, we used the median Dutch price per DBC to calculate the expenditures on type 2 diabetes-related complications. For every specific DBC, the median DBC price was determined by arranging all countrywide reimbursed DBCs of that type to find the median accordingly. As DBC prices vary over the years, this was done separately for each study year. Finally, to determine the total expenditures per type 2 diabetes-related complication, the associated reimbursed DBCs were multiplied by the related median DBC prices.

Statistical analysis

Data were analyzed descriptively. The continuous variables age and per treated patient expenditures on type 2 diabetes-related complications were presented as means and standard deviations (SDs). For complications, the median expenditures per treated patient and the 5th and 95th percentile were also described. The categorical variables gender, presence of comorbidities, presence of type 2 diabetes-related complications, and healthcare sector and service utilization were reported as frequencies and valid percentages of the total type 2 diabetes population. Population and per patient expenditures on healthcare sectors and service types and type 2 diabetes-related complications were presented as frequencies and valid percentages. Due to the economic function of Vektis data, missing data are rare but in case of missing data the expenditures were imputed as zero, age was not imputed, and gender was set to unknown.

The data were recovered and reported from the Vektis databases based on a detailed data extraction and processing request. The data were obtained and analyzed using statistical package SAS 7.15. According to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch 'Research involving Human Subjects act' (registration number 2019-1445).

Patient and public involvement

This study aimed to gain an overview of healthcare utilization of and expenditures on the Dutch type 2 diabetes population. Patients were not involved in the design, management, or reporting of this study.

RESULTS

Characteristics of the type 2 diabetes population

In 2018, 900,522 people or 6.5% of the Dutch population aged 18 and above were identified as having type 2 diabetes (Table 1). The type 2 diabetes population increased by 2.3% compared to 2016 (n=880,121). In 2018, the mean age of the Dutch type 2 diabetes population was 68.7 (±12.3) years and 46.7% of the population was female. The most common comorbidity (based on medication) was heart disease, with a prevalence of 12.1% in 2018. This was followed by depression and thyroid disorders, with 2018-prevalences of 5.7% and 5.0%, respectively. Moreover, based on specialized care utilization, 5.6% of patients received care for macrovascular type 2 diabetes-related complications and 16.2% of patients received care for microvascular type 2 diabetes-related complications. The most frequently occurring complications were diabetic eye complications: 12.2% of the type 2 diabetes population received specialized care for this. The second most common type 2 diabetes-related complication identifiable through reimbursement was heart failure, as 2.8% of type 2 diabetes patients received specialized care for this. The third most prevalent were care for diabetic foot/peripheral angiopathy and diabetic kidney disease (reimbursed for 2.6% and 2.5%, respectively).

Table 1 Characteristics of the Dutch type 2 diabetes population in 2016-2018

	2016	2017	2018
Annual prevalence, n	880,121	890,682	900,522
New patients, n	58,606	57,877	57,411
Loss to follow-up, n			
Deceased	38,042	38,962	40,050
Other reasons*	19,055	9,274	8,609
Mean age, years (SD)	67.4 (±12.4)	68.5 (±12.4)	68.7 (±12.3)
Gender, female, n (%)	417,912 (47.5)	419,658 (47.1)	420,988 (46.7)
Prevalence of comorbidities, n (%)			
Heart disease	111,106 (12.6)	109,892 (12.3)	109,022 (12.1)
Depression	51,906 (5.9)	52,427 (5.9)	51,729 (5.7)
Thyroid disorders	43,879 (5.0)	43,786 (4.9)	44,612 (5.0)
COPD / severe asthma	41,162 (4.7)	41,183 (4.6)	41,383 (4.6)
Asthma	39,768 (4.5)	40,611 (4.6)	41,021 (4.6)
Glaucoma	33,364 (3.8)	33,852 (3.8)	39,200 (4.4)
Psychosis and addiction	13,841 (1.6)	14,105 (1.6)	16,929 (1.9)
Neuropathic pain	10,461 (1.2)	10,945 (1.2)	11,451 (1.3)
Prevalence of type 2 diabetes-related complications, n (%)			
Macrovascular type 2 diabetes-related complications	51,684 (5.9)	51,355 (5.8)	50,825 (5.6)
Heart failure	25,835 (2.9)	25,964 (2.9)	25,627 (2.8)
Stroke	17,718 (2.0)	17,449 (2.0)	17,653 (2.0)
Acute coronary syndrome	10,712 (1.2)	10,468 (1.2)	9,932 (1.1)
Microvascular type 2 diabetes-related complications	144,877 (16.5)	144,881 (16.3)	146,216 (16.2)
Diabetic eye complications	109,332 (12.4)	108,841 (12.2)	109,859 (12.2)
Diabetic foot/peripheral angiopathy	22,724 (2.6)	22,878 (2.6)	23,221 (2.6)
Diabetic kidney disease	22,431 (2.5)	22,736 (2.6)	22,758 (2.5)
Diabetic mono/polyneuropathy	1,835 (0.2)	1,754 (0.2)	1,730 (0.2)

* Other reasons for loss to follow-up may include people who no longer meet the inclusion criteria, people admitted to a nursing home, and people who emigrated. Calculated as: (number of patients y-1) + (number of new patients y) – (number of deceased y-1) – (number of patients y)

Healthcare utilization

All type 2 diabetes patients utilized care reimbursed under the Health Insurance Act in the timeframe 2016-2018. In 2018, 4.4% of patients additionally utilized care reimbursed under the Long-term Care Act. Regarding services covered by the Health Insurance Act, Table 2 shows that relatively large shares of the population used care in the specified healthcare sectors and service types. Almost all people with type 2 diabetes used pharmaceutical (99.1%) and medical specialist care (97.0%) in 2018. Moreover, the large majority of this population had GP consultations (90.5%) and half of the type 2 diabetes population had reimbursements for the use of assistive devices. Mental health care was used by the smallest share of type 2 diabetes patients (4.7%). Reimbursements for paramedical care and district nursing increased most during the study period, by 17.4% and 8.2%, respectively.

Table 2 Share of the type 2 diabetes population with service use per health care sector and service type, 2016-2018

	2016	2017	2018
Healthcare sectors			
Primary care, n (%)	879,578 (99.9)	890,161 (99.9)	899,998 (99.9)
Medical specialist care, n (%)	845,121 (96)	853,478 (95.8)	873,606 (97.0)
Healthcare service types			
Pharmaceutical care, n (%)	871,999 (99.1)	882,431 (99.1)	892,250 (99.1)
GP consultations, n (%)	800,037 (90.9)	808,774 (90.8)	815,289 (90.5)
Assistive devices, n (%)	431,867 (49.1)	439,249 (49.3)	445,438 (49.5)
Paramedical care, n (%)	137,206 (15.6)	147,129 (16.5)	161,035 (17.9)
District nursing, n (%)	130,571 (14.8)	134,209 (15.1)	141,252 (15.7)
Mental health care, n (%)	42,207 (4.8)	42,004 (4.7)	41,989 (4.7)

Healthcare expenditures

In Figure 1, total healthcare expenditures of the Dutch type 2 diabetes population in 2018 are displayed. In total, €8,173 million was reimbursed, an increase of 7.2% from 2016 (Supplementary Fig. 1a). Of the total expenditures, 18.6% was on care under the Long-term Care Act, while the remaining 81.4% were expenditures reimbursed under the Health Insurance Act. As to the latter, medical specialist care accounted for the largest share of spending, i.e. €3,115 million or 38.1%. District nursing accounted for the second largest share and increased by 12.0% from 2016 to €1,012 million in 2018. Expenditures on pharmaceutical care were €942 million, accounting for 11.5% of the total. The fourth largest share results from expenditures on primary care (including GP consultations), accounting for 6.0% of the total (€488 million).

[Fig. 1 here]

Mean annual per patient expenditures

With regard to the Health Insurance Act, mean annual per patient spending increased by 4.4% from 2016 to 2018: €7,077 to €7,386 (Figure 2). The annual spending on medical specialist care accounted for the largest share (47%) or €3,459 per patient in 2018. Secondly, district nursing and pharmaceutical care contributed to a significant share of annual per patient expenditures: €1,124 and €1,047, respectively. Moreover, the mean annual per patient expenditures on district nursing increased by 9.4% from 2016 to 2018. Annual primary care expenditures were €542 per patient in 2018. As to the category other, expenditures increased by 18.6% from 2016 and on average €517 was spent per patient in 2018. Per patient spending on assistive devices, mental health care, and paramedical care were all under 5.0% of the total mean annual per patient expenditures. The type 2 diabetes patients who received care under the Long-term Care Act as well as under the Health Insurance Act (4.4%) had an average long-term care spending of €38,033 in 2018. This increased by 14.4% in comparison to 2016.

[Fig. 2 here]

Expenditures on type 2 diabetes-related complications

In total, €556 million was spent on specialized care for type 2 diabetes-related complications in 2018 (Table 3). The majority of these expenditures related to microvascular complications (55.0%), which increased by 10.8% from 2016 to 2018. Spending on macrovascular complications increased by 2.1% during the same period. In 2018, €250 million was spent on macrovascular type 2 diabetes-related complications. Diabetic foot/peripheral angiopathy accounted for the largest share of spending on diabetes-related complications with 20.9% or €116 million in 2018. Secondly, expenditures on strokes were 19.9% (€111 million) in 2018. Thirdly, total spending on diabetic eye complications increased by 11.2% over the studied period and accounted for 17.9% of the total in 2018. Moreover, for diabetic kidney disease, total expenditures increased by 12.8% from 2016 to 2018 (to 15.7% of the total). The per treated patient mean and median expenditures on type 2 diabetes-related complications were lowest for diabetic eye complications and diabetic mono/polyneuropathy. The highest mean and median expenditures per treated patient were for stroke and acute coronary syndrome (Supplementary Table 2).

Table 3 Total expenditures type 2 diabetes related complications 2016-2018 (million €)

	2016	2017	2018	Change in % 2016-2018
Macrovascular type 2 diabetes-related complications, n (%)	245 (47.0)	249 (46.7)	250 (45.0)	2.1%
Heart failure, n (%)	81 (15.5)	80 (15.1)	81 (14.6)	0.5%
Stroke, n (%)	106 (20.3)	111 (20.8)	111 (19.9)	5.0%
Acute coronary syndrome, n (%)	59 (11.3)	58 (10.9)	58 (10.5)	-0.8%
Microvascular type 2 diabetes-related complications, n (%)	276 (53.0)	284 (53.3)	306 (55.0)	10.8%
Diabetic eye complications, n (%)	90 (17.2)	92 (17.2)	100 (17.9)	11.2%
Diabetic foot/peripheral angiopathy, n (%)	106 (20.4)	110 (20.7)	116 (20.9)	9.7%
Diabetic kidney disease, n (%)	78 (14.9)	79 (14.9)	88 (15.7)	12.8%
Diabetic mono/polyneuropathy, n (%)	3 (0.6)	3 (0.5)	3 (0.5)	-14.3%
Total expenditures, n (%)	521 (100.0)	532 (100.0)	556 (100.0)	6.7%

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DISCUSSION

This study is the first to use an APCD of the Dutch population to identify and characterize the type 2 diabetes population. Hereby, this study extends the knowledge of its characteristics and provides insight into healthcare utilization and expenditures across healthcare sectors, service types, and for type 2 diabetes-related complications. In 2018, the annual prevalence of type 2 diabetes in the Netherlands was 900,522 people (6.5% of Dutch adults). The most prevalent comorbidity, based on medication use, was heart disease with a prevalence of 12.1%. Moreover, 5.6% received specialized care for macrovascular and 16.2% of the 2018 population received specialized care for microvascular complications. Regarding healthcare utilization, almost all type 2 diabetes patients utilized pharmaceutical care, medical specialist care, and GP care. In total, €8,173 million, about 9.4% of total healthcare expenditures, was reimbursed for the type 2 diabetes population in 2018.[33] Expenditures on medical specialist care represented the largest share of total healthcare expenditures (38.1%), followed by expenditures on district nursing (12.4%) and pharmaceutical care (11.5%).

The current study has a number of strengths. A major strength is the use of an APCD covering virtually all Dutch citizens, which ensures a heterogeneous cohort. Another advantage of an APCD is the accuracy of the data; for the economic function (support of claims reimbursement and decision making of the main players in the Dutch healthcare market) the data undergo extensive quality control. The combination of a virtually complete dataset, data accuracy, and completeness allows a reliable estimation of disease prevalence, resource utilization, and expenditures. However, using all-payer claims data also presents drawbacks. Despite the heterogeneous cohort, the generalizability of certain findings may be limited on an international due to differences in the organization of healthcare. For instance, the number and duration of hospitalizations and expenditures on pharmaceutical care are found to vary between established markets.[34–36] Additionally, for claims data, real- or near-time data use e.g. for research findings to apply in policy and practice and vice versa is hampered by the two-year time lag in data. Moreover, the Dutch claims data do not include specific diagnostic codes for type 2 diabetes. Therefore, we determined the type 2 diabetes population with a number of inclusion criteria. However, a small share

of type 2 diabetes patients cannot be identified through claims data, i.e. patients who do not receive integrated diabetes care and do not use any diabetes medication or use insulin only, and type 2 diabetes patients who live in nursing homes and receive all care within the facility. Nevertheless, the effect of not detecting these patients is likely to be minimal, as the large majority of type 2 diabetes patients receive integrated diabetes care (83%) and if not, many are included due to medication use for type 2 diabetes (80% received diabetes medication in 2018).[25,37]

Notwithstanding these limitations, our APCD enables a detailed and complete overview of the type 2 diabetes population. However, our findings regarding population size differ from the type 2 diabetes population as estimated by NIVEL (Netherlands Institute for Health Services Research).[38] Their findings indicated an annual prevalence of 1,079,624 people with type 2 diabetes in 2018.[6] However, this estimate is based on GP registration data representing approximately 10% of the Dutch population,[38] whereas we included data on the total Dutch population. Also, morbidity estimates of GPs may be less reliable as these are potentially influenced by the local organization of the healthcare system, methods of morbidity registration, the organization of the GP practice, and patient characteristics.[39] Lastly, once a type 2 diabetes patient is included in the NIVEL cohort, they do leave the cohort for reasons other than mortality. Hence, their approach potentially results in an overestimation of the actual prevalence of type 2 diabetes.

Notably, our findings indicated that the majority of healthcare utilization and expenditures of the type 2 diabetes population are not directly related to diabetes. Type 2 diabetes patients utilize care throughout the healthcare system, i.e. across healthcare sectors and service types. Additionally, 97.0% of type 2 diabetes patients utilize medical specialist care despite 83% receiving integrated diabetes care in the primary care setting.[25] Moreover, medical specialist care utilization of the type 2 diabetes population is considerably higher than the share of the entire insured population in the Netherlands that utilizes medical specialist care (43% in 2017).[40] The wide dispersion of service use across the health system, as well as the high utilization of medical specialist care, may be explained by the presence of comorbidities and complications. Many patients not only have type 2 diabetes but additionally suffer from other conditions, as is confirmed in this study as well as shown in previous literature.[7,8] Findings that comorbidities

substantially increase healthcare expenditures and utilization are also in line with previous studies on this topic.[7–12]

The high utilization of non-diabetes care of the type 2 diabetes population has several implications for policymakers. As a large share of healthcare utilization and expenditures is caused by comorbidities or type 2 diabetes-related complications, it could be beneficial to organize care more holistically and approach diabetes and non-diabetes complaints more concentrated in the health system. Such an approach would underpin the need to shift from a disease-specific approach to a person-centered and integrated care approach. This is in agreement with prior findings indicating that person-centered integrated care may be meaningful in making the care process less fragmented and improving physical and psychological health in patients with multi-morbidity.[41,42] Additionally, the high utilization of and expenditures across the healthcare system show that diabetes care is not necessarily expensive but the total care for patients known with type 2 diabetes is. Therefore, when addressing healthcare expenditures, policymakers should not only focus on utilization of and expenditures on diabetes care but also on care for concurrent morbidities and complications. Prior research has also shown that integrated care adapted to the needs of chronically ill patients could lead to better outcomes at lower costs.[43]

Therefore, future research exploring the characteristics of high-need (utilization) and high-cost (expenditures) subgroups within the type 2 diabetes population may contribute to initiatives to reduce spending growth and thereby maintain the financial sustainability of healthcare systems. Moreover, APCDs can be used for longitudinal retrospective analyses, for instance to show long-term effects of policies or treatment changes to determine whether these were effective and support sustainability. Additionally, future research should focus further on the dispersion of healthcare utilization of and expenditures on the type 2 diabetes population. Insight into pharmaceutical care and medical specialist care utilization would be particularly meaningful as these healthcare services are heavily utilized by this population. Moreover, to better understand the impact of type 2 diabetes on healthcare utilization and healthcare expenditures, future research should compare people with and without type 2 diabetes.

CONCLUSIONS

APCDs can be used to identify the national type 2 diabetes population and describe its characteristics, healthcare utilization, and healthcare expenditures. This insight can inform policymakers and practice about dispersion of reimbursed care, directly and indirectly related to type 2 diabetes, and in turn support better decisions to promote long-term (financial) sustainability of healthcare systems.

Acknowledgements We thank Michiel ten Hove, Robin Stoof, and Paul Sterkenburg of Vektis for their assistance on developing the study design and for answering our questions about the data.

Contributors RG, AE, DR, JS, and DR were involved in the design of the study. A detailed data extraction and processing request for data acquisition was made by RG, AE, and HB and approved by DR and JS. CT performed data acquisition and assisted data analysis. All authors were involved in checking the accuracy and completeness of the data. RG conducted data analysis, drafting, and manuscript writing. AE, HB, JS, and DR all critically reviewed and revised the drafts and contributed to writing. All authors approved the final version and were involved in the decision to submit it for publication. RG is the guarantor of this work and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Funding The current study was funded by AstraZeneca Netherlands.

Disclaimer The study sponsor was not involved in the design of the study; the collection, analysis, and interpretation of data; writing the report; and did not impose any restrictions regarding the publication of the report.

Competing Interests None declared.

Patient consent for publication Not required.

Ethics approval According to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch 'Research involving Human Subjects act' (registration number 2019-1445)

Data availability statement The datasets generated and analyzed during this study are not publicly available, as formal consent from the Dutch health insurers is needed to gain access to these files. Data are however available from Vektis upon reasonable request and with formal consent of the Dutch health insurers.

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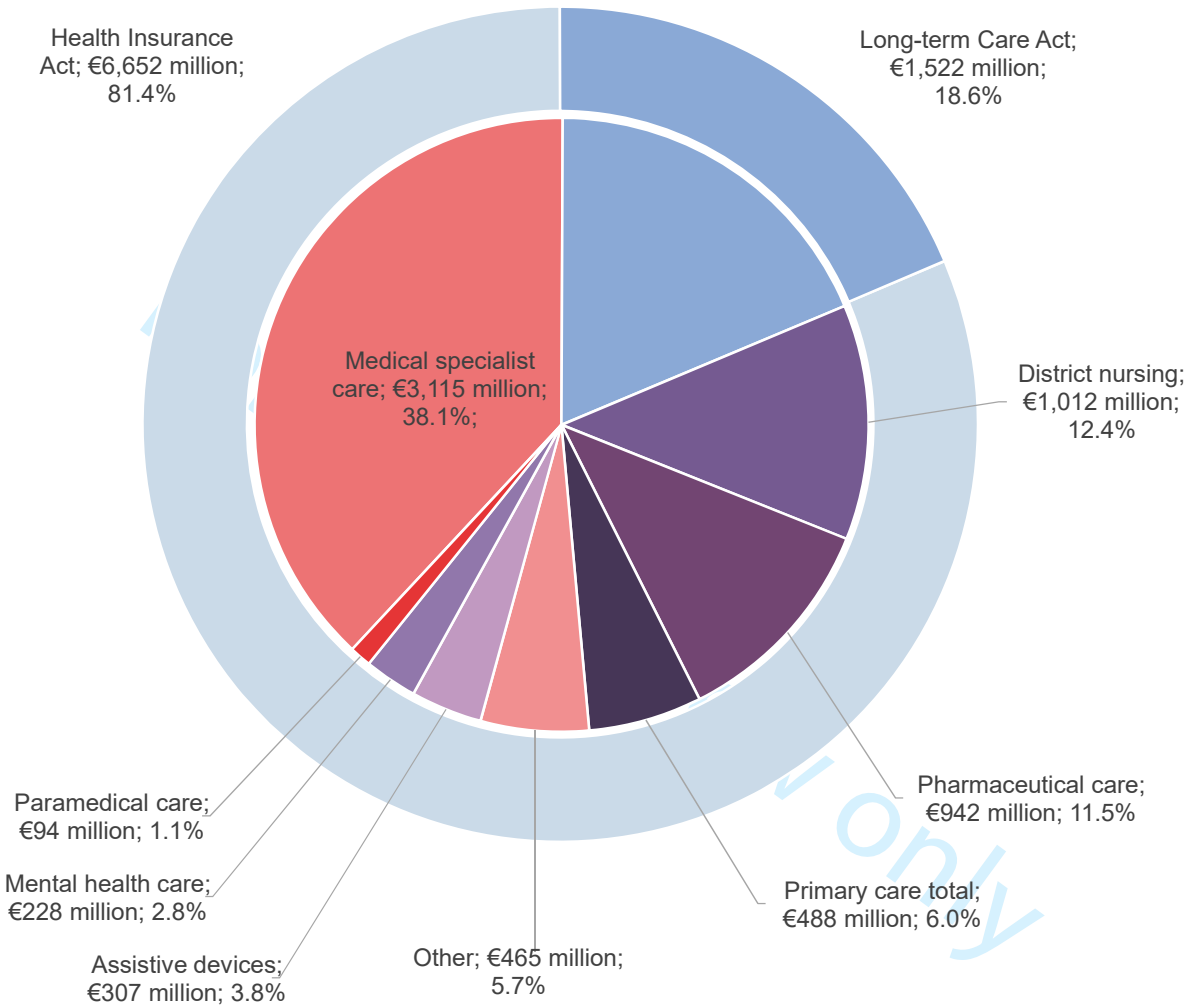
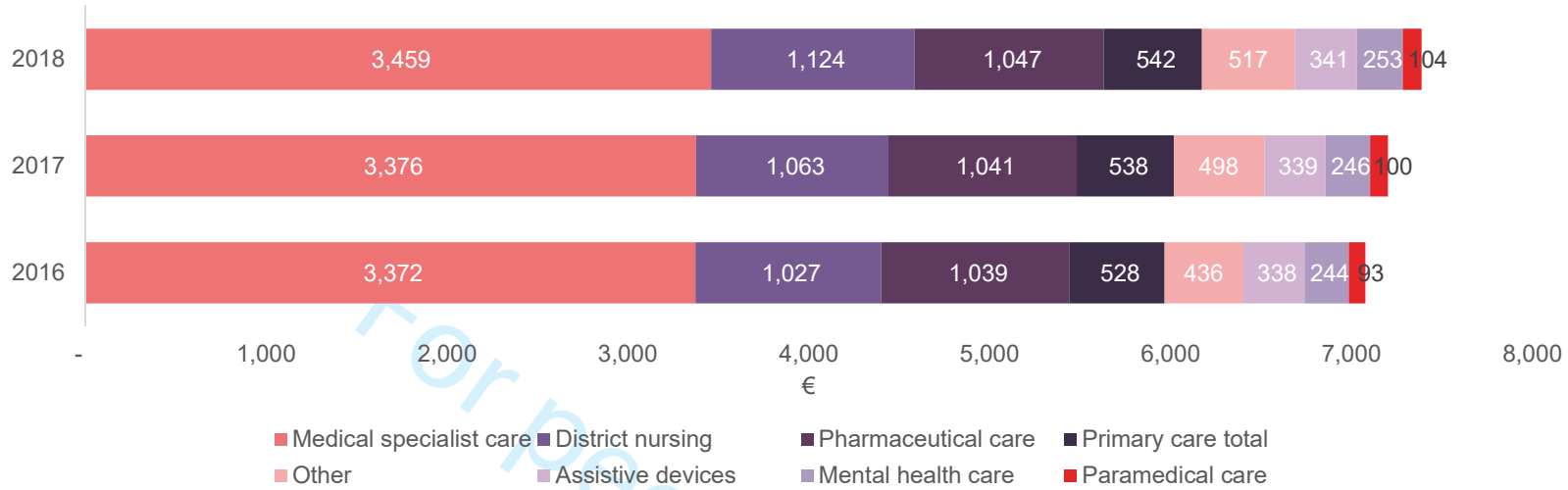
Figure legends

Figure 1 Total healthcare expenditures of the type 2 diabetes population in 2018

Figure 2 Mean annual per patient healthcare expenditures under the Health Insurance Act, 2016-2018

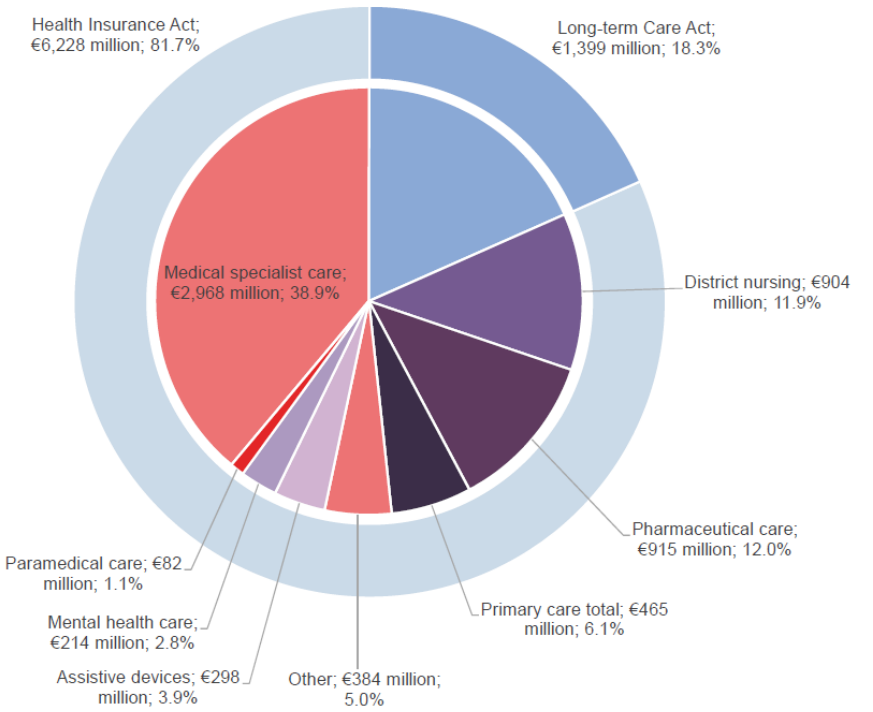




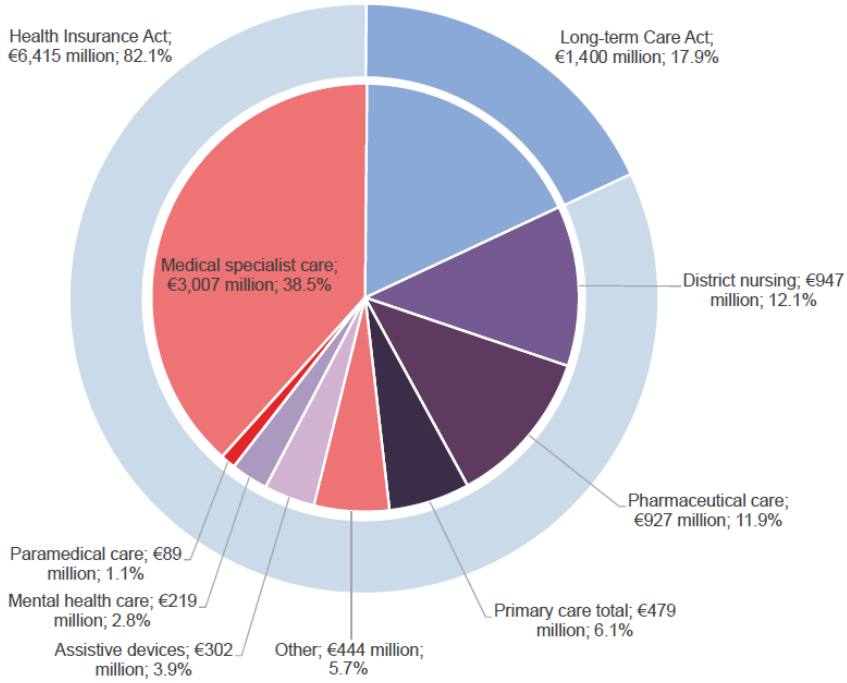
Supplementary Table 1 Matched reimbursement codes per type 2 diabetes-related complication

Disease group	Reimbursement codes (DBCs)
Macrovascular type 2 diabetes – related complications	
Acute Coronary Syndrome	Unstable Angina Pectoris (0320.203); ST-elevated myocardial infarction (0320.204); Non-ST-elevated myocardial infarction (0320.205); Instable AP, myocardial infarction (0313.102); Symptomatic ischemic heart disease, not in 0313.102 (0313.101)
Stroke	Cerebrovascular Accident (0327.313); Cerebrovascular Accident/ Transient Ischemic Attack (0313.121); Intracerebral hemorrhage (0330.1102); Intracranial hemorrhage (sub- / epidural) (0330.1103); Stroke (0330.1111); Cerebrovascular Accident (8418.101); Cerebrovascular Accident/ Transient Ischemic Attack (0335.263); Transient Ischemic Attack (including amaurosis fugax) (0330.1112)
Heart failure	Acute heart failure (0320.301); Chronic heart failure (0320.302); Decompensatio cordis (0335.262); Decompensatio cordis (0313.107)
Microvascular type 2 diabetes – related complications	
Diabetic mono/polyneuropathy	Nervous system and sensory disorders (0335.251); Peripheral nerve injury, nerve disorders (0327.413)
Diabetic eye complications	Cataract (0301.554); Anterior uveitis (0301.502); Posterior uveitis / Panuveitis (0301.503); Retinal defect / retinal detachment (0301.654); Subretinal neovascularization (0301.704); Maculopathy (0301.705); Macular degeneration (0301.707); Non-proliferative diabetic retinopathy (0301.754); Preproliferative diabetic retinopathy (0301.755); Proliferative diabetic retinopathy (0301.757); Other pathology diabetic retinopathy (0301.759)
Diabetic foot/peripheral angiopathy	Amputation (0327.200); Amputation through or above the elbow (0327.211); Lower arm / hand amputation, excluding fingers (0327.212); Finger(s) amputation (0327.213); Amputation of upper extremity, not specified (0327.214); Amputation of upper leg and higher (0327.215); Foot, lower leg and knee amputation (0327.216); Amputation of toe(s) (0327.217); Amputation of lower extremity, not specified (0327.218); Amputation of upper leg and higher (8418.401); Foot and/or lower leg and/or toe(s) amputation (8418.402); Amputation of upper extremity (8418.403); Diabetic

	foot (305.2065); Diabetic foot (0303.432); Other peripheral vascular diseases (0303.439); PAOD arm (0303.0412); PAOD 2, claudicatio intermittens (0303.0418); PAOD 3, rest pain (0303.0419); PAOD 4, gangrene (0303.0420)
Diabetic kidney disease	Kidney transplant, recipient (0313.076); Kidney and pancreatic transplant, recipient (0313.078); Chronic renal failure, eGFR 30-60 ml/min (0313.324), Chronic renal failure, eGFR <30 ml/min (0313.325); Continuous ambulatory peritoneal dialysis (CAPD) (0313.331); Automatic peritoneal dialysis (APD) (0313.332); Chronic hemodialysis at home (0313.336); Chronic hemodialysis in institution (0313.339)



a) 2016



b) 2017

Supplementary Figure 1 Healthcare expenditures of the type 2 diabetes population a) in 2016 b) in 2017

Supplementary Table 2 Mean and median expenditures type 2 diabetes related-complications per treated patient in 2016-2018 (€)

	2016 Mean expenditures per patient ± SD[a]	2016 Median per patient expenditures (P5; P95)[a]	2017 Mean expenditures per patient ± SD[a]	2017 Median per patient expenditures (P5; P95)[a]	2018 Mean expenditures per patient ± SD[a]	2018 Median per patient expenditures (P5; P95)[a]
Macrovascular T2DM-related complications	4,739.6±7,510.0	2,301.8 (208.3; 19,453.1)	4,846.5±103.5	2,327.9 (199.8; 19,049.2)	4922.9±7,763.3	2,351.5 (200.3; 19,848.7)
HF	3,118±5,261	689 (208; 12,677)	3,090±5,100	673 (200; 12,873)	3,160±5,296	673 (200; 13,235)
Stroke	5,967±10,215	2,418 (229; 26,980)	6,348±10,749	2,430 (215; 28,514)	6,287±10,587	2,472 (221; 28,830)
ACS	5,479±3,988	5,548 (524; 12,654)	5,530±3,842	5,924 (359; 12,165)	5,863±4,139	6,100 (360; 13,496)
Microvascular T2DM-related complications	1,907.7±80.9	393.9 (80.9; 7,146.7)	1,957.3±80.1	401.0 (80.1; 7,200.0)	2,094.4±6,818.2	407.8 (82.1; 7,768.2)
Diabetic eye complications	820±1,247	161 (81; 3,031)	843±1,272	165 (80; 3,150)	908±1,332	178 (82; 3,512)
Diabetic foot/peripheral angiopathy	4,671±9,255	585 (124; 20,513)	4,817±9,680	588 (124; 21,739)	5,013±9,922	608 (126; 22,133)
Diabetic kidney disease	3,461±12,020	677 (226; 13,654)	3,479±11,857	679 (230; 16,187)	3,848±12,430	689 (230; 21,200)
Diabetic mono/polyneuropathy	1,608±6,066	458 (229; 3,886)	1,438±6,135	430 (215; 3,543)	1,462±5,323	443 (221; 4,020)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4 & 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6 & 7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6 & 7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7 - 9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7 - 9
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6 & 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6 & 7
		(*e*) Describe any sensitivity analyses	-

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	-
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	(9)
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-15
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	-
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17 & 18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Identifying and delineating the type 2 diabetes population in the Netherlands using an all-payer claims database: Characteristics, healthcare utilization, and expenditures

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-049487.R1
Article Type:	Original research
Date Submitted by the Author:	18-Aug-2021
Complete List of Authors:	Geurten, Rose; Maastricht University, Department of Health Services Research, CAPHRI Care and Public Health Research Institute, Faculty of Health, Medicine and Life Sciences Elissen, Arianne; Maastricht University, Department of Health Services Research, CAPHRI Care and Public Health Research Institute, Faculty of Health, Medicine and Life Sciences Bilo, Henk J G; University Medical Centre Groningen, Department of Internal Medicine Struijs, Jeroen; RIVM, (National Institute of Public Health and the Environment) Department of Quality of Care and Health Economics, Center for Nutrition, Prevention and Health Services; Leiden University Medical Center, Campus The Hague, Department Public Health and Primary Care van Tilburg, Chantal; Vektis Healthcare Information Center Ruwaard, Dirk; Maastricht University, Department of Health Services Research, CAPHRI Care and Public Health Research Institute, Faculty of Health, Medicine and Life Sciences
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Diabetes and endocrinology, Health economics, Health services research
Keywords:	General diabetes < DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, HEALTH ECONOMICS

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Identifying and delineating the type 2 diabetes population in the Netherlands using an all-payer claims database: Characteristics, healthcare utilization, and expenditures

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ABSTRACT

Objectives We aimed to identify and delineate the Dutch type 2 diabetes population and the distribution of healthcare utilization and expenditures across the health system from 2016 to 2018 using an all-payer claims database.

Design Retrospective observational cohort study based on an all-payer claims database of the Dutch population.

Setting The Netherlands

Participants The whole Dutch type 2 diabetes population (n=900,522 in 2018), determined based on bundled payment codes for integrated diabetes care and medication use indicating type 2 diabetes.

Outcome measures Annual prevalence of type 2 diabetes, comorbidities, and characteristics of the type 2 diabetes population, as well as the distribution of healthcare utilization and expenditures were analyzed descriptively.

Results In 2018, 900,522 people (6.5% of adults) were identified as having type 2 diabetes. The most common comorbidity in the population was heart disease (12.1%). Additionally, 16.2% and 5.6% of patients received specialized care for microvascular and macrovascular diabetes-related complications, respectively. Most type 2 diabetes patients received pharmaceutical care (99.1%), medical specialist care (97.0%), and general practitioner consultations (90.5%). In total, €8,173 million, 9.4% of total healthcare expenditures, was reimbursed for the type 2 diabetes population. Medical specialist care accounted for the largest share of spending (38.1%), followed by district nursing (12.4%), and pharmaceutical care (11.5%).

Conclusions All-payer claims databases can be used to delineate healthcare use: this insight can inform health policy and practice and, thereby, support better decisions to promote long-term sustainability of healthcare systems. The healthcare utilization of the Dutch type 2 diabetes population is distributed across the health system and utilization of medical specialist care is high. This is likely to be due to presence of concurrent morbidities and complications. Therefore, a shift from a disease-specific approach to a person-centered and integrated care approach could be beneficial in the treatment of type 2 diabetes.

Strengths and limitations of this study

- The use of an all-payer claims database enables an overview of the complete Dutch type 2 diabetes population
- Due to the economic function of claims data, the data is accurate and complete enabling a reliable estimation of healthcare utilization and expenditures
- Internationally, the generalizability of findings could be limited because of the differences in the organization of healthcare
- Real- or near-time data use of claims data is hampered by a two-year time lag

INTRODUCTION

Internationally, there are rising concerns regarding the financial sustainability of healthcare systems. This financial strain is caused by increasing costs associated with ageing populations, rising life expectancy, expensive technological advances, and higher patient expectations.[1–3] In particular, the burden caused by chronic diseases is rapidly increasing.[4] Diabetes mellitus is currently one of the most prevalent chronic diseases affecting an estimated 463 million people in the age group 20 - 79 years, or 9.3% of adults worldwide.[4,5] This number is expected to rise to 700 million by 2045.[5] Within the diabetes population, 90% of patients suffer from type 2 diabetes.[5,6] Many develop at least one diabetes-related macro- or microvascular complication during the course of their disease.[7,8] The presence of these complications substantially increases healthcare utilization and expenditures.[7–12] For instance, the presence of both micro- and macrovascular complications increases patients' care expenditures by up to 250%.[7] In total, expenditures on diabetes–related complications are estimated to amount to more than half of all diabetes care expenditures.[13,14]

However, to date, knowledge on healthcare utilization and expenditures of nationwide type 2 diabetes populations remains limited as national diabetes registries are rare and studies on diabetes care costs are often based on data from smaller subgroups of patients. These subgroups are generally based on diabetes patients who suffered a specific event, geographically defined groups, insurance defined groups, patients of specific care organizations, or random samples.[9–11,15–21] Thus, the use of data representing a heterogeneous, nationwide type 2 diabetes populations is rare,[16] and therefore the generalizability of prior research findings is limited. Additionally, prior studies are often based on self-reported cost data which may lead to recall bias.[8,9,12,15] Existing insights into expenditures on type 2 diabetes-related complications are similarly fragmented and unclear.[11,14,15] This is caused by the limited number of papers covering this topic, difficulties in separating diabetes-related expenditures, as well as poor transparency regarding cost sources in existing studies.[11,22] In addition, previous studies in this area have often focused on hospital care or analyzed only one specific diabetes-related complication.[8] Accordingly, estimates of expenditures on complications vary widely.[22]

Because of the increasing concerns about the financial sustainability of healthcare systems and the rising prevalence of type 2 diabetes, a more exact insight into the healthcare utilization and expenditures of type 2 diabetes populations is needed. The current focus on specific subgroups limits available evidence on heterogeneity of healthcare utilization and costs in whole diabetes populations. Such insight would enhance understanding of where and how much diabetes care is provided, support better decisions to promote long-term sustainability, and aid tailoring policies and practice to achieve improvements on the Quadruple Aim.[23] Therefore, we use an all-payer claims database (APCD) that covers 99% of the Dutch population to identify the Dutch type 2 diabetes population and present a detailed and complete overview of population characteristics, healthcare utilization, and expenditures. APCDs are becoming increasingly important in facing health care challenges as these enable analysis of whole populations across the health system, as well as over time.[24–26] Accordingly, the aim of this study is twofold. The first aim is to specify the size and characteristics of the Dutch type 2 diabetes population, including the annual prevalence of chronic comorbidities and type 2 diabetes-related complications, over the years 2016 to 2018. The second aim is to determine the total healthcare utilization and expenditures of this population and the distribution of use and expenditures (a) across healthcare sectors (e.g. primary care, specialized care); (b) related to specific service types (e.g. mental health care, pharmaceutical care), and; (c) for type 2 diabetes-related complications (e.g. heart failure, diabetic foot) over the same time period.

METHODS

Data source

This retrospective observational study was based on an APCD from the national health insurance registry managed by the Vektis Healthcare Information Center. Vektis was set up by Dutch health insurers in 2006 to support claims reimbursement, provide high-quality, accurate, and complete data for Dutch risk equalization model, and enable the main players in the Dutch healthcare market to base their decision-making and policy execution on reliable, essential and timely data.[27] For this purpose, the Vektis databases contain information on all procedures covered by Dutch statutory health insurance, as well as a set of data on patients, providers, care products, and prices. Before integration into the Vektis databases, health insurers' data undergo rigorous inspection and validation. Vektis' coverage rate has gradually expanded since 2006: the information center now receives data from all Dutch health insurers and covers over 99% of the Dutch population. For this study, comprehensive claims data on the type 2 diabetes population spanning across healthcare sectors and service types for the timeframe 2016-2018 were drawn from the Vektis registry. The timeframe 2016-2018 was chosen to examine most recent data and because no major policy changes regarding diabetes care were made during this period.

Study population

In the Netherlands, the vast majority of type 2 diabetes patients (83% in 2018) receive integrated diabetes care within a primary care setting organized by care groups,[28] i.e. regionally organized health care provider groups comprising general practitioners (GPs) and affiliated personnel. These integrated diabetes care programs are funded by health insurers on the basis of a bundled payment per patient per year.[29] We used existing bundled payment claim codes to identify type 2 diabetes patients in the APCD. Most of the remaining 17% of Dutch type 2 diabetes patients are treated in secondary care, by a medical specialist, due to the complexity of their condition. Complex diabetes cases include patients who cannot reach glycemic control in primary care or patients who need a more intricate treatment for complications or risk factors (e.g. treatment resistant cardiovascular risk factors) under management of a medical specialist.[30] In addition, a small group of patients is treated in primary care by a GP who is not affiliated with a care group

and, as such, are not covered by the bundled payment system. To identify these remaining type 2 diabetes patients, we assessed medication use (based on ATC-codes) indicating type 2 diabetes. Identification based on medication use is possible in the Netherlands due to the relatively strict and stepwise medication guideline for type 2 diabetes management.[31] Thus, to be as accurate and inclusive as possible, we identified individuals as type 2 diabetes patients if they met one or more of the following criteria: (a) received integrated diabetes care or (b) were treated for their type 2 diabetes with (b.1.) only oral medication (A10B blood glucose lowering drugs excl. insulins); (b.2.) a combination of insulin (A10A insulins and analogues for injection) and oral medication (A10B blood glucose lowering drugs excl. insulins), or (b.3.) a combination medication (A10AE54 or A10AE56: mix of insulins and GLP-1 for injection, long-acting). Individuals were included based on medication use if they received any of the medications described at least once in that year. We determined the type 2 diabetes population separately for each year within the timeframe 2016 to 2018. Individuals were included in the annual population prevalence if one or more of the inclusion criteria applied at any time during that year. Accordingly, the study population had the nature of an open and dynamic cohort, to which individuals could be added or excluded from each year. No exclusion criteria were applied.

Patient and population characteristics

To describe the study population, we included age, gender, and presence of chronic comorbidities and type 2 diabetes complications. The presence of chronic comorbidities was assessed by 'pharmaceutical costs groups' (In Dutch: *Farmaceutische KostenGroepen*, FKGs) which are used for the Dutch risk equalization scheme for health insurers.[32] FKGs are a proven tool to identify insured persons with chronic conditions, such as glaucoma or heart disease, by means of medication claims.[33] An FKG is ascribed to an insured person when he/she is issued prescriptions for more than a certain dose of medication (i.e. enough from approximately six months' use) in a given year.

Presence of type 2 diabetes-related complications was assessed per year based on 'diagnosis-treatment combinations' (in Dutch: *diagnose-behandelcombinaties*, DBCs). In the Netherlands, specialized care is reimbursed via DBCs, a concept similar to diagnosis-related groups (DRGs). DBCs consider

complete episodes of care for a specific diagnosis, thus DBCs contain information on specialism or responsible specialized physician, patient diagnosis, and provided treatment.[34] Moreover, one DBC may contain a number of healthcare consultations, tests, or treatments. For one DBC, health insurers reimburse the average expenditures made for the related diagnosis. One of the authors, who is an internist (HB), matched the associated DBCs to the type 2 diabetes-related complications (Supplementary Table 1). We focused on the most common complications listed by Nathanson et al.[35] For macrovascular complications, these were acute coronary syndrome, stroke, and heart failure. Microvascular complications included diabetic mono-/polyneuropathy, diabetic eye complications, diabetic foot/peripheral angiopathy, and diabetic kidney disease. If a relevant DBC was reimbursed once in a given year, that patient was registered as having the associated type 2 diabetes-related complication.

Healthcare utilization and expenditures

This study considered total healthcare expenditures of the type 2 diabetes population under the Dutch Health Insurance Act (In Dutch: *Zorgverzekeringswet*, Zvw), as well as under the Long-term Care Act (In Dutch: *Wet Langdurige Zorg,* Wlz). Together, these two Acts account for the bulk of the available health care budget in the Netherlands. For the Dutch Health Insurance Act, utilization and expenditures of the type 2 diabetes population related to a number of healthcare sectors and service types were extracted from the Vektis databases. Data on the primary care and specialized care (care provided in hospitals and Independent Specialized Treatment Centers) sectors were studied in detail. Utilization of primary care covered patients registered with a GP, whereas utilization of GP consultations included patients that utilized regular consultations (excluding integrated diabetes care consultations), home visits, and consultations via e-mail and by phone. Moreover, we distinguished data regarding service types: pharmaceutical care, assistive devices, mental health care, district nursing, paramedical care, and other care. Other care included maternity care, obstetrics, oral care, patient transport, care abroad, geriatric rehabilitation, primary care support, and inpatient primary care. Expenditures within these specified healthcare sectors and services were also considered at the individual patient level. Utilization and expenditures both directly related to diabetes care

as well as other (non-diabetes related) services were included. The expenditures considered under the Dutch Health Insurance Act include mandatory deductibles paid by patients; other (co)payments are not included.[36] Indirect costs were not considered in this study, since no information on this aspect is available in the Vektis database.

Utilization and expenditures of type 2 diabetes-related complications

We studied utilization of and expenditures on specialized care for type 2 diabetes-related macro- and microvascular complications in more detail. We used DBCs indicating macro- and microvascular type 2 diabetes-related complications (Supplementary Table 1) to assess both utilization of and expenditures on specialized care.

Total expenditures on medical specialist care services were determined using the total reimbursed costs for this service type per study year, drawn from the APCD. However, in determining expenditures per type 2 diabetes-related complication, a median Dutch price per DBC was calculated. This is because the prices for specific DBCs can differ to some extent between hospitals due to variations in contractual agreements made between individual hospitals and health insurers.[37] Moreover, hospitals are known to raise or reduce the prices of specific DBCs for administrative purposes, e.g. to meet a hospital-wide turnover constraint. As a consequence, DBC prices do not necessarily reflect the true cost of the correlated care episode.[38] Thus, to mitigate the variation in expenditures introduced by administrative DBC pricing, we used the median Dutch price per DBC to calculate the expenditures on type 2 diabetes-related complications. For every specific DBC, the median DBC price was determined by arranging all countrywide reimbursed DBCs of that type to find the median accordingly. As DBC prices vary over the years, this was done separately for each study year. Finally, to determine the total expenditures per type 2 diabetes-related complication, the associated reimbursed DBCs were multiplied by the related median DBC prices.

Statistical analysis

Data were analyzed descriptively. The continuous variables age and per treated patient expenditures on type 2 diabetes-related complications were presented as means and standard deviations (SDs). For

complications, the median expenditures per treated patient and the 5th and 95th percentile were also described. The categorical variables gender, presence of comorbidities, presence of type 2 diabetes-related complications, and healthcare sector and service utilization were reported as frequencies and valid percentages of the total type 2 diabetes population. Population and per patient expenditures on healthcare sectors and service types and type 2 diabetes-related complications were presented as frequencies and valid percentages. Due to the economic function of Vektis data, missing data are rare but in case of missing data the expenditures were imputed as zero, age was not imputed, and gender was set to unknown.

The data were recovered and reported from the Vektis databases based on a detailed data extraction and processing request. The data were obtained and analyzed using statistical package SAS 7.15. According to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch 'Research involving Human Subjects act' (registration number 2019-1445).

Patient and public involvement

This study aimed to gain an overview of healthcare utilization of and expenditures on the Dutch type 2 diabetes population. Patients were not involved in the design, management, or reporting of this study.

RESULTS

Characteristics of the type 2 diabetes population

In 2018, 900,522 people or 6.5% of the Dutch population aged 18 and above were identified as having type 2 diabetes (Table 1). In total, 740,353 patients received integrated diabetes care in that year. The type 2 diabetes population increased by 2.3% compared to 2016 (n=880,121). In 2018, the mean age of the Dutch type 2 diabetes population was 68.7 (±12.3) years and 46.7% of the population was female. The most common chronic comorbidity (based on medication) was heart disease, with a prevalence of 12.1% in 2018. This was followed by depression and thyroid disorders, with 2018-prevalences of 5.7% and 5.0%, respectively. Moreover, based on specialized care utilization, 5.6% of patients received care for macrovascular type 2 diabetes-related complications and 16.2% of patients received care for microvascular type 2 diabetes-related complications. The most frequently occurring complications were diabetic eye complications: 12.2% of the type 2 diabetes population received specialized care for this. The second most common type 2 diabetes-related complication identifiable through reimbursement was heart failure, as 2.8% of type 2 diabetes patients received specialized care for this. The third most prevalent were care for diabetic foot/peripheral angiopathy and diabetic kidney disease (reimbursed for 2.6% and 2.5%, respectively).

Table 1 Characteristics of the Dutch type 2 diabetes population in 2016-2018

	2016	2017	2018
Annual prevalence, n	880,121	890,682	900,522
New patients, n	58,606	57,877	57,411
Loss to follow-up, n			
Deceased	38,042	38,962	40,050
Other reasons*	19,055	9,274	8,609
Mean age, years (SD)	67.4 (±12.4)	68.5 (±12.4)	68.7 (±12.3)
Gender, female, n (%)	417,912 (47.5)	419,658 (47.1)	420,988 (46.7)
Prevalence of chronic comorbidities, n (%)†			
Heart disease	111,106 (12.6)	109,892 (12.3)	109,022 (12.1)
Depression	51,906 (5.9)	52,427 (5.9)	51,729 (5.7)
Thyroid disorders	43,879 (5.0)	43,786 (4.9)	44,612 (5.0)
COPD / severe asthma	41,162 (4.7)	41,183 (4.6)	41,383 (4.6)
Asthma	39,768 (4.5)	40,611 (4.6)	41,021 (4.6)
Glaucoma	33,364 (3.8)	33,852 (3.8)	39,200 (4.4)
Psychosis and addiction	13,841 (1.6)	14,105 (1.6)	16,929 (1.9)
Neuropathic pain	10,461 (1.2)	10,945 (1.2)	11,451 (1.3)
Prevalence of type 2 diabetes-related complications, n (%)			
Macrovascular type 2 diabetes-related complications	51,684 (5.9)	51,355 (5.8)	50,825 (5.6)
Heart failure	25,835 (2.9)	25,964 (2.9)	25,627 (2.8)
Stroke	17,718 (2.0)	17,449 (2.0)	17,653 (2.0)
Acute coronary syndrome	10,712 (1.2)	10,468 (1.2)	9,932 (1.1)
Microvascular type 2 diabetes-related complications	144,877 (16.5)	144,881 (16.3)	146,216 (16.2)
Diabetic eye complications	109,332 (12.4)	108,841 (12.2)	109,859 (12.2)
Diabetic foot/peripheral angiopathy	22,724 (2.6)	22,878 (2.6)	23,221 (2.6)
Diabetic kidney disease	22,431 (2.5)	22,736 (2.6)	22,758 (2.5)
Diabetic mono/polyneuropathy	1,835 (0.2)	1,754 (0.2)	1,730 (0.2)

* Other reasons for loss to follow-up may include people who no longer meet the inclusion criteria, people admitted to a nursing home, and people who emigrated. Calculated as: (number of patients y-1) + (number of new patients y) – (number of deceased y-1) – (number of patients y)

† The FKGs present in over 1% of the type 2 diabetes population are displayed

Healthcare utilization

All type 2 diabetes patients utilized care reimbursed under the Health Insurance Act in the timeframe 2016-2018. In 2018, 4.4% of patients additionally utilized care reimbursed under the Long-term Care Act. Regarding services covered by the Health Insurance Act, Table 2 shows that relatively large shares of the population used care in the specified healthcare sectors and service types. Almost all people with type 2 diabetes used pharmaceutical (99.1%) and medical specialist care (97.0%) in 2018. Moreover, the large majority of this population had GP consultations (90.5%) and half of the type 2 diabetes population had reimbursements for the use of assistive devices. Mental health care was used by the smallest share of type 2 diabetes patients (4.7%). Reimbursements for paramedical care and district nursing increased most during the study period, by 17.4% and 8.2%, respectively.

Table 2 Share of the type 2 diabetes population with service use per health care sector and service type, 2016-2018

	2016	2017	2018
Healthcare sectors			
Primary care, n (%)	879,578 (99.9)	890,161 (99.9)	899,998 (99.9)
Medical specialist care, n (%)	845,121 (96)	853,478 (95.8)	873,606 (97.0)
Healthcare service types			
Pharmaceutical care, n (%)	871,999 (99.1)	882,431 (99.1)	892,250 (99.1)
GP consultations, n (%)	800,037 (90.9)	808,774 (90.8)	815,289 (90.5)
Assistive devices, n (%)	431,867 (49.1)	439,249 (49.3)	445,438 (49.5)
Paramedical care, n (%)	137,206 (15.6)	147,129 (16.5)	161,035 (17.9)
District nursing, n (%)	130,571 (14.8)	134,209 (15.1)	141,252 (15.7)
Mental health care, n (%)	42,207 (4.8)	42,004 (4.7)	41,989 (4.7)

Healthcare expenditures

In Figure 1, total healthcare expenditures of the Dutch type 2 diabetes population in 2018 are displayed. In total, €8,173 million was reimbursed, an increase of 7.2% from 2016 (Supplementary Fig. 1). Of the total expenditures, 18.6% was on care under the Long-term Care Act, while the remaining 81.4% were expenditures reimbursed under the Health Insurance Act. As to the latter, medical specialist care accounted for the largest share of spending, i.e. €3,115 million or 38.1%. District nursing accounted for the second largest share and increased by 12.0% from 2016 to €1,012 million in 2018. Expenditures on pharmaceutical care were €942 million, accounting for 11.5% of the total. The fourth largest share results from expenditures on primary care (including GP consultations), accounting for 6.0% of the total (€488 million).

[Fig. 1 here]

Mean annual per patient expenditures

With regard to the Health Insurance Act, mean annual per patient spending increased by 4.4% from 2016 to 2018: €7,077 to €7,386 (Figure 2). The annual spending on medical specialist care accounted for the largest share (47%) or €3,459 per patient in 2018. Secondly, district nursing and pharmaceutical care contributed to a significant share of annual per patient expenditures: €1,124 and €1,047, respectively. Moreover, the mean annual per patient expenditures on district nursing increased by 9.4% from 2016 to 2018. Annual primary care expenditures were €542 per patient in 2018. As to the category other, expenditures increased by 18.6% from 2016 and on average €517 was spent per patient in 2018. Per patient spending on assistive devices, mental health care, and paramedical care were all under 5.0% of the total mean annual per patient expenditures. The type 2 diabetes patients who received care under the Long-term Care Act as well as under the Health Insurance Act (4.4%) had an average long-term care spending of €38,033 in 2018. This increased by 14.4% in comparison to 2016.

[Fig. 2 here]

Expenditures on type 2 diabetes-related complications

In total, €556 million was spent on specialized care for type 2 diabetes-related complications in 2018 (Table 3). The majority of these expenditures related to microvascular complications (55.0%), which increased by 10.8% from 2016 to 2018. Spending on macrovascular complications increased by 2.1% during the same period. In 2018, €250 million was spent on macrovascular type 2 diabetes-related complications. Diabetic foot/peripheral angiopathy accounted for the largest share of spending on diabetes-related complications with 20.9% or €116 million in 2018. Secondly, expenditures on strokes were 19.9% (€111 million) in 2018. Thirdly, total spending on diabetic eye complications increased by 11.2% over the studied period and accounted for 17.9% of the total in 2018. Moreover, for diabetic kidney disease, total expenditures increased by 12.8% from 2016 to 2018 (to 15.7% of the total). The per treated patient mean and median expenditures on type 2 diabetes-related complications were lowest for diabetic eye complications and diabetic mono/polyneuropathy. The highest mean and median expenditures per treated patient were for stroke and acute coronary syndrome (Supplementary Table 2).

Table 3 Total expenditures type 2 diabetes related complications 2016-2018 (million €)

	2016	2017	2018	Change in % 2016-2018
Macrovascular type 2 diabetes-related complications, n (%)	245 (47.0)	249 (46.7)	250 (45.0)	2.1%
Heart failure, n (%)	81 (15.5)	80 (15.1)	81 (14.6)	0.5%
Stroke, n (%)	106 (20.3)	111 (20.8)	111 (19.9)	5.0%
Acute coronary syndrome, n (%)	59 (11.3)	58 (10.9)	58 (10.5)	-0.8%
Microvascular type 2 diabetes-related complications, n (%)	276 (53.0)	284 (53.3)	306 (55.0)	10.8%
Diabetic eye complications, n (%)	90 (17.2)	92 (17.2)	100 (17.9)	11.2%
Diabetic foot/peripheral angiopathy, n (%)	106 (20.4)	110 (20.7)	116 (20.9)	9.7%
Diabetic kidney disease, n (%)	78 (14.9)	79 (14.9)	88 (15.7)	12.8%
Diabetic mono/polyneuropathy, n (%)	3 (0.6)	3 (0.5)	3 (0.5)	-14.3%
Total expenditures, n (%)	521 (100.0)	532 (100.0)	556 (100.0)	6.7%

DISCUSSION

This study is the first to use an APCD of the Dutch population to identify and characterize the type 2 diabetes population. Hereby, this study extends the knowledge of its characteristics and provides insight into healthcare utilization and expenditures across healthcare sectors, service types, and for type 2 diabetes-related complications. In 2018, the annual prevalence of type 2 diabetes in the Netherlands was 900,522 people (6.5% of Dutch adults). The most prevalent comorbidity, based on medication use, was heart disease with a prevalence of 12.1%. Moreover, 5.6% received specialized care for macrovascular and 16.2% of the 2018 population received specialized care for microvascular complications. Regarding healthcare utilization, almost all type 2 diabetes patients utilized pharmaceutical care, medical specialist care, and GP care. In total, €8,173 million, about 9.4% of total healthcare expenditures, was reimbursed for the type 2 diabetes population in 2018.[39] Expenditures on medical specialist care represented the largest share of total healthcare expenditures (38.1%), followed by expenditures on district nursing (12.4%) and pharmaceutical care (11.5%).

The current study has a number of strengths. A major strength is the use of an APCD covering virtually all Dutch citizens, which ensures a heterogeneous cohort. Another advantage of an APCD is the accuracy of the data: to enable optimal risk equalization among health insurers, data undergo extensive quality control before they are included in the Vektis databases.[27] Quality control of the data used for risk equalization is extremely important as Dutch health insurers have an obligation to accept all applicants and, as such, are highly dependent on a fair compensation for risk differences in order to survive in the market.[33] The combination of a virtually complete dataset, high data accuracy, and completeness allowed us to estimate disease prevalence, resource utilization, and expenditures in a reliable manner. However, using all-payer claims data also presents drawbacks. Because of the nature of our data, we were only able to report direct medical costs and could not assess indirect medical costs. A recent Dutch study based on self-reported data, showed that indirect medical costs, such as productivity losses and informal care, accounted for 30% of total societal costs for type 2 diabetes patients.[12] As 70% is related to direct medical costs, we did assess the majority of expenditures in this study. In addition, despite the heterogeneous cohort,

the generalizability of certain findings may be limited on an international level due to differences in the organization of healthcare. For instance, the number and duration of hospitalizations and expenditures on pharmaceutical care are found to vary between established markets.[40–42] Additionally, for claims data, real- or near-time data use e.g. for research findings to apply in policy and practice and vice versa is hampered by the two-year time lag in data. Moreover, the Dutch claims data do not include specific diagnostic codes for type 2 diabetes. Therefore, we determined the type 2 diabetes population with a number of inclusion criteria. However, a small share of type 2 diabetes patients cannot be identified through claims data, i.e. patients who do not receive integrated diabetes care and do not use any diabetes medication or use insulin only, and type 2 diabetes patients who live in nursing homes and receive all care within the facility. Nevertheless, the effect of not detecting these patients is likely to be minimal, as the large majority of type 2 diabetes patients receive integrated diabetes care (83%) and if not, many are included due to medication use for type 2 diabetes (80% received diabetes medication in 2018).[28,43] Similarly, we found that with our first inclusion criterion ("received integrated diabetes care") we identified 740,353 patients with type 2 diabetes, i.e. 82.2% of the total number of patients identified in 2018. Thus, the size of our identified population matches existing estimates on the number of T2DM patients treated in integrated primary care. Moreover, as we used claims data, we were only able to identify chronic comorbidities and type 2 diabetes-related complications for which patients recently used care, which could lead to an underestimation of the prevalences of these conditions. However, we believe this underestimation is limited in scope, as prior research has shown that the presence of comorbidities and complications in diabetes strongly predicts a higher volume of medical health care utilization. [7–12]

Notwithstanding these limitations, our APCD enables a detailed and complete overview of the type 2 diabetes population. However, our findings regarding population size differ from the type 2 diabetes population as estimated by NIVEL (Netherlands Institute for Health Services Research).[44] Their findings indicated an annual prevalence of 1,079,624 people with type 2 diabetes in 2018.[6] However, this estimate is based on GP registration data representing approximately 10% of the Dutch population,[44] whereas we included data on the total Dutch population. Also, morbidity estimates of GPs may be less reliable as these

are potentially influenced by the local organization of the healthcare system, methods of morbidity registration, the organization of the GP practice, and patient characteristics.[45] Lastly, once a type 2 diabetes patient is included in the NIVEL cohort, they do leave the cohort for reasons other than mortality. Hence, their approach potentially results in an overestimation of the actual prevalence of type 2 diabetes.

Notably, our findings indicated that the majority of healthcare utilization and expenditures of the type 2 diabetes population are not directly related to diabetes. Type 2 diabetes patients utilize care throughout the healthcare system, i.e. across healthcare sectors and service types. Additionally, 97.0% of type 2 diabetes patients utilize medical specialist care despite 83% receiving integrated diabetes care in the primary care setting.[28] Moreover, medical specialist care utilization of the type 2 diabetes population is considerably higher than the share of the entire insured population in the Netherlands that utilizes medical specialist care (43% in 2017).[46] The wide dispersion of service use across the health system, as well as the high utilization of medical specialist care, may be explained by the presence of comorbidities and complications. Many patients not only have type 2 diabetes but additionally suffer from other conditions, as is confirmed in this study as well as shown in previous literature.[7,8] Findings that comorbidities substantially increase healthcare expenditures and utilization are also in line with previous studies on this topic.[7–12]

The high utilization of non-diabetes care of the type 2 diabetes population has several implications for policymakers. As a large share of healthcare utilization and expenditures is caused by comorbidities or type 2 diabetes-related complications, it could be beneficial to organize care more holistically and approach diabetes and non-diabetes complaints more concentrated in the health system. Such an approach would underpin the need to shift from a disease-specific approach to a person-centered and integrated care approach. This is in agreement with prior findings indicating that person-centered integrated care may be meaningful in making the care process less fragmented and improving physical and psychological health in patients with multi-morbidity.[47,48] Additionally, the high utilization of and expenditures across the healthcare system show that diabetes care is not necessarily expensive but the total care for patients known with type 2 diabetes is. Therefore, when addressing healthcare expenditures, policymakers should not only

focus on utilization of and expenditures on diabetes care but also on care for concurrent morbidities and complications. Prior research has also shown that integrated care adapted to the needs of chronically ill patients could lead to better outcomes at lower costs.[49]

Therefore, future research exploring the characteristics of high-need (utilization) and high-cost (expenditures) subgroups within the type 2 diabetes population may provide new insights into relevant trigger factors for high care consumption. Such insights can inform initiatives to reduce spending growth and thereby maintain the financial sustainability of healthcare systems. We identified a high level of dispersion in care use, combined with a large share of type 2 diabetes patients that utilize specialized care. These findings illustrate the need to further delineate specific type 2 diabetes subgroups with similar resource use, and better understand their courses of disease, background characteristics, and exposure to risk factors, to enable evidence-based tailoring and improvement of care. Moreover, APCDs can be used for longitudinal retrospective analyses, for instance to show long-term effects of policies or treatment changes to determine whether these were effective and support sustainability. Additionally, future research should focus further on the dispersion of healthcare utilization of and expenditures on the type 2 diabetes population. Insight into pharmaceutical care and medical specialist care utilization would be particularly meaningful as these healthcare services are heavily utilized by this population. Moreover, to better understand the impact of type 2 diabetes on healthcare utilization and healthcare expenditures, future research should compare people with and without type 2 diabetes.

CONCLUSIONS

APCDs can be used to identify the national type 2 diabetes population and describe its characteristics, healthcare utilization, and healthcare expenditures. This insight can inform policymakers and practice about dispersion of reimbursed care, directly and indirectly related to type 2 diabetes, and in turn support better decisions to promote long-term (financial) sustainability of healthcare systems.

Contributors RG, AE, DR, JS, and DR were involved in the design of the study. A detailed data extraction and processing request for data acquisition was made by RG, AE, and HB and approved by DR and JS. CT performed data acquisition and assisted data analysis. All authors were involved in checking the accuracy and completeness of the data. RG conducted data analysis, drafting, and manuscript writing. AE, HB, JS, and DR all critically reviewed and revised the drafts and contributed to writing. All authors approved the final version and were involved in the decision to submit it for publication. RG is the guarantor of this work and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Competing Interests None declared.

Funding The current study was funded by AstraZeneca Netherlands. The study sponsor was not involved in the design of the study; the collection, analysis, and interpretation of data; writing the report; and did not impose any restrictions regarding the publication of the report.

Data sharing statement The datasets generated and analyzed during this study are not publicly available, as formal consent from the Dutch health insurers is needed to gain access to these files. Data are however available from Vektis upon reasonable request and with formal consent of the Dutch health insurers.

Ethics approval According to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch 'Research involving Human Subjects act' (registration number 2019-1445)

Patient consent for publication Not required.

Acknowledgements We thank Michiel ten Hove, Robin Stoof, and Paul Sterkenburg of Vektis for their assistance on developing the study design and for answering our questions about the data.

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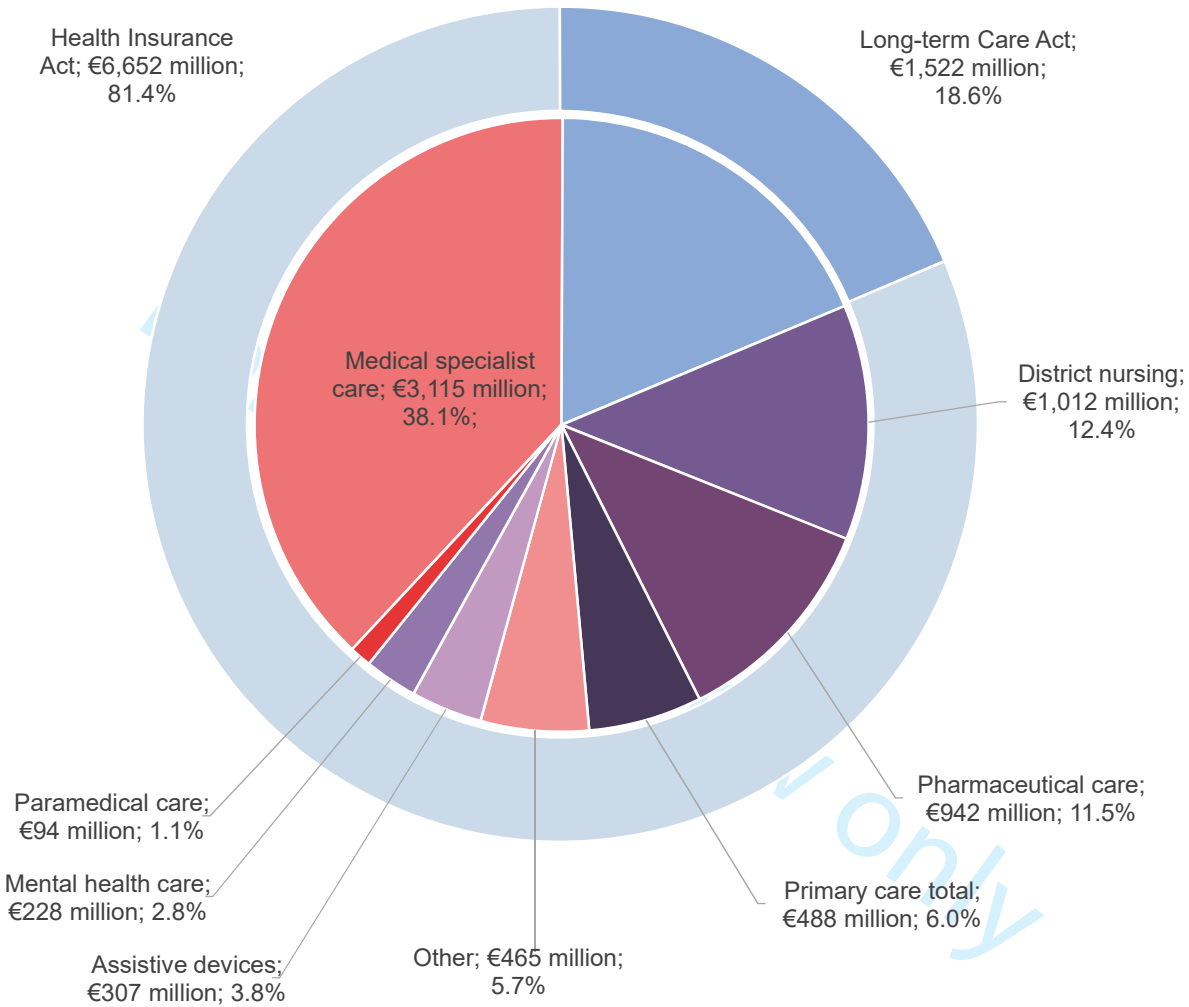
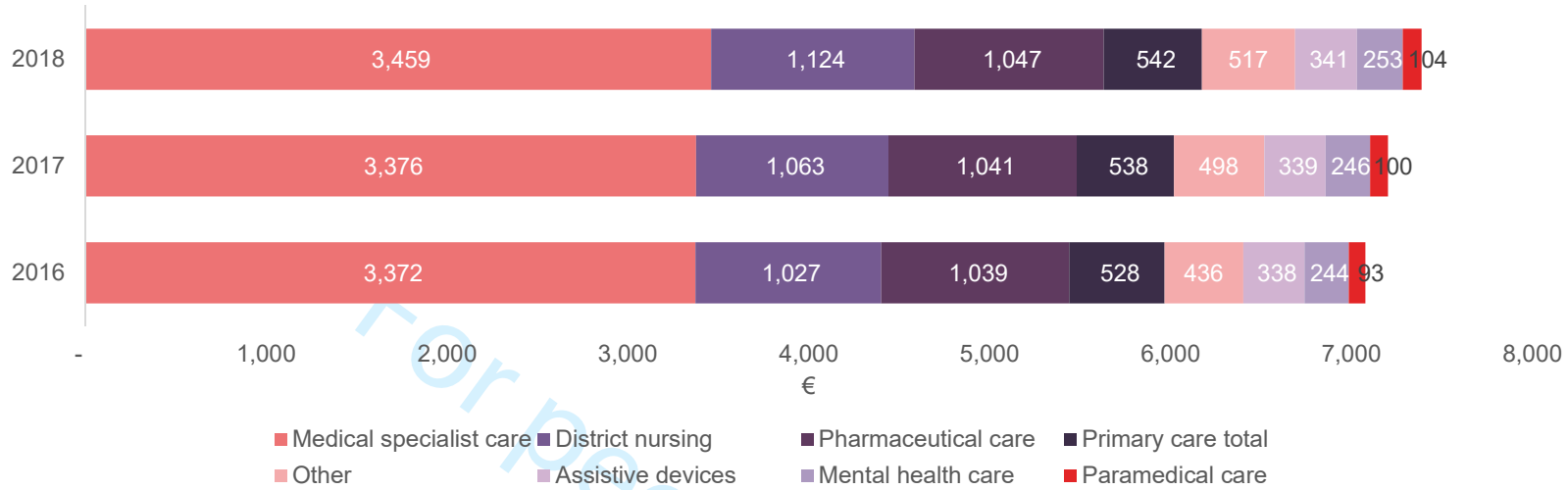
Figure legends

Figure 1 Total healthcare expenditures of the type 2 diabetes population in 2018

Figure 2 Mean annual per patient healthcare expenditures under the Health Insurance Act, 2016-2018

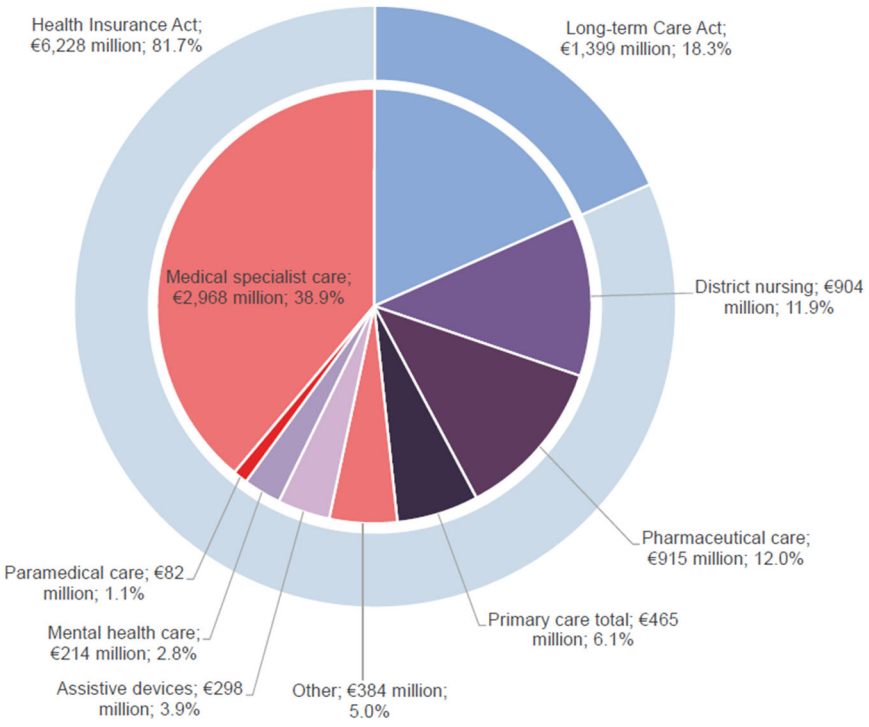




Supplementary Table 1 Matched reimbursement codes per type 2 diabetes-related complication

Disease group	Reimbursement codes (DBCs)
Macrovascular type 2 diabetes – related complications	
Acute Coronary Syndrome	Unstable Angina Pectoris (0320.203); ST-elevated myocardial infarction (0320.204); Non-ST-elevated myocardial infarction (0320.205); Instable AP, myocardial infarction (0313.102); Symptomatic ischemic heart disease, not in 0313.102 (0313.101)
Stroke	Cerebrovascular Accident (0327.313); Cerebrovascular Accident/ Transient Ischemic Attack (0313.121); Intracerebral hemorrhage (0330.1102); Intracranial hemorrhage (sub- / epidural) (0330.1103); Stroke (0330.1111); Cerebrovascular Accident (8418.101); Cerebrovascular Accident/ Transient Ischemic Attack (0335.263); Transient Ischemic Attack (including amaurosis fugax) (0330.1112)
Heart failure	Acute heart failure (0320.301); Chronic heart failure (0320.302); Decompensatio cordis (0335.262); Decompensatio cordis (0313.107)
Microvascular type 2 diabetes – related complications	
Diabetic mono/polyneuropathy	Nervous system and sensory disorders (0335.251); Peripheral nerve injury, nerve disorders (0327.413)
Diabetic eye complications	Cataract (0301.554); Anterior uveitis (0301.502); Posterior uveitis / Panuveitis (0301.503); Retinal defect / retinal detachment (0301.654); Subretinal neovascularization (0301.704); Maculopathy (0301.705); Macular degeneration (0301.707); Non-proliferative diabetic retinopathy (0301.754); Preproliferative diabetic retinopathy (0301.755); Proliferative diabetic retinopathy (0301.757); Other pathology diabetic retinopathy (0301.759)
Diabetic foot/peripheral angiopathy	Amputation (0327.200); Amputation through or above the elbow (0327.211); Lower arm / hand amputation, excluding fingers (0327.212); Finger(s) amputation (0327.213); Amputation of upper extremity, not specified (0327.214); Amputation of upper leg and higher (0327.215); Foot, lower leg and knee amputation (0327.216); Amputation of toe(s) (0327.217); Amputation of lower extremity, not specified (0327.218); Amputation of upper leg and higher (8418.401); Foot and/or lower leg and/or toe(s) amputation (8418.402); Amputation of upper extremity (8418.403); Diabetic

	foot (305.2065); Diabetic foot (0303.432); Other peripheral vascular diseases (0303.439); PAOD arm (0303.0412); PAOD 2, claudicatio intermittens (0303.0418); PAOD 3, rest pain (0303.0419); PAOD 4, gangrene (0303.0420)
Diabetic kidney disease	Kidney transplant, recipient (0313.076); Kidney and pancreatic transplant, recipient (0313.078); Chronic renal failure, eGFR 30-60 ml/min (0313.324), Chronic renal failure, eGFR <30 ml/min (0313.325); Continuous ambulatory peritoneal dialysis (CAPD) (0313.331); Automatic peritoneal dialysis (APD) (0313.332); Chronic hemodialysis at home (0313.336); Chronic hemodialysis in institution (0313.339)



Supplementary Figure 1 Healthcare expenditures of the type 2 diabetes population in 2016

Supplementary Table 2 Mean and median expenditures type 2 diabetes related-complications per treated patient in 2016-2018 (€)

	2016 Mean expenditures per patient ± SD[a]	2016 Median per patient expenditures (P5; P95)[a]	2017 Mean expenditures per patient ± SD[a]	2017 Median per patient expenditures (P5; P95)[a]	2018 Mean expenditures per patient ± SD[a]	2018 Median per patient expenditures (P5; P95)[a]
Macrovascular T2DM-related complications	4,739.6±7,510.0	2,301.8 (208.3; 19,453.1)	4,846.5±103.5	2,327.9 (199.8; 19,049.2)	4922.9±7,763.3	2,351.5 (200.3; 19,848.7)
HF	3,118±5,261	689 (208; 12,677)	3,090±5,100	673 (200; 12,873)	3,160±5,296	673 (200; 13,235)
Stroke	5,967±10,215	2,418 (229; 26,980)	6,348±10,749	2,430 (215; 28,514)	6,287±10,587	2,472 (221; 28,830)
ACS	5,479±3,988	5,548 (524; 12,654)	5,530±3,842	5,924 (359; 12,165)	5,863±4,139	6,100 (360; 13,496)
Microvascular T2DM-related complications	1,907.7±80.9	393.9 (80.9; 7,146.7)	1,957.3±80.1	401.0 (80.1; 7,200.0)	2,094.4±6,818.2	447.8 (82.1; 7,768.2)
Diabetic eye complications	820±1,247	161 (81; 3,031)	843±1,272	165 (80; 3,150)	908±1,332	178 (82; 3,512)
Diabetic foot/peripheral angiopathy	4,671±9,255	585 (124; 20,513)	4,817±9,680	588 (124; 21,739)	5,013±9,922	608 (126; 22,133)
Diabetic kidney disease	3,461±12,020	677 (226; 13,654)	3,479±11,857	679 (230; 16,187)	3,848±12,430	689 (230; 21,200)
Diabetic mono/polyneuropathy	1,608±6,066	458 (229; 3,886)	1,438±6,135	430 (215; 3,543)	1,462±5,323	443 (221; 4,020)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1 & 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4 & 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6 & 7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6 & 7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7 - 9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7 - 9
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6 & 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6 & 7
		(*e*) Describe any sensitivity analyses	-

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	-
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	(9)
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9-15
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	-
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17 & 18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.