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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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4 **1 Identifying and delineating the type 2 diabetes population in the Netherlands**  
5 **2 using an all-payer claims database: Characteristics, healthcare utilization, and**  
6 **3 expenditures**  
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## 21 ABSTRACT

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

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

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

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

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3 **43 Strengths and limitations of this study**  
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- 5 44 - The use of an all-payer claims database enables an overview of the complete Dutch type 2 diabetes  
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7 45 population  
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9 46 - Due to the economic function of claims data, the data is accurate and complete enabling a reliable  
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11 47 estimation of healthcare utilization and expenditures  
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13 48 - Internationally, the generalizability of findings could be limited because of the differences in the  
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15 49 organization of healthcare  
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17 50 - Real- or near-time data use of claims data is hampered by a two-year time lag  
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## 51 INTRODUCTION

52 Internationally, there are rising concerns regarding the financial sustainability of healthcare systems. This  
53 financial strain is caused by increasing costs associated with ageing populations, rising life expectancy,  
54 expensive technological advances, and higher patient expectations.[1–3] In particular, the burden caused  
55 by chronic diseases is rapidly increasing.[4] Diabetes mellitus is currently one of the most prevalent chronic  
56 diseases affecting an estimated 463 million people in the age group 20 - 79 years, or 9.3% of adults  
57 worldwide.[4,5] This number is expected to rise to 700 million by 2045.[5] Within the diabetes population,  
58 90% of patients suffer from type 2 diabetes.[5,6] Many develop at least one diabetes-related macro- or  
59 microvascular complication during the course of their disease.[7,8] The presence of these complications  
60 substantially increases healthcare utilization and expenditures.[7–12] For instance, the presence of both  
61 micro- and macrovascular complications increases patients' care expenditures by up to 250%.[7] In total,  
62 expenditures on diabetes-related complications are estimated to amount to more than half of all diabetes  
63 care expenditures.[13,14]

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

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3 77 Because of the increasing concerns about the financial sustainability of healthcare systems and the  
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5 78 rising prevalence of type 2 diabetes, a more exact insight into the healthcare utilization and expenditures of  
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7 79 type 2 diabetes populations is needed. Such insight would enhance understanding of where and how much  
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9 80 diabetes care is provided in the health system and support better decisions to promote long-term  
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11 81 sustainability.[21] Therefore, we use an all-payer claims database (APCD) that covers 99% of the Dutch  
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13 82 population to identify the Dutch type 2 diabetes population and present a detailed and complete overview  
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15 83 of population characteristics, healthcare utilization, and expenditures. APCDs are becoming increasingly  
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17 84 important in facing health care challenges as these enable analysis of whole populations across the health  
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19 85 system, as well as over time.[22–24] Accordingly, the aim of this study is twofold. The first aim is to specify  
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21 86 the size and characteristics of the Dutch type 2 diabetes population, including the annual prevalence of  
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23 87 comorbidities and type 2 diabetes-related complications, over the years 2016 to 2018. The second aim is to  
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25 88 determine the total healthcare utilization and expenditures of this population and the distribution of use and  
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27 89 expenditures (a) across healthcare sectors (e.g. primary care, specialized care); (b) related to specific service  
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29 90 types (e.g. mental health care, pharmaceutical care), and; (c) for type 2 diabetes-related complications (e.g.  
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31 91 heart failure, diabetic foot) over the same time period.  
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## 92 METHODS

### 93 Data source

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

### 106 Study population

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

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3 118 mix of insulins and GLP-1 for injection, long-acting). The type 2 diabetes population was determined  
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5 119 separately for each year within the timeframe 2016 to 2018. Individuals were included in the annual  
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7 120 population prevalence if one or more of the inclusion criteria applied at any time during that year.  
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9 121 Accordingly, the study population had the nature of an open and dynamic cohort, to which individuals could  
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11 122 be added or excluded from each year. No exclusion criteria were applied.

### 13 123 **Patient and population characteristics**

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15 124 To describe the study population, we included age and gender as demographic variables. Moreover, the  
16  
17 125 presence of comorbidities and type 2 diabetes-related complications were assessed using 'pharmaceutical  
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19 126 costs groups' (In Dutch: *Farmaceutische KostenGroepen*, FKGs) and reimbursement codes, respectively.  
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21 127 FKGs indicate the presence of specific chronic conditions based on patients' medication use and are used  
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23 128 for risk equalization between health insurers in the Dutch health insurance system.[27] In this study, the  
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25 129 FKGs present in over 1% of the type 2 diabetes population were displayed. Additionally, presence of type  
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27 130 2 diabetes-related complications was assessed based on reimbursement codes. The type 2 diabetes-related  
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29 131 complications included were largely based on the most common complications listed by Nathanson et  
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31 132 al.[28] For macrovascular type 2 diabetes-related complications, we included acute coronary syndrome,  
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33 133 stroke, and heart failure. Microvascular type 2 diabetes-related complications included were diabetic mono-  
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35 134 /polyneuropathy, diabetic eye complications, diabetic foot/peripheral angiopathy, and diabetic kidney  
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37 135 disease. One of the authors, who is an internist (HB), matched the associated reimbursement codes to the  
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39 136 type 2 diabetes-related complications (Supplementary Table 1).

### 40 137 **Healthcare utilization and expenditures**

41  
42 138 This study considered total healthcare expenditures of the type 2 diabetes population under the Dutch Health  
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44 139 Insurance Act (In Dutch: *Zorgverzekeringswet*, Zvw), as well as under the Long-term Care Act (In Dutch:  
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46 140 *Wet Langdurige Zorg*, Wlz). Together, these two Acts account for the bulk of the available health care  
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48 141 budget in the Netherlands. For the Dutch Health Insurance Act, utilization and expenditures of the type 2  
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50 142 diabetes population related to a number of healthcare sectors and service types were extracted from the  
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52 143 Vektis databases. Data on the primary care and specialized care (care provided in hospitals and Independent  
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3 144 Specialized Treatment Centers) sectors were studied in detail. Utilization of primary care covered patients  
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5 145 registered with a GP, whereas utilization of GP consultations included patients that utilized regular  
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7 146 consultations (excluding integrated diabetes care consultations), home visits, and consultations via e-mail  
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9 147 and by phone. Moreover, we distinguished data regarding service types: pharmaceutical care, assistive  
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11 148 devices, mental health care, district nursing, paramedical care, and other care. Other care included maternity  
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13 149 care, obstetrics, oral care, patient transport, care abroad, geriatric rehabilitation, primary care support, and  
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15 150 inpatient primary care. Expenditures within these specified healthcare sectors and services were also  
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17 151 considered at the individual patient level. Utilization and expenditures both directly related to diabetes care  
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19 152 as well as other (non-diabetes related) services were included. The expenditures considered under the Dutch  
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21 153 Health Insurance Act include mandatory deductibles paid by patients; other (co)payments are not  
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23 154 included.[29] Indirect costs were not considered in this study, since no information on this aspect is  
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25 155 available in the Vektis database.

### 26 27 28 156 **Utilization and expenditures of type 2 diabetes-related complications**

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30 157 We studied utilization of and expenditures on specialized care for type 2 diabetes-related macro- and  
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32 158 microvascular complications in more detail. In the Netherlands, specialized care is reimbursed via  
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34 159 ‘diagnosis-treatment combinations’ (in Dutch: *diagnose-behandelcombinaties*, DBCs), a concept similar to  
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36 160 diagnosis-related groups (DRGs). DBCs consider complete episodes of care and thus contain information  
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38 161 on specialism or responsible specialized physician, patient diagnosis, and provided treatment.[30]  
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40 162 Moreover, one DBC may contain a number of healthcare consultations, tests, or treatments. DBCs were  
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42 163 used to assess both utilization of and expenditures on specialized care.

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44 164 Total expenditures on medical specialist care services were determined using the total reimbursed  
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46 165 costs for this service type per study year, drawn from the APCD. However, in determining expenditures per  
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48 166 type 2 diabetes-related complication, a median Dutch price per DBC was calculated. This is because the  
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50 167 prices for specific DBCs can differ to some extent between hospitals due to variations in contractual  
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52 168 agreements made between individual hospitals and health insurers.[31] Moreover, hospitals are known to  
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54 169 raise or reduce the prices of specific DBCs for administrative purposes, e.g. to meet a hospital-wide turnover

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3 170 constraint. As a consequence, DBC prices do not necessarily reflect the true cost of the correlated care  
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5 171 episode.[32] Thus, to mitigate the variation in expenditures introduced by administrative DBC pricing, we  
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7 172 used the median Dutch price per DBC to calculate the expenditures on type 2 diabetes-related  
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9 173 complications. For every specific DBC, the median DBC price was determined by arranging all  
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11 174 countrywide reimbursed DBCs of that type to find the median accordingly. As DBC prices vary over the  
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13 175 years, this was done separately for each study year. Finally, to determine the total expenditures per type 2  
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15 176 diabetes-related complication, the associated reimbursed DBCs were multiplied by the related median DBC  
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17 177 prices.

### 18 178 **Statistical analysis**

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22 179 Data were analyzed descriptively. The continuous variables age and per treated patient expenditures on type  
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24 180 2 diabetes-related complications were presented as means and standard deviations (SDs). For  
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26 181 complications, the median expenditures per treated patient and the 5<sup>th</sup> and 95<sup>th</sup> percentile were also  
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28 182 described. The categorical variables gender, presence of comorbidities, presence of type 2 diabetes-related  
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30 183 complications, and healthcare sector and service utilization were reported as frequencies and valid  
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32 184 percentages of the total type 2 diabetes population. Population and per patient expenditures on healthcare  
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34 185 sectors and service types and type 2 diabetes-related complications were presented as frequencies and valid  
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36 186 percentages. Due to the economic function of Vektis data, missing data are rare but in case of missing data  
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38 187 the expenditures were imputed as zero, age was not imputed, and gender was set to unknown.

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41 188 The data were recovered and reported from the Vektis databases based on a detailed data extraction  
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43 189 and processing request. The data were obtained and analyzed using statistical package SAS 7.15. According  
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45 190 to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch  
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47 191 ‘Research involving Human Subjects act’ (registration number 2019-1445).

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## 193 Patient and public involvement

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

## 196 RESULTS

### 197 Characteristics of the type 2 diabetes population

198 In 2018, 900,522 people or 6.5% of the Dutch population aged 18 and above were identified as having type  
199 2 diabetes (Table 1). The type 2 diabetes population increased by 2.3% compared to 2016 (n=880,121). In  
200 2018, the mean age of the Dutch type 2 diabetes population was 68.7 ( $\pm$ 12.3) years and 46.7% of the  
201 population was female. The most common comorbidity (based on medication) was heart disease, with a  
202 prevalence of 12.1% in 2018. This was followed by depression and thyroid disorders, with 2018-  
203 prevalences of 5.7% and 5.0%, respectively. Moreover, based on specialized care utilization, 5.6% of  
204 patients received care for macrovascular type 2 diabetes-related complications and 16.2% of patients  
205 received care for microvascular type 2 diabetes-related complications. The most frequently occurring  
206 complications were diabetic eye complications: 12.2% of the type 2 diabetes population received  
207 specialized care for this. The second most common type 2 diabetes-related complication identifiable  
208 through reimbursement was heart failure, as 2.8% of type 2 diabetes patients received specialized care for  
209 this. The third most prevalent were care for diabetic foot/peripheral angiopathy and diabetic kidney disease  
210 (reimbursed for 2.6% and 2.5%, respectively).

211

**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)

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

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3 **215 Healthcare utilization**  
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5 **216** All type 2 diabetes patients utilized care reimbursed under the Health Insurance Act in the timeframe 2016-  
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7 **217** 2018. In 2018, 4.4% of patients additionally utilized care reimbursed under the Long-term Care Act.  
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9 **218** Regarding services covered by the Health Insurance Act, Table 2 shows that relatively large shares of the  
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11 **219** population used care in the specified healthcare sectors and service types. Almost all people with type 2  
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13 **220** diabetes used pharmaceutical (99.1%) and medical specialist care (97.0%) in 2018. Moreover, the large  
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15 **221** majority of this population had GP consultations (90.5%) and half of the type 2 diabetes population had  
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17 **222** reimbursements for the use of assistive devices. Mental health care was used by the smallest share of type  
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19 **223** 2 diabetes patients (4.7%). Reimbursements for paramedical care and district nursing increased most during  
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21 **224** the study period, by 17.4% and 8.2%, respectively.  
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25 **Table 2 Share of the type 2 diabetes population with service use per health care sector and service**  
26 **type, 2016-2018**  
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	2016	2017	2018
<b>Healthcare sectors</b>			
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)
<b>Healthcare service types</b>			
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)

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## 226 **Healthcare expenditures**

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

235 **[Fig. 1 here]**

## 236 **Mean annual per patient expenditures**

237 With regard to the Health Insurance Act, mean annual per patient spending increased by 4.4% from 2016  
238 to 2018: €7,077 to €7,386 (Figure 2). The annual spending on medical specialist care accounted for the  
239 largest share (47%) or €3,459 per patient in 2018. Secondly, district nursing and pharmaceutical care  
240 contributed to a significant share of annual per patient expenditures: €1,124 and €1,047, respectively.  
241 Moreover, the mean annual per patient expenditures on district nursing increased by 9.4% from 2016 to  
242 2018. Annual primary care expenditures were €542 per patient in 2018. As to the category other,  
243 expenditures increased by 18.6% from 2016 and on average €517 was spent per patient in 2018. Per patient  
244 spending on assistive devices, mental health care, and paramedical care were all under 5.0% of the total  
245 mean annual per patient expenditures. The type 2 diabetes patients who received care under the Long-term  
246 Care Act as well as under the Health Insurance Act (4.4%) had an average long-term care spending of  
247 €38,033 in 2018. This increased by 14.4% in comparison to 2016.

248 **[Fig. 2 here]**

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### 250 Expenditures on type 2 diabetes-related complications

251 In total, €556 million was spent on specialized care for type 2 diabetes-related complications in 2018 (Table  
252 3). The majority of these expenditures related to microvascular complications (55.0%), which increased by  
253 10.8% from 2016 to 2018. Spending on macrovascular complications increased by 2.1% during the same  
254 period. In 2018, €250 million was spent on macrovascular type 2 diabetes-related complications. Diabetic  
255 foot/peripheral angiopathy accounted for the largest share of spending on diabetes-related complications  
256 with 20.9% or €116 million in 2018. Secondly, expenditures on strokes were 19.9% (€111 million) in 2018.  
257 Thirdly, total spending on diabetic eye complications increased by 11.2% over the studied period and  
258 accounted for 17.9% of the total in 2018. Moreover, for diabetic kidney disease, total expenditures increased  
259 by 12.8% from 2016 to 2018 (to 15.7% of the total). The per treated patient mean and median expenditures  
260 on type 2 diabetes-related complications were lowest for diabetic eye complications and diabetic  
261 mono/polyneuropathy. The highest mean and median expenditures per treated patient were for stroke and  
262 acute coronary syndrome (Supplementary Table 2).

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**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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## 265 **DISCUSSION**

266 This study is the first to use an APCD of the Dutch population to identify and characterize the type 2  
267 diabetes population. Hereby, this study extends the knowledge of its characteristics and provides insight  
268 into healthcare utilization and expenditures across healthcare sectors, service types, and for type 2 diabetes-  
269 related complications. In 2018, the annual prevalence of type 2 diabetes in the Netherlands was 900,522  
270 people (6.5% of Dutch adults). The most prevalent comorbidity, based on medication use, was heart disease  
271 with a prevalence of 12.1%. Moreover, 5.6% received specialized care for macrovascular and 16.2% of the  
272 2018 population received specialized care for microvascular complications. Regarding healthcare  
273 utilization, almost all type 2 diabetes patients utilized pharmaceutical care, medical specialist care, and GP  
274 care. In total, €8,173 million, about 9.4% of total healthcare expenditures, was reimbursed for the type 2  
275 diabetes population in 2018.[33] Expenditures on medical specialist care represented the largest share of  
276 total healthcare expenditures (38.1%), followed by expenditures on district nursing (12.4%) and  
277 pharmaceutical care (11.5%).

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

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3 291 of type 2 diabetes patients cannot be identified through claims data, i.e. patients who do not receive  
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5 292 integrated diabetes care and do not use any diabetes medication or use insulin only, and type 2 diabetes  
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7 293 patients who live in nursing homes and receive all care within the facility. Nevertheless, the effect of not  
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9 294 detecting these patients is likely to be minimal, as the large majority of type 2 diabetes patients receive  
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11 295 integrated diabetes care (83%) and if not, many are included due to medication use for type 2 diabetes (80%  
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13 296 received diabetes medication in 2018).[25,37]

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16 297 Notwithstanding these limitations, our APCD enables a detailed and complete overview of the type  
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18 298 2 diabetes population. However, our findings regarding population size differ from the type 2 diabetes  
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20 299 population as estimated by NIVEL (Netherlands Institute for Health Services Research).[38] Their findings  
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22 300 indicated an annual prevalence of 1,079,624 people with type 2 diabetes in 2018.[6] However, this estimate  
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24 301 is based on GP registration data representing approximately 10% of the Dutch population,[38] whereas we  
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26 302 included data on the total Dutch population. Also, morbidity estimates of GPs may be less reliable as these  
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28 303 are potentially influenced by the local organization of the healthcare system, methods of morbidity  
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30 304 registration, the organization of the GP practice, and patient characteristics.[39] Lastly, once a type 2  
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32 305 diabetes patient is included in the NIVEL cohort, they do leave the cohort for reasons other than mortality.  
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34 306 Hence, their approach potentially results in an overestimation of the actual prevalence of type 2 diabetes.

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37 307 Notably, our findings indicated that the majority of healthcare utilization and expenditures of the  
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39 308 type 2 diabetes population are not directly related to diabetes. Type 2 diabetes patients utilize care  
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41 309 throughout the healthcare system, i.e. across healthcare sectors and service types. Additionally, 97.0% of  
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43 310 type 2 diabetes patients utilize medical specialist care despite 83% receiving integrated diabetes care in the  
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45 311 primary care setting.[25] Moreover, medical specialist care utilization of the type 2 diabetes population is  
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47 312 considerably higher than the share of the entire insured population in the Netherlands that utilizes medical  
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49 313 specialist care (43% in 2017).[40] The wide dispersion of service use across the health system, as well as  
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51 314 the high utilization of medical specialist care, may be explained by the presence of comorbidities and  
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53 315 complications. Many patients not only have type 2 diabetes but additionally suffer from other conditions,  
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55 316 as is confirmed in this study as well as shown in previous literature.[7,8] Findings that comorbidities

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3 317 substantially increase healthcare expenditures and utilization are also in line with previous studies on this  
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5 318 topic.[7–12]  
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7 319 The high utilization of non-diabetes care of the type 2 diabetes population has several implications  
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9 320 for policymakers. As a large share of healthcare utilization and expenditures is caused by comorbidities or  
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11 321 type 2 diabetes-related complications, it could be beneficial to organize care more holistically and approach  
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13 322 diabetes and non-diabetes complaints more concentrated in the health system. Such an approach would  
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15 323 underpin the need to shift from a disease-specific approach to a person-centered and integrated care  
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17 324 approach. This is in agreement with prior findings indicating that person-centered integrated care may be  
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19 325 meaningful in making the care process less fragmented and improving physical and psychological health  
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21 326 in patients with multi-morbidity.[41,42] Additionally, the high utilization of and expenditures across the  
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23 327 healthcare system show that diabetes care is not necessarily expensive but the total care for patients known  
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25 328 with type 2 diabetes is. Therefore, when addressing healthcare expenditures, policymakers should not only  
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27 329 focus on utilization of and expenditures on diabetes care but also on care for concurrent morbidities and  
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29 330 complications. Prior research has also shown that integrated care adapted to the needs of chronically ill  
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31 331 patients could lead to better outcomes at lower costs.[43]  
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34 332 Therefore, future research exploring the characteristics of high-need (utilization) and high-cost  
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36 333 (expenditures) subgroups within the type 2 diabetes population may contribute to initiatives to reduce  
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38 334 spending growth and thereby maintain the financial sustainability of healthcare systems. Moreover, APCDs  
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40 335 can be used for longitudinal retrospective analyses, for instance to show long-term effects of policies or  
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42 336 treatment changes to determine whether these were effective and support sustainability. Additionally, future  
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44 337 research should focus further on the dispersion of healthcare utilization of and expenditures on the type 2  
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46 338 diabetes population. Insight into pharmaceutical care and medical specialist care utilization would be  
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48 339 particularly meaningful as these healthcare services are heavily utilized by this population. Moreover, to  
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50 340 better understand the impact of type 2 diabetes on healthcare utilization and healthcare expenditures, future  
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52 341 research should compare people with and without type 2 diabetes.  
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3 343 **CONCLUSIONS**  
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5 344 APCDs can be used to identify the national type 2 diabetes population and describe its characteristics,  
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7 345 healthcare utilization, and healthcare expenditures. This insight can inform policymakers and practice about  
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9 346 dispersion of reimbursed care, directly and indirectly related to type 2 diabetes, and in turn support better  
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11 347 decisions to promote long-term (financial) sustainability of healthcare systems.  
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362 **Patient consent for publication** Not required.

363 **Ethics approval** According to the Maastricht University Medical Center ethics committee, this study is not  
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365 **Data availability statement** The datasets generated and analyzed during this study are not publicly  
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367 however available from Vektis upon reasonable request and with formal consent of the Dutch health  
368 insurers.

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3 **370 REFERENCES**

- 4 371 1 Maarse H, Jeurissen P, Ruwaard D. Concerns over the financial sustainability of the dutch healthcare  
5 372 system. *DICE Rep* 2013;11:32–6.
- 7 373 2 Liaropoulos L, Goranitis I. Health care financing and the sustainability of health systems. *Int J*  
8 374 *Equity Health* 2015;14:5–8. doi:10.1186/s12939-015-0208-5
- 10 375 3 Birch S, Murphy GT, MacKenzie A, *et al.* In place of fear: aligning health care planning with system  
11 376 objectives to achieve financial sustainability. *J Heal Serv Res Policy* 2015;20:109–14.  
12 377 doi:10.1177/1355819614562053
- 14 378 4 WHO. Programmes and projects - Nutrition - Nutrition health topics - 5. Population nutrient intake  
15 379 goals for preventing diet-related chronic diseases. Available:  
16 380 [https://www.who.int/nutrition/topics/5\\_population\\_nutrient/en/](https://www.who.int/nutrition/topics/5_population_nutrient/en/) [Accessed 13 November 2019]
- 17 381 5 Williams R, Colagiuri S, Almutairi R, *et al.* IDF Diabetes Atlas: Ninth Edition 2019. Brussels, BE:  
18 382 International Diabetes Federation 2019:36-39.
- 20 383 6 Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Diabetes mellitus - Cijfers & Context -  
21 384 Huidige situatie. 1. [The National Institute of Public Health and the Environment on Diabetes  
22 385 Mellitus – Numbers and Context: The current situation] Available:  
23 386 [https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-](https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht)  
24 387 [situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht](https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht) [Accessed 28 October 2018]
- 26 388 7 Williams R, Van Gaal L, Lucioni C. Assessing the impact of complications on the costs of Type II  
27 389 diabetes. *Diabetologia* 2002;45:S13–7. doi:10.1007/s00125-002-0859-9
- 29 390 8 Struijs JN, Baan CA, Schellevis FG, *et al.* Comorbidity in patients with diabetes mellitus: Impact  
30 391 on medical health care utilization. *BMC Health Serv Res* 2006;6:1–9. doi:10.1186/1472-6963-6-84
- 32 392 9 Tamayo T, Rosenbauer J, Wild SH, *et al.* Diabetes in Europe: An update. *Diabetes Res Clin Pract*  
33 393 2013;103:206–17. doi:10.1016/j.diabres.2013.11.007
- 34 394 10 Hazel-Fernandez L, Li Y, Nero D, *et al.* Relationship of diabetes complications severity to  
35 395 healthcare utilization and costs among Medicare Advantage beneficiaries. *Am J Manag Care*  
36 396 2015;21:e62–70.
- 38 397 11 Kanavos P, Aardweg S Van Den, Schurer W. Diabetes Expenditure, Burden of Disease and  
39 398 Management in 5 EU Countries. LSE Heal London Sch Econ, 2012. Available:  
40 399 [http://eprints.lse.ac.uk/54896/1/\\_libfile\\_REPOSITORY\\_Content\\_LSE\\_Health\\_and\\_Social](http://eprints.lse.ac.uk/54896/1/_libfile_REPOSITORY_Content_LSE_Health_and_Social_Care_Jan_2012_LSEDiabetesReport26Jan2012.pdf)  
41 400 [Care\\_Jan\\_2012\\_LSEDiabetesReport26Jan2012.pdf](http://eprints.lse.ac.uk/54896/1/_libfile_REPOSITORY_Content_LSE_Health_and_Social_Care_Jan_2012_LSEDiabetesReport26Jan2012.pdf). [Accessed 30 October 2019]
- 43 401 12 Janssen LMM, Hiligsmann M, Elissen AMJ, *et al.* Burden of disease of type 2 diabetes mellitus:  
44 402 cost of illness and quality of life estimated using the Maastricht Study. *Diabet Med* 2020;:1–7.  
45 403 doi:10.1111/dme.14285
- 47 404 13 Ogurtsova K, da Rocha Fernandes JD, Huang Y, *et al.* IDF Diabetes Atlas: Global estimates for the  
48 405 prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Pract* 2017;128:40–50.  
49 406 doi:10.1016/j.diabres.2017.03.024
- 51 407 14 Pagano E, De Rosa M, Rossi E, *et al.* The relative burden of diabetes complications on healthcare  
52 408 costs: The population-based CINECA-SID ARNO Diabetes Observatory. *Nutr Metab Cardiovasc*  
53 409 *Dis* 2016;26:944–50. doi:10.1016/j.numecd.2016.05.002
- 55 410 15 van Schoonhoven A V., Gout-Zwart JJ, de Vries MJS, *et al.* Costs of clinical events in type 2  
56 411 diabetes mellitus patients in the Netherlands: A systematic review. *PLoS One* 2019;14:e0221856.



- 1  
2  
3 412 doi:10.1371/journal.pone.0221856  
4  
5 413 16 Li R, Bilik D, Brown MB, *et al.* Medical costs associated with type 2 diabetes complications and  
6 414 comorbidities. *Am J Manag Care* 2013;19:421–30.  
7  
8 415 17 Zgibor JC, Orchard TJ, Saul M, *et al.* Developing and validating a diabetes database in a large health  
9 416 system. *Diabetes Res Clin Pract* 2007;75:313–9. doi:10.1016/j.diabres.2006.07.007  
10  
11 417 18 De Groot S, Enters-Weijnen CF, Geelhoed-Duijvestijn PH, *et al.* A cost of illness study of  
12 418 hypoglycaemic events in insulin-treated diabetes in the Netherlands. *BMJ Open* 2018;8:6–10.  
13 419 doi:10.1136/bmjopen-2017-019864  
14 420 19 Nichols GA, Desai J, Lafata JE, *et al.* Construction of a multisite datalink using electronic health  
15 421 records for the identification, surveillance, prevention, and management of diabetes mellitus: The  
16 422 SUPREME-DM project. *Prev Chronic Dis* 2012;9:1–9. doi:10.5888/pcd9.110311  
17  
18 423 20 Slabaugh SL, Curtis BH, Clore G, *et al.* Factors associated with increased healthcare costs in  
19 424 Medicare Advantage patients with type 2 diabetes enrolled in a large representative health insurance  
20 425 plan in the US. *J Med Econ* 2015;18:106–12. doi:10.3111/13696998.2014.979292  
21  
22 426 21 Jo C. Cost-of-illness studies: concepts, scopes, and methods. *Clin Mol Hepatol* 2014;20:327–37.  
23 427 doi:10.3350/cmh.2014.20.4.327  
24  
25 428 22 Freedman JD, Green L, Landon BE. All-Payer Claims Databases — Uses and Expanded Prospects  
26 429 after Gobeille. *N Engl J Med* 2016;375:2215–7. doi:10.1056/NEJMp1609578  
27  
28 430 23 Love D, Custer W, Miller P. All-payer claims databases: state initiatives to improve health care  
29 431 transparency. *Issue Brief (Commonw Fund)* 2010;99:1–14.  
30 432 24 Dworsky M. Using All-Payer Claims Databases to Study Insurance and Health Care Utilization  
31 433 Dynamics. *J Gen Intern Med* 2017;32(10):1069–70. doi:10.1056/NEJMp1609578  
32  
33 434 25 Klomp M, Romeijnders A, de Braal E, *et al.* InEen - Transparante Ketenzorg Rapportage 2019  
34 435 Zorggroepen: Diabetes Mellitus, VRM, COPD en Astma. Spiegel voor het verbeteren van  
35 436 chronische zorg. 2019 p.13–20. [Report on Transparency in Integrated Diabetes Care and Care  
36 437 Groups] Available: [https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-](https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-ketenzorg-2019-web.pdf)  
37 438 [ketenzorg-2019-web.pdf](https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-ketenzorg-2019-web.pdf) [Accessed 30 September 2020]  
38  
39 439 26 Struijs JN, Baan CA. Integrating care through bundled payments - Lessons from the Netherlands. *N*  
40 440 *Engl J Med* 2011;364:990–1. doi:10.1056/NEJMp1011849  
41  
42 441 27 Overheid. Besluit zorgverzekering - Hoofdstuk 1. Definities en algemene bepalingen - Artikel 1.  
43 442 [Decisions on health insurance – Chapter 1. Definitions and general provisions – Article 1]  
44 443 Available: <https://wetten.overheid.nl/BWBR0018492/2021-01-01> [Accessed 13 March 2020]  
45  
46 444 28 Nathanson D, Sabale U, Eriksson JW, *et al.* Healthcare Cost Development in a Type 2 Diabetes  
47 445 Patient Population on Glucose-Lowering Drug Treatment: A Nationwide Observational Study  
48 446 2006–2014. *PharmacoEconomics - Open* 2017;2:393–402. doi:10.1007/s41669-017-0063-y  
49  
50 447 29 Vektis. Bijsluiter: Vektis Open Databestanden Zorgverzeketingswet 2011-2018 [Information leaflet  
51 448 of open-access Health-Insurance Act Vektis databases]. Available:  
52 449 [https://www.vektis.nl/uploads/Docs%20per%20pagina/Open%20Data%20Bestanden/Bijsluiter%20](https://www.vektis.nl/uploads/Docs%20per%20pagina/Open%20Data%20Bestanden/Bijsluiter%20bij%20de%20Vektis%20Open%20Databestanden%20Zorgverzekeringswet%202011%20-%202018%20.pdf)  
53 450 [0bij%20de%20Vektis%20Open%20Databestanden%20Zorgverzekeringswet%202011%20-](https://www.vektis.nl/uploads/Docs%20per%20pagina/Open%20Data%20Bestanden/Bijsluiter%20bij%20de%20Vektis%20Open%20Databestanden%20Zorgverzekeringswet%202011%20-%202018%20.pdf)  
54 451 [%202018%20.pdf](https://www.vektis.nl/uploads/Docs%20per%20pagina/Open%20Data%20Bestanden/Bijsluiter%20bij%20de%20Vektis%20Open%20Databestanden%20Zorgverzekeringswet%202011%20-%202018%20.pdf) [Accessed 12 November 2020]  
55  
56 452 30 Elissen A, Duimel-Peters I, Spreeuwenberg C, *et al.* Assessing Chronic Disease Management in

- 1  
2  
3 453 European Health Systems. Country reports. Copenhagen, DK: WHO Regional Office for Europe,  
4 454 2015:99–110.
- 5  
6 455 31 Berden C, Croes R, Kemp R, et al. Hospital Competition in the Netherlands: An Empirical  
7 456 Investigation. Discuss Pap. 2019. [article online]. Available:  
8 457 [https://pure.uvt.nl/ws/portalfiles/portal/30034784/DP2019\\_008.pdf](https://pure.uvt.nl/ws/portalfiles/portal/30034784/DP2019_008.pdf) [Accessed 12 November 2020]  
9
- 10 458 32 Nederlandse Zorgautoriteit (NZA). Advies bekostiging medisch-specialistische zorg, Belonen van  
11 459 zorg die waarde toevoegt [Presentation of The Dutch Healthcare Authority regarding advice on  
12 460 medical specialist care reimbursement]. Available:  
13 461 [https://www.rijksoverheid.nl/documenten/rapporten/2018/10/04/belonen-van-zorg-die-waarde-](https://www.rijksoverheid.nl/documenten/rapporten/2018/10/04/belonen-van-zorg-die-waarde-toevoegt)  
14 462 [toevoegt](https://www.rijksoverheid.nl/documenten/rapporten/2018/10/04/belonen-van-zorg-die-waarde-toevoegt) [Accessed 12 November 2020]
- 15  
16 463 33 CBS. StatLine - Zorguitgaven in drie benaderingen; zorgaanbieders [Care expenditures approached  
17 464 in three ways; care providers]. Available:  
18 465 <https://opendata.cbs.nl/#/CBS/nl/dataset/84054NED/table?dl=3AB46&ts=1605793224356>  
19 466 [Accessed 19 November 2020]
- 20  
21 467 34 Alzaid A, Ladrón de Guevara P, Beillat M, et al. Burden of disease and costs associated with type  
22 468 2 diabetes in emerging and established markets: systematic review analyses. *Expert Review of*  
23 469 *Pharmacoeconomics & Outcomes Research* 2020;1–14. doi:10.1080/14737167.2020.1782748
- 24 470 35 Müller N, Heller T, Freitag MH, et al. Healthcare utilization of people with Type 2 diabetes in  
25 471 Germany: An analysis based on health insurance data. *Diabet Med* 2015;32:951–7.  
26 472 doi:10.1111/dme.12747
- 27  
28 473 36 Jönsson B. Revealing the cost of Type II diabetes in Europe. *Diabetologia* 2002;45.  
29 474 doi:10.1007/s00125-002-0858-x
- 30  
31 475 37 Stichting Farmaceutische Kerngetallen. Data en feiten 2019 - Het jaar 2018 in cijfers [The  
32 476 Foundation of Pharmaceutical Key figures on data and facts – the year 2018 in numbers][online  
33 477 article] 2019. Available: <https://www.sfk.nl/publicaties/data-en-feiten/data-en-feiten-2019>.  
34 478 [Accessed 29 September 2020]
- 35  
36 479 38 Nivel. Volksgezondheidszorg.info - NIVEL Zorgregistraties eerste lijn - Algemeen [The Dutch  
37 480 Institute for Health Services Research - care records in primary care] Available:  
38 481 <https://bronnen.zorggegevens.nl/Bron?naam=Nivel-Zorgregistraties-eerste-lijn> [Accessed 30  
39 482 October 2020]
- 40  
41 483 39 van den Dungen C, Hoeymans N, Gijsen R, et al. What factors explain the differences in morbidity  
42 484 estimations among general practice registration networks in the Netherlands? A first analysis. *Eur J*  
43 485 *Gen Pract* 2008;14:53–62. doi:10.1080/13814780802436218
- 44  
45 486 40 Vektis. Inzichten in medisch-specialistische zorg [Insights into Medical Specialist Care]. Available:  
46 487 <https://www.zorgprismapubliek.nl/producten/ziekenhuiszorg/medisch-specialistische-zorg/>  
47 488 [Accessed 30 September 2020]
- 48  
49 489 41 Inzucchi SE, Bergenstal RM, Buse JB, et al. Management of hyperglycemia in type 2 diabetes: A  
50 490 patient-centered approach. *Diabetes Care* 2012;35:1364–79. doi:10.2337/dc12-0413
- 51 491 42 Berntsen G, Høyem A, Lettrem I, et al. A person-centered integrated care quality framework, based  
52 492 on a qualitative study of patients' evaluation of care in light of chronic care ideals. *BMC Health Serv*  
53 493 *Res* 2018;18:1–15. doi:10.1186/s12913-018-3246-z
- 54  
55 494 43 Mitri J, Gabbay R. Understanding Population Health Through Diabetes Population Management.  
56 495 *Endocrinol Metab Clin North Am* 2016;45:933–42. doi:10.1016/j.ecl.2016.06.006

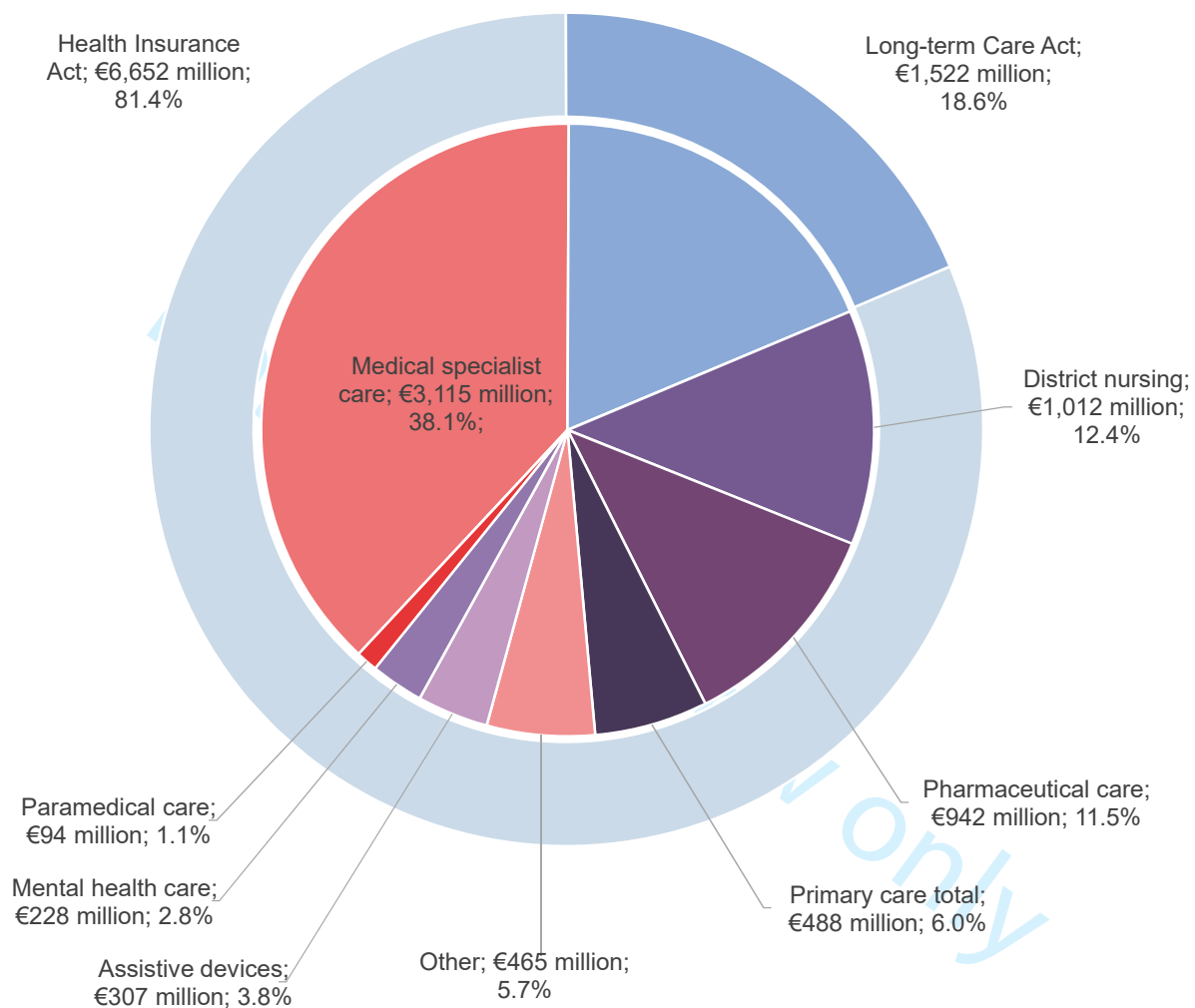
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496 **Figure legends**

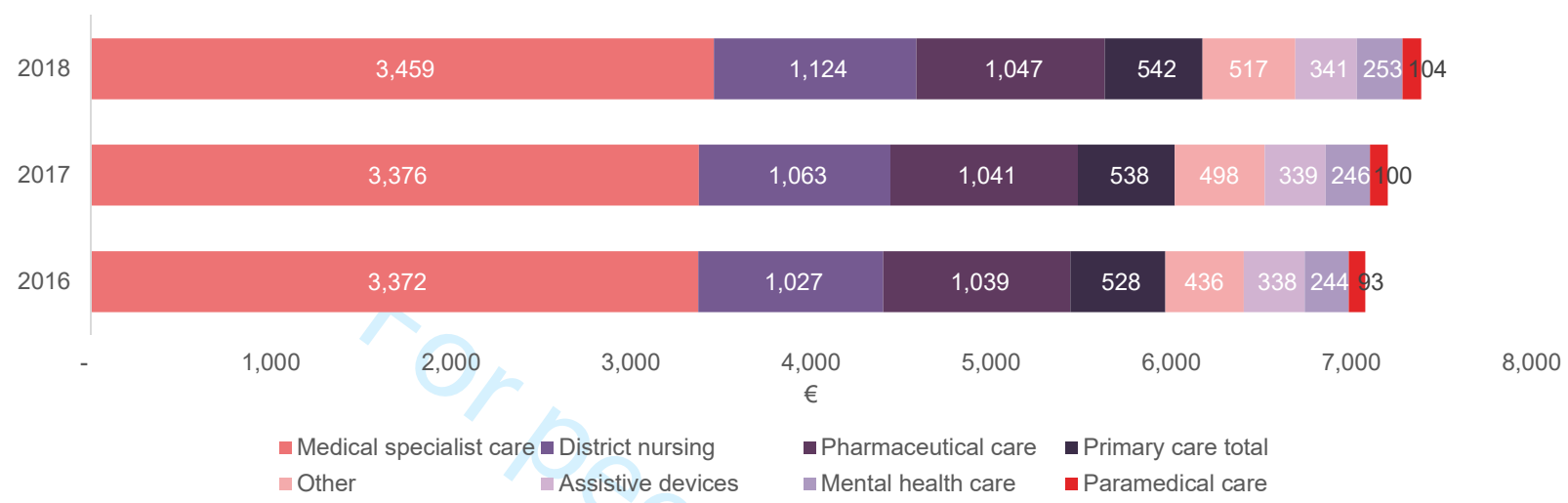
497 Figure 1 Total healthcare expenditures of the type 2 diabetes population in 2018

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

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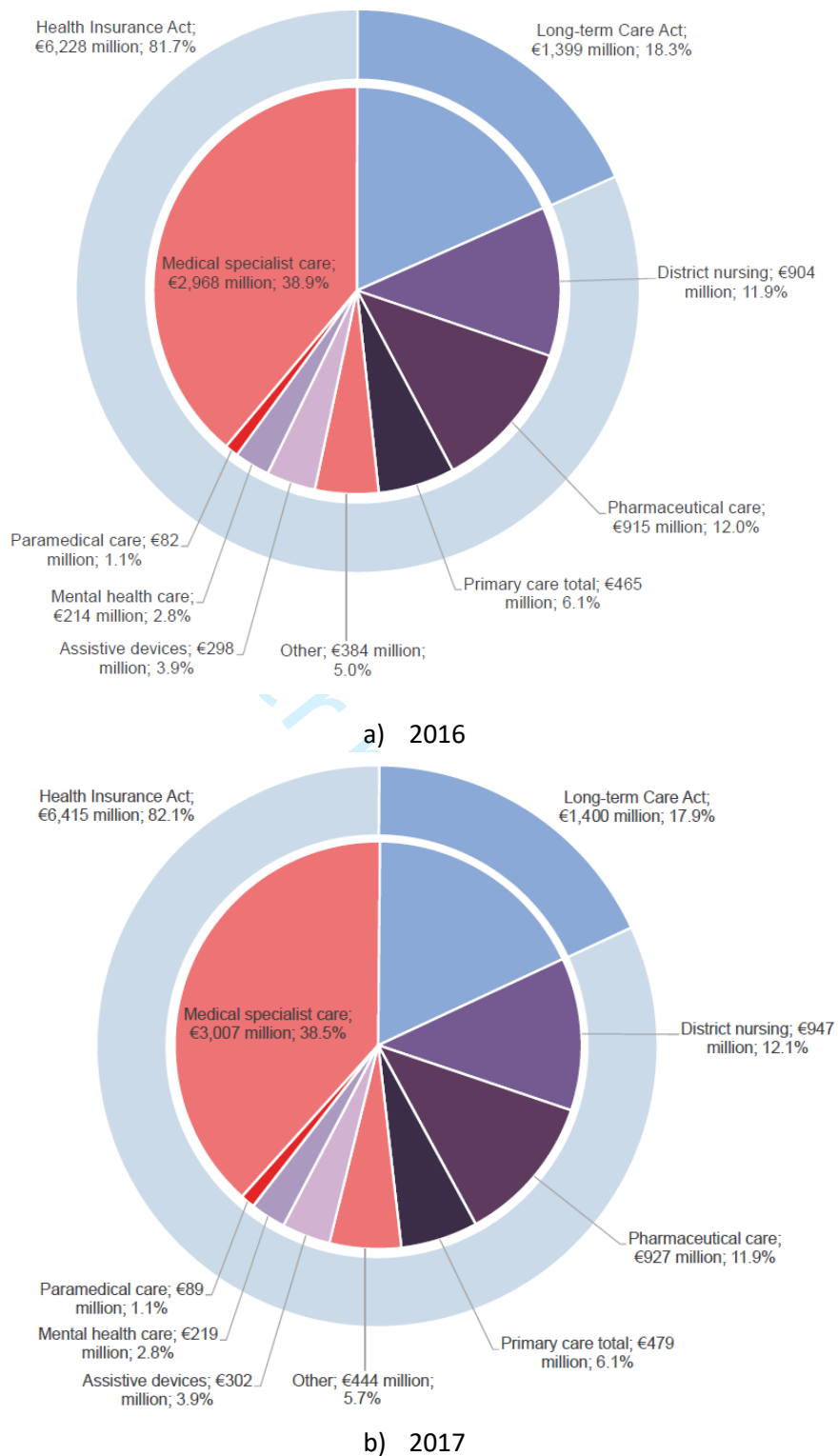
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**Supplementary Table 1 Matched reimbursement codes per type 2 diabetes-related complication**

Disease group	Reimbursement codes (DBC's)
<b>Macrovascular type 2 diabetes – related complications</b>	
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)
<b>Microvascular type 2 diabetes – related complications</b>	
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); Proliferative 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

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3 foot (305.2065); Diabetic foot (0303.432); Other peripheral vascular diseases  
4 (0303.439); PAOD arm (0303.0412); PAOD 2, claudicatio intermittens  
5 (0303.0418); PAOD 3, rest pain (0303.0419); PAOD 4, gangrene (0303.0420)  
6  
7  
8 Diabetic kidney disease Kidney transplant, recipient (0313.076); Kidney and pancreatic transplant,  
9 recipient (0313.078); Chronic renal failure, eGFR 30-60 ml/min (0313.324),  
10 Chronic renal failure, eGFR <30 ml/min (0313.325); Continuous ambulatory  
11 peritoneal dialysis (CAPD) (0313.331); Automatic peritoneal dialysis (APD)  
12 (0313.332); Chronic hemodialysis at home (0313.336); Chronic hemodialysis  
13 in institution (0313.339)  
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**Supplementary Figure 1 Healthcare expenditures of the type 2 diabetes population a) in 2016 b) in 2017**



<b>Supplementary Table 2 Mean and median expenditures type 2 diabetes related-complications per treated patient in 2016-2018 (€)</b>						
	2016	2016	2017	2017	2018	2018
	Mean expenditures per patient $\pm$ SD <sup>a</sup>	Median per patient expenditures (P5; P95) <sup>a</sup>	Mean expenditures per patient $\pm$ SD <sup>a</sup>	Median per patient expenditures (P5; P95) <sup>a</sup>	Mean expenditures per patient $\pm$ SD <sup>a</sup>	Median per patient expenditures (P5; P95) <sup>a</sup>
Macrovascular T2DM-related complications	4,739.6 $\pm$ 7,510.0	2,301.8 (208.3; 19,453.1)	4,846.5 $\pm$ 103.5	2,327.9 (199.8; 19,049.2)	4922.9 $\pm$ 7,763.3	2,351.5 (200.3; 19,848.7)
HF	3,118 $\pm$ 5,261	689 (208; 12,677)	3,090 $\pm$ 5,100	673 (200; 12,873)	3,160 $\pm$ 5,296	672 (200; 13,235)
Stroke	5,967 $\pm$ 10,215	2,418 (229; 26,980)	6,348 $\pm$ 10,749	2,430 (215; 28,514)	6,287 $\pm$ 10,587	2,472 (221; 28,830)
ACS	5,479 $\pm$ 3,988	5,548 (524; 12,654)	5,530 $\pm$ 3,842	5,924 (359; 12,165)	5,863 $\pm$ 4,139	6,400 (360; 13,496)
Microvascular T2DM-related complications	1,907.7 $\pm$ 80.9	393.9 (80.9; 7,146.7)	1,957.3 $\pm$ 80.1	401.0 (80.1; 7,200.0)	2,094.4 $\pm$ 6,818.2	407.8 (82.1; 7,468.2)
Diabetic eye complications	820 $\pm$ 1,247	161 (81; 3,031)	843 $\pm$ 1,272	165 (80; 3,150)	908 $\pm$ 1,332	178 (82; 3,512)
Diabetic foot/peripheral angiopathy	4,671 $\pm$ 9,255	585 (124; 20,513)	4,817 $\pm$ 9,680	588 (124; 21,739)	5,013 $\pm$ 9,922	608 (126; 22,133)
Diabetic kidney disease	3,461 $\pm$ 12,020	677 (226; 13,654)	3,479 $\pm$ 11,857	679 (230; 16,187)	3,848 $\pm$ 12,430	689 (230; 21,200)
Diabetic mono/polyneuropathy	1,608 $\pm$ 6,066	458 (229; 3,886)	1,438 $\pm$ 6,135	430 (215; 3,543)	1,462 $\pm$ 5,323	444 (221; 4,020)

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

	Item No	Recommendation	Page number
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6 & 7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	6 & 7
		(e) Describe any sensitivity analyses	-

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<b>Results</b>			
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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	9-15
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	-
		<i>Cross-sectional study</i> —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	-
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://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

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<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Diabetes and endocrinology, Health economics, Health services research
Keywords:	General diabetes < DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, HEALTH ECONOMICS

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4 **1 Identifying and delineating the type 2 diabetes population in the Netherlands**  
5 **2 using an all-payer claims database: Characteristics, healthcare utilization, and**  
6 **3 expenditures**  
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9 4 Rose J Geurten<sup>1</sup>, Arianne M J Elissen<sup>1</sup>, Henk J G Bilo<sup>2</sup>, Jeroen N Struijs<sup>3</sup>, Chantal van Tilburg<sup>4</sup>, Dirk  
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3 20 **ABSTRACT**  
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5 21 **Objectives** We aimed to identify and delineate the Dutch type 2 diabetes population and the distribution of  
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7 22 healthcare utilization and expenditures across the health system from 2016 to 2018 using an all-payer claims  
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9 23 database.

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11 24 **Design** Retrospective observational cohort study based on an all-payer claims database of the Dutch  
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13 25 population.

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15 26 **Setting** The Netherlands

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17 27 **Participants** The whole Dutch type 2 diabetes population (n=900,522 in 2018), determined based on  
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19 28 bundled payment codes for integrated diabetes care and medication use indicating type 2 diabetes.

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21 29 **Outcome measures** Annual prevalence of type 2 diabetes, comorbidities, and characteristics of the type 2  
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23 30 diabetes population, as well as the distribution of healthcare utilization and expenditures were analyzed  
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25 31 descriptively.

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27 32 **Results** In 2018, 900,522 people (6.5% of adults) were identified as having type 2 diabetes. The most  
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29 33 common comorbidity in the population was heart disease (12.1%). Additionally, 16.2% and 5.6% of  
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31 34 patients received specialized care for microvascular and macrovascular diabetes-related complications,  
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33 35 respectively. Most type 2 diabetes patients received pharmaceutical care (99.1%), medical specialist care  
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35 36 (97.0%), and general practitioner consultations (90.5%). In total, €8,173 million, 9.4% of total healthcare  
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37 37 expenditures, was reimbursed for the type 2 diabetes population. Medical specialist care accounted for the  
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39 38 largest share of spending (38.1%), followed by district nursing (12.4%), and pharmaceutical care (11.5%).

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41 39 **Conclusions** All-payer claims databases can be used to delineate healthcare use: this insight can inform  
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43 40 health policy and practice and, thereby, support better decisions to promote long-term sustainability of  
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45 41 healthcare systems. The healthcare utilization of the Dutch type 2 diabetes population is distributed across  
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47 42 the health system and utilization of medical specialist care is high. This is likely to be due to presence of  
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49 43 concurrent morbidities and complications. Therefore, a shift from a disease-specific approach to a person-  
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51 44 centered and integrated care approach could be beneficial in the treatment of type 2 diabetes.  
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3 45 **Strengths and limitations of this study**  
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- 5 46 - The use of an all-payer claims database enables an overview of the complete Dutch type 2 diabetes  
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7 47 population  
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9 48 - Due to the economic function of claims data, the data is accurate and complete enabling a reliable  
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11 49 estimation of healthcare utilization and expenditures  
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13 50 - Internationally, the generalizability of findings could be limited because of the differences in the  
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15 51 organization of healthcare  
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17 52 - Real- or near-time data use of claims data is hampered by a two-year time lag  
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## 64 INTRODUCTION

65 Internationally, there are rising concerns regarding the financial sustainability of healthcare systems. This  
66 financial strain is caused by increasing costs associated with ageing populations, rising life expectancy,  
67 expensive technological advances, and higher patient expectations.[1–3] In particular, the burden caused  
68 by chronic diseases is rapidly increasing.[4] Diabetes mellitus is currently one of the most prevalent chronic  
69 diseases affecting an estimated 463 million people in the age group 20 - 79 years, or 9.3% of adults  
70 worldwide.[4,5] This number is expected to rise to 700 million by 2045.[5] Within the diabetes population,  
71 90% of patients suffer from type 2 diabetes.[5,6] Many develop at least one diabetes-related macro- or  
72 microvascular complication during the course of their disease.[7,8] The presence of these complications  
73 substantially increases healthcare utilization and expenditures.[7–12] For instance, the presence of both  
74 micro- and macrovascular complications increases patients' care expenditures by up to 250%.[7] In total,  
75 expenditures on diabetes-related complications are estimated to amount to more than half of all diabetes  
76 care expenditures.[13,14]

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

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3 90 Because of the increasing concerns about the financial sustainability of healthcare systems and the  
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5 91 rising prevalence of type 2 diabetes, a more exact insight into the healthcare utilization and expenditures of  
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7 92 type 2 diabetes populations is needed. The current focus on specific subgroups limits available evidence on  
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9 93 heterogeneity of healthcare utilization and costs in whole diabetes populations. Such insight would enhance  
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11 94 understanding of where and how much diabetes care is provided, support better decisions to promote long-  
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13 95 term sustainability, and aid tailoring policies and practice to achieve improvements on the Quadruple  
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15 96 Aim.[23] Therefore, we use an all-payer claims database (APCD) that covers 99% of the Dutch population  
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17 97 to identify the Dutch type 2 diabetes population and present a detailed and complete overview of population  
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19 98 characteristics, healthcare utilization, and expenditures. APCDs are becoming increasingly important in  
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21 99 facing health care challenges as these enable analysis of whole populations across the health system, as  
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23 100 well as over time.[24–26] Accordingly, the aim of this study is twofold. The first aim is to specify the size  
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25 101 and characteristics of the Dutch type 2 diabetes population, including the annual prevalence of chronic  
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27 102 comorbidities and type 2 diabetes-related complications, over the years 2016 to 2018. The second aim is to  
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29 103 determine the total healthcare utilization and expenditures of this population and the distribution of use and  
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31 104 expenditures (a) across healthcare sectors (e.g. primary care, specialized care); (b) related to specific service  
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33 105 types (e.g. mental health care, pharmaceutical care), and; (c) for type 2 diabetes-related complications (e.g.  
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35 106 heart failure, diabetic foot) over the same time period.  
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## 107 **METHODS**

### 108 **Data source**

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

### 122 **Study population**

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

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3 133 and, as such, are not covered by the bundled payment system. To identify these remaining type 2 diabetes  
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5 134 patients, we assessed medication use (based on ATC-codes) indicating type 2 diabetes. Identification based  
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7 135 on medication use is possible in the Netherlands due to the relatively strict and stepwise medication  
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9 136 guideline for type 2 diabetes management.[31] Thus, to be as accurate and inclusive as possible, we  
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11 137 identified individuals as type 2 diabetes patients if they met one or more of the following criteria: (a)  
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13 138 received integrated diabetes care or (b) were treated for their type 2 diabetes with (b.1.) only oral medication  
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15 139 (A10B blood glucose lowering drugs excl. insulins); (b.2.) a combination of insulin (A10A insulins and  
16  
17 140 analogues for injection) and oral medication (A10B blood glucose lowering drugs excl. insulins), or (b.3.)  
18  
19 141 a combination medication (A10AE54 or A10AE56: mix of insulins and GLP-1 for injection, long-acting).  
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21 142 Individuals were included based on medication use if they received any of the medications described at  
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23 143 least once in that year. We determined the type 2 diabetes population separately for each year within the  
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25 144 timeframe 2016 to 2018. Individuals were included in the annual population prevalence if one or more of  
26  
27 145 the inclusion criteria applied at any time during that year. Accordingly, the study population had the nature  
28  
29 146 of an open and dynamic cohort, to which individuals could be added or excluded from each year. No  
30  
31 147 exclusion criteria were applied.

### 34 148 **Patient and population characteristics**

35 149 To describe the study population, we included age, gender, and presence of chronic comorbidities and type  
36  
37 150 2 diabetes complications. The presence of chronic comorbidities was assessed by ‘pharmaceutical costs  
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39 151 groups’ (In Dutch: *Farmaceutische KostenGroepen*, FKGs) which are used for the Dutch risk equalization  
40  
41 152 scheme for health insurers.[32] FKGs are a proven tool to identify insured persons with chronic conditions,  
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43 153 such as glaucoma or heart disease, by means of medication claims.[33] An FKG is ascribed to an insured  
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45 154 person when he/she is issued prescriptions for more than a certain dose of medication (i.e. enough from  
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47 155 approximately six months’ use) in a given year.

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49  
50  
51 156 Presence of type 2 diabetes-related complications was assessed per year based on ‘diagnosis-  
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53 157 treatment combinations’ (in Dutch: *diagnose-behandelcombinaties*, DBCs). In the Netherlands, specialized  
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55 158 care is reimbursed via DBCs, a concept similar to diagnosis-related groups (DRGs). DBCs consider

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3 159 complete episodes of care for a specific diagnosis, thus DBCs contain information on specialism or  
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5 160 responsible specialized physician, patient diagnosis, and provided treatment.[34] Moreover, one DBC may  
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7 161 contain a number of healthcare consultations, tests, or treatments. For one DBC, health insurers reimburse  
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9 162 the average expenditures made for the related diagnosis. One of the authors, who is an internist (HB),  
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11 163 matched the associated DBCs to the type 2 diabetes-related complications (Supplementary Table 1). We  
12  
13 164 focused on the most common complications listed by Nathanson et al.[35] For macrovascular  
14  
15 165 complications, these were acute coronary syndrome, stroke, and heart failure. Microvascular complications  
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17 166 included diabetic mono-/polyneuropathy, diabetic eye complications, diabetic foot/peripheral angiopathy,  
18  
19 167 and diabetic kidney disease. If a relevant DBC was reimbursed once in a given year, that patient was  
20  
21 168 registered as having the associated type 2 diabetes-related complication.  
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### 25 169 **Healthcare utilization and expenditures**

26  
27 170 This study considered total healthcare expenditures of the type 2 diabetes population under the Dutch Health  
28  
29 171 Insurance Act (In Dutch: *Zorgverzekeringswet*, Zvw), as well as under the Long-term Care Act (In Dutch:  
30  
31 172 *Wet Langdurige Zorg*, Wlz). Together, these two Acts account for the bulk of the available health care  
32  
33 173 budget in the Netherlands. For the Dutch Health Insurance Act, utilization and expenditures of the type 2  
34  
35 174 diabetes population related to a number of healthcare sectors and service types were extracted from the  
36  
37 175 Vektis databases. Data on the primary care and specialized care (care provided in hospitals and Independent  
38  
39 176 Specialized Treatment Centers) sectors were studied in detail. Utilization of primary care covered patients  
40  
41 177 registered with a GP, whereas utilization of GP consultations included patients that utilized regular  
42  
43 178 consultations (excluding integrated diabetes care consultations), home visits, and consultations via e-mail  
44  
45 179 and by phone. Moreover, we distinguished data regarding service types: pharmaceutical care, assistive  
46  
47 180 devices, mental health care, district nursing, paramedical care, and other care. Other care included maternity  
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49 181 care, obstetrics, oral care, patient transport, care abroad, geriatric rehabilitation, primary care support, and  
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51 182 inpatient primary care. Expenditures within these specified healthcare sectors and services were also  
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53 183 considered at the individual patient level. Utilization and expenditures both directly related to diabetes care  
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3 184 as well as other (non-diabetes related) services were included. The expenditures considered under the Dutch  
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5 185 Health Insurance Act include mandatory deductibles paid by patients; other (co)payments are not  
6  
7 186 included.[36] Indirect costs were not considered in this study, since no information on this aspect is  
8  
9 187 available in the Vektis database.

### 11 188 **Utilization and expenditures of type 2 diabetes-related complications**

13  
14 189 We studied utilization of and expenditures on specialized care for type 2 diabetes-related macro- and  
15  
16 190 microvascular complications in more detail. We used DBCs indicating macro- and microvascular type 2  
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18 191 diabetes-related complications (Supplementary Table 1) to assess both utilization of and expenditures on  
19  
20 192 specialized care.

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22 193 Total expenditures on medical specialist care services were determined using the total reimbursed  
23  
24 194 costs for this service type per study year, drawn from the APCD. However, in determining expenditures per  
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26 195 type 2 diabetes-related complication, a median Dutch price per DBC was calculated. This is because the  
27  
28 196 prices for specific DBCs can differ to some extent between hospitals due to variations in contractual  
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30 197 agreements made between individual hospitals and health insurers.[37] Moreover, hospitals are known to  
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32 198 raise or reduce the prices of specific DBCs for administrative purposes, e.g. to meet a hospital-wide turnover  
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34 199 constraint. As a consequence, DBC prices do not necessarily reflect the true cost of the correlated care  
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36 200 episode.[38] Thus, to mitigate the variation in expenditures introduced by administrative DBC pricing, we  
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38 201 used the median Dutch price per DBC to calculate the expenditures on type 2 diabetes-related  
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40 202 complications. For every specific DBC, the median DBC price was determined by arranging all  
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42 203 countrywide reimbursed DBCs of that type to find the median accordingly. As DBC prices vary over the  
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44 204 years, this was done separately for each study year. Finally, to determine the total expenditures per type 2  
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46 205 diabetes-related complication, the associated reimbursed DBCs were multiplied by the related median DBC  
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48 206 prices.

### 51 207 **Statistical analysis**

53  
54 208 Data were analyzed descriptively. The continuous variables age and per treated patient expenditures on type  
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56 209 2 diabetes-related complications were presented as means and standard deviations (SDs). For

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3 210 complications, the median expenditures per treated patient and the 5<sup>th</sup> and 95<sup>th</sup> percentile were also  
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5 211 described. The categorical variables gender, presence of comorbidities, presence of type 2 diabetes-related  
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7 212 complications, and healthcare sector and service utilization were reported as frequencies and valid  
8  
9 213 percentages of the total type 2 diabetes population. Population and per patient expenditures on healthcare  
10  
11 214 sectors and service types and type 2 diabetes-related complications were presented as frequencies and valid  
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13 215 percentages. Due to the economic function of Vektis data, missing data are rare but in case of missing data  
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15 216 the expenditures were imputed as zero, age was not imputed, and gender was set to unknown.

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18 217 The data were recovered and reported from the Vektis databases based on a detailed data extraction  
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20 218 and processing request. The data were obtained and analyzed using statistical package SAS 7.15. According  
21  
22 219 to the Maastricht University Medical Center ethics committee, this study is not subject to the Dutch  
23  
24 220 ‘Research involving Human Subjects act’ (registration number 2019-1445).

### 25 26 221 **Patient and public involvement**

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28 222 This study aimed to gain an overview of healthcare utilization of and expenditures on the Dutch type 2  
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30 223 diabetes population. Patients were not involved in the design, management, or reporting of this study.  
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## 224 RESULTS

### 225 Characteristics of the type 2 diabetes population

226 In 2018, 900,522 people or 6.5% of the Dutch population aged 18 and above were identified as having type  
227 2 diabetes (Table 1). In total, 740,353 patients received integrated diabetes care in that year. The type 2  
228 diabetes population increased by 2.3% compared to 2016 (n=880,121). In 2018, the mean age of the Dutch  
229 type 2 diabetes population was 68.7 ( $\pm$ 12.3) years and 46.7% of the population was female. The most  
230 common chronic comorbidity (based on medication) was heart disease, with a prevalence of 12.1% in 2018.  
231 This was followed by depression and thyroid disorders, with 2018-prevalences of 5.7% and 5.0%,  
232 respectively. Moreover, based on specialized care utilization, 5.6% of patients received care for  
233 macrovascular type 2 diabetes-related complications and 16.2% of patients received care for microvascular  
234 type 2 diabetes-related complications. The most frequently occurring complications were diabetic eye  
235 complications: 12.2% of the type 2 diabetes population received specialized care for this. The second most  
236 common type 2 diabetes-related complication identifiable through reimbursement was heart failure, as 2.8%  
237 of type 2 diabetes patients received specialized care for this. The third most prevalent were care for diabetic  
238 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 ( $\pm$ 12.4)	68.5 ( $\pm$ 12.4)	68.7 ( $\pm$ 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)

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

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

### 243 **Healthcare utilization**

244 All type 2 diabetes patients utilized care reimbursed under the Health Insurance Act in the timeframe 2016-  
 245 2018. In 2018, 4.4% of patients additionally utilized care reimbursed under the Long-term Care Act.  
 246 Regarding services covered by the Health Insurance Act, Table 2 shows that relatively large shares of the  
 247 population used care in the specified healthcare sectors and service types. Almost all people with type 2  
 248 diabetes used pharmaceutical (99.1%) and medical specialist care (97.0%) in 2018. Moreover, the large  
 249 majority of this population had GP consultations (90.5%) and half of the type 2 diabetes population had  
 250 reimbursements for the use of assistive devices. Mental health care was used by the smallest share of type  
 251 2 diabetes patients (4.7%). Reimbursements for paramedical care and district nursing increased most during  
 252 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
<b>Healthcare sectors</b>			
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)
<b>Healthcare service types</b>			
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)

253

## 254 **Healthcare expenditures**

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

263 **[Fig. 1 here]**

## 264 **Mean annual per patient expenditures**

265 With regard to the Health Insurance Act, mean annual per patient spending increased by 4.4% from 2016  
266 to 2018: €7,077 to €7,386 (Figure 2). The annual spending on medical specialist care accounted for the  
267 largest share (47%) or €3,459 per patient in 2018. Secondly, district nursing and pharmaceutical care  
268 contributed to a significant share of annual per patient expenditures: €1,124 and €1,047, respectively.  
269 Moreover, the mean annual per patient expenditures on district nursing increased by 9.4% from 2016 to  
270 2018. Annual primary care expenditures were €542 per patient in 2018. As to the category other,  
271 expenditures increased by 18.6% from 2016 and on average €517 was spent per patient in 2018. Per patient  
272 spending on assistive devices, mental health care, and paramedical care were all under 5.0% of the total  
273 mean annual per patient expenditures. The type 2 diabetes patients who received care under the Long-term  
274 Care Act as well as under the Health Insurance Act (4.4%) had an average long-term care spending of  
275 €38,033 in 2018. This increased by 14.4% in comparison to 2016.

276 **[Fig. 2 here]**

## 277 Expenditures on type 2 diabetes-related complications

278 In total, €556 million was spent on specialized care for type 2 diabetes-related complications in 2018 (Table  
 279 3). The majority of these expenditures related to microvascular complications (55.0%), which increased by  
 280 10.8% from 2016 to 2018. Spending on macrovascular complications increased by 2.1% during the same  
 281 period. In 2018, €250 million was spent on macrovascular type 2 diabetes-related complications. Diabetic  
 282 foot/peripheral angiopathy accounted for the largest share of spending on diabetes-related complications  
 283 with 20.9% or €116 million in 2018. Secondly, expenditures on strokes were 19.9% (€111 million) in 2018.  
 284 Thirdly, total spending on diabetic eye complications increased by 11.2% over the studied period and  
 285 accounted for 17.9% of the total in 2018. Moreover, for diabetic kidney disease, total expenditures increased  
 286 by 12.8% from 2016 to 2018 (to 15.7% of the total). The per treated patient mean and median expenditures  
 287 on type 2 diabetes-related complications were lowest for diabetic eye complications and diabetic  
 288 mono/polyneuropathy. The highest mean and median expenditures per treated patient were for stroke and  
 289 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%

## 290 **DISCUSSION**

291 This study is the first to use an APCD of the Dutch population to identify and characterize the type 2  
292 diabetes population. Hereby, this study extends the knowledge of its characteristics and provides insight  
293 into healthcare utilization and expenditures across healthcare sectors, service types, and for type 2 diabetes-  
294 related complications. In 2018, the annual prevalence of type 2 diabetes in the Netherlands was 900,522  
295 people (6.5% of Dutch adults). The most prevalent comorbidity, based on medication use, was heart disease  
296 with a prevalence of 12.1%. Moreover, 5.6% received specialized care for macrovascular and 16.2% of the  
297 2018 population received specialized care for microvascular complications. Regarding healthcare  
298 utilization, almost all type 2 diabetes patients utilized pharmaceutical care, medical specialist care, and GP  
299 care. In total, €8,173 million, about 9.4% of total healthcare expenditures, was reimbursed for the type 2  
300 diabetes population in 2018.[39] Expenditures on medical specialist care represented the largest share of  
301 total healthcare expenditures (38.1%), followed by expenditures on district nursing (12.4%) and  
302 pharmaceutical care (11.5%).

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

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3 316 the generalizability of certain findings may be limited on an international level due to differences in the  
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5 317 organization of healthcare. For instance, the number and duration of hospitalizations and expenditures on  
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7 318 pharmaceutical care are found to vary between established markets.[40–42] Additionally, for claims data,  
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9 319 real- or near-time data use e.g. for research findings to apply in policy and practice and vice versa is  
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11 320 hampered by the two-year time lag in data. Moreover, the Dutch claims data do not include specific  
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13 321 diagnostic codes for type 2 diabetes. Therefore, we determined the type 2 diabetes population with a number  
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15 322 of inclusion criteria. However, a small share of type 2 diabetes patients cannot be identified through claims  
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17 323 data, i.e. patients who do not receive integrated diabetes care and do not use any diabetes medication or use  
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19 324 insulin only, and type 2 diabetes patients who live in nursing homes and receive all care within the facility.  
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21 325 Nevertheless, the effect of not detecting these patients is likely to be minimal, as the large majority of type  
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23 326 2 diabetes patients receive integrated diabetes care (83%) and if not, many are included due to medication  
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25 327 use for type 2 diabetes (80% received diabetes medication in 2018).[28,43] Similarly, we found that with  
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27 328 our first inclusion criterion (“received integrated diabetes care”) we identified 740,353 patients with type 2  
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29 329 diabetes, i.e. 82.2% of the total number of patients identified in 2018. Thus, the size of our identified  
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31 330 population matches existing estimates on the number of T2DM patients treated in integrated primary care.  
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33 331 Moreover, as we used claims data, we were only able to identify chronic comorbidities and type 2 diabetes-  
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35 332 related complications for which patients recently used care, which could lead to an underestimation of the  
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37 333 prevalences of these conditions. However, we believe this underestimation is limited in scope, as prior  
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39 334 research has shown that the presence of comorbidities and complications in diabetes strongly predicts a  
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41 335 higher volume of medical health care utilization. [7–12]

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43 336 Notwithstanding these limitations, our APCD enables a detailed and complete overview of the type  
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45 337 2 diabetes population. However, our findings regarding population size differ from the type 2 diabetes  
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47 338 population as estimated by NIVEL (Netherlands Institute for Health Services Research).[44] Their findings  
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49 339 indicated an annual prevalence of 1,079,624 people with type 2 diabetes in 2018.[6] However, this estimate  
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51 340 is based on GP registration data representing approximately 10% of the Dutch population,[44] whereas we  
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53 341 included data on the total Dutch population. Also, morbidity estimates of GPs may be less reliable as these

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3 342 are potentially influenced by the local organization of the healthcare system, methods of morbidity  
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5 343 registration, the organization of the GP practice, and patient characteristics.[45] Lastly, once a type 2  
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7 344 diabetes patient is included in the NIVEL cohort, they do leave the cohort for reasons other than mortality.  
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9 345 Hence, their approach potentially results in an overestimation of the actual prevalence of type 2 diabetes.

11 346 Notably, our findings indicated that the majority of healthcare utilization and expenditures of the  
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13 347 type 2 diabetes population are not directly related to diabetes. Type 2 diabetes patients utilize care  
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15 348 throughout the healthcare system, i.e. across healthcare sectors and service types. Additionally, 97.0% of  
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17 349 type 2 diabetes patients utilize medical specialist care despite 83% receiving integrated diabetes care in the  
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19 350 primary care setting.[28] Moreover, medical specialist care utilization of the type 2 diabetes population is  
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21 351 considerably higher than the share of the entire insured population in the Netherlands that utilizes medical  
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23 352 specialist care (43% in 2017).[46] The wide dispersion of service use across the health system, as well as  
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25 353 the high utilization of medical specialist care, may be explained by the presence of comorbidities and  
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27 354 complications. Many patients not only have type 2 diabetes but additionally suffer from other conditions,  
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29 355 as is confirmed in this study as well as shown in previous literature.[7,8] Findings that comorbidities  
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31 356 substantially increase healthcare expenditures and utilization are also in line with previous studies on this  
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33 357 topic.[7–12]

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37 358 The high utilization of non-diabetes care of the type 2 diabetes population has several implications  
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39 359 for policymakers. As a large share of healthcare utilization and expenditures is caused by comorbidities or  
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41 360 type 2 diabetes-related complications, it could be beneficial to organize care more holistically and approach  
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43 361 diabetes and non-diabetes complaints more concentrated in the health system. Such an approach would  
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45 362 underpin the need to shift from a disease-specific approach to a person-centered and integrated care  
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47 363 approach. This is in agreement with prior findings indicating that person-centered integrated care may be  
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49 364 meaningful in making the care process less fragmented and improving physical and psychological health  
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51 365 in patients with multi-morbidity.[47,48] Additionally, the high utilization of and expenditures across the  
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53 366 healthcare system show that diabetes care is not necessarily expensive but the total care for patients known  
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55 367 with type 2 diabetes is. Therefore, when addressing healthcare expenditures, policymakers should not only

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3 368 focus on utilization of and expenditures on diabetes care but also on care for concurrent morbidities and  
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5 369 complications. Prior research has also shown that integrated care adapted to the needs of chronically ill  
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7 370 patients could lead to better outcomes at lower costs.[49]  
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9  
10 371 Therefore, future research exploring the characteristics of high-need (utilization) and high-cost  
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12 372 (expenditures) subgroups within the type 2 diabetes population may provide new insights into relevant  
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14 373 trigger factors for high care consumption. Such insights can inform initiatives to reduce spending growth  
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16 374 and thereby maintain the financial sustainability of healthcare systems. We identified a high level of  
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18 375 dispersion in care use, combined with a large share of type 2 diabetes patients that utilize specialized care.  
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20 376 These findings illustrate the need to further delineate specific type 2 diabetes subgroups with similar  
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22 377 resource use, and better understand their courses of disease, background characteristics, and exposure to  
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24 378 risk factors, to enable evidence-based tailoring and improvement of care. Moreover, APCDs can be used  
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26 379 for longitudinal retrospective analyses, for instance to show long-term effects of policies or treatment  
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28 380 changes to determine whether these were effective and support sustainability. Additionally, future research  
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30 381 should focus further on the dispersion of healthcare utilization of and expenditures on the type 2 diabetes  
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32 382 population. Insight into pharmaceutical care and medical specialist care utilization would be particularly  
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34 383 meaningful as these healthcare services are heavily utilized by this population. Moreover, to better  
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36 384 understand the impact of type 2 diabetes on healthcare utilization and healthcare expenditures, future  
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38 385 research should compare people with and without type 2 diabetes.  
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41 386

## 42 387 **CONCLUSIONS**

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45 388 APCDs can be used to identify the national type 2 diabetes population and describe its characteristics,  
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47 389 healthcare utilization, and healthcare expenditures. This insight can inform policymakers and practice about  
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49 390 dispersion of reimbursed care, directly and indirectly related to type 2 diabetes, and in turn support better  
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51 391 decisions to promote long-term (financial) sustainability of healthcare systems.  
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3 392 **Contributors** RG, AE, DR, JS, and DR were involved in the design of the study. A detailed data extraction  
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5 393 and processing request for data acquisition was made by RG, AE, and HB and approved by DR and JS. CT  
6  
7 394 performed data acquisition and assisted data analysis. All authors were involved in checking the accuracy  
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9 395 and completeness of the data. RG conducted data analysis, drafting, and manuscript writing. AE, HB, JS,  
10  
11 396 and DR all critically reviewed and revised the drafts and contributed to writing. All authors approved the  
12  
13 397 final version and were involved in the decision to submit it for publication. RG is the guarantor of this work  
14  
15 398 and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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17  
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20  
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22  
23 401 in the design of the study; the collection, analysis, and interpretation of data; writing the report; and did not  
24  
25 402 impose any restrictions regarding the publication of the report.

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28 403 **Data sharing statement** The datasets generated and analyzed during this study are not publicly available,  
29  
30 404 as formal consent from the Dutch health insurers is needed to gain access to these files. Data are however  
31  
32 405 available from Vektis upon reasonable request and with formal consent of the Dutch health insurers.

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35 406 **Ethics approval** According to the Maastricht University Medical Center ethics committee, this study is not  
36  
37 407 subject to the Dutch 'Research involving Human Subjects act' (registration number 2019-1445)

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39  
40 408 **Patient consent for publication** Not required.

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42  
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## REFERENCES

- 1  
2  
3 411  
4 412 1 Maarse H, Jeurissen P, Ruwaard D. Concerns over the financial sustainability of the dutch healthcare  
5 413 system. *DICE Rep* 2013;**11**:32–6.
- 6  
7 414 2 Liaropoulos L, Goranitis I. Health care financing and the sustainability of health systems. *Int J*  
8 415 *Equity Health* 2015;**14**:5–8. doi:10.1186/s12939-015-0208-5
- 9  
10 416 3 Birch S, Murphy GT, MacKenzie A, *et al*. In place of fear: aligning health care planning with system  
11 417 objectives to achieve financial sustainability. *J Heal Serv Res Policy* 2015;**20**:109–14.  
12 418 doi:10.1177/1355819614562053
- 13  
14 419 4 WHO. Programmes and projects - Nutrition - Nutrition health topics - 5. Population nutrient intake  
15 420 goals for preventing diet-related chronic diseases. Available:  
16 421 [https://www.who.int/nutrition/topics/5\\_population\\_nutrient/en/](https://www.who.int/nutrition/topics/5_population_nutrient/en/) [Accessed 13 November 2019]
- 17  
18 422 5 Williams R, Colagiuri S, Almutairi R, *et al*. IDF Diabetes Atlas: Ninth Edition 2019. Brussels, BE:  
19 423 International Diabetes Federation 2019:36-39.
- 20  
21 424 6 Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Diabetes mellitus - Cijfers & Context -  
22 425 Huidige situatie. 1. [The National Institute of Public Health and the Environment on Diabetes  
23 426 Mellitus – Numbers and Context: The current situation] Available:  
24 427 [https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-](https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht)  
25 428 [situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht](https://www.volksgezondheidenzorg.info/onderwerp/diabetes-mellitus/cijfers-context/huidige-situatie#node-aandeel-diabetes-type-1-totaal-naar-leeftijd-en-geslacht) [Accessed 28 October 2018]
- 26  
27 429 7 Williams R, Van Gaal L, Lucioni C. Assessing the impact of complications on the costs of Type II  
28 430 diabetes. *Diabetologia* 2002;**45**:S13–7. doi:10.1007/s00125-002-0859-9
- 29  
30 431 8 Struijs JN, Baan CA, Schellevis FG, *et al*. Comorbidity in patients with diabetes mellitus: Impact  
31 432 on medical health care utilization. *BMC Health Serv Res* 2006;**6**:1–9. doi:10.1186/1472-6963-6-84
- 32  
33 433 9 Tamayo T, Rosenbauer J, Wild SH, *et al*. Diabetes in Europe: An update. *Diabetes Res Clin Pract*  
34 434 2013;**103**:206–17. doi:10.1016/j.diabres.2013.11.007
- 35  
36 435 10 Hazel-Fernandez L, Li Y, Nero D, *et al*. Relationship of diabetes complications severity to  
37 436 healthcare utilization and costs among Medicare Advantage beneficiaries. *Am J Manag Care*  
38 437 2015;**21**:e62–70.
- 39  
40 438 11 Kanavos P, Aardweg S Van Den, Schurer W. Diabetes Expenditure, Burden of Disease and  
41 439 Management in 5 EU Countries. LSE Heal London Sch Econ, 2012. Available:  
42 440 [http://eprints.lse.ac.uk/54896/1/\\_libfile\\_REPOSITORY\\_Content\\_LSE\\_Health\\_and\\_Social](http://eprints.lse.ac.uk/54896/1/_libfile_REPOSITORY_Content_LSE_Health_and_Social_Care_Jan_2012_LSEDiabetesReport26Jan2012.pdf)  
43 441 [Care\\_Jan\\_2012\\_LSEDiabetesReport26Jan2012.pdf](http://eprints.lse.ac.uk/54896/1/_libfile_REPOSITORY_Content_LSE_Health_and_Social_Care_Jan_2012_LSEDiabetesReport26Jan2012.pdf). [Accessed 30 October 2019]
- 44  
45 442 12 Janssen LMM, Hiligsmann M, Elissen AMJ, *et al*. Burden of disease of type 2 diabetes mellitus:  
46 443 cost of illness and quality of life estimated using the Maastricht Study. *Diabet Med* 2020;**1**:1–7.  
47 444 doi:10.1111/dme.14285
- 48  
49 445 13 Ogurtsova K, da Rocha Fernandes JD, Huang Y, *et al*. IDF Diabetes Atlas: Global estimates for the  
50 446 prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Pract* 2017;**128**:40–50.  
51 447 doi:10.1016/j.diabres.2017.03.024
- 52  
53 448 14 Pagano E, De Rosa M, Rossi E, *et al*. The relative burden of diabetes complications on healthcare  
54 449 costs: The population-based CINECA-SID ARNO Diabetes Observatory. *Nutr Metab Cardiovasc*  
55 450 *Dis* 2016;**26**:944–50. doi:10.1016/j.numecd.2016.05.002
- 56  
57 451 15 Li R, Bilik D, Brown MB, *et al*. Medical costs associated with type 2 diabetes complications and  
58 452 comorbidities. *Am J Manag Care* 2013;**19**:421–30.

- 1  
2  
3 453 16 Zgibor JC, Orchard TJ, Saul M, *et al.* Developing and validating a diabetes database in a large health  
4 454 system. *Diabetes Res Clin Pract* 2007;**75**:313–9. doi:10.1016/j.diabres.2006.07.007  
5  
6 455 17 De Groot S, Enters-Weijnen CF, Geelhoed-Duijvestijn PH, *et al.* A cost of illness study of  
7 456 hypoglycaemic events in insulin-treated diabetes in the Netherlands. *BMJ Open* 2018;**8**:6–10.  
8 457 doi:10.1136/bmjopen-2017-019864  
9  
10 458 18 Nichols GA, Desai J, Lafata JE, *et al.* Construction of a multisite datalink using electronic health  
11 459 records for the identification, surveillance, prevention, and management of diabetes mellitus: The  
12 460 SUPREME-DM project. *Prev Chronic Dis* 2012;**9**:1–9. doi:10.5888/pcd9.110311  
13  
14 461 19 Slabaugh SL, Curtis BH, Clore G, *et al.* Factors associated with increased healthcare costs in  
15 462 Medicare Advantage patients with type 2 diabetes enrolled in a large representative health insurance  
16 463 plan in the US. *J Med Econ* 2015;**18**:106–12. doi:10.3111/13696998.2014.979292  
17  
18 464 20 Charbonnel B, Simon D, Dallongeville J, *et al.* Direct Medical Costs of Type 2 Diabetes in France:  
19 465 An Insurance Claims Database Analysis. *PharmacoEconomics - Open* 2018;**2**:209–19.  
20 466 doi:10.1007/s41669-017-0050-3  
21  
22 467 21 Jacobs E, Hoyer A, Brinks R, *et al.* Healthcare costs of Type 2 diabetes in Germany. *Diabet Med*  
23 468 2017;**34**:855–61. doi:10.1111/dme.13336  
24  
25 469 22 van Schoonhoven A V., Gout-Zwart JJ, de Vries MJS, *et al.* Costs of clinical events in type 2  
26 470 diabetes mellitus patients in the Netherlands: A systematic review. *PLoS One* 2019;**14**:e0221856.  
27 471 doi:10.1371/journal.pone.0221856  
28  
29 472 23 Jo C. Cost-of-illness studies: concepts, scopes, and methods. *Clin Mol Hepatol* 2014;**20**:327–37.  
30 473 doi:10.3350/cmh.2014.20.4.327  
31  
32 474 24 Freedman JD, Green L, Landon BE. All-Payer Claims Databases — Uses and Expanded Prospects  
33 475 after Gobeille. *N Engl J Med* 2016;**375**:2215–7. doi:10.1056/NEJMp1609578  
34  
35 476 25 Love D, Custer W, Miller P. All-payer claims databases: state initiatives to improve health care  
36 477 transparency. *Issue Brief (Commonw Fund)* 2010;**99**:1–14.  
37  
38 478 26 Dworsky M. Using All-Payer Claims Databases to Study Insurance and Health Care Utilization  
39 479 Dynamics. *J Gen Intern Med* 2017;**32**(10):1069–70. doi:10.1056/NEJMp1609578  
40  
41 480 27 Hrzic R, Clemens T, Westra D, *et al.* Comparability in Cross-National Health Research Using  
42 481 Insurance Claims Data: The Cases of Germany and the Netherlands. *Gesundheitswesen, Suppl*  
43 482 2019;**82**:S83–90. doi:10.1055/a-1005-6792  
44  
45 483 28 Klomp M, Romeijnders A, de Braal E, *et al.* InEen - Transparante Ketenzorg Rapportage 2019  
46 484 Zorggroepen: Diabetes Mellitus, VRM, COPD en Astma. Spiegel voor het verbeteren van  
47 485 chronische zorg. 2019 p.13–20. [Report on Transparency in Integrated Diabetes Care and Care  
48 486 Groups] Available: [https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-](https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-ketenzorg-2019-web.pdf)  
49 487 [ketenzorg-2019-web.pdf](https://ineen.nl/wp-content/uploads/2020/07/200715-Benchmark-Transparante-ketenzorg-2019-web.pdf) [Accessed 30 September 2020]  
50  
51 488 29 Struijs JN, Baan CA. Integrating care through bundled payments - Lessons from the Netherlands. *N*  
52 489 *Engl J Med* 2011;**364**:990–1. doi:10.1056/NEJMp1011849  
53  
54 490 30 Sluiter AC, Van Wijland JJ, Arntzenius A, *et al.* Landelijke Transmurale Afspraak Diabetes mellitus  
55 491 type 2 [National Transmural Agreement Type 2 diabetes mellitus]. *Huisarts Wet* 2012;**55**:S1-12.  
56 492 doi:10.1007/s12445-012-0012-z  
57  
58 493 31 Barents ESE, Bilo HJG, Bouma M, *et al.* NHG standaard - Diabetes mellitus type 2 - Richtlijnen

- 1  
2  
3 494 beleid - Medicamenteuze therapie [Medication guidelines for type 2 diabetes Melitus type]  
4 495 Available: <https://richtlijnen.nhg.org/standaarden/diabetes-mellitus-type-2> [Accessed 19-07-2021]  
5
- 6 496 32 Overheid. Besluit zorgverzekering - Hoofdstuk 1. Definities en algemene bepalingen - Artikel 1.  
7 497 [Decisions on health insurance – Chapter 1. Definitions and general provisions – Article 1]  
8 498 Available: <https://wetten.overheid.nl/BWBR0018492/2021-01-01> [Accessed 13 March 2020]  
9
- 10 499 33 Van Kleef RC, Van Vliet RC, Van De Ven WP. Risk equalization in the Netherlands: An empirical  
11 500 evaluation. *Expert Rev Pharmacoeconomics Outcomes Res* 2013;**13**:829–39.  
12 501 doi:10.1586/14737167.2013.842127
- 13 502 34 Elissen A, Duimel-Peeters I, Spreuwenberg C, *et al.* Assessing Chronic Disease Management in  
14 503 European Health Systems. Country reports. Copenhagen, DK: WHO Regional Office for Europe,  
15 504 2015:99–110.
- 16 505 35 Nathanson D, Sabale U, Eriksson JW, *et al.* Healthcare Cost Development in a Type 2 Diabetes  
17 506 Patient Population on Glucose-Lowering Drug Treatment: A Nationwide Observational Study  
18 507 2006–2014. *PharmacoEconomics - Open* 2017;**2**:393–402. doi:10.1007/s41669-017-0063-y
- 19 508 36 Vektis. Bijsluiter: Vektis Open Databestanden Zorgverzekeringswet 2011-2018 [Information leaflet  
20 509 of open-access Health-Insurance Act Vektis databases]. Available:  
21 510 <https://www.vektis.nl/uploads/Docs%20per%20pagina/Open%20Data%20Bestanden/Bijsluiter%20bij%20de%20Vektis%20Open%20Databestanden%20Zorgverzekeringswet%202011%20-%202018%20.pdf> [Accessed 12 November 2020]  
22 511  
23 512
- 24 513 37 Berden C, Croes R, Kemp R, *et al.* Hospital Competition in the Netherlands: An Empirical  
25 514 Investigation. *Discuss Pap.* 2019. [article online]. Available:  
26 515 [https://pure.uvt.nl/ws/portalfiles/portal/30034784/DP2019\\_008.pdf](https://pure.uvt.nl/ws/portalfiles/portal/30034784/DP2019_008.pdf) [Accessed 12 November 2020]
- 27 516 38 Nederlandse Zorgautoriteit (NZa). Advies bekostiging medisch-specialistische zorg, Belonen van  
28 517 zorg die waarde toevoegt [Presentation of The Dutch Healthcare Authority regarding advice on  
29 518 medical specialist care reimbursement]. Available:  
30 519 <https://www.rijksoverheid.nl/documenten/rapporten/2018/10/04/belonen-van-zorg-die-waarde-toevoegt> [Accessed 12 November 2020]  
31 520
- 32 521 39 CBS. StatLine - Zorguitgaven in drie benaderingen; zorgaanbieders [Care expenditures approached  
33 522 in three ways; care providers]. Available:  
34 523 <https://opendata.cbs.nl/#/CBS/nl/dataset/84054NED/table?dl=3AB46&ts=1605793224356>  
35 524 [Accessed 19 November 2020]
- 36 525 40 Alzaid A, Ladrón de Guevara P, Beillat M, *et al.* Burden of disease and costs associated with type  
37 526 2 diabetes in emerging and established markets: systematic review analyses. *Expert Rev*  
38 527 *Pharmacoeconomics Outcomes Res* 2020;:1–14. doi:10.1080/14737167.2020.1782748
- 39 528 41 Müller N, Heller T, Freitag MH, *et al.* Healthcare utilization of people with Type 2 diabetes in  
40 529 Germany: An analysis based on health insurance data. *Diabet Med* 2015;**32**:951–7.  
41 530 doi:10.1111/dme.12747
- 42 531 42 Jönsson B. Revealing the cost of Type II diabetes in Europe. *Diabetologia* 2002;**45**.  
43 532 doi:10.1007/s00125-002-0858-x
- 44 533 43 Stichting Farmaceutische Kerngetallen. Data en feiten 2019 - Het jaar 2018 in cijfers [The  
45 534 Foundation of Pharmaceutical Key figures on data and facts – the year 2018 in numbers][online  
46 535 article] 2019. Available: <https://www.sfk.nl/publicaties/data-en-feiten/data-en-feiten-2019>.  
47 536 [Accessed 29 September 2020]

- 1  
2  
3 537 44 Nivel. Volksgezondheidszorg.info - NIVEL Zorgregistraties eerste lijn - Algemeen [The Dutch  
4 538 Institute for Health Services Research - care records in primary care] Available:  
5 539 <https://bronnen.zorggegevens.nl/Bron?naam=Nivel-Zorgregistraties-eerste-lijn> [Accessed 30  
6 540 October 2020]  
7  
8 541 45 van den Dungen C, Hoeymans N, Gijsen R, *et al.* What factors explain the differences in morbidity  
9 542 estimations among general practice registration networks in the Netherlands? A first analysis. *Eur J*  
10 543 *Gen Pract* 2008;**14**:53–62. doi:10.1080/13814780802436218  
11  
12 544 46 Vektis. Inzichten in medisch-specialistische zorg [Insights into Medical Specialist Care]. Available:  
13 545 <https://www.zorgprismapubliek.nl/producten/ziekenhuiszorg/medisch-specialistische-zorg/>  
14 546 [Accessed 30 September 2020]  
15  
16 547 47 Inzucchi SE, Bergenstal RM, Buse JB, *et al.* Management of hyperglycemia in type 2 diabetes: A  
17 548 patient-centered approach. *Diabetes Care* 2012;**35**:1364–79. doi:10.2337/dc12-0413  
18  
19 549 48 Berntsen G, Høyem A, Lettrem I, *et al.* A person-centered integrated care quality framework, based  
20 550 on a qualitative study of patients' evaluation of care in light of chronic care ideals. *BMC Health Serv*  
21 551 *Res* 2018;**18**:1–15. doi:10.1186/s12913-018-3246-z  
22  
23 552 49 Mitri J, Gabbay R. Understanding Population Health Through Diabetes Population Management.  
24 553 *Endocrinol Metab Clin North Am* 2016;**45**:933–42. doi:10.1016/j.ecl.2016.06.006  
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**555 Figure legends**

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

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

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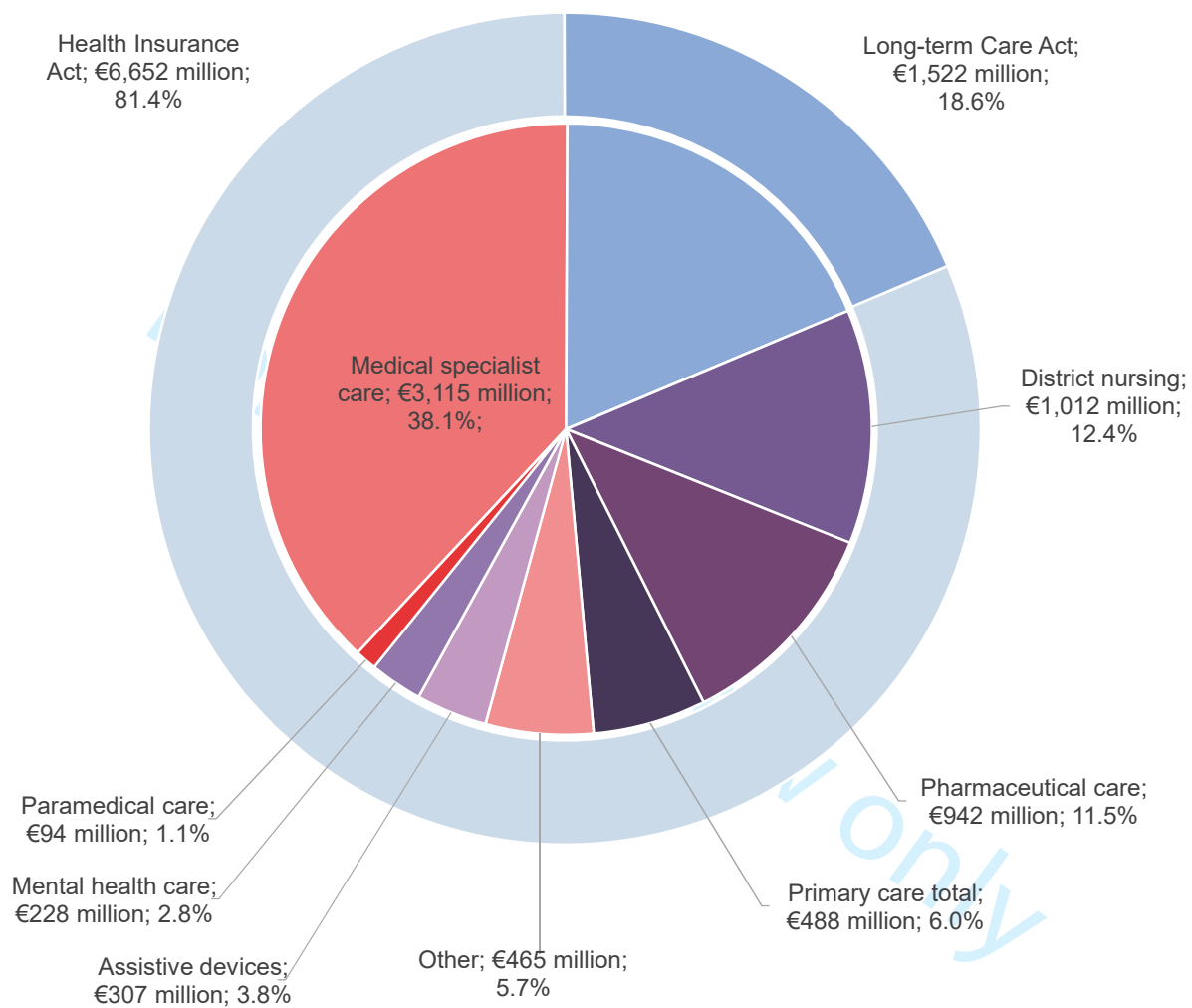
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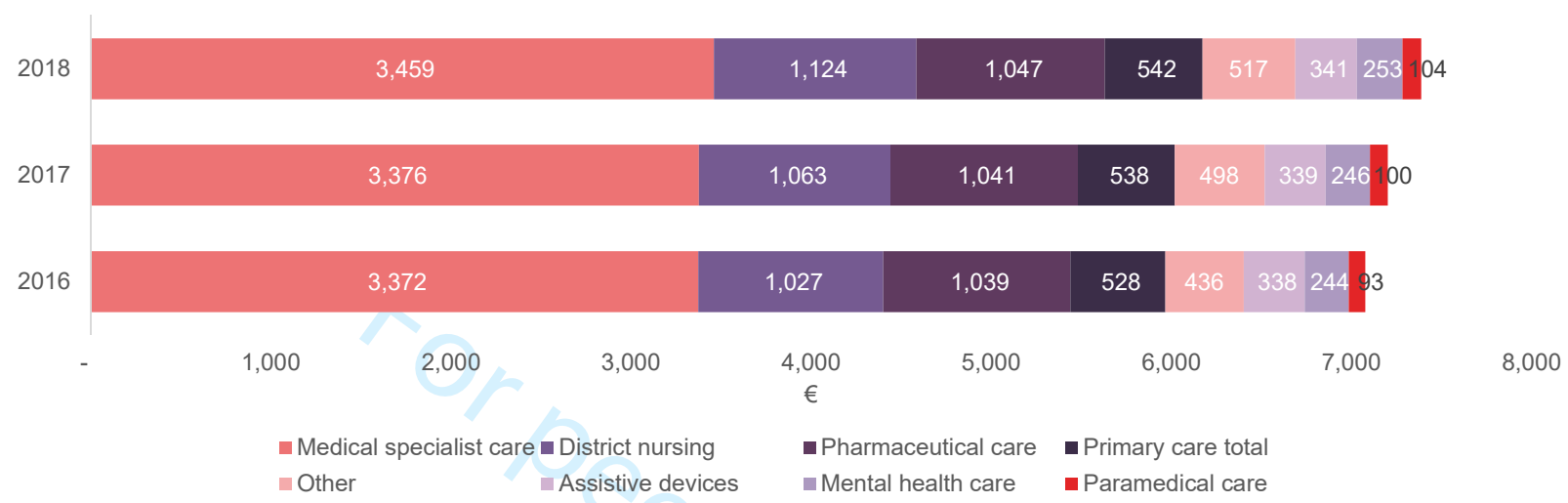
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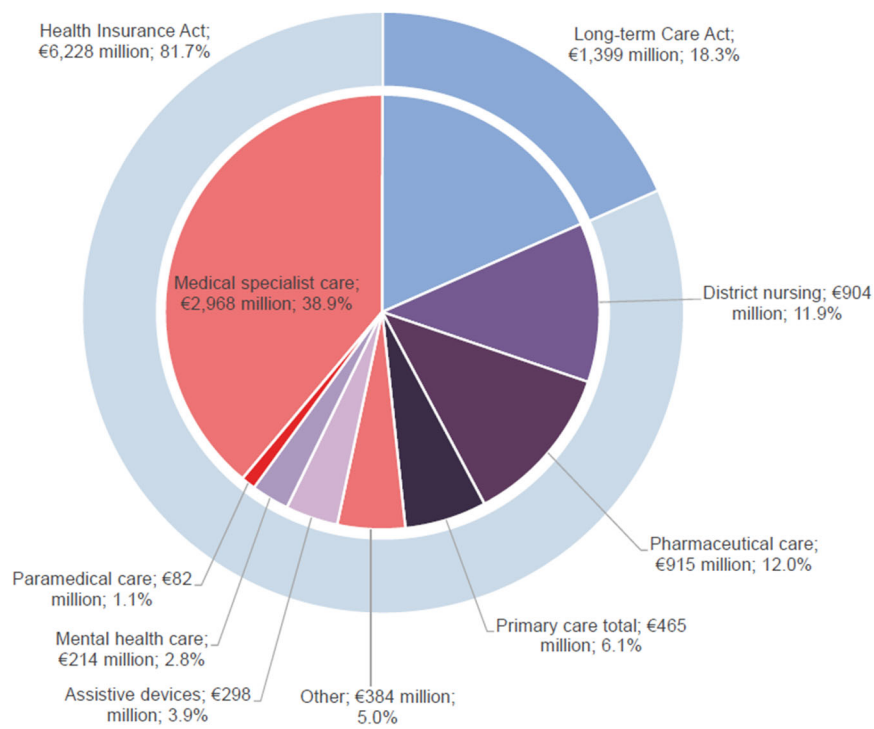
**Supplementary Table 1 Matched reimbursement codes per type 2 diabetes-related complication**

Disease group	Reimbursement codes (DBC's)
<b>Macrovascular type 2 diabetes – related complications</b>	
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)
<b>Microvascular type 2 diabetes – related complications</b>	
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); Proliferative 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



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3 foot (305.2065); Diabetic foot (0303.432); Other peripheral vascular diseases  
4 (0303.439); PAOD arm (0303.0412); PAOD 2, claudicatio intermittens  
5 (0303.0418); PAOD 3, rest pain (0303.0419); PAOD 4, gangrene (0303.0420)  
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8 Diabetic kidney disease Kidney transplant, recipient (0313.076); Kidney and pancreatic transplant,  
9 recipient (0313.078); Chronic renal failure, eGFR 30-60 ml/min (0313.324),  
10 Chronic renal failure, eGFR <30 ml/min (0313.325); Continuous ambulatory  
11 peritoneal dialysis (CAPD) (0313.331); Automatic peritoneal dialysis (APD)  
12 (0313.332); Chronic hemodialysis at home (0313.336); Chronic hemodialysis  
13 in institution (0313.339)  
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**Supplementary Figure 1 Healthcare expenditures of the type 2 diabetes population in 2016**

Preview only

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

	2016	2016	2017	2017	2018	2018
	Mean	Median per	Mean	Median per	Mean	Median per patient
	expenditures	patient	expenditures	patient	expenditures	expenditures (P5;
	per patient ±	expenditures	per patient ±	expenditures	per patient ±	P95) <sup>a</sup>
	SD <sup>a</sup>	(P5; P95) <sup>a</sup>	SD <sup>a</sup>	(P5; P95) <sup>a</sup>	SD <sup>a</sup>	
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
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6 & 7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —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) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	6 & 7
		(e) Describe any sensitivity analyses	-

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<b>Results</b>			
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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	9-15
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	-
		<i>Cross-sectional study</i> —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	-
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://www.strobe-statement.org).