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Distribution and Economic Burden of Diabetes-Related Microvascular Complications in Türkiye

ABSTRACT

Background: The aim of the study was to map microvascular complications associated with diabetes mellitus from personal health records and to guide chronic disease management by revealing the economic burden of the disease.

Method: The data of patients with diabetes who developed microvascular complications were obtained from the e-Pulse database of the Ministry of Health, with the definitions of the disease. First, the distribution of patients by province and gender was determined and then patients with multiple complications were identified. Only direct costs and their distribution on the basis of complications were determined from the database according to the cost of illness methodology from the payer's perspective. Then, average annual per-patient costs were determined using a top-down costing approach.

Results: Between 2016 and 2020, a total of 7 656 700 patients with diabetes were reached. The number of patients with microvascular complications between 2016 and 2020 obtained from the e-Pulse database with the above definitions was 1 466 387. Regarding the complications, a total of 66 838 people developed nephropathy, 314 706 people developed retinopathy, and 1 084 843 people developed neuropathy. The total cost of patients with microvascular complications was $1 482 278 950.76 and the average annual cost per patient was $1010.84. The average annual cost of neuropathy is $659 862 971.96, retinopathy is $356 594 282.51 and nephropathy is $465 821 696.29, with per-patient costs of $701.82, $1495.24, and $10 516.11, respectively.

Conclusion: Diabetes mellitus, with its microvascular complications, causes significant disease and economic burden. Türkiye's national health database system, e-Pulse, is an important database that provides patient follow-up at both individual and population levels and helps with the management of the disease and taking preventive measures before the development of the complications.

Keywords: Diabetes mellitus, economic burden of diabetes related microvascular complications, neuropathy, nephropathy, retinopathy, personal health record

ORIGINAL INVESTIGATION

INTRODUCTION

An electronic personal health record (PHR) is an electronic application through which individuals can access, manage, and share their own health information and the health information of others for whom they are authorized in a private, secure, and confidential environment. At a minimum, PHRs allow individuals to manually enter their health information on a website, which can then be accessed over the internet as needed. Advanced, interoperable PHRs can electronically transfer a patient's clinical data from electronic health records (EHRs) of different hospitals, pharmacies, health insurers, and other institutions so that other health-care organizations can have access to the patient. In addition to storing and accessing clinical data, many PHRs provide secure patient–clinician messaging, prescription request and renewal features, access to high-quality educational materials, and other features designed to promote patient self-management and improved communication with health-care professionals.[1]

The collection of Turkish citizens' health records electronically under the umbrella of "e-Nabız/e-Pulse" has been ongoing since 2015. The statisticalization and interpretation of these data is carried out through the SINA (Statistical Causation and Analyses in Health) system. In order to interpret the information from this system

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and provide added value to chronic disease management, this study focuses on diabetes mellitus (DM), which is of critical importance for Türkiye.[2]

Diabetes mellitus is a chronic disease with an increasing prevalence worldwide. In 2021, there were 537 million people living with DM, which causes significant disease burden and economic burden. According to the International Diabetes Federation (IDF), this number is projected to increase to 643 million in 2030 and 783 million in 2045. With a dramatic increase observed in all continents, it is obvious that it will create significant pressure on the health systems of countries.[3]

According to IDF estimates, 9 million people with diabetes live in Türkiye and the prevalence is estimated to be 15.9%. A cost study on diabetic patients in Türkiye was conducted by the SSI (Social Security Institution) in 2010 and was estimated at 10 billion Turkish liras (TL).[4] In another study published in 2014, the estimated cost of diabetes to Türkiye was estimated to be in the range of 12.5 billion TL.[5] In a report published in 2017, it was estimated that type 2 diabetes mellitus (T2DM) complication costs would reach 19 billion TL.[6] In addition, complications cause serious negative health problems for the patient if they are not prevented and treated. In addition, while there is minimal resource utilization in case of precautions, the progression of the disease causes very high resource utilization, prolonged hospitalization, even disability, and early death.[7]

Prevention of acute and chronic complications and halting the progression of chronic complications are considered among the goals of diabetes treatment. The importance of increasing health literacy and access to primary health-care services is emphasized in preventing diabetes-related complications and reducing their effects.[8] In Türkiye, the rate of individuals with diabetes with low treatment compliance and continuity can reach up to 40.4%, according to the results of a study conducted in a university hospital between October 2010 and October 2011. In the report published by IQVIA, when the CORE Diabetes Model is adapted by taking into account the level of T2DM treatment compliance and continuity in Türkiye, it is calculated that 7.42% of this cost (approximately 1.26 billion TL per year) is due to complications related to low T2DM treatment compliance and continuity. This avoidable expenditure and economic loss is only one dimension of the total cost of low T2DM treatment adherence and continuity; it is only associated with preventable complications.[6]

HIGHLIGHTS

- Between 2016 and 2020, a total of number of 7 656 700 patients with diabetes were reached.
- The total cost of patients with microvascular complications was $1 482 278 950.76, and the average annual cost per patient was $1010.84.
- The number of patients with microvascular complications is 1 466 387. In terms of patient sex distribution: 557 227 were male (38%) and 909 160 (62%) were female.
- On a provincial basis, the provinces with the highest number of complications were Gaziantep, Burdur, and Manisa, and the provinces with the lowest number were Ankara, Edirne, and Artvin.

In this direction, we aimed to reveal the microvascular complication map of the disease for Türkiye and to determine the current economic burden of the disease by using the Ministry of Health digital database e-nabız for microvascular complications related to DM, which is known to be an important disease and economic burden.

METHODS

In order to obtain data on microvascular complications of diabetes and diabetes-related patients, different definitions were made on the basis of both type 1 DM and T2DM and complications in order to obtain accurate data through the e-Pulse electronic registration system. In this definition, ICD (International Classification of Disease) data codes and patients who were in the system but did not meet the definitions but entered the system once with the correct ICD code were excluded. Microvascular complications were defined by the following criteria (Table 1). Based on the relevant ICD codes, patients with diabetes who developed microvascular complications in 2016-2020 were extracted from the system.

Launched in 2015 by the Ministry of Health, the e-Pulse system is a digital database where the personal health records of each individual who is a citizen of the Republic of Türkiye and has General Health Insurance are stored. The system contains the data of 68 million people. With the permission of the Ministry of Health, the E-95741342-708.01-2063856 72 number code was used to anonymize patient personal data, and patients were reached with the relevant codes. The reason for analyzing the data between 2016 and 2020 is that the e-Pulse system has been collecting data since 2015. The data were cleaned and were ready for analysis in 6 months. Between 2016 and 2020, a total of 7 656 700 patients (7 438 764 patients with T2DM and 217 936 patients with Type 1 DM) with diabetes were reached. Between 2016 and 2020, 1 466 387 patients who were diagnosed with DM and developed microvascular complications were identified. The provinces where these patients lived, the prevalence of the disease according to province, and the prevalence of retinopathy, nephropathy, and neuropathy according to gender and province of residence were determined. Then, the economic burden of each complication according to the cost of disease method was determined from a payer perspective.

Cost of illness studies consisting of direct, indirect, and intangible costs can be presented differently according to the databases of countries and the data obtained. Moral costs are excluded from the studies since they cannot be quantified.[9] In this study, only direct costs were calculated from the perspective of the reimbursing institution (SSI).

Direct cost is the money spent by individuals, insurance institutions, or the state for the care, cure, and prevention of a disease. It is the use or consumption of resources in the process of the direct treatment of a disease. Examples such as the use of time and knowledge of physicians, nurses, and

Table 1. Definitions of DM Microvascular Complications

Microvascular complications	1	Nephropathy ①ICD10 Codes: E11.2 E13.2 E08.2, E09.2, E14.2 N18.x, I12, I13 OR ②Patients with kidney transplant (ICD Z94.0 or procedure P618610) OR ③Patients on chronic dialysis program (with one of the procedures P704230 P704233 530710 704260 704270)
	2	Retinopathy ①ICD10 Codes: E08.3 E09.3 E11.3 E13.3 E14.3 H36 H35.0 H35.3 H35.9 OR Non-proliferative Diabetic Retinopathy Proliferative Diabetic Retinopathy ② Vitrectomy (SUT Code: P617660 or 617660 /P617640 or 617640 / P617650 or 617650 / 617640) OR Diffuse Diabetic Macular Edema ③Macular Laser/Panretinal photocoagulation (SUT Code: 617630 Laser photocoagulation) OR Diffuse Diabetic Macular Edema ④Intravitreal injection (SUT code: 617620 AND ATC codes S01LA04 or S01LA05) OR Stable Diabetic Retinopathy ⑤Intravitreal injection (SUT code: 617620 and ATC code S01BA01)
	3	Cataract ①ICD10: E08.36, E09.36, E10.36, E11.36, E13.36 H28 H26.2 H26.4 H26.8 H26.9 OR ②Those with cataract intervention (SUT Codes: P617341/P617342/P617540 / 617341 / 617342 / 617540)
	4	Neuropathy ①ICD10: E11.4 E14.4 G63.2 OR ②Use of pregabalin (N03AX) or duloxetine (N06AX21) or alpha-lipoic acid (A16AX01)

medical care personnel, the use of machines and medical equipment, and the use of medicines and other consumables can be given for direct costs.[9]

Generally, direct costs are classified as direct medical and nondirect medical costs. This classification depends on whether the resource is used directly in treatment. Direct medical costs are the amount spent on outpatient clinic, other clinics, medical supplies, all laboratory or imaging tests, and interventions. Only direct medical costs were taken into consideration in the study.

For the calculation of direct disease costs, the method developed by Cowley et al[10] on behalf of the World Bank (WB) and WHO was used. In the method, the clinical path is followed, and the number of uses of each expenditure item is multiplied by the percentage of cases using it and unit costs to reach the main total expenditure. The formulation used is as follows:

- Unit cost of health services required to deliver the intervention (C)
- Quantity of each type of service required for the intervention (V)
- Number of people applying to the health institution for that service (n)

In the following equation, "i" denotes the service levels and "j" denotes the required services needed for the intervention. The equation assumes that there are s-types of appropriate services. If some of the services are not needed in the production of intervention j, the values of V will be 0.

$$M_j = \sum_{i=1}^{s} C_{ij} * V_{ij} * n_{ij}$$

Direct medical costs were obtained by multiplying the type and amount of service received by the utilization rate and unit cost.[10] Total costs were then converted to per-patient costs based on the total number of patients using a top-down costing approach.

RESULTS

Frequency Rate of Microvascular Complications in Patients with Diabetes

The number of patients with microvascular complications between 2016 and 2020, obtained from the e-Pulse database with the above definitions, was determined as 1 466 387. About 557 227 were male (38%) and 909 160 (62%) were female. On a provincial basis, the provinces with the highest number of complications were Gaziantep, Burdur, and Manisa, and the provinces with the lowest number were Ankara, Edirne, and Artvin (Table 2, Figure 1).

The frequency rate of microvascular complications by district is presented in Figure 2. According to this detail, the Nizip district of Gaziantep had the highest frequency of microvascular complications (40.3%), while the Hamamözü district of Amasya had the lowest frequency rate (9.6%).

In terms of complications, there were a total of 66 838 people with nephropathy, 33 065 men (49%) and 33.773

Table 2. Number of People with DM Related Microvascular Complications (Türkiye)

Province	Male	Microvascular Complication Rate—Male	Female	Microvascular Complication Rate—Female	Microvascular Complication Number	Microvascular Complication Rate	Total Diabetes Mellitus Patients
Adana	15 359	16.7	24 028	18.2	39 386	17.6	224 266
Adıyaman	2826	17.6	5041	19.7	7868	18.9	41 589
Afyonkarahisar	6387	19.0	12 220	22.0	18 609	20.9	89 123
Ağrı	1346	17.9	2680	21.8	4026	20.3	19 805
Amasya	2473	15.1	3925	16.1	6398	15.7	40 813
Ankara	28 065	13.2	47 462	15.3	75 529	14.4	523 944
Antalya	18 757	17.4	26 295	19.9	45 047	18.8	239 538
Artvin	1072	14.2	1532	15.9	2604	15.2	17 178
Aydın	11 371	20.1	16 977	22.6	28 346	21.5	131 762
Balıkesir	10 794	17.4	16 574	19.0	27 367	18.3	149 417
Bilecik	1590	17.0	2760	20.1	4351	18.8	23 123
Bingöl	1075	21.3	1527	20.5	2602	20.8	12 502
Bitlis	1314	22.4	2029	22.9	3343	22.7	14 731
Bolu	2235	15.3	3031	15.1	5265	15.2	34 707
Burdur	3351	23.9	4953	26.7	8303	25.5	32 560
Bursa	17 865	15.1	29 473	17.3	47 338	16.4	288 748
Çanakkale	4330	15.9	7124	18.6	11 455	17.5	65 449
Çankırı	2212	18.5	3489	22.0	5701	20.5	27 773
Çorum	4241	17.0	7363	19.8	11 604	18.7	62 187
Denizli	11 977	20.8	18 157	23.5	30 132	22.3	134 877
Diyarbakır	4987	16.7	9756	20.2	14 744	18.9	78 189
Edirne	2932	14.2	4417	15.4	7348	14.9	49 461
Elazığ	3792	19.2	5747	19.7	9539	19.5	48 919
Erzincan	1549	16.8	2327	18.4	3875	17.7	21 864
Erzurum	3207	17.7	4720	18.6	7927	18.2	43 558
Eskişehir	6450	16.4	12 195	20.1	18 647	18.6	100 129
Gaziantep	15 548	24.8	28 664	28.1	44 215	26.8	164 682
Giresun	3809	17.0	6 862	20.8	10 672	19.2	55 490
Gümüşhane	867	17.9	1345	19.6	2212	18.9	11 712
Hakkâri	501	16.7	952	21.1	1453	19.3	7514
Hatay	10 914	17.3	15 510	19.9	26 422	18.7	140 986
Isparta	5162	22.8	7892	24.4	13 054	23.8	54 927
Mersin	14 322	18.2	21 469	20.7	35 789	19.6	182 442
İstanbul	82 124	15.0	132 777	17.1	214 900	16.2	1325 186
İzmir	34 474	16.4	52 579	17.8	87 049	17.2	506 049
Kars	924	16.1	1531	19.5	2455	18.0	13 604
Kastamonu	4062	17.5	5592	18.6	9653	18.1	53 371
Kayseri	7723	15.9	13 101	17.9	20 825	17.1	121 524
Kırklareli	2777	15.4	4225	16.8	7002	16.2	43 270
Kırşehir	2029	17.4	3328	19.7	5357	18.8	28 489
Kocaeli	11 749	15.4	21 258	18.6	33 009	17.3	190 275
Konya	14 140	16.7	25 129	19.7	39 271	18.5	212 254
Kütahya	5855	19.9	10 438	23.4	16 294	22.0	73 947
Malatya	4215	14.9	6930	16.7	11 146	16.0	69 856
Manisa	16 308	24.3	26 357	26.3	42 665	25.5	167 396
Kahramanmaraş	6763	19.8	12 463	24.0	19 227	22.3	86 086

(*Continued*)

Table 2. Number of People with DM Related Microvascular Complications (Türkiye) (*Continued*)

Province	Male	Microvascular Complication Rate—Male	Female	Microvascular Complication Rate—Female	Microvascular Complication Number	Microvascular Complication Rate	Total Diabetes Mellitus Patients
Mardin	2855	18.6	6082	24.7	8939	22.4	39 989
Muğla	8204	15.9	10 459	18.1	18 660	17.1	109 416
Muş	1212	20.0	2007	21.9	3219	21.1	15 254
Nevşehir	2091	15.6	3544	18.1	5634	17.1	32 900
Niğde	2314	17.5	4501	21.1	6816	19.7	34 530
Ordu	6673	19.0	12 132	22.7	18 806	21.2	88 750
Rize	2303	15.3	3382	17.7	5685	16.6	34 187
Sakarya	8090	19.3	13 159	21.7	21 249	20.7	102 510
Samsun	10 900	18.5	18 796	22.0	29 697	20.5	144 594
Siirt	1066	19.2	1902	23.0	2968	21.5	13 828
Sinop	2546	17.2	3726	19.2	6272	18.4	34 163
Sivas	4338	16.0	8286	19.4	12 626	18.1	69 765
Tekirdağ	6645	15.8	10 367	17.6	17 012	16.9	100 867
Tokat	5170	18.8	9950	22.8	15122	21.2	71 193
Trabzon	4698	14.8	7111	16.2	11 809	15.6	75 849
Tunceli	476	17.4	527	16.6	1003	17.0	5 908
Şanlıurfa	6818	19.0	11 859	22.8	18 678	21.3	87 782
Uşak	3488	17.8	5186	18.6	8674	18.3	47 483
Van	3614	21.3	5941	22.5	9555	22.0	43 406
Yozgat	3170	17.4	5464	19.2	8634	18.5	46 705
Zonguldak	5409	17.4	8928	20.0	14 338	18.9	75 678
Aksaray	2478	15.7	4630	18.9	7 108	17.7	40 253
Bayburt	417	15.4	620	18.3	1036	17.0	6099
Karaman	1905	19.7	3387	22.7	5292	21.5	24 569
Kırıkkale	2146	16.5	3678	18.3	5825	17.6	33 047
Batman	1803	17.7	3364	20.5	5167	19.4	26 585
Şırnak	1178	18.9	2410	22.6	3588	21.3	16 877
Bartın	2345	19.9	3876	24.0	6220	22.3	27 928
Ardahan	337	15.0	455	16.4	791	15.8	5015
Iğdır	759	18.9	1295	22.6	2054	21.1	9755
Yalova	1843	14.1	3046	16.2	4889	15.3	31 937
Karabük	2475	17.3	3745	19.6	6219	18.6	33 426
Kilis	1108	21.4	1867	24.7	2975	23.3	12 748
Osmaniye	4479	21.1	7690	25.5	12 169	23.7	51 394
Düzce	2946	19.4	5209	23.8	8155	22.0	37 039
Unknown	9570						
	534 124	17.0	872 780	19.4	1 406 387	18.4	7 656 700

women (51%). Its weight in microvascular complications is 5%. The highest prevalence is in Ardahan, Nevşehir, Rize, and Erzincan, and the lowest in Şanlıurfa, Uşak, Aksaray, and Denizli. The proportion of the population with a glycated hemoglobin (HbA1c) value >7, which is considered uncontrolled, is 55%, 53.5%, 51.9%, and 50.1% in the provinces with the highest frequency of microvascular complications and 58.4%, 47.6%, 47.3%, and 40.4% in the provinces with the lowest frequency of complications, respectively (Table 3).

The total number of patients who developed retinopathy was 314 706, with 146 810 (47%) males and 167 896 (53%) females. Its weight in microvascular complications is 22%. When weighing the frequency of diabetes, Gaziantep, Burdur, Manisa, and Osmaniye have the highest frequency and Ankara, Bolu, and Ardahan have the lowest frequency. The proportion of the population with HbA1c values > 7 in these provinces is 50.9% in Gaziantep, 40.9% in Burdur, 40.8% in Manisa, 46.4% in Osmaniye, 40.3% in Ankara, 43.7% in Bolu, and 55% in Ardahan (Table 4).

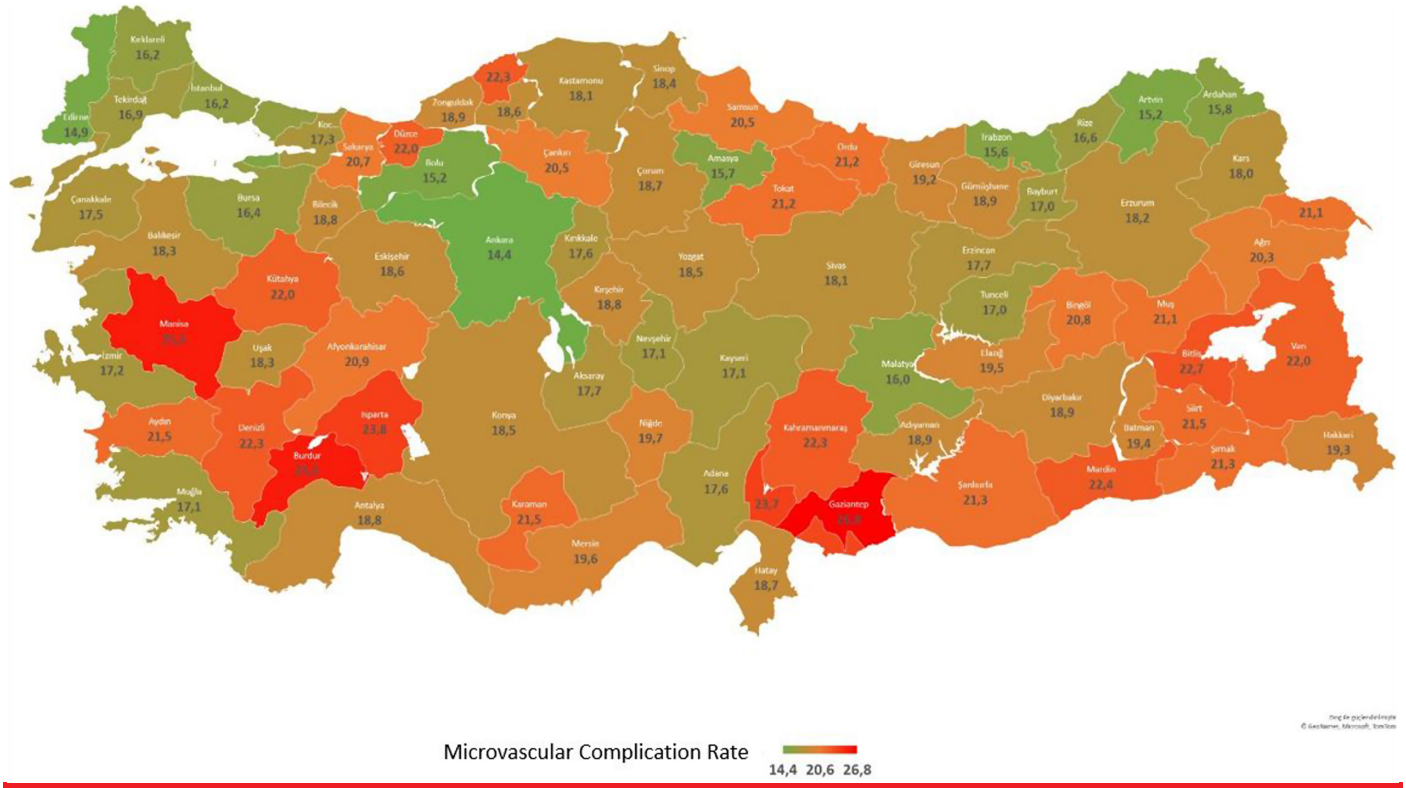

Figure 1. Prevalence of Microvascular Complications by Province, % (minimum—maximum 14.4%-26.8%).

The total number of patients with DM-related neuropathy was 1084 843, with 377 852 men (35%), and 706 991 women (65%) experiencing neuropathy complications. The highest rates were observed in Gaziantep (22.8%), Burdur (20.1%), and Manisa (19.3%). In these provinces, the population of patients with diabetes with HbA1c values > 7 was 50.9% in Gaziantep, 40.9% in Burdur, and 40.8% in Manisa (Table 5).

Cost of Microvascular Complications

For 2020, the costs of patients with microvascular complications were calculated from a reimburser perspective. The dollar exchange rate was taken as the average for 2020 ($1 = 7.006 TL). The total cost of patients with microvascular complications from the total number of DM patients is $1 482 278 950.76 per year, with inpatient (41%), intervention

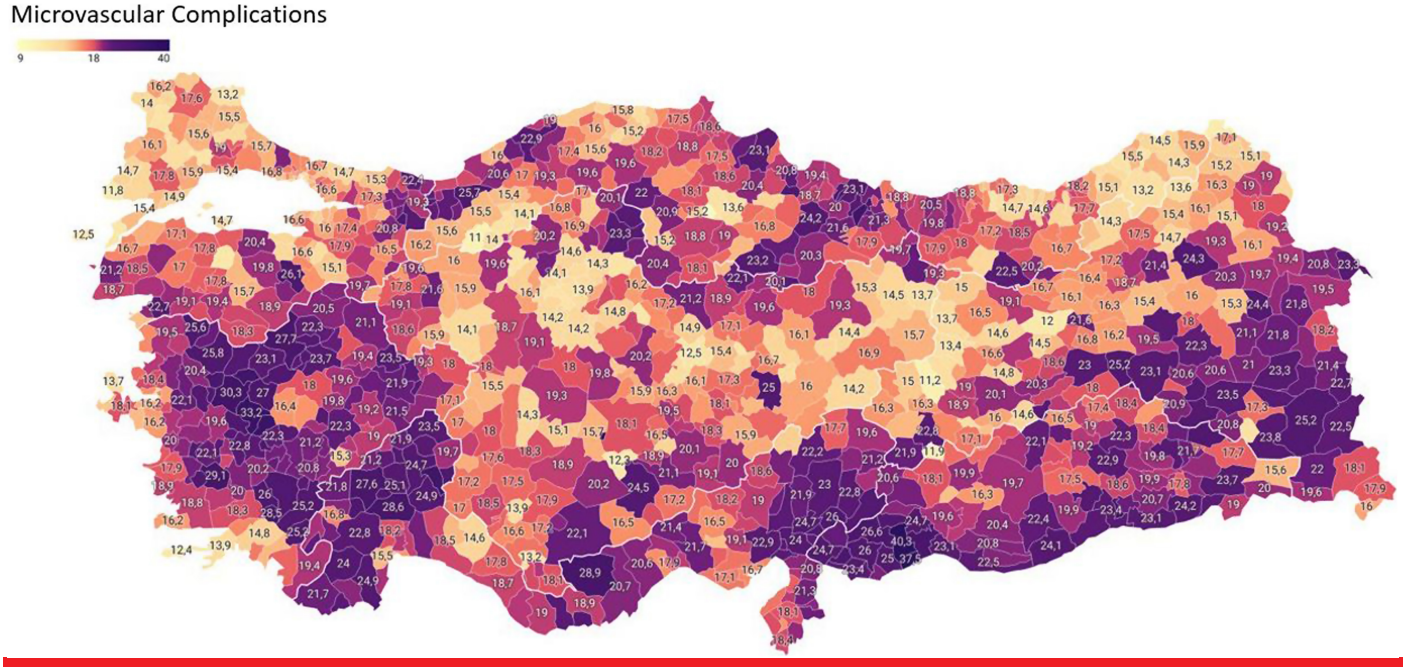

Figure 2. Prevalence of Microvascular Complications by District.

Table 3. Patients Developing Nephropathy by Gender and Province (Türkiye)

City	Male	Female	Total Patients
Adana	919	938	1857
Adıyaman	153	157	310
Afyonkarahisar	344	352	696
Ağrı	83	85	167
Amasya	176	179	355
Ankara	2025	2068	4093
Antalya	1290	1318	2608
Artvin	112	115	227
Aydın	758	774	1532
Balıkesir	576	589	1165
Bilecik	74	75	149
Bingöl	68	70	138
Bitlis	56	57	114
Bolu	172	175	347
Burdur	129	131	260
Bursa	1238	1265	2503
Çanakkale	258	264	523
Çankırı	123	125	248
Çorum	314	320	634
Denizli	443	453	896
Diyarbakır	261	266	527
Edirne	175	178	353
Elazığ	146	149	295
Erzincan	148	151	299
Erzurum	221	225	446
Eskişehir	404	412	816
Gaziantep	690	704	1394
Giresun	237	242	479
Gümüşhane	58	59	118
Hakkâri	29	29	58
Hatay	732	747	1479
Isparta	217	221	438
Mersin	720	736	1456
İstanbul	5778	5901	11679
İzmir	2199	2246	4444
Kars	53	54	107
Kastamonu	271	277	547
Kayseri	609	622	1231
Kırklareli	146	149	295
Kırşehir	151	154	306
Kocaeli	845	863	1708
Konya	754	770	1524
Kütahya	334	341	675
Malatya	258	264	523
Manisa	716	732	1448
Kahramanmaraş	298	305	603
Mardin	168	171	339
Muğla	557	569	1126
Muş	57	58	116
Nevşehir	192	196	388
Niğde	123	125	248
Ordu	481	492	973
Rize	258	264	523
Sakarya	562	574	1136
Samsun	592	604	1196
Siirt	52	53	105
Sinop	151	154	306
Sivas	296	303	599
Tekirdağ	378	386	764
Tokat	314	320	634
Trabzon	430	439	869
Tunceli	25	25	50
Şanlıurfa	206	211	417
Uşak	137	140	277
Van	187	191	378
Yozgat	204	209	413
Zonguldak	428	437	865
Aksaray	121	123	244
Bayburt	28	28	56
Karaman	91	93	184
Kırıkkale	132	135	266
Batman	73	74	147
Şırnak	62	64	126
Bartın	127	129	256
Ardahan	43	44	87
Iğdır	39	40	78
Yalova	158	162	320
Karabük	170	173	343
Kilis	55	56	112
Osmaniye	237	242	479
Düzce	173	176	349
Total	33 065	33 773	66 838

(22%), and outpatient (16%) treatments accounting for the highest cost. The share of drugs and medical supplies in total cost is 20%. The average annual cost per patient was $1010.84 (Table 6).

The average 1-year total cost of patients with neuropathy from microvascular complications is $659 862 971.96, with the highest cost item being inpatient treatments (36%). This was followed by drugs and medical supplies (29%) and outpatient treatments (23%). The average annual cost per patient was $701.82 (Table 7).

The total cost of retinopathy from microvascular complications is $356 594 282.51, with the highest cost in inpatient treatments (40%), followed by drugs and medical supplies (26%), and intervention (20%). The total annual average cost per patient was $1495.24 (Table 8).

Table 4. Patients with Retinopathy According to Gender and Province

City	Male	Female	Total Patients
Adana	4715	5231	9946
Adıyaman	636	894	1530
Afyonkarahisar	1820	2243	4063
Ağrı	235	344	579
Amasya	645	822	1467
Ankara	9160	10 655	19 815
Antalya	4548	3915	8462
Artvin	321	322	643
Aydın	3223	3120	6343
Balıkesir	3028	3384	6412
Bilecik	330	422	752
Bingöl	285	313	598
Bitlis	260	329	589
Bolu	627	661	1288
Burdur	989	1009	1998
Bursa	4643	5349	9991
Çanakkale	1232	1255	2487
Çankırı	631	723	1354
Çorum	1116	1461	2577
Denizli	3172	3267	6439
Diyarbakır	1034	1438	2472
Edirne	617	555	1172
Elazığ	937	1107	2044
Erzincan	442	476	919
Erzurum	552	604	1157
Eskişehir	1268	1605	2873
Gaziantep	3302	4013	7315
Giresun	1045	1209	2254
Gümüşhane	252	259	511
Hakkâri	110	140	250
Hatay	2703	2511	5214
Isparta	1531	1998	3529
Mersin	3680	3907	7587
İstanbul	26 377	29 290	55 667
İzmir	10 066	11 347	21 413
Kars	180	183	364
Kastamonu	1337	1288	2625
Kayseri	2070	2799	4869
Kırklareli	730	647	1376
Kırşehir	521	687	1208
Kocaeli	3195	3972	7167
Konya	3415	4278	7693
Kütahya	1384	1857	3241
Malatya	1280	1520	2800
Manisa	5193	6214	11 407
Kahramanmaraş	1708	2044	3753
Mardin	554	836	1390
Muğla	2628	2014	4642
Muş	283	365	648
Nevşehir	526	704	1230
Niğde	561	711	1272
Ordu	1458	1902	3360
Rize	566	507	1073
Sakarya	2291	2700	4991
Samsun	2636	3264	5900
Siirt	200	273	472
Sinop	751	782	1532
Sivas	1177	1612	2790
Tekirdağ	1428	1495	2923
Tokat	1737	2544	4281
Trabzon	1315	1443	2759
Tunceli	137	114	251
Şanlıurfa	1292	1611	2904
Uşak	832	922	1754
Van	647	713	1360
Yozgat	1112	1390	2502
Zonguldak	1149	1407	2556
Aksaray	619	805	1424
Bayburt	90	128	218
Karaman	438	545	983
Kırıkkale	512	758	1270
Batman	386	625	1011
Şırnak	259	381	640
Bartın	620	893	1513
Ardahan	93	83	175
Iğdır	148	205	354
Yalova	543	604	1148
Karabük	773	836	1609
Kilis	318	340	658
Osmaniye	1105	1259	2364
Düzce	1,078	1459	2537
Türkiye	146 810	167 896	314 706

Finally, the total annual cost of patients with nephropathy is $465 821 696.29, with the largest cost item being inpatient treatment at 50% and intervention at 41%. The annual cost per patient is $10 516.11 (Table 9).

DISCUSSION

Türkiye's population is aging and the burden of chronic diseases is increasing, forcing health-care organizations to seek innovations for the efficient and effective care of these patients. In order to make the most effective use of scarce resources allocated to health, PHRs offer important outputs. Thanks to the outputs obtained, it is possible to ensure proper treatment, prevention of complications, and control of the disease. Personal health records can be used for a variety of purposes but may have the greatest potential clinical value in chronic disease management,

Table 5. Patients with Neuropathy by Gender and Province

City	Male	Female	Total Patients
Adana	10 595	19 116	29 710
Adıyaman	2164	4181	6345
Afyonkarahisar	4529	10 115	14 645
Ağrı	1059	2287	3347
Amasya	1763	3087	4851
Ankara	17 977	36 654	54 634
Antalya	13 693	22 308	35 997
Artvin	682	1182	1864
Aydın	7961	13 973	21 933
Balıkesir	7699	13 330	21 028
Bilecik	1255	2359	3613
Bingöl	791	1213	2004
Bitlis	1045	1686	2731
Bolu	1520	2330	3849
Burdur	2458	4074	6532
Bursa	12 679	23 877	36 557
Çanakkale	3051	5867	8919
Çankırı	1563	2805	4368
Çorum	3022	5932	8954
Denizli	8961	15 251	24 211
Diyarbakır	3842	8231	12 074
Edirne	2230	3757	5986
Elazığ	2884	4741	7624
Erzincan	1027	1816	2843
Erzurum	2468	3998	6465
Eskişehir	5030	10 516	15 547
Gaziantep	12 313	25 164	37 479
Giresun	2703	5693	8398
Gümüşhane	603	1081	1684
Hakkâri	378	805	1183
Hatay	7984	12 952	20 934
Isparta	3764	6187	9950
Mersin	10 641	17 805	28 444
İstanbul	53 278	102 764	156 045
İzmir	23 670	41 133	64 800
Kars	720	1338	2058
Kastamonu	2690	4356	7046
Kayseri	5346	10 223	15 569
Kırklareli	2007	3546	5553
Kırşehir	1445	2646	4091
Kocaeli	8204	17 223	25 429
Konya	10 546	21 010	31 557
Kütahya	4304	8624	12 928
Malatya	2833	5421	8255
Manisa	11 449	20 834	32 282
Kahramanmaraş	5071	10 630	15 703
Mardin	2239	5263	7503
Muğla	5406	8473	13 878
Muş	923	1658	2581
Nevşehir	1460	2791	4251
Niğde	1702	3817	5520
Ordu	5063	10 213	15 277
Rize	1587	2783	4370
Sakarya	5568	10 386	15 954
Samsun	8204	15 697	23 901
Siirt	842	1646	2489
Sinop	1727	2944	4671
Sivas	3060	6685	9747
Tekirdağ	5077	8829	13 906
Tokat	3444	7703	11 148
Trabzon	3138	5505	8642
Tunceli	346	402	747
Şanlıurfa	5576	10 393	15 969
Uşak	2647	4304	6950
Van	2898	5224	8122
Yozgat	2021	4091	6113
Zonguldak	3986	7333	11 319
Aksaray	1825	3853	5679
Bayburt	315	492	808
Karaman	1470	2908	4378
Kırıkkale	1601	2930	4531
Batman	1420	2767	4187
Şırnak	888	1982	2870
Bartın	1733	3066	4799
Ardahan	213	351	563
Iğdır	605	1086	1691
Yalova	1214	2388	3602
Karabük	1675	2951	4625
Kilis	804	1557	2361
Osmaniye	3399	6515	9913
Düzce	1876	3884	5761
Türkiye	377 852	706 991	1 084 843

which requires continuity of care and long-term follow-up. In Europe, Estonia is among the leading countries with e-prescription and digital health infrastructure. National electronic patient records are kept in a system called the

Table 6. Cost of Microvascular Complications

	Cost ($)	Share of Total Cost	Cost Per Patient ($)
Oral antidiabetics	89 502 850.91	6%	61.04
Insulin	190 196 620.44	13%	129.70
Needle tip and strip	16 630 952.86	1%	11.34
Outpatient	230 984 525.82	16%	157.52
Inpatient	612 980 749.01	41%	418.02
Intervention	341 983 251.71	23%	233.21
Total	1 482 278 950.76	100%	1010.84

Table 7. Cost of Neuropathy Complication

	Cost ($)	Share of Total Cost	Cost Per Patient ($)
Oral antidiabetics	67 291 122.98	10%	62.35
Insulin	109 393 522.77	17%	101.36
Needle tip and strip	10 613 244	2%	9.83
Outpatient	154 895 646.33	23%	143.52
Inpatient	237 418 502.64	36%	252.51
Intervention	80 250 933.24	12%	85.35
Total	659 862 971.96	100%	701.82

Table 8. Retinopathy Complication Cost ($)

	Cost ($)	Share of Total Cost	Cost Per Patient ($)
Oral antidiabetics	20 535 767.64	6%	78.36
Insulin	68 637 546.83	19%	261.91
Needle tip and strip	5 084 155.69	1%	19.40
Outpatient	50 907 939.84	14%	194.26
Inpatient	141 542 315.79	40%	593.50
Intervention	69 886 556.73	20%	293.04
Total	356 594 282.51	100%	1495.24

Table 9. Cost of Nephropathy Complications ($)

	Cost ($)	Share of Total Cost	Cost Per Patient ($)
Oral antidiabetics	1 675 960.29	0,4%	27.32
Insulin	12 165 550.85	3%	198.29
Needle tip and strip	933 553.18	0,2%	15.22
Outpatient	25 180 939.66	5%	410.44
Inpatient	234 019 930.58	50%	5283.09
Intervention	191 845 761.73	41%	4331.00
Total	465 821 696.29	100%	10516.11

Estonian National Health Information System (ENHIS), which includes all disease histories of the entire population of the country and where health data is recorded. The system has facilitated the early diagnosis of diseases, and thus treatment processes have been both correctly managed and shortened.[11] Another example of a country whose citizens trust its health infrastructure is Denmark. On the portal developed, citizens' health histories are stored with an identification number. Israel started a similar health digitalization project in 1995.[12] In Israel, e-prescription, telemedicine, and online access to health data have been implemented within the scope of health services organizations. Another important example is Spain. There are digital health projects in different regions of the country with their own budgets.[11] The costs associated with diabetes and related conditions are rising even higher. Diabetes can be successfully managed, and associated complications can be prevented, especially if it is diagnosed and treated early.[13] Significant advances and global initiatives in chronic disease management have focused on leveraging digital health solutions such as mobile apps, wearables, remote monitoring systems, EHRs and disease management platforms. Electronic health record digitally store patients' medical histories, lab results, allergy information, drug prescriptions, and treatment plans, allowing health-care providers and patients to easily access and share them. These systems enable better and faster decisions in chronic disease management, help patients adjust treatment plans based on their current condition, and improve continuity of care.

In this study, the total cost of patients with microvascular complications was $1 482 278 950.76, and the average annual cost per patient was $1010.84. The highest complication cost belongs to patients who developed nephropathy, and the average annual cost is $10 516.11. Then retinopathy had an average annual cost per patient of $1495.24, and neuropathy had an average annual cost per patient of $701.82. Of the total costs for patients with microvascular complications, inpatient treatment at 41% and intervention at 23% accounted for the highest cost. The total annual cost of neuropathy was $659 862 971.96, and the cost of retinopathy was $356 594 282.51. On a provincial basis, the provinces with the highest complications have a large population whose HbA1c value cannot be controlled according to population weight.

The United Kingdom Prospective Diabetes Study (UKPDS) and other studies have clearly demonstrated that glycemic control is important in DM.[14,15] For every 1% decrease in HbA1c levels in T2DM, DM-related mortality can be reduced by 25% and all-cause mortality by 7%. A 1% reduction in HbA1c also leads to an 18% reduction in the prevalence of myocardial infarction (AMI), a 16% reduction in the development of heart failure (congestive heart failure), a 43% reduction in lower limb amputations, a 12% reduction in the development of stroke, and a 35% risk reduction in microvascular complications. There is also a 34% risk reduction in the development of microalbuminuria with tight blood glucose control. The results of the UKPDS and some other epidemiologic studies have shown that an HbA1c level of 7% and a systolic blood pressure below 130 mmHg reduce the risk of chronic complications.[14,15] For type 1 DM, a 1% decrease in HbA1c reduces the risk of retinopathy by 35%, neuropathy by 30%, and nephropathy by 24%-44%.[16]

In general, if there is no special condition that increases the risk of hypoglycemia in T2DM and life expectancy is long enough, it should be preferred to set the HbA1c target at ≤7.0% (53 mmol/mol) to reduce microvascular complications. In order to manage the complications that arise according to the study results and to protect patients who have not yet developed complications, the course of the disease should be well followed, the health literacy of patients should be increased, and awareness should be raised. The distribution of patients with microvascular complications on a provincial basis is known from this study, so preventive and preventive medicine services should be mobilized in accordance with the regional conditions. Follow-up of DM patients should primarily be performed by the family medicine system, and

patient education should be ensured. In order to eliminate risk factors, both primary care and secondary care should take an active role, and measures to reduce risk factors (such as smoking cessation) should be developed.

Study Limitations

The number of patients with microvascular complications is expected to be much higher, according to previously published national data. The frequency of nephropathy is given as 5% of the microvascular complications in this study. This is a much lower rate when compared to the previous national reports published so far. The frequency of diabetic kidney disease is given as between 20% and 30% of the patient population with diabetes.[17] Using the ICD codes alone would inevitably miss patients without ICD codes but with albuminuria or low glomerular filtration rate. Because many of the clinicians do not use these codes in their daily practice. That is why analyses were made based on data from the relevant ICD codes, as far as the available data allowed. We think that using ICD codes alone would inevitably miss many subjects who were not registered with codes.

CONCLUSION

In conclusion, these and similar cost-of-illness studies reveal the economic burden that society has to bear when any member of society suffers from a disease. This will provide important evidence on how much of the scarce resources allocated to health care are spent on which diseases, how to prevent these diseases, and how to ensure efficiency through proper resource allocation. It is essential to ensure the continuity of studies. Diabetes mellitus causes significant disease burden and economic burden. For the management of the disease, patients can be followed up thanks to the e-Pulse system in Türkiye. By using this important resource, disease management can be achieved with correct and appropriate interventions, and complications can be prevented.

Ethics Committee Approval: Anonymous data usage decision approval was provided by the Ministry of Health at the date of January 5, 2023. Approval number: E-95741342-708.01-206385672.

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ERRATUM

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In the article by Birinci and Simten-Malhan, entitled "Distribution and Economic Burden of Diabetes-Related Microvascular Complications in Türkiye" that was published in the October issue of the Anatolian Journal of Cardiology (Anatol J Cardiol. 2023; 27(10): 597-607 - 10.14744/AnatolJCardiol.2023.3762), a material error occurred within the text and tables (Table 7, 8 and 9) of the article, unintentionally. Specifically, the costs of insulin and needle tips were mistakenly switched, with the insulin cost being listed under the needle tip column, and vice versa. We apologize to our readers for this mistake and any confusion it may have caused.

You may access the updated version of the article via the link below.

https://jag.journalagent.com/anatoljcardiol/pdfs/AJC-95875-ORIGINAL_INVESTIGATION-BIRINCI.pdf