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Direct Costs of Diabetes Care in Pediatric Patients with Type 1 Diabetes in Greece

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Abstract

Background: Type 1 diabetes (T1D) is a chronic disease with increasing incidence and major impact on the health care costs. **Aim:** To estimate the direct cost of pediatric T1D in the Greek National Health System (NHS) and its distribution by service category. **Methods:** This is a retrospective cost-of-illness study, focusing on the direct costs from the healthcare system's point of view. All patients aged 0 - 16 years, diagnosed with T1D, who were followed in the Diabetes Outpatients' Clinic of the University Pediatric Department of one of the two main Pediatric Hospitals in Athens, for a two-year period (1st January 2011 to 31st December 2012) were included. **Results:** Total diabetes-related direct costs per person-year were estimated at €2,712 (95% CI 2468 - 2956). Diabetes healthcare provider and education visits including laboratory tests, accounted for only 7.6% of total costs. Cost for hospitalizations was only 1.7%. Medication costs were 17% of total costs and were the highest for multi-injection therapy. Supply costs accounted for 73.7% of the total costs and were the highest for insulin pump therapy (p = 0.000). 12.4% of patients were admitted yearly for diabetes related cause and the mean length of hospitalization was 0.18 days per person-year (95%CI: 0.05 - 0.3). **Conclusion:** This is a preliminary study based on a single institution's data, which however constitutes a major referral center, thus dealing with a balanced sample of the Greek pediatric diabetic population. Considering that standards of diabetes care are common throughout the NHS, the management of patients in our hospital represents the common practice for pediatric diabetes in Greece. Data are suggesting that cost for hospitalization and outpatients' care for T1D patients followed in the public sector was rather low compared to other countries, the medication cost was at similar or lower levels and the cost of supplies was generally higher.

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Keywords

Type 1 Diabetes Mellitus, Economics, Cost

1. Introduction

Type 1 diabetes (T1D) is a chronic disease with increasing incidence and severe long-term complications. Its impact on the rising health care costs is often overlooked, since most of the studies focus on type 2 diabetes (T2D), which is a more common type of the disease. In several cost studies, the two types of the disease are combined. However, although T1D patients represent only 5% - 10% of the diabetic population, the cost attributed to T1D is disproportionately high [1].

There is a paucity of published data on the economics of T1D in the literature. In Germany, Icks *et al.* [2] estimated that mean total direct cost per patient-year was €2611 in 2004. This number was increased to €3524 in a recent study evaluating the cost of T1D in the same country in 2007, an average increase of 20% per patient while the total annual cost of pediatric diabetes was increased by 47% [3]. The annual cost for T1D in a recent study from Texas, USA, in 2011 was estimated at $4730 [4] and was shown to be inversely correlated to the degree of metabolic control. Further, the Diabetes Control and Complication Trial estimated that the annual cost of T1D is strongly associated with the regimen of therapy, being threefold higher in intensive therapy ($4000 in multi injection and $5800 in pump therapy) compared to conventional therapy ($1700 for injections twice a day) [5].

To the best of our knowledge, apart from the studies from Germany [2] [3], France [6], UK [7] [8] and Texas [4], there are no data from southern European countries, and especially those affected by the economic crisis, such as Greece, relating to the cost of T1D in the pediatric population and its distribution by category of health service.

To examine the true economic impact of the disease, both medical and non medical costs need to be estimated. The aim of this study was to estimate the direct cost of pediatric T1D in the Greek National Health System and its distribution by service category.

2. Patients and Methods

Our cohort included all patients with T1D, who were followed in the University Department of "P. & A. Kyriakou" Children's Hospital, one of the two main pediatric hospitals in Athens, from 1st January 2011 to 31st December 2012. It is a retrospective cost-of-illness study focusing on the direct costs from the healthcare system point of view.

The first 6-months' interval after diagnosis of T1D is a high cost period since it entails the initial hospitalization (usually 7 - 10 days) and frequent outpatient appointments for glycaemic stabilization and educational purposes. Since this study focused on the long-term maintenance of diabetes costs, the cost of the first 6 months following diagnosis was excluded from the analysis. Consequently, patients with a duration of diabetes of less than 6 months were excluded from the study. The final analysis involved 89 patients.

Data concerning gender, ethnicity and duration of diabetes were collected. Also the average total daily dose of insulin was estimated. Insulin regimen was also recorded as conventional (two injections a day), intensive multi-injection (≥4 injections a day) and intensive pump therapy. Metabolic control was estimated as the mean of all HbA1c measurements obtained for each patient over the 2-year study period.

All laboratory examinations for each patient during the study period were recorded and their cost was estimated based on the National Health System prices. These tests included a yearly check-up of biochemistry, of associated autoimmunity and estimation of microalbumin levels in a 24 h urine collection.

All visits at the diabetic outpatient clinic over the study period were recorded. Since a diabetic clinic was carried out twice a week, the cost of each visit was estimated as the 20% of the monthly physician's salary divided by the average number of patients seen in a month plus the cost of the specialist nurse estimated in the same way. Visits to dietitians, ophalmologists, nehprologists or any other subspecialities necessary for the assessment of diabetes-related conditions were estimated at the base of the cost of an outpatient visit in the Hospital.

All diabetes-related admissions during the 2-year period were counted, the number of hospital days was recorded and the cost was estimated based on the National System Diagnosis Related Groups (DRGs).

The cost of medication was estimated from the total daily insulin dose based on the commercial prices of the used types of insulin. Additionally the cost of glucagon used for the control of hypoglycaemic episodes was added to the calculations.

Finally, the cost of supplies was estimated based on the monthly cost of strips, lancets, syringes to which each patient is entitled. For the patients who were diagnosed during the study period the price of the glucose measuring device was added. For the patients using a pump the monthly cost of pump supplies (infusion sets etc.) was estimated and the cost of the pump hardware was also calculated for those who started the pump during the 2-year study period.

All costs were estimated for each patient for the months studied during the 2-yr study period and then annualized.

3. Statistical Methods

Data were expressed as mean ± sd. Non-parametric tests (Mann-Whitney test and Kruskall-Wallis test respectively) were used for data not normally distributed. Costs were expressed as total costs per patient-year and stratified for the different test categories. Mean costs and 95% CIs were determined for all cost categories. Analysis was performed using SPSS, version 17.0.

4. Results

The demographic and clinical characteristics of the children of our cohort are shown in **Table 1**. The study included 45 boys and 44 girls with a mean ± SD age of 12.05 ± 5.15 years, of whom 76% were Greeks. The mean ± SD duration of disease was 4.9 ± 3.88 years and then mean time of data record was 21.3 months. The mean HbA1c of the patients was 8.2 ± 1.5% (66nmol/mol). The mean daily insulin dose was 0.85 U/kg. The majority of patients (80%) were on intensive multi-injection regimen, 10% on conventional regimen and 10% on an insulin pump. The comparison of the population characteristics and costs according to therapeutic regimen are shown in **Table 2**. The mean age of the patients was significantly different among the three groups (p = 0.001) with the group on conventional regimen being the youngest one (5.36 vs 12.71 years, p = 0.001) with the shortest diabetes duration (2.66 vs 5.05 years, p = 0.040). The mean daily insulin dose was significantly different among the three groups (p = 0.001), with the pump group having the lowest mean daily insulin dose (p = 0.001). The HbA1c levels were marginally significantly different among the three regimen groups (p = 0.059), with the pump group having the best control (HbA1c: 7.23%) and the conventional treatment group having the poorest control (HbA1c: 8.5%, p = 0.020).

4.1. Cost of Admissions

11 patients (12.4%) were hospitalized for at least one time during the 2-yr period. The duration of hospitalization varied between one and five days, with a mean length of hospitalization 0.18 days per person-year (95% CI: 0.05 - 0.3). The causes were all diabetes related (severe hypoglycaemia, diabetic ketoacidosis, metabolic dysregulation during febrile illness). Mean number of hospitalization per person-year was 0.067 (95% CI: 0.03 - 0.1). None of the patients of our cohort during the study period needed an emergency room admission.

The mean cost for hospitalizations per person-year was €47 (95% CI: 12 - 82), with no significant difference among the three regimen groups.

Table 1. Clinical and demographic characteristics (n = 89).

Age (yrs) (mean ± sd)	12.05 ± 5.15
Sex (M/F)	45/44
Ethnicity (G/I)	75/14
Duration of disease(yrs) (mean ± sd)	4.94 ± 3.88
Duration of data record (months) (mean ± sd)	21.29(5.7)
Insulin dose (IU/kgr) ((mean ± sd))	0.85(0.2)
Mean HbA1c% <7.5% 7.5 - 8.5 >8.5	8.2(1.5) 28(31.5%) 32 (36%) 28 (32.5%)
Insulin regimen Conventional Multi-injection Pump therapy	 9 (10%) 71(80%) 9 (10%)

Table 2. Comparison of population characteristics and costs according to therapeutic regimen.

Population characteristics	Conventional mean, 95% CI N = 9 (a)	Multi-injection mean, 95% CI N = 71 (b)	Pump mean, 95% CI N = 9 (c)	p Kruskall-Wallis
Age (yrs)	5.36 ± 2.99 (a) vs (b) p = 0.001	12.71 ± 5.04 (b) vs (c) p = 0.641	13.51 ± 2.15 (a) vs (c) p = 0.001	0.001
Diabetes duration (yrs)	2.66 ± 1.85 (a) vs (b) p = 0.067	5.05 ± 3.78 (b) vs (c) p = 0.233	6.72 ± 5.14 (a) vs (c) p = 0.040	0.074
HbA1c (%)	8.5 ± 0.98 (a) vs (b) p = 0.553	8.21 ± 1.32 (b) vs (c) p = 0.036	7.23 ± 1.01 (a) vs (c) p = 0.020	0.059
Total dose (Iu/kg/day)	0.90 ± 0.22 (a) vs (b) p = 0.353	0.90 ± 0.22 (b) vs (c) p = 0.017	0.72 ± 0.07 (a) vs (c) p = 0.001	0.001
Cost by service category (euro/pppy)				
Outpatient visits	66 (21 - 111) (a) vs (b) p = 0.807	65 (55.5 - 74) (b) vs (c) p = 0.320	74 (42 - 106) (a) vs (c) p = 0.492	0.69
Laboratory tests	151 (45 - 257) (a) vs (b) p = 0.691	137 (116 - 158) (b) vs (c) p = 0.564	156.5 (57 - 256) (a) vs (c) p = 0.928	0.97
Hospitalizations	67 (38 - 173) (a) vs (b) p = 0.793	45 (3 - 87) (b) vs (c) p = 0.371	41 (53 - 134) (a) vs (c) p = 0.332	0.65
Medications	125 (71 - 179) (a) vs (b) p = 0.001	500 (441 - 560) (b) vs (c) p = 0.635	450 (337 - 581) (a) vs (c) p = 0.001	0.000
Supplies	1570 (1341 - 1798) (a) vs (b) p = 0.360	1699.5 (1603 - 1796) (b) vs (c) p = 0.001	4808 (3707 - 5909) (a) vs (c) p = 0.001	0.000
Total cost	1978.5 (1682 - 2275) (a) vs (b) p = 0.014	2447 (2320 - 2574) (b) vs (c) p = 0.001	5538 (4480 - 6597) (a) vs (c) p = 0.001	0.000

4.2. Cost of Laboratory Tests

The mean cost for laboratory tests per person-year was €141 (95% CI 120 - 161), with no significant difference among the three regimen groups.

4.3. Cost of Outpatient Visits

All patients had at least one outpatient visit in diabetic clinic during the 2-yr period. The mean number of outpatient visits per year was 2.88 (95% CI: 2.5 - 3.2). The mean cost of outpatient visits in diabetic clinic per person-year was €65 (95% CI: 55 - 78), with no significant difference among the three regimen groups. During the study period 30 patients (33.7%) needed once an ophthalmologist evaluation. The total mean cost of outpatients visits per person-year was €66 (95% CI: 57 - 75).

4.4. Cost of Medications

Nine only (10%) of the patients were on conventional (2 injections/day) regimen, nine (10%) on pump and 71 (80%) were on multi-injection scheme. The mean cost for medication per person-year was €458 (95% CI 390 - 497). The cost of medications differed significantly (p = 0.000) among the three groups, being much lower for the patients on conventional regimen, compared with patients on pump (€125 vs €450, p = 0.001) and those on multi-injection regimen (€500, p = 0.001) (**Table 2**).

4.5. Cost of Supplies

During the 2-year period, there were 18 newly diagnosed children who needed a glucose-measuring device (mean cost €35 per device). Six children started using the pump and needed the device (mean cost of €2770). Another 4 children in this study group were already on pump, thus the monthly cost of pump supplies was calculated for these 10 children (average €350/month). The mean total cost for the rest of supplies (needles, strips, lancets) was estimated at €145.85/month, according to the monthly allowed cost for each patient from the Greek National Health System.

The total mean cost of supplies per person-year was €2000.71 (SD: 1107, 95% CI 1767.5 - 2234). The cost

differed significantly among the three regimen groups (Kruskall Wallis test = 27.05, p = 0.000), being the highest for the patients on pump therapy (€4808). This cost was significantly higher than that of patients on multi-injection (€1699.5, p = 0.001) and those on conventional scheme (€1570, p = 0.001) (**Table 2**).

4.6. Total Costs

Total diabetes-related direct costs per person-year were estimated at €2712 (95% CI 2468-2956, **Table 3**). Diabetes healthcare provider and education visits accounted for only 2.4% of total costs. Even when the cost of laboratory tests performed during these visits was combined, ambulatory care accounted for 7.6% of total costs. Cost for hospitalizations was only 1.7%. Medication costs were 17% of total costs and were the highest for multi-injection therapy. Supply costs accounted for 73.7% of the total costs and were the highest for insulin pump therapy (**Table 3**). Consequently patients on pump therapy had significantly higher cost €5538 compared to patients on multi-injection €2447 (p = 0.001) and conventional regimen €1978.5 (p = 0.001) (**Table 2**).

5. Discussion

This is a preliminary study examining direct costs of illness in pediatric patients with type 1 diabetes in Greece from the healthcare system point of view.

The mean annual cost was found to be €2712 per person for the study period (2011-2012).

The amount of €2712 was close to the cost reported in studies from USA ($4730, 95CI: 4516 - 4944) (*i.e.* €3730) in 2011 [4]. It is also close to the cost reported in Great Britain, estimated at 1399 pounds (€2059) for primary care treatment and at 3233pounds (€4744) for total cost, by a simple combination of inpatient [7] and outpatient [8] costs by type [9]. Similarly, in 2007, *The Economist* estimated total per patient costs to be $4,794 in UK, as part of an international study [10] (**Table 4**).

In France, French ENTRED 2007 data estimate the total cost for T1D at €6927 per patient. Annual outpatient costs per patient with T1D were estimated at €4329 and annual inpatient costs per patient at €2597 [6].

Finally in Germany, mean direct diabetes-associated costs per patient were 3524 euro, with the total costs of pediatric diabetes care exceeding €110 million in 2007 [3].

In Italy, cost data are provided from 2 studies published in 2010 [11] and 2011 [12] and referring to 2008 and 2010 respectively. According to them, total direct diabetes-associated costs are reported to reach €7.94 billion in 2010, with T1D being twice as costly as T2D patients [11].

The most recent study of Spanish national diabetes direct costs calculates per patient costs at €1708 annually for Type 1 & 2; 2002 costs were extrapolated to 2010 [13]. Data did not differentiate between type 1 and 2.

Table 3. Cost by service category.

Service category	Mean (euro/pppy) (95% CI)	% annual cost
Outpatient visits	69 (27 - 35.0)	2.4%
Hospitalizations	47 (9 - 80)	1.7%
Laboratory tests	141 (120 - 161)	5.2%
Supplies	2001 (2092 - 2592)	73.7%
Medications	458 (390 - 497)	17%
Total cost	2712 (2740 - 3262.5)	100%

Table 4. Annual cost per person with diabetes type 1 in different countries.

	Outpatient visits	Hospitalization	Supplies	Medication	Total annual cost (pppy)
Greece 2012	2.4% + 5.2 = 7.6%	1.7 %	73.7%	17%	€2712 (outpatient)
USA 2005 (4)	10%	19%	38%	33%	$4730 (outpatient)
Germany 2004 (2)		26%	44%	21%	€2611 (out- and inpatient)
Germany 2007 (3)		32%	47%	15%	€3524 out-and inpatient)
France (6)					€4329 outpatient €2597 inpatient
UK (7, 8)			31.3%	17.7%	€2059 (1399 pounds) outpatient €4744 (3.233 pounds) Out- and inpatient)

In our study, the majority of costs 73.7% concerned supplies and it was significantly higher for patients using the pump (€5538 per person-year) compared with patients on multi-injection regimen (€2477 per person-year) and patients on conventional scheme (€1978 per person-year). The association of supply costs with the regimen is reasonable and is also reported in all countries [2] [4].

The distribution of costs by category of service could not be compared to other European countries due to structural differences in healthcare systems and data collection methodologies. When comparing our data to those from the USA study in which the direct cost of T1D care was estimated in a similar way, it was observed that the costs by category of service were distributed in a different way. The cost of supplies in our study represented 73.7% of the total cost compared to 38% in USA. It is possible that this cost is overestimated to a certain degree as it was based on the cost of the supply allowances for each patient and not the actually used ones. Thus, if patients measured their blood sugar less frequently and thus used less supplies than the amount that they were entitled to, this could not be captured. The medication cost represented 17% of total cost, compared to 33% in USA [4]. The relatively lower medication cost could be attributed to the lower prices of the insulins. This cost was estimated on the daily insulin dose for each patient, thus representing the true cost and matched well with the cost of medication in other European countries [7]. The cost of outpatients' visits at 7.6% (including the necessary laboratory tests performed during the visits) was rather low, due to relatively low number of outpatient visits per person per year pppy (2.88 visits pppy) and relatively low healthcare provider compensations. Finally the hospitalization cost for diabetes related causes in our study was very low (1.7% of the total cost) due to both low admission rate and low cost of day of hospitalization. The admission rate for diabetes-related causes in our study was 0.067 admission pppy and was lower to that reported in Germany (0.45 ppyy) [14] and USA (0.1 ppyy) [4]. Also the mean number of hospital days was low 0.18 days ppyy compared to that reported in other studies in Europe [9] and USA [4], although data are not entirely comparable. The low admission rate for diabetes related causes, resulting in low hospitalization cost can be attributed to the continuous 24 h support of the families by the diabetic team for the management of different problems of glycaemic control.

To the best of our knowledge this is the first study examining direct costs of T1D in Greece. However, there are several limitations. First, as this study aimed to focus on the long-term maintenance cost of T1D, the analysis did not include costs of the first post diagnosis 6-months period, which contribute disproportionally high to the total cost. Also this analysis included pediatric patients of a mean age of 12.05 years with a mean duration of disease of 4.94 years, in whom impaired indices of early microvascular complications can be observed, but development clinical symptoms and signs of complications (which constitute a major component of the cost in adult patients) is extremely rare and was not observed in any of the patients of our cohort.

Also, the analysis was restricted only to direct costs and these were evaluated for patients followed-up on an outpatient basis in the public sector. Previous studies suggest that inpatient costs account for around 50% of total healthcare costs for people with diabetes [2]. Although the study is based on a single institution's data, it is important to emphasize that this is a major referral center from central and southern Greece and the Aegean islands, thus dealing with a balanced sample of the Greek pediatric diabetic population. Similarly, as the standards of diabetes care are common throughout the NHS, the management of T1D patients in our hospital represents the common practice for the disease in Greece.

6. Conclusion

To conclude, very few studies have assessed the total cost of T1D, especially in countries affected by the economic crisis and there is a need for up-to-date estimates. This is a preliminary study, reporting that the annual cost of diabetes care in Greece is lower than in other countries, with the cost of supplies representing the majority of annual direct costs and the pump therapy being the most expensive therapeutic regimen, while the hospitalization cost was very low. It is necessary that the study is expanded to greater numbers of pediatric patients with T1D in order to assess the relationship of the diabetes care cost with different demographic and clinical parameters and target the effort towards achieving the best clinical outcomes with the less possible cost.

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