Costs and Its Drivers for Diabetes Mellitus Type 2 Patients in France and Germany: A Systematic Review of Economic Studies

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Abstract

Background

Type 2 diabetes represents an increasingly critical challenge for health policy worldwide. It absorbs massive resources for both patients and national economies to sustain direct and associated costs of treatment and indirect costs related to loss of work and wages. Last years are fuelling of innovations grounded on the remote control and personalised programs which are significantly improving the management of diabetes and the reduction of its related complications. In this view, this work attempts to update cost analysis reviews on type 2 diabetes, focusing on France and Germany, in order to explore most significant cost drivers and rooms for cost savings by technology advancement. Although characterized by different approaches in delivering care, France and Germany represent the primary European markets for diabetes technologies.

Methods

A systematic review of the literature was carried out in MEDLINE, Embase and EconLit for interventional, observational, and modelling studies on expenditures for type 2 diabetes management in France or Germany published since 2012. Included articles were analysed for annual direct, associated, and indirect costs of type 2 diabetes patients. An appraisal of study quality was performed. Results are summarised narratively.

Results

From 1,260 records, the final sample was composed of 24 papers selected according to predefined inclusion/exclusion criteria. Both France and Germany revealed a predominant focus on direct cost. Comparability was limited due to different study populations and cost categories used. Nevertheless, France seems to reimburse higher direct costs than Germany. Indirect costs were only available for Germany. According to prior literature, reported cost drivers are hospitalisation and prescriptions as well as higher HbA1c and BMI, treatment with insulin and complications all indicating the severity of the disease. Diversity in available data and in included costs limit the results and may explain differences found.

Conclusions

Preventing complications and glycaemic control are widely recognized as the most effective ways to govern the expenditure for the treatment of diabetes. The implementation of self-based supports, such as hybrid closed-loop metabolic, already implemented for type 1 diabetes management, are the key pillars for further debates and policymaking, involving the perspectives of both caregivers and patients.
Background

The increasing burden of non-communicable chronic diseases represents a critical challenge for healthcare systems. Diabetes is one of the leading public health challenges (1). The prevalence, and therefore, diabetes costs are increasing rapidly (2). In 2014 the global prevalence of diabetes among adults was estimated at 8.5% (3), and it is still growing (4), with a majority of type 2 diabetes mellitus patients. Due to its impact on everyday activities, diabetes is considered a “prospective disability” (5, 6). It represented the direct cause of more than 1.6 million deaths in 2015, and it is expected to become the seventh leading cause by 2030 (7).

Although various therapeutics have demonstrated to be successful at controlling type 2 diabetes, it still represents a mechanistic hub for the evolution of chronic disease cluster and multimorbidity, predisposing to frailty and physical and mental decline. Diabetes and its multidimensional implications involve a large disbursement of resources for both patients and national economies due to direct and associated costs of treatment, and indirect costs related to loss of work and wages (8). The steadily increasing of individuals affected by type 2 diabetes engenders a larger prevalence of related morbidities and a higher risk of mortality, meaning the primary concern for healthcare policy-makers (9).

Studies aimed at understanding the costs of type 2 diabetes represent valid support to quantify the impact of the disease on society and to support health policy towards most cost-efficient therapies (10). Direct and indirect costs of type 2 diabetes have to be considered in order to estimate the societal impact of the disease (11). Associated costs, mainly composed by the cost of complications, are considered as the primary driver of healthcare expenditure for type 2 diabetes by many scholars (12, 13). Losses in Gross Domestic Product (GDP) worldwide from 2011 to 2030, including both the direct and indirect costs of diabetes, will be 89 billion euros in Europe (8, 10, 14) indicating that the indirect and associated costs are often higher than the direct ones. Therefore, the involvement of all cost categories is critical for performing a worthwhile analysis (15).

Over time, several international studies dealt with the estimation of costs for treating diabetes (16–23), pointing out several issues. Whereas in low- and middle-income countries, inadequate access to insulin (24, 25) and oral drugs for controlling glucose and blood pressure represent the main bottleneck in type 2 diabetes treatment; in high-income countries, main problems concern with lifestyle and are related to nutrition, exercise habits and obesogenic living environments (26). Evidence demonstrated that type 2 diabetes is potentially reversible (27, 28) and that early diagnosis and higher participation of patients in disease management could reverse current trends (29). Accordingly, health policy must deal with the implementation of diabetes management regimens more tailored to the individual patient’s treatment-effect-modifiers (30) and aimed even to increase their awareness and satisfaction (31). Traditional therapies revealed to entail increased costs in the long-term due to the need for treatment intensification after around eight years and the increased requirement for medication and outpatient visits caused by non-fatal events (9). Hence, to reduce complications and improve treatment outcomes, there is a demand for a more integrated personalized diabetes management (32).
New drugs combined with digital diabetes technologies which acquire and exploit patient-generated data for individual therapy decisions could critically contribute to the personalization of diabetes management. Recently, an unusually high potential for personalizing type 2 diabetes management has been attributed to the usage of continuous monitoring glucose tools and automated insulin delivery (i.e. artificial pancreas) systems (33). These innovative solutions are widely considered fundamental for effectively reducing the risk of hypo- and hyperglycaemic events and the risk of follow-up complications (34). Furthermore, continuous monitoring contributes to minimizing medical errors (35).

However, a successful introduction of such innovations requires careful management of stakeholder expectations and innovation barriers. Several studies demonstrated that clinical benefits are only achieved when there is a high level of adherence over time by patients (36). Nonadherence and early discontinuation also lead to significant resource wastes (37).

This article is part of an EU-funded project which intends to implement automated insulin delivery systems employing an artificial pancreas for persons with type 2 diabetes in France and Germany (33). Carrying out a systematic literature review, it attempts to identify the most relevant cost drivers in type 2 diabetes management in France and Germany, which represent the largest markets for diabetes technologies in Europe and the best contexts for testing new solutions. Although formally both are Bismarckian systems, the two countries are characterized by different approaches to healthcare provision, which also allow addressing the different needs owing to healthcare system characteristics. While the German health system is based on a “pay for service” reimbursement system, the French one is closer to the Beveridgian system, where services are reimbursed through the Diagnosis Related Group method.

Besides updating cost analysis for type 2 diabetes and underlying most significant cost drivers, the aim of this is to pave the theoretical basis for defining a value proposition of innovative solutions such as artificial pancreas systems in the treatment of persons with type 2 diabetes. Benefits for payers and patients, indeed, can be underlined only once that all costs are recognized.

**Methodology**

**Systematic search**

A systematic review of the literature was carried out to identify German and French type 2 diabetes costs.

We searched for studies meeting the following predefined inclusion/exclusion criteria:

- **Language:** to allow replication of the process and avoiding missing relevant studies in the specific contexts, studies published in English, French or German were included.
- **Time frame:** because of the last cost analysis of type 2 diabetes was published in 2012; our analysis refers to papers published after 01/01/2012.
- Topic: consistently to the above-explained aims, the selection of articles focused on report direct or indirect type 2 diabetes costs for France or Germany.

- Source: journal articles on studies; case studies, case series, notes, conference abstracts, editorials, letters, methodology studies were removed to ensure a high quality of the selection process.

- Type of publication: original articles with abstract were included for performing the first-level screening on the abstract content.

The systematic literature search was conducted in MEDLINE, Embase (both via Embase) and EconLit (via EBSCOhost). A search strategy was developed for each search interface. We used available controlled vocabulary, keywords/headings and limits. The search strategies were based on a combination of terms for type 2 diabetes, for expenditures and for France or Germany, respectively. The terms were combined with Boolean Operators AND or OR. If possible, the inclusion/exclusion criteria were included (for detailed search strategies, see tables 1, 2; additional material). The searches were conducted on June 5th, 2019.

**Selection process**

Applying the aforementioned criteria each hit was screened for eligibility independently by two researchers, first only by title and abstract and in a second step, if they seem to fit or if a decision was not possible based on the abstract, also by full text. Four researchers participated in the screening process. Discrepancies were discussed and decided together.

**Data collection and analysis**

For all included papers, the following data was extracted:

- author(s), title, and publication year
- country
- study design
- description of population
- number of included patients
- source of cost data
- year(s) of reported costs
- performed statistical analyses
- different kind of reported costs, cost classes (direct, associated, and indirect costs)
- all reported annual costs per patient

The data was gathered into an excel spreadsheet by one researcher which was used for the analysis and narrative summary of the costs. All costs were converted and adjusted to December 2018 Euros (€) using Statbureau (38). We used July of the year of the reported costs as starting month for this adjustment or the median month if there was a longer or shorter time period. If there were studies that provide no costs that could be extracted as annual cost per patient the study was excluded post hoc.
Cost classification

The analysis differentiates the direct and indirect costs of the disease. Direct costs are those generated to the condition by itself (e.g. hospital admissions, drugs, specialist and general practitioners’ visits, services for measuring blood glucose level and administering insulin, transport, rehabilitation, but also the time spent by family members on the patient care). To better evaluate the economic magnitude of type 2 diabetes, direct costs are considered as:

- overall healthcare costs when they include all direct costs of any consumption of health care, also including costs that are not related to diabetes (e.g. vaccination, treating a broken arm);
- specific costs for diabetes treatment when they directly affect the consumption of in-patient and outpatient care for diabetes treatment;
- associated costs for additional services related to consequences of the type 2 diabetes, usually specialist visits to monitor correlated problems and health services delivered to prevent complications.

Indirect costs are represented by the share of present and future loss of productivity due to the disease, such as reduced income from work, lost working days, disability, early retirement and premature death (16, 39).

Quality assessment

Since there is no generally accepted method to assess the quality of economic studies, we decided to follow the recent proposal from the British Medical Journal Checklist for economic submissions (40). This quality assessment consists of the following 10 criteria related to specific aspects of cost reporting articles:

1. Was a clear definition of the illness given?
2. Were epidemiological sources carefully described?
3. Were direct/indirect costs sufficiently disaggregated?
4. Were activity data sources carefully described?
5. Were activity data appropriately assessed?
6. Were the sources of all cost values analytically described?
7. Were unit costs appropriately valued?
8. Were the methods adopted carefully explained?
9. Were the major assumptions tested in a sensitivity analysis?
10. Was the presentation of results consistent with the methodology of the study?

We extracted information on these 10 criteria and examined if the criteria were fully, not, or partially met. Based on this assessment a score was calculated for each paper (fully met = 1 point, partially met = 0.5 points, not met = 0 points). The range of this score is 0–10, with higher scores indicating better quality. Results of the quality assessment are reported in the results section but are not used to exclude studies.
Results

Search results

Our search strategy resulted in 1260 hits, including 19 duplicates. Hence, 1241 papers were included in the selection process, leaving 51 articles for full text screening. The selection process resulted in 24 papers for inclusion. Figure 1 documents this process.

Included papers

Of these 24 papers, nine papers report on French costs and 16 on German costs. Cost assessment was based on different numbers of patients ranging from 32 patients in a study performing a survey (41) up to 2.7 Mio patients in a study analysing health insurance claims data (42). The population varied regarding age and treatment, one study only included employed patients (43). Five studies did not assess the actual costs but used models to estimate costs (35, 41, 44–46). These studies often refer to previous studies for incidence rates and costs. Most studies based their cost assessment on secondary data, e.g. statutory health insurance data. Two studies collected data prospectively (47, 48). The year of reported costs varied between 2005–2017 (for detailed information on the included studies see table 3; additional material).

Results of quality assessment

The included studies have a moderate to good quality (scores between four (42) to nine points (45, 48–50)). No paper hit all 10 criteria. 15 studies reached eight or more points. Most studies presented their results as described in the methodology part and appropriately valued the unit costs. Five studies performed a sensitivity analysis for their major assumption (for detailed assessment results see table 4; additional material).

Diabetes costs in Germany

Of all included studies 16 report about costs in Germany (35, 41–46, 48, 50–57). All studies included direct costs (for detailed results see tables 5–20, additional material). One study also assessed indirect costs (56). Except for indirect costs, all costs were presented from the perspective of statutory health insurances, including only costs that are reimbursed by them.

Direct costs - overall healthcare costs: Five studies did not limit their cost analysis to costs for type 2 diabetes treatment but included all expenses for any healthcare of type 2 diabetes patients. Total direct annual healthcare costs were between €3081.11 for employed patients (43) and €4882.11 for an average type 2 diabetes patient (42). Average annual healthcare costs during the first three years in the disease management program diabetes mellitus type 2 for patients with antidiabetic medication were €3973.15 (€4274.27 for patients not participating) (53). A representative survey of the German population estimated €3482.73 annual healthcare costs of type 2 diabetes patients (56). Another study reported annual healthcare costs for type 2 diabetes patients with different complications: patients with
amputations (€20512.96), end-stage renal disease (€32738.14) and fatal ischemic heart disease (€19874.15) were patients with highest healthcare costs in the year of complication occurrence compared to patients without complications (€2793.33) (44). Two studies report on annual healthcare costs for type 2 diabetes patients for different services and resources (e.g. outpatient visits, rehabilitation, medication), with inpatient care and drug prescriptions as main cost drivers (43, 56).

Direct costs - specific costs for diabetes treatment: Six studies reported direct costs for type 2 diabetes treatment. Three focused on the period around insulin initiation. Costs for type 2 diabetes treatment in the year prior insulin initiation ranged between €757.00 and €843.07 and rose to €1277.85 up to €2204.41 after insulin initiation (48, 52). Costs for the year around insulin initiation (6 months prior and 6 months after initiation) amount between €1828.43 and €1844.00, respectively (48, 51). Another study estimated direct specific costs for two different types of insulin: €1671.11 (Exenatide BID twice daily) and €1887.27 (Liraglutide), respectively (55). The other studies report about prescription costs (54) and costs of treatment for hypoglycaemia (35, 41). Average annual direct costs for severe hypoglycaemic events (inpatient and outpatient care) of patients with multiple daily insulin injections were €98.91 per patient with annually 0.1 hypoglycaemic events per patient (41). Average annual costs for hypoglycaemic episodes per patient are separated in inpatient €2434.74 and outpatient care €531.96, originating from annually 0.19 events per patient (35). Annual costs for antidiabetic prescriptions were €516.28 with a trend of higher costs for men (€537.01), younger patients (≤ 60 years: €568.11), for patients with higher HbA1c (≥ 9: €882.23), for patients with higher BMI (≥ 35: €718.43) and more complications (> 3 complications: €780.64) (54).

Direct costs - associated costs: Associated costs were often assessed as excess costs, comparing direct healthcare costs for patients with and without type 2 diabetes. Annual excess costs for type 2 diabetes were estimated between €1561.62 and €3796.34 (46, 50, 56). A study modelling excess costs for diabetes for the year 2040 concluded €4357.73 (46). The comparison of annual healthcare costs of type 2 diabetes patients with and without urinary tract infection results in €4253.26 annual healthcare excess costs (57). Two studies analysed costs for diabetes associated complications: myocardial infarction, stroke or transient ischaemic attack, peripheral vascular disease, coronary heart disease. They report average annual diabetes-associated costs of €1642.24 for patients treated with insulin aspart and €2220.76 for patients treated with regular insulin (45). Another study reported diabetes-associated costs for myocardial infarctions of €12448.04 in an acute situation and another €5138.78 in the follow-up (35).

Indirect costs: Indirect costs were assessed by one study (56). Excess costs for patients with and without type 2 diabetes were estimated, based on a survey of the working population aged ≤65 years. Annual indirect costs (sick leaves, incapacity benefits) for this type 2 diabetes population were €4263.02, including €3474.42 for sick leaves. With this, type 2 diabetes people caused €2204.76 indirect excess costs, including €2124.76 for sick leaves.

Diabetes costs in France
Nine studies report costs for type 2 diabetes patients in France (49, 51, 58–64). They report on annual overall healthcare costs as well as on specific costs for diabetes treatment and associated costs (for detailed results see tables 21–29, additional material). No study assessed indirect costs. Seven studies based their analysis on the same data base: L’Échantillon Généraliste de Bénéficiaires (58–64).

Direct costs - overall healthcare costs: Several studies report healthcare costs for type 2 diabetes patients (49, 58, 59, 61–64). These ranged between €3717.22 for patients treated with metformin and sulfonamides hypoglycemic agents (61) and €13061.90 for patients treated with insulin (59). Direct comparison for patients treated with and without insulin resulted in three- to fourfold higher costs for insulin treated patients (62, 64). Healthcare costs for inpatient care ranged from €1366.39 for patients around insulin initiation (6 months before and after insulin initiation) (51) and €4542.94 for patients treated with insulin (62). Ambulatory costs between €2303.53 for patients treated with metformin and sulfonamides hypoglycemic agents (61) and €8749.88 for the year after initiation of insulin therapy (64) were reported. Most of these ambulatory costs account for drugs, paramedical services (most of it nursing care) and medical devices (58, 59, 62). When distinguishing between patients treated with insulin and patients treated with any antidiabetic paramedical services becomes the biggest part of ambulatory healthcare costs for insulin treated patients (59, 62, 64).

Direct costs – specific costs for diabetes treatment: One study (51) report on disease-specific costs for six months before and after insulin initiation. €3229.75 total costs were reported, including €1366.39 for diabetes-related hospitalisations, €709.29 for physician consultations, €476.81 for oral antidiabetics and €250.27 for insulin as well as €315.50 for blood glucose monitoring.

Direct costs – associated costs: Associated healthcare costs were expressed as the excess costs by three studies (49, 58, 59), ranging between €1958.33 (€549.45 for inpatient care) for patients newly treated for type 2 diabetes (49) and €4050.45 (€1409.67 for inpatient care) for patients treated with insulin (59). Hence, excess costs for ambulatory care are higher than hospitalisation (49, 58, 59). Costs for drugs (€845.80), nursing care (€553.42) and medical devices (€286.11) contribute most to ambulatory excess costs (58). Another study (60) analysed associated costs for hospitalisations for hypoglycaemia in patients with at least one hospitalisation with a type 2 diabetes diagnosis. Average annual costs for hospitalisation with hypoglycaemia as main diagnosis were €4926.54, for any hospitalisation with a hypoglycaemia diagnosis and without diabetic coma €5241.13 and for any hospitalisation with a diagnosis of hypoglycaemia and diabetic coma €5133.00.

Indirect costs of diabetes: No included study reported indirect costs for France.

Cost drivers in France and Germany

Looking at healthcare costs for type 2 diabetes patients, highest healthcare expenditures were caused by hospitalisation and prescriptions (42, 56, 58, 59, 61, 62). When only costs directly attributable to type 2 diabetes treatment were considered, hospitalisation (here diabetes-related hospitalisation) is no longer the main cost driver, especially in patients with insulin therapy in Germany (48). Instead costs for blood
glucose self-management and prescriptions contribute most to type 2 diabetes treatment costs (51). Whereas in France diabetes-related hospitalisations followed by prescriptions remains the main cost driver (51).

For Germany, a trend for higher antihyperglycemic treatment costs can be seen in patients with higher HbA1c (€288.20 for HbA1c < 6.5; €882.23 for HbA1c ≥ 9) and higher BMI (€405.35 for BMI < 30; €718.43 for BMI ≥ 35) (54). Higher direct healthcare costs were reported for patients with longer disease duration (56). For France as well as for Germany, patients treated with insulin caused higher costs than patients treated without insulin (43, 48, 51, 52, 56, 62, 64).

Complications or comorbidities contribute to higher overall direct healthcare costs and direct costs for diabetes treatment, respectively (44, 54). For Germany, the most expensive diabetes-related complications are end-stage renal disease (occurrence €32738.14, one-year follow-up €23629.17), amputations (occurrence €20512.96, one-year follow-up €12818.02) and fatal ischaemic heart disease (occurrence €19874.15) (44). No comparable studies were found for France.

A few studies also analysed direct costs for different sex and age groups, but no explicit trends became apparent. Three German studies stratified direct costs for different age groups with the result of higher costs for younger patients (€568.11 for patients aged ≤ 60 years vs. €402.24 for patients aged < 80 years) (54) and for older patients (43, 50). One French study also reported higher costs for younger patients (€15299.46 for patients aged < 60 years vs. €9728.25 for patients aged ≥ 75 years) (64). Similar heterogeneous results were found for sex: higher costs for men (54) and also higher costs for women (43).

**Discussion**

The objective of this study was to assess and compare the costs of type 2 diabetes in France and Germany and emphasise cost drivers in order to understand which issues must be addressed by innovators in diabetes care to improve patient care and coincident reduces costs. The decision to focus on France and Germany, thus, was due to the fact that these countries represent significant markets for health technology innovations in Europe and entail various needs owing to differences in healthcare delivery.

Among the 24 studies included, a higher number of studies are investigating into the German cohort than in the French one (respectively, sixteen and nine). The higher number of persons with diabetes and the higher diversity of reimbursement mechanisms (65) may explain the higher interest around the type 2 diabetes costs in Germany. The analysis was carried out by evaluating direct, direct-associated and indirect costs related to type 2 diabetes. While direct costs refer to resources specifically employed for inpatient and outpatient treatment; indirect costs measure the share of present and future loss of productivity due to the disease. Direct-associated costs, mainly related to complications, are estimated through the excess costs, which provide valuable information on the contribution of type 2 diabetes to the overall disease burden on healthcare expenditure, by several authors (46, 49, 50, 56–59).
The results of this literature review show large cost differences, for example between average annual direct healthcare costs (€3081-€4882 for Germany and €3717-€13062 for France) or average annual direct disease-specific costs for patients in the year around insulin initiation (€1844 for Germany vs. €3230 for France). Whereas excess costs seem quite similar (€1562-€3796 for Germany vs. €1958-€4051 for France). Only one included study (56) assessed indirect costs of type 2 diabetes.

The scarce attention to indirect costs reveals an important gap within health policy debate as the treatment of diabetes represents a critical issue for the overall sustainability of healthcare systems. Moreover, it underlines a lack of studies aimed to explore patients’ standpoint in order to better identify room for innovation in type 2 diabetes which would go beyond glycaemic management and improve the quality of life of type 2 diabetes persons.

Since any study referring to costs of type 2 diabetes patients were searched, heterogeneous studies in terms of the patient population, data sources and cost categories were included. These different approaches in the design of the study allow a comprehensive picture of costs for type 2 diabetes but concurrently limited the immediate comparison of costs and seems to be one major reason for costs differences. The different approaches in healthcare delivery of the two national health systems also contribute to these differences. Germany has a universal single-payer system funded by statutory health insurances and private insurances. All citizens and permanent residents must subscribe to health insurance. Hence, data included into studies are inferred from statutory health insurance databases, which allows to better identify the various cost items. France, instead, has a universal healthcare system mostly paid by government national health insurance, which covers 70%-75% of health expenditure. Most of the included studies from France and Germany are based on claims data from these insurances, taking their perspective.

The mapped cost drivers appear to express the severity of the disease, e.g. treatment with insulin, HbA1c ≥ 9 or more and severe complications. Results on patients’ characteristics, i.e. age and sex, are not clear-cut. Most costs were caused by hospitalisations and prescriptions, which are firmly correlated to diabetes-related complications and comorbidities (13). As asserted by several authors (12, 66), the prevention of complications represents the primary policy measure to decrease expenditure for diabetes. Besides, the cost of hospitalisation may be decreased by a gradual shift from the hospital setting to ambulatory care in the management of diabetes (67). However, past experiences do not provide robust evidence on whether ambulatory care could reduce type 2 diabetes costs. On the one hand, ambulatory care delays the development of chronic diseases, reducing the risk of costly episodes of inpatient care; on the other, it might prompt additional investigations, increasing the probability of hospitalisation (68).

A future-oriented perspective identifies the self-monitoring of blood glucose as a key pillar for type 2 diabetes management (34, 69). Such an approach underlines the need for integrated personalized diabetes management (32). This would require interactive collaboration among users, healthcare providers, and payers and included structured training and education for type 2 diabetes persons. To that end, telemedicine can facilitate integrated management of diabetes through an enhancement of the
communication between patients and healthcare providers and the continuous sharing of real-life data (35). Hybrid closed-loop metabolic control by means of artificial pancreas systems but also digitally enhanced technologies for multiple-daily insulin administration, such as smart pens in combination with continuous glucose monitoring, are arising as cost-effective solutions in type 2 diabetes management (70). Over the time, similar technologies grounded on telehealth indeed revealed to be an essential tool for filling the lack of personalized support in daily life (30), producing significant improvement in HbA1c levels and in reducing diabetes-related complications than usual care (71).

The development of such innovative systems is heavily influenced by the needs perceived by patients, but its implementation also depends on the availability of reimbursement (12). Accordingly, probing direct, direct-associated, and indirect costs for treating type 2 diabetes represents a former attempt for designing a reimbursement strategy. The purpose is to develop a tariff that covers actual resources disbursement and enhances the added value for patients.

However, several limitations undermine the usefulness of the results achieved here. First, the scarce generalization of findings that are strongly influenced by specific national health systems and reimbursement policies. Besides, the wide range of methods and patients’ populations involved in the studies, that did not allow to adopt a common framework for the analysis of costs. Lastly, while some studies analysed the total costs, other studies focused on single parts of the care or specific patients’ groups. Nevertheless, the different approaches in providing health care underline the importance to involve both healthcare provider characteristics (72) and patients perspective (73) in developing an effective value proposition to tackle type 2 diabetes management.

**Conclusions**

The study pointed out how most significant cost drivers are represented by hospitalization and complications, which may be stemmed by the employment of remote control technologies and innovative services. Besides reducing diabetes-related expenditure, these novel solutions can benefit patient’s daily life, enhancing their autonomy. Efforts by policy-makers have to deal with the promotion of these patient-centred treatments through the development of ad hoc policies and reimbursement tariff.

**Abbreviations**

BMI – Body Mass Index; GDP – Gross Domestic Product; HbA1c – glycated haemoglobin.

**Declarations**

**Ethical approval and consent to participate**

Since this study is a systematic review no patients are included, and ethical approval is not applicable.
Consent for publication

This manuscript does not contain any individual person’s data. Therefore, consent for publication is not applicable.

Availability of data and materials

Data extracted from the included papers and used for the analysis is provided as additional materials of this manuscript.

Competing interests

All authors declare that they have no conflicting interests.

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Author’s contribution

C. Stegbauer (guarantor) conducted the systematic searches, participated in the screening process, quality assessment and data extraction and worked on the draft for methods section and for the summary of the results for Germany. C. Falivena participated in the screening process, quality assessment and data extraction and worked on the draft for the introduction and discussion section. Ariadna Moreno participated in the screening process, quality assessment and data extraction and worked on the draft of the summary of the French results. Anna Hentschel contributed substantial to the conception and design of the review and the underlying project. T. Heise contributed substantial to the conception and design of the review and the underlying project. J. Szecsenyi contributed substantial to the conception and design of the review and the underlying project. F. Schliess contributed substantial to the conception and design of the review and the underlying project. All authors revised the manuscript critically and provided contextual amendments and refinement and approved the final version of the manuscript.
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Figure 1
Selection process of the systematic literature search

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