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What drives patient cost variability in psoriasis care: a single centre study

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Abstract

Background Psoriasis a chronic inflammatory skin disease, poses a substantial economic burden on healthcare systems globally. This study examines psoriasis consultations from the provider's perspective within a dermatology department, aiming to generate detailed cost data to support value-based care. Specifically, it investigates the drivers of consultation-level cost variability, explores opportunities for efficiency, and also estimates one-year treatment costs to inform the development of bundled payment models. The goal is to highlight the importance of patient cost transparency and improving cost structures in chronic disease settings.

Methods Using Time-Driven Activity-Based Costing (TD-ABC), treatment costs associated with nurses, doctors, and total visits for 127 patients with mild and moderate forms of psoriasis were measured. Financial data was collected in collaboration with the hospital's financial department. During consultations, nurses and physicians recorded time and patient-related information. Additional or missing details were retrieved from patient medical files. Descriptive analyses assessed mean costs and variability by patient and disease characteristics. Independent variables: therapy type, patient status (new vs. returning), comorbidities, and treatment changes, were stratified to compare cost differences across groups.

Results Mean consultation costs were €55, with a minimum and maximum of €25 and €110. New patients incurred 40% higher costs than returning ones, mainly due to longer interactions with nurses and physicians. Key cost drivers for a total consultation included patient status, personality traits, nurse experience, and therapy switches. Physician consultations were particularly impacted by treatment changes and patient engagement levels. Annual treatment costs varied substantially by medication type: topical treatments averaged €325 per year, systemic treatments €1,353, and biological therapies €11,920, highlighting the significant impact of medication choice on overall expenses.

Conclusions This study highlighted substantial variability in consultation and yearly treatment costs for psoriasis patients. These findings emphasized the critical need for detailed cost data to optimise departmental workflows, support efficient resource allocation, and inform the design of equitable bundled payment models. Improving cost transparency was shown to strengthen clinical and financial decision-making. Future research was recommended to explore the cost implications of comorbidities and to extend benchmarking efforts across dermatology settings to guide system-wide improvements in care delivery and sustainability.

Keywords Psoriasis, Dermatology, Time-driven activity-based costing (TD-ABC), Cost variability, Value-based healthcare, Cost drivers, Healthcare costs

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Introduction

In recent years, significant changes have occurred in the healthcare system, driven in part by the growing demand for a value-based approach [1]. More specifically, Value-Based Health Care (VBHC) has resulted in a paradigm shift from the traditional volume-driven approach, which emphasizes the quantity of services provided, to one that prioritizes delivering the greatest value to patients [2, 3]. To achieve value, a key component of VBHC involves accurately measuring and managing patient costs and cost variability, which can have a substantial impact on decision-making and care delivery [4]. While various academic studies have explored patient cost variability across different disease areas [5], few have focused specifically on chronic diseases. This is a critical gap, as chronic conditions typically require long-term treatment, making cost variability especially important to understand in these contexts.

Given the need to better understand cost variability in chronic disease settings, it is important to examine specific conditions where this issue is particularly pronounced. Psoriasis serves as a strong candidate for such an investigation. As a chronic inflammatory skin disease affecting approximately 2–3% of the global population [6], psoriasis is marked by lifelong persistence and fluctuating severity [7, 8]. It is also frequently accompanied by comorbidities such as psoriatic arthritis (PsA) and obesity [9], further complicating treatment needs and resource use over time. From an economic perspective, the disease represents a significant societal burden, with numerous studies highlighting its impact on work productivity and household income [10–12]. These characteristics make psoriasis a particularly relevant case for exploring patient-level cost variability in chronic care settings.

To better understand the cost structures and drivers within chronic care settings, we utilize Time-Driven Activity-Based Costing (TD-ABC) to measure both consultation costs and annual treatment costs for patients with both mild and moderate forms of psoriasis. Originally developed within the VBHC framework, TD-ABC offers a more accurate and transparent approach to costing, addressing the limitations of traditional methods [13, 14]. While TD-ABC has been applied in inpatient settings to reveal inefficiencies and guide strategic decision-making [15–18], its use remains largely unexplored in dermatology, and notably absent in the context of psoriasis care. This represents a critical gap, given that effective cost measurement is essential for identifying value-improving opportunities in chronic disease management.

While relevant academic studies may remain limited in the context, one related study applied Activity-Based Costing (ABC) to skin disorders including psoriasis [13, 14], however, it stopped short of examining TD-ABC or analysing the underlying drivers of patient-level cost variability. Without such insights, efforts to improve efficiency, design appropriate payment models, or support clinical decision-making remain limited. Importantly, detailed cost data are essential for informing reimbursement innovations such as bundled payments, a central mechanism in the shift toward VBHC.

Although bundled payments have shown promise in improving care coordination and cost-effectiveness in conditions like diabetes and renal disease [19–24], their relevance for chronic dermatological conditions remains underexplored. By applying TD-ABC in this context, our study aims to address these gaps and contribute critical knowledge needed to support high-value, cost-conscious care for patients with psoriasis.

To advance the goal of cost transparency in chronic disease care, and to support value-based decision-making, our study addresses two critical gaps. First, despite the recognized importance of understanding patient-level cost variability, little empirical work has examined which factors drive these variations in chronic dermatological care. By focusing on consultation costs in psoriasis treatment, we investigate how variability is shaped by a range of factors, including patient characteristics, self-reported outcomes, disease severity, and comorbidities. Identifying these drivers is a necessary step toward improving departmental processes and reducing unnecessary variation in care delivery.

Second, while bundled payment models have gained traction in managing chronic diseases, their design depends on reliable cost estimates, yet such data are scarce in dermatology. By analysing yearly treatment costs for psoriasis patients, we provide initial insights that can inform the development of bundled payment models in this field. More broadly, our application of TD-ABC illustrates how greater cost transparency can not only support reimbursement reform but also drive more efficient and equitable care in chronic disease settings.

Methods

Aim, design and setting of study

This retrospective observational study was conducted in collaboration with the dermatology department of UZ Ghent. The primary aim was to measure consultation-related costs for psoriasis patients using TD-ABC and to investigate the drivers of cost variability. The study was conducted at the outpatient dermatology clinic referred to as PsoPlus. The local system allows patients with both mild and moderate forms of psoriasis to access specialist care without a referral from a general practitioner regardless of disease severity. In Belgium, medication costs, including biologics, are covered under a national reimbursement system, with access regulated by federal eligibility criteria. Ethical approval was obtained from the

hospital's ethics committee (ONZ-2022-0518). Informed consent was not required as only anonymized patient data were used.

Participants and data collection

Data were collected prospectively for patients diagnosed with psoriasis who attended consultations at the PsoPlus clinic between May 2019 and March 2020. During these consultations, nurses and physicians recorded key patient and disease-related variables. At a later stage, the data were retrospectively validated and supplemented through a review of the patients' medical records to ensure completeness and accuracy. Collected variables included patient demographics, disease severity, comorbidities, and patient-reported outcomes.

Patients diagnosed with unrelated dermatological conditions (e.g., eczema) or with missing data for independent variables were excluded. The final sample consisted of 127 patients. Patients included in this study were not referred from other healthcare providers or institutions. Instead, they voluntarily presented themselves to the centre for evaluation and treatment, reflecting the self-referred nature of our patient population.

Application of TD-ABC

TD-ABC was used to calculate the cost of an individual consultation as well as the total annual treatment cost. This methodology involved calculating a cost rate per minute of practical capacity for each resource, developing a process map outlining the various activities involved in patient care, and measuring the time each resource spent executing these activities.

Financial data were collected in collaboration with the hospital's financial department. Due to the sensitive nature of remuneration data, salary scales provided by the financial department were used for the nurses and the secretary, while the exact salary was applied for the physician. The facilities department supplied a daily rate to cover the costs associated with the consultation room, covering all necessary departmental expenses. Practical capacity was based on the total clinical time available for PsoPlus patients, accounting for medical personnel's vacations, clinical duties, and administrative breaks. Capacity cost rates (CCR) for each resource were then calculated using the salary and facility data alongside the practical capacity.

By directly observing consultations, we constructed a generic pathway followed by patients and visualized this in a process map. This allowed the identification of all necessary activities performed (e.g., nurse consultations, doctor consultations, etc.) and the corresponding resources (personnel and facilities). Given the outpatient nature of psoriasis care, no medical machines are used during the consultations. A critical step in applying TD-ABC relates to the time measurement of each activity. For this purpose, medical staff used a stopwatch to estimate consultation durations. Additionally, an average of five minutes was added to account for interactions with the secretary.

Estimating one-year treatment costs

To estimate the cost of one year of treatment, which included all consultations and direct medication, we made several assumptions. We calculated the average consultation cost using data from returning patients. To determine the number of additional consultations per year, we considered disease severity, the presence of comorbidities, and the type of medication prescribed. Based on these factors, patients were assumed to have two or three additional consultations annually.

For medication costs, we referred to the Belgian Centre for Pharmacotherapeutic Information (BCFi; https://www.bcfi.be/nl/start), a drug-costing resource commonly used by physicians. Although patients could be prescribed combinations of drugs, only the primary medication prescribed at the time of data collection was considered for this analysis. As such, each patient was associated with a single medication.

We categorized medications into four main types: topical treatments, light therapy, systemic treatments, and biologics, following medical guidelines. The total annual treatment cost was calculated by summing the observed consultation cost, the projected cost of additional consultations, and the cost of the primary medication.

Independent variables for cost variability analysis

Variables impacting cost variability were grouped into five categories: patient characteristics, patient-reported outcomes, disease characteristics, comorbidities, and additional factors. Regarding patient characteristics, we collected patients' ages during the consultation as a continuous variable and gender was coded as a dummy variable (a binary variable used in regression analysis to represent categorical data, where a value of 1 indicates the presence of a particular condition or category, and 0 indicates its absence). The nurse also calculated the Body Mass Index (BMI) during the consultation; which is a recognized as an aggravating risk factor for psoriasis [25].

The patient-reported outcome used was the Dermatology Life Quality Index (DLQI), a brief questionnaire consisting of ten questions, each scored from 0 to 3. The questions cover a broad range of topics, including treatment, emotional well-being and symptoms, daily routine, work or school environment, and personal relationships [26]. Scores above ten indicate that the disease has a significant impact on the patient's quality of life. As with the patient characteristics, all patient-reported outcomes

were collected during the consultation and subsequently verified through a review of the medical records.

For disease-specific characteristics, we collected the Psoriasis Area and Severity Index (PASI) score, a physician-assessed measure of disease severity. To calculate the PASI score, the body is divided into four regions: the head, the trunk, and the lower and upper extremities [27]. Each region is scored on a scale from 0 to 6, resulting in a total ranging from 0 to 24, with higher scores indicating greater disease severity [28]. As with other measures, the PASI scores were recorded during the consultation and subsequently verified through a review of the patients' medical records.

The DLQI and PASI scores were collected by trained clinical staff as part of routine care during patient consultations. Both instruments are validated and widely used in dermatology to assess quality of life and disease severity [29]. All collected data were fully anonymized prior to analysis, and no individual scores could be traced back to specific patients. Adhering to ethical approval and standards, and all data handling complied with applicable data protection regulations.

Given the chronic nature of the disease and the significant role comorbidities play in its management, we extracted several relevant data points. First, we recorded the presence of PsA; as existing literature highlights a strong correlation between psoriasis and the development of PsA [30]. Additionally, due to the known psychological impact of psoriasis [31], we collected scores from the Hospital Anxiety and Depression Scales (HADS), which assesses both anxiety and depression. The HADS consists of 14 items—seven for anxiety and seven for depression—each scored from 0 to 3, with higher scores indicating more severe symptoms. The questionnaires used in this study were developed by the collaborating dermatology department. A score greater than eight indicates more significant symptoms of anxiety and depression.

Additionally, we gathered information about the personality types of patients, divided into two distinct components: first, disease burden, which reflects how psoriasis affects patients' lives; and second, engagement with treatment, which measures patient satisfaction with their treatments and perceived treatment effectiveness. Both variables were assessed using of eight questions, with scores ranging from 0 to 3, where 3 indicates the highest level of satisfaction. Recognizing patients' personality types is paramount in the treatment of psoriasis, as research shows that the interplay between personality traits and the impact of the disease has the potential to intensify the disease's effects, jeopardize therapeutic compliance, and even exacerbate symptoms [32]. The personality types used in this study were based on the classification developed by Bewley et al., which identifies individual psychosocial and adherence support needs in patients with psoriasis through a multinational, two-stage qualitative and quantitative study [33].

Finally, we collected data on additional factors that could impact cost variability. Specifically, we recorded whether a therapy switch occurred during the consultation, the patient's status (new or returning), and the nurse's level of experience. When a treatment change was made, consultations tended to be longer due to the time required for the physician to explain the new medication. Similarly, new patients typically required more time with both the nurse and the physician, leading to extended consultation durations and, consequently, higher associated costs.

Data analysis

We calculated the mean, standard deviation, minimum, and maximum for the costs associated with different consultation stages as well as for the yearly treatment cost. For continuous independent variables, we reported their mean, standard deviation, and range. For categorical variables, we presented the frequency and percentage of occurrence for each category.

To examine the relationship between consultation costs (the dependent variables) and the independent variables, we conducted several statistical tests. Firstly, we assessed the relationship using bivariate regressions for the continuous independent variables. Given the use of binary variables for the different categories, we only used the Mann–Whitney U test to understand the relationship with the dependent variables. We found that the distribution of the three dependent variables, the nurse, the doctoral, and the total consultation costs, was normal.

We employed a stepwise regression technique with forward elimination to determine the appropriate regression model. Correlations between all the dependent and independent variables were examined to understand the underlying relations. The DLQI score, which measures the impact of disease on quality of life, showed a strong positive correlation with the burden of disease personality type ($r = 0.7975$). Similarly, HADS-A and HADS-D scores displayed a strong positive correlation ($r = 0.7164$), reflecting a strong relationship between the anxiety and depression levels of patients. To address these strong correlations, we generated interaction terms and included them as independent variables in the stepwise regression models. However, these interaction terms were not statistically significant in explaining variation therefore were excluded from the final models.

A significance level of 0.05 was used to retain variables in the final model. We assessed the results by testing the normality of residuals using the Jarque–Bera test, supplemented by visual inspections of histograms and Q-Q plots. The residuals met the normality assumption for the

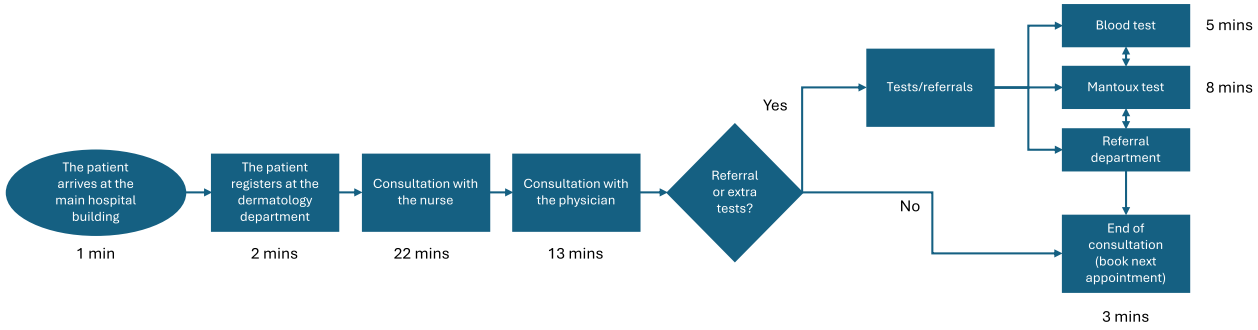

Fig. 1 Overview of the patient pathway. * All activities performed at the dermatology department of the hospital

Table 1 Breakdown of the costs of the different consultations

	All patients	Existing patients	New patients
Secretary	€ 2.88	€ 2.88	€ 2.88
Nurse consultation			
Min	€ 4.89	€4.89	€ 11.61
Max	€ 30.56	€ 26.28	€ 30.56
Mean (SD)	€ 13.79 (€ 4.45)	€13.24 (€ 3.77)	€ 21.05 (€5.81)
Physician consultation			
Min	€ 13.65	€13.65	€ 30.03
Max	€ 76.45	€ 76.45	€ 76.45
Mean (SD)	€ 37.97 (€ 13.54)	€ 37.02 (€ 12.75)	€ 50.36 (€ 16.39)
Total consultation			
Min	€ 25.09	€ 25.09	€ 44.53
Max	€ 109.89	€ 93.39	€ 109.89
Mean (SD)	€ 54.64 (€ 15.62)	€ 53.14 (€ 14.00)	€ 74.29 (€ 20.85)

doctor and yearly consultation cost regression models ($p > 0.063$ and $p > 0.064$, respectively), but this assumption was violated for the nurse consultation model. To correct this, we applied a natural logarithm (ln) transformation to the nurse consultation costs, which achieved normality ($p > 0.385$). Consequently, we reported exponential coefficients for the nurse regression model due to the log transformation. Regression models were checked for multicollinearity using the tolerance and variance inflation factor (VIF), no evidence was found in any of the three regression models. All sample data was consolidated in Microsoft Excel and used the Software Tool for Data Analysis and Statistics, STATA 13 (StataCorp LP, College Station, TX).

Results

Cost of a consultation

Based on observations of the consultations, we constructed a generic treatment pathway followed by patients, which were visualized as a process map in Fig. 1. Upon arriving for their consultation, patients first saw a dedicated psoriasis nurse. During this initial interaction, the nurse asked the patients a series of questions related to their medical records and checked whether any updates or additions to the existing information were necessary. Following the consultation with the nurse, the patient met with the physician. The physician examined the patients to assess the severity of the disease. At this stage, the physician could decide whether a change in the patient's medication was required. The consultation concluded with a brief interaction with the secretary, who scheduled the patient's next appointment.

Using the process map and applying TD-ABC to estimate costs, we calculated the cost for the secretary, the nurse consultation, and the physician consultation. Table 1 provides an overview of the cost structure of a consultation for an average patient (column all patients). The average costs for patients across various consultations show minimal variance compared to those of existing patients. However, a substantial contrast emerges when conducting the same comparison for new patients.

One of the key variables driving consultation cost variability was patient status. This variable was frequently mentioned during discussions with the PsoPlus team and confirmed in the regression analysis (see Sect. "Independent variables and their impact on the cost of a consultation"). Table 1 shows the differences in cost structure between existing and new patients. Focusing on the results of the nurse consultation, a 137% difference was observed when comparing the minimum values (€4.89 vs. €11.61). In constract, the difference between the maximum values was limited to only 16% (€26.28 vs. €30.56). Regarding the average cost of the nurse consultation, existing patients incurred a cost of €13.24, whereas new patients incurred a higher cost of €21.05. Observations of the consultations revealed that new patients spent more time with the nurse due to the need to complete their medical files.

Similarly, when considering the physician's cost in isolation, notable differences between the two patient groups were observed. A 120% difference was found when comparing the minimum costs (€13.65 for existing patients vs. €30.03 for new patients). No difference was noted in the maximum costs between the patient groups'. On average, existing patients incurred a physician consultation cost of €37.02, whereas for new patients, the average cost was €50.36. As with the nurse consultation, the physician

spent more time with new patients to understand their psoriasis history and previous treatments. Additionally, more time was devoted to determining an appropriate treatment plan moving forward. This extended interaction likely accounted for the higher consultation costs observed for new patients.

Finally, we examined the total consultation cost by summing both the nurse and physician consultations costs. As expected, similar cost differences between the patient groups were observed. The minimum costs for existing patients amounted to €25.09, while new patients incurred a minimum cost of €44.53, resulting in a 77% difference. In some cases, existing patients also required more time with medical staff, as reflected in a maximum cost of €93.39. However, new patients still had a higher maximum cost of €109.89. On average, new patients incurred 40% higher consultation costs compared to returning patients (€74.29 vs. €53.14), likely due to the additional time required to gather medical history and establish an appropriate treatment plan.

Independent variables and their impact on the cost of a consultation

Table 2 presents an overview of the summary statistics for the various independent variables. It also displays the individual impact of each variable on the cost of the nurse consultation, the physician consultation, and the total consultation, as determined through bivariate analysis. These impacts are indicated by the corresponding *p*-values for each cost category (*p*-value nurse consultation cost, *p*-value physician consultation cost, and *p*-value total consultation cost).

With respect to patient characteristics, 82.7% of the patients were aged between 25 and 64, followed by seniors classified as 65 and above (8.6%) and youth (7.9%). The average age of the included patients was 43 years, with a minimum age of 17 and a maximum age of 71. In terms of gender distribution, males made up approximately 63.8% of the patient population. Regarding BMI, the majority of patients fell into the normal weight and overweight categories, each accounting for 33.1% of the sample, followed by 32.2% classified as obese. The mean BMI was approximately 28, with values ranging from a minimum of 17.4 to a maximum of 45.5. The *p*-values indicated that patient characteristics did not have a statistically significant impact on consultation costs.

Regarding personality types, approximately 96.9% of patients reported a high level of engagement with their medical condition, while 89.8% perceived the disease burden as low. The average scores for engagement and perceived disease burden were 21 and 5, respectively. For the patient-reported outcome, DLQI, 57.5% of patients reported a score between 0 and 1, indicating that the disease had no impact on their lives. This was followed by 18.9% of patients who reported a minor impact. The average score for the DLQI was 3.7. For the disease-specific factor, 81.1% of patients had a PASI score between 0 and 5, corresponding to a mild classification of psoriasis. The mean PASI score across all patients was approximately 2.5. The *p*-values showed that personality type, DLQI, and PASI scores had a statistically significant impact on consultation costs.

For variabilities linked to comorbidities, only 15% of patients reportedly had PsA. When considering the outcomes relating to HADS-A, 79.5% of patients displayed low anxiety levels; the average score for this variable was 5. For HADS-D, roughly 91.3% of patients showed low levels of depression, with an average score of 3. *P*-values showed no statistically significant association for PsA, as well as for HADS-A and HADS-D scores.

Regarding the additional variables collected, 43.3% of patients had their medication changed during the physicans consultation. Of the included patients, 92.9% were known patients (i.e., having already had treatment previously at the department). Finally, the division of labour between the nurses was unequal; the second nurse conducted 59.0% of all the consultations. The *p*-values for therapy switch and patient status indicated that both variables had a statistically significant impact.

The results of the regression analysis, split up into 3 parts: the cost of the nurse consultation, the cost of the physician consultation, and the cost of the total consultation, are presented in Table 3. In the regression model focused on nurse consultation costs, patient status was found to have a statistically significant impact ($p < 0.001$). The analysis showed that nurse consultation costs were higher for new patients compared to existing ones. As previously noted, new patients required more time with the nurse, primarily due to the need to complete their medical records. Upon arrival, nurses asked new patients a series of questions related to their psoriasis history and other relevant information, which took longer than the updates typically needed for returning patients. These findings suggested that the greater number of data fields requiring completion during consultations with new patients contributed to cost variability.

Furthermore, patients identified as having a personality type associated with a high perceived disease burden were also a significant cost driver ($p < 0.001$). As the perceived disease burden increased, so did the on nurse consultation costs. These patients tended to ask more questions regarding their condition and available treatment options, which extended the duration of the consultation and, consequently, increased associated costs. Finally, the nurse conducting the consultation itself significantly impacts the costs ($p < 0.001$). The analysis revealed variability in costs based on differences in the nurses' levels of experience.

Table 2 Overview of the patient and disease characteristics

Patient Factors	All included patients ($n=127$) N (%)	Mean (SD)	Min	Max	*P*-value nurse consultation costs	*P*-value physician consultation cost	*P*-value total consultation costs
Age		43.4 (14.2)	12	71	0.742	0.474	0.599
Children = 0 to 14 years	1 (0.8%)						
Youth = 15 to 24 years	10 (7.9%)						
Adults = 25 to 64 years	105 (82.7%)						
Seniors = 65 years and over	11 (8.6%)						
Gender		-	-	-	0.168	0.744	0.495
Female	46 (36.2%)						
Male	81 (63.8%)						
BMI		27.8 (5.1)	17.4	45.5	0.487	0.812	0.993
< 18.5 (underweight)	2 (1.6%)						
18.5–24.9 (normal)	42 (33.1%)						
25–29.9 (overweight)	42 (33.1%)						
> 30 (obese)	41 (32.2%)						
Personality type							
Engagement with disease		20.7 (3.8)	5	24	**< 0.001**	**< 0.000**	**< 0.000**
Low engagement: 0 to 12	4 (3.1%)						
High engagement: 13 to 24	123 (96.9%)						
Burden of disease		5.4 (5.1)	0	24	**< 0.000**	**< 0.019**	**< 0.001**
Low burden of disease: 0 to 12	114 (89.8%)						
High burden of disease: 13 to 24	13 (10.2%)						
Patient-reported outcomes							
DLQI Score		3.7 (5.6)	0	22	**< 0.000**	**< 0.007**	**< 0.000**
No effect on patients' life = 0 to 1	73 (57.5%)						
Small effect on patient's life = 2 to 5	24 (18.9%)						
Moderate effect on patient's life = 6 to 10	13 (10.2%)						
Very large effect on patient's life = 11 to 20	14 (11.0%)						
Extremely large effect on patient's life = 21 to 30	3 (2.4%)						
Disease characteristics							
PASI Score		2.5 (3.7)	0	20.7	**< 0.005**	**< 0.002**	**< 0.000**
Mild = ≤ 0 and < 5	103 (81.1%)						
Moderate = ≤ 5 and < 10	18 (14.2%)						
Severe = ≥ 10	6 (4.7%)						
Comorbidities							
PsA		-	-	-	0.452	0.562	0.514
No	108 (85.0%)						
Yes	19 (15%)						
HADS*							
Presence of HADS-A		4.9 (4.1)	0	17	0.164	**0.077†**	**0.053†**
Low levels of anxiety: 0 to 8	101 (79.5%)						
High levels of anxiety: > 8	26 (20.5%)						
Presence of HADS-D		3.1 (3.4)	0	14	**0.071†**	0.188	**0.098†**
Low levels of depression: 0 to 8	116 (91.3%)						
High levels of depression: > 8	11 (8.7%)						
Additional variables							
Therapy switch		**-**	**-**	**-**	**0.030**	**< 0.000**	**< 0.000**
No	72 (56.7%)						
Yes	55 (43.3%)						
Patient status		**-**	**-**	**-**	**< 0.000**	**< 0.024**	**< 0.007**
Known	118 (92.9%)						
New	9 (7.1%)						
Nurse		**-**	**-**	**-**	0.214	0.848	0.895

Table 2 (continued)

Patient Factors	All included patients ($n=127$) N (%)	Mean (SD)	Min	Max	*P*-value nurse consultation costs	*P*-value physician consultation cost	*P*-value total consultation costs
Nurse 1	52 (40.1%)						
Nurse 2	75 (59.0%)						

†: significant at 10%

Table 3 Regression results for all consultations

Nurse consultation[#]	Coefficient	Std. Error	*P*-value	95% Conf. interval		R^2
Patient status	0.354	0.099	**< 0.001**[*]	0.159	0.550	**0.295**
Burden of disease	0.024	0.005	**< 0.001**[*]	0.015	0.035	
Nurse	0.154	0.051	**0.003**[*]	0.053	0.255	
Constant	2.233	0.051	**< 0.001**[*]	2.221	2.42	
Physician consultationτ	**Coefficient**	**Std. Error**	***P*-value**	**95% Conf. interval**		**R^2**
Therapy switch	8.274	2.581	**0.002**[*]	3.165	13.384	**0.196**
Engagement with disease	−0.720	0.343	**0.038**[*]	−1.400	−0.040	
Constant	49.295	7.836	**< 0.001**[*]	33.784	64.805	
Total consultation	**Coefficient**	**Std. Error**	***P*-value**	**95% Conf. interval**		**R^2**
Therapy switch	10.593	2.618	**< 0.001**[*]	5.411	15.775	**0.224**
Patient status	14.688	5.055	**0.004**[*]	4.682	24.693	
Constant	49.012	1.635	**< 0.001**[*]	45.777	52.247	

[#]A logarithmic transformation was performed on the dependent variable

τNo transformation was performed on the dependent variables

[*]Significant at $p \leq 0.05$

Therapy switch ($p=0.002$) was identified as a significant variable in the regression model for physician consultation costs. Treatment switches typically occured when the physician was dissatisfied with the effectiveness of a prescribed medication. In such cases, additional time was required to explain the rationale for the change, as well as the implications and potential side effects of the new therapy. The results indicated that a therapy switch was associated with an increase in physician consultation costs. Furthermore, personality type, specifically, the level of patient engagement with the disease, was found to contribute to cost variability ($p=0.038$). The results indicated that higher engagement levels were associated with lower physician consultation costs. As a result of their engagement, patients required less extensive discussion during consultations. Consequently, physicians spent less time explaining the disease and addressing questions, which in turn lowered consultation costs. However, the explanatory power of this regression model was limited, accounting for only 20% of the variance in consultation costs (Table 3).

In the final regression model, therapy switch emerged as a significant factor influencing total consultation costs ($p<0.001$). As previously discussed, when a physician decided to alter the course of treatment during a consultation, additional time was required to explain the new medication to the patient. This often prompted further questions from the patient, thereby extending the consultation duration and increasing overall costs. Patient status also played a significant role in explaining total consultation costs ($p=0.004$). New patients incurred higher costs compared to existing patients. This difference could be attributed to the additional time required for nurses to complete initial medical documentation, as well as the extended interaction needed for physicians to familiarize themselves with the patient's medical history and disease progression. The explanatory power of this regression model was relatively modest, accounting for 22% of the variance in total consultation costs (Table 3).

Table 4 Breakdown of the yearly costs using medical categories

	Patients on topical medication	Patients on systemic medication	Patients on biological medication
Min	€ 156.31	€ 209.24	€ 4,059.47
Max	€ 642.19	€ 9,780.45	€ 14,784.61
Mean (SD)	€ 324.93 (€ 183.87)	€ 1,353.07 (€ 1,743.59)	€ 11,919.93 (€2,967.08)

Cost of treatment for one year

Given the importance of medication costs in this analysis [34], patients were categorized according to their primary treatment type: topical, systemic, and biological therapies. As shown in Table 4, direct medication costs accounted for the majority of total expenses. In addition to the consultation cost variability, discussed earlier, the

analysis revealed substantial differences in overall costs depending on the type of medication used to treat psoriasis. Focusing on average annual costs, patients receiving only topical treatments incurred an average total cost of €324.93, including all consultations. In contrast, those prescribed biological therapies faced an average yearly cost of €11,919.93 for a year. Patients on systemic medications had an intermediate average annual cost of €1,353.07, significantly lower than the cost associated with biological treatments. Furthermore, considerable variability also existed within each medical categories. For instance, among patients using biological drugs, the minimum annual cost was €4,059.47, while the maximum reached €14,784.61. One factor contributing to this variation was the use of generic versus brand-name medications, with generics generally being less expensive.

Discussion

Transparency in consultation costs and patients' annual expenditures creates opportunities to streamline internal processes and optimize cost structures without compromising patient outcomes. It also serves as the foundation in developing alternative payment models, such as bundled payments, where accurate cost information is essential for effective implementation. By leveraging these insights, healthcare systems can align financial incentives with value-based care objectives.

With the growing need to reduce and control healthcare expenditures, providers are forced to investigate their internal processes to identify ways to optimize the use of resources and reduce their expenditures [35]. In this setting , the accurate measurement of costs and the understanding of determinants of cost variability have remained a fundamental priority for both hospitals and policymakers. Yet, within the clinical domain of psoriasis, cost analyses from the provider's perspective have been notably limited. Existing studies have largely focused on societal costs of the disease, i.e., the patient's loss of work and impact on family income or the cost-effectiveness of the medications used for treatment [12, 36, 37]. Addressing this gap, our analysis offered a preliminary examination of provider-incurred costs in psoriasis care and demonstrated how such insights could inform improvements in operational efficiency and resource allocation.

When interpreting the results, it became evident that patient status influenced consultation costs, both in the regression analyses and in the broader cost patterns observed. At the time of this analysis, the dermatology department did not differentiate between new and returning patients during consultations. Patients with lower engagement levels and a higher disease burden typically required more consultation time and could have been grouped and scheduled accordingly. Assigning such patients to designated staff with the appropriate training would have allowed for better resource utilization and supported more personalized care. To optimize the consultation schedule, the department could have reorganized appointments to reflect these patient differences. This approach could have enabled the implementation of dedicated intake and follow-up consultation days, potentially improving efficiency by streamlining staff workflows and enhancing the use of high-cost resources.

The regression results also indicated that personality type played a significant role in driving cost variations between patients. These findings could be leveraged by the department to optimize care delivery. Since personality types were obtained through a questionnaire, a consideration that could be made is having patients complete the survey when booking their appointment. In doing so, the department knows the different personality types of the patients upfront, allowing them to anticipate patient needs in advance. Educating staff on how to effectively engage with different personality types, along with the typical concerns each group faces, could have further supported personalized care. For instance, the development of educational materials addressing frequently asked questions about the disease and its treatments may have improved patient understanding. Prior evidence suggested that such resources positively influenced patient outcomes and helped reduce unnecessary resource utilization [38].

Furthermore, adjustments to the consultation schedule could contribute to more efficient care delivery. Personalized health care, an approach that emphasizes patient engagement, prevention, prediction, shared decision-making, and coordinated care, has been associated with improved outcomes and better cost management [39–41]. Reseearch indicates that when patients are knowledgeable about their condition and confident in managing it, they tend to experience better health outcomes, incur lower costs, and report greater satisfaction with their care [42, 43]. In support of this, the regression results from the consultation analysis suggested that patients who demonstrate higher levels of engagement with their condition were associated with reduced consultation costs.

Addressing medication adherence is crucial, especially for lower-cost treatments. Previous research has shown that patient-support interventions can improve adherence cost-effectively [44]. However, despite many economic evaluations, the overall cost-effectiveness of psoriasis therapies remains uncertain, partly due to a lack of studies on innovative care delivery models [45]. Applying value-based healthcare principles, which focus on patient-centered outcomes relative to costs, may offer a promising approach. In particular, integrated practice units could enhance treatment effectiveness by

accounting for factors such as comorbidities and patient education that influence outcomes.

This study also reported the costs associated with one year of psoriasis treatment, figures that could inform the design of bundled payment models. In light of the growing global financial strain on healthcare systems, reimbursement reform has become an increasingly pressing issue.VBHC literature outlines five key conditions for designing effective bundled payments [46]: (1) coverage of the full cycle of care for a given condition; (2) payment contingent on delivering good outcomes; (3) payment is adjusted for risk; (4) payment provides a fair profit for effective and efficient care; and (5) exclusion of unrelated or catastrophic cases from provider responsibility.

The first condition requires that a bundle should cover a cycle of care for a primary care segment. For chronic conditions, like psoriasis, this is typically structured as a time-based bundle. In this context, cost calculations over a defined period, such as one year, were particularly relevant, as they captured the full financial burden of care over a treatment cycle. As shown in the results, cost structures varied significantly across medication types. These distinctions could represent separate primary care segments, each warranting its own tailored bundled payment.

The third condition, which requires risk adjustment to account for differences in patient complexity and to discourage cherry-picking, also aligned with our findings. The regression analysis offered insights into how various patient-level factors influenced cost variability, providing a foundation for adjusting payments based on complexity. Taken together, this information may serve as a critical starting point for the thoughtful design of condition-specific bundled payment models. Finally, the fourth condition emphasizes that bundle payments should cover all costs of the necessary care plus a fair profit, rather than rely on historical claims data. This further strengthens the need for current, detailed cost analyses like those provided in our study.

Given the growing push toward value-based healthcare, further cost studies are essential not only for improving operational efficiency but also for shaping payment policy at regional and national levels. Cost analyses, particularly those grounded in patient-level data, allow providers to benchmark performance, identify inefficiencies, and develop care models that are both clinically and economically sustainable [14, 47]. In this light, expanding cost studies across disease areas and institutional contexts is a crucial step toward achieving a more value-oriented, data-informed healthcare system.

This study has several limitations that also offer opportunities for future research. First, the analysis was based on a relatively small patient cohort from a single centre, which may limit the generalizability of the findings. Expanding the study to include multiple centres could provide a basis for benchmarking outcomes and determining whether operational models like PsoPlus could inform improvements in other dermatology departments. Second, the unique structure of PsoPlus, where patients engage with a multidisciplinary team rather than only a physician, may not reflect the typical setup in most dermatology clinics. Comparative studies across different institutional models would help assess whether similar efficiencies or cost patterns emerge elsewhere. Third, the study did not consider the costs associated with treating comorbidities in other departments, which is a notable omission given the high prevalence of comorbid conditions in patients with psoriasis. From VBHC perspective, understanding the total cost of care, including comorbidities, is important when evaluating the full burden of disease and designing bundled payment models. Future studies should investigate how referrals and comorbidity management impact overall costs and care coordination. Moreover, the relatively short observation window limited our ability to assess long-term cost–benefit dynamics, such as whether initiating more expensive therapies earlier for patients with severe psoriasis leads to better outcomes or cost savings over time. Finally, while this study focused primarily on costs, it did not link those costs to clinical outcomes. Future research should aim to connect cost data with treatment effectiveness to advance the discussion around achieving greater value in psoriasis care.

Conclusion

This study demonstrated how TD-ABC can be applied in a dermatology setting to produce granular insights into both consultation-level and annual treatment costs for psoriasis patients. By identifying key drivers of cost variability, such as patient status, personality type, the experience of nursing staff, and treatment adjustments, we showed how such data can inform more efficient internal operations and targeted resource allocation. These findings highlight that accurate, patient-level costing is not merely an operational tool but a strategic lever for improving the organization and delivery of chronic care.

More critically, this work illustrates how detailed cost data can lay the groundwork for future reimbursement reforms, particularly in the design of bundled payment models. As healthcare systems increasingly adopt value-based payment schemes, reliable cost estimates are essential to ensuring fair compensation for providers while promoting high-quality, cost-effective care. National policymakers and healthcare payers can benefit from such data when evaluating the feasibility, risk adjustment mechanisms, and financial sustainability of bundled payments in chronic disease care. In this way,

cost transparency can act as a catalyst for system-wide improvements that align financial incentives with patient value.

Abbreviations

VBHC	Value-based health care
PsA	Psoriatic arthritis
TD-ABC	Time-driven activity-based costing
BMI	Body mass index
DLQI	Dermatology life quality index
PASI	Psoriasis area and severity index
HADS	Hospital anxiety and depression scale
CCR	Capacity cost rates
LN	Natural logarithm
VIF	Variance inflation factor

Supplementary Information

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Supplementary material 1.

Supplementary material 2

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Authors' contributions
E.R. was involved in the conceptualization, methodology, formal analysis, data validation, investigation, writing—original draft, writing – reviewing, and editing of the research article. F.R. was involved in the conceptualization, writing—review & editing, supervision, and funding acquisition for the research. J.L. was involved in data collection, conceptualization, writing—review & editing, supervision, and funding acquisition for this article. E.D. was involved in data collection, writing—review & editing B.C was involved in the conceptualization, writing—review & editing, supervision, funding acquisition for the research.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The 'Commissie voor Medische Ethiek U(Z) Gent' – the ethical committee of the hospital approved this study (ONZ-2022-0518). Informed consent was not required as we used anonymized data from patients.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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