An Economic Analysis of Presurgical Teledermatology in Patients with Nonmelanoma Skin Cancer

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Abstract. *Introduction.* In patients with nonmelanoma skin cancer, store-and-forward teledermatology allows satisfactory diagnosis and surgical planning, thus shortening waiting lists and reducing travel requirements for patients in special situations.

Objective. The aim of this study was to undertake an economic analysis of presurgical teledermatology, comparing it with a conventional health care approach.

Material and methods. The cost and cost-effectiveness of presurgical teledermatology were analyzed from a societal perspective in the setting of a public hospital with a corporate intranet. The mean delay in surgery was used to measure effectiveness. Over a 12-month period, teledermatology was used in 134 patients with nonmelanoma skin cancer. The unit cost of each intervention (teledermatology and conventional health care approach), the cost ratio between the most and least expensive alternative, and the incremental cost-effectiveness ratio were calculated. We distinguished between 2 groups of patients: those with and those without physical impediments for travel.

Results. The unit cost of the patients in whom teledermatology was used was 1 156.40 compared to 1 278.42 per patient in the conventional system; the conventional system was therefore 1.78 times more expensive than presurgical teledermatology. Teledermatology was more cost-effective, with an incremental cost-effectiveness ratio of 1 3.10 per patient and per day of delay avoided in patients without impediments for travel and 1 4.87 in those with impediments for travel.

Conclusion. Teledermatology used for remote presurgical planning and preparation in patients with nonmelanoma skin cancer is more cost-effective than the conventional referral system in a health setting with a communication network available.

Key words: teledermatology, presurgical teledermatology, dermatologic surgery, skin cancer, economic analysis, cost-effectiveness, health costs.

TELEDERMATOLOGÍA PREQUIRÚRGICA EN PACIENTES CON CÁNCER CUTÁNEO NO MELANOMA. EVALUACIÓN ECONÓMICA

Resumen. *Introducción.* En pacientes con cáncer de piel no melanoma la teledermatología diferida permite una adecuada aproximación diagnóstica y planificación quirúrgica, acortando la demora y evitando desplazamientos en pacientes con situaciones especiales.

Objetivo. Evaluación económica de la teledermatología prequirúrgica, comparándola con la asistencia convencional.

Material y método. Descripción de costes y análisis coste-efectividad bajo una perspectiva social de la teledermatología prequirúrgica en el ámbito de un hospital público dotado de infraestructura de redes (intranet corporativa). Se consideró como medida de efectividad la demora media hasta la intervención quirúrgica. Durante un período de 12 meses se atendieron un total de 134 pacientes con cáncer no melanoma mediante teledermatología, calculando el coste unitario de cada intervención (teledermatología y asistencia convencional), la ratio de coste entre la alternativa más cara

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y la más barata y la ratio de coste-efectividad incremental. Se diferenciaron dos grupos de pacientes, con y sin dificultades físicas para el desplazamiento.

Resultados. El coste unitario de los pacientes atendidos mediante teledermatología fue de 156,40 euros, frente a 278,42 euros por paciente en el sistema convencional; la asistencia convencional resultó 1,78 veces más cara que la teledermatología prequirúrgica. La teledermatología demostró ser más coste-efectiva, con una ratio coste-efectividad incremental de 3,10 euros ahorrados por paciente y día de demora evitado en pacientes sin dificultades para el desplazamiento, y de 4,87 euros en pacientes con dificultades para el desplazamiento.

Conclusión. La teledermatología orientada a la planificación y preparación prequirúrgica remota de pacientes con cáncer no melanoma es una intervención más coste-efectiva que el sistema de derivación convencional en un medio sanitario dotado de infraestructura de redes de comunicación.

Palabras clave: teledermatología, teledermatología prequirúrgica, cirugía dermatológica, cáncer de piel, evaluación económica, coste-efectividad, costes sanitarios.

In patients with skin cancer, store-and-forward teledermatology has been shown to be an effective triage tool that reduces the time to an initial intervention in the specialized dermatology service.[1-7] The use of the Internet to transmit clinical information and digital images relating to lesions suspected of being malignant facilitates the decision-making process. Teledermatology has been shown to be more effective in the management of circumscribed and tumoral lesions than in the remote management of patients with generalized dermatoses.[8]

In many cases of suspected malignant lesions, a teleconsultant using a store-and-forward system can establish a correct diagnosis and even obtain sufficient information to plan the surgical intervention (type of anesthesia, surgical technique, etc). Consequently, in the field of surgical dermatology, teledermatology offers added value as a complementary tool for the assessment and presurgical management of patients with skin cancer. This application, known as presurgical teledermatology (PSTD), has been evaluated in an earlier study, which reported favorable results in terms of diagnostic reliability and clinical effectiveness.[9] The chief advantages reported for this application were the reductions in both time to surgery (wait time) and the number of visits involving travel for patients in special clinical and social situations.[9]

The economic analysis described in this study is part of a broader overall evaluation of the use of store-and-forward teledermatology as a tool for remote presurgical management and preparation of patients with nonmelanoma skin cancer.[9]

Materials and Methods

The teledermatology network covering the area served by the Virgen Macarena Hospital in Seville, Spain, (Área Hospitalaria Virgen Macarena) links the primary care centers of 20 health districts with the hospital's dermatology department via the corporate intranet of the Andalusian public health service (Sistema Sanitario Público Andaluz). Store-and-forward teledermatology is currently being used as a complementary tool for the triage of patients with suspected malignant lesions and the management of patient referral from the primary care center to the hospital.[1,2,10,11]

Our economic analysis was based on cost-identification and cost-effectiveness analyses and took a societal economic perspective. We used intention-to-treat analysis and took into account incremental costs. To analyze the cost of PSTD, we analyzed the data from a nonrandomized sample comprising all the patients whose care was managed with the teledermatology system during the study period. The results obtained were compared with the costs on both primary and specialist levels of managing the same number of patients using the conventional referral system.

The study was carried out between March 2005 and February 2006 with the participation of the primary health care centers using the teledermatology system. The study protocol and the descriptive analysis of the reliability and clinical effectiveness of the teledermatology system have been described in an earlier study.[9]

Given the societal perspective of the analysis, in addition to the costs incurred by the institutions delivering the health care we also took into account the economic impact of the teledermatology program on the patients in terms of the cost of travel and lost work time.[12]

The protocol specified the inclusion in the analysis of PSTD of all the patients assessed by teleconsultation who had a lesion requiring surgical treatment under local or regional anesthesia and fulfilled at least 1 of the following criteria: a) presented a lesion correctly diagnosed as nonmelanoma cancer. Telediagnosis was considered to be correct when the teledermatologist specified a diagnostic confidence level of 3 on a 3-point scale[1]; b) presented a

Figure 1. Activity map for presurgical teledermatology and the conventional referral system. Cost PC indicates cost of the initial visit to the primary care center; Cost PSPC, cost of the presurgical management of the patient in the primary care center; Cost PSD, cost of presurgical management of the patient in the Dermatology Department; Cost TCPC, cost of the preparation and submission of the teleconsultation in the primary care center; Cost TCD, cost of the dermatologist's assessment of the teleconsultation; CostH, cost incurred by the loss of work time; CostT, cost of transport.
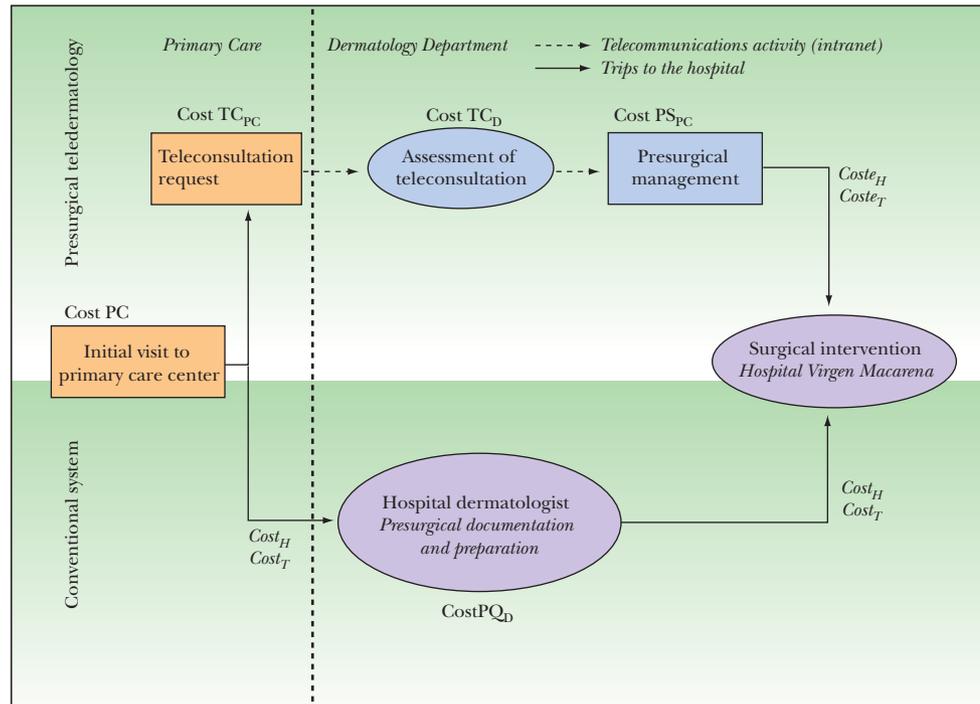
rapidly growing vascular lesion (for example pyogenic granuloma). Lesions possibly caused by major reconstructive surgery and those consistent with a diagnosis of melanoma were excluded from the PSTD analysis.

All the patients who were managed using teleconsulting during the study and who fulfilled the aforementioned inclusion criteria were included in the economic analysis.

As a first step before undertaking the economic analysis we mapped all the activities involved in the process including both the direct health care expenditures (health care procedures and interventions) and the nonmedical costs (the cost of travel for patients with skin cancer in the 2 modalities being compared: PSTD and conventional face-to-face consultation) (Figure). Indirect health care costs were not included.

On the basis of this activity map, a specific cost was assigned to each of the activities and trips involved in the process. The cost of a trip included both the cost of travel and the cost associated with lost work time.

Since one of the stated objectives of the teledermatology system was to minimize the number of unnecessary trips, particularly among patients with impediments to travel, 2 subgroups were also analyzed. The first of these included the patients without impediments to travel and the second those who presented limitations or would encounter difficulties in traveling to the hospital (bedridden patients and those in other incapacitating situations) and required home treatment and medical transport.

When assigning the health care costs we used the public prices fixed by the pertinent health authority (Orden de la Consejería de Salud; BOJA no. 96; May 19, 2005)[13] and assigned an analogous cost to the items not specified by this body (the preparation and assessment of the teleconsultations) on the basis of the time spent on these tasks, the personnel involved, and the health care setting (primary care facility or dermatology department) (Table 1). The differences in the cost of primary care shown in Table 1 arise from the need for a home visit (in some cases involving digital photography of the lesion depending on the modality).

The calculation of travel costs took into account the type of transportation used (public, private, or medical transport), the distance to the hospital, and the location of the primary care center (urban or interurban), and was based on the official published fares for public transportation and the price of medical transportation as fixed by the order cited above.[13,14] The mean cost of travel excluding trips involving medical transport was €6.34 per trip, irrespective of the town or locality where travel originated. The mean cost of medical transport was €91.19 per trip.

The calculation of the cost incurred through loss of work time was based on the minimum wage (as per Royal Decree 2388/04, Official State Journal 31-12-2004, no. 315) and the loss of an entire work day was computed for each hospital visit (€17.10 /d).[15]

The cost of acquiring the infrastructure necessary for PSTD (telecommunications, information technology, and

Table 1. Cost of Personnel and Health Care in the 2 Modalities Compared (Presurgical Teledermatology and Conventional Care)

	Teledermatology e/Patient		Conventional Referral System e/patient	
	Patient With No Difficulty Traveling	*Patient With Impediments to Travel*	*Patient With No Difficulty Traveling*	*Patient With Impediment to Travel*
Cost PC	41.77	62.67	41.77	50.12
Cost TC_{PC}	16.68	16.68	–	–
Cost TC_D	14.63	14.63	–	–
Cost PS_{PC}	26.11	37.60		
Cost PS_D			145.92	145.92

Abbreviations: Cost PC, cost of the initial visit to the primary health care center; Cost PS_D: cost of presurgical patient management in the hospital dermatology department; Cost PS_{PC}, cost of presurgical patient management in the primary care center; Cost TC_D, cost of the dermatologist's assessment of the teleconsultation; Cost TC_{PC}, cost of the preparation and submission of the teleconsultation in the primary care center.

Table 2. Cost-Identification Analysis

	Teledermatology €		Conventional Referral System €	
	Patient With No Difficulty Traveling	*Patient With Impediments to Travel*	*Patient With No Difficulty Traveling*	*Patient With Impediment to Travel*
Cost PC	41.77	62.67	41.77	50.12
Cost TCP_C	16.68	16.68	–	–
Cost TC_D	14.63	14.63	–	–
Cost PS_{PC}	26.11	37.6	–	–
Cost PS_D	–	–	145.92	145.92
$Cost_T$	6.34	91.19	12.68	182.38
$Cost_H$	17.1	17.1	34.2	34.2
$Cost_E$	4.9	4.9	–	–
Unit cost (e/patient)	127.53	244.77	234.57	412.62
	156.4		278.42	
Total cost	12 880.53 No. = 101	8 077.41 No. = 33	23 691.57 No. = 101	13 616.46 No. = 33
	20 957.94 No. = 134		37 308.03 No. = 134	

Abbreviations: $Cost_E$, cost of telecommunications equipment; $Cost_H$, cost of lost work time; $Cost_T$, cost of travel; Cost PC, cost of the initial visit to the primary health care center; Cost PS_D: cost of presurgical patient management in the hospital dermatology department; Cost PS_{PC}, cost of presurgical patient management in the primary care center; Cost TC_D, cost of the dermatologist's assessment of the teleconsultation; Cost TC_{PC}, cost of the preparation and submission of the teleconsultation in the primary care center.

digital photography equipment) was not included in the analysis because the system used had been implemented earlier to support a teledermatology program already functioning in our area.[1] We did, however, include the cost of equipment depreciation and obsolescence, attributing an mean cost for these items of €4.90 per teleconsultation (Table 2). The information technology equipment was depreciated over 3 years, giving rise to a depreciation of 33.33% of the initial cost during the study period.

The implementation of PSTD did not involve the creation of a dedicated or specific telecommunications infrastructure or any expansion of the health authority's existing corporate intranet. The cost of using the intranet for teleconsulting was insignificant in the context of the overall cost of the network to the public health care system; the impact of teledermatology on the total overhead was so minimal–amounting to only a few cents–that this item was excluded from the cost identification analysis.

Based on the costs described above, the cost identification analysis yielded the following results:

1. Total cost of care in euros for the 134 patients broken down into the following 4 categories: a) PSTD in patients with no difficulties in traveling; b) PSTD in patients with impediments to travel; c) conventional in-person consultation process in patients with no difficulties in traveling; and d) conventional consult process in patients with impediments to travel.
2. Unit cost or mean cost of the healthcare process per patient for each modality and subgroup.
3. The mean incremental cost (δt_{cost}) is the difference between the cost per patient of conventional treatment (cost$_{CONV}$) and the cost of PSTD (cost$_{PSTD}$) calculated according to the following formula:

$$\delta t_{cost} = cost_{PSTD} - cost_{CONV}$$

4. The cost ratio of the 2 modalities is the ratio of the most expensive modality to the least expensive modality, which expresses how much more expensive one is than the other. The formula used to calculate this ratio was as follows:

$$\text{Ratio} = \frac{\text{mean cost of the most expensive modality}}{\text{mean cost of the least expensive modality}}$$

Cost-Effectiveness Analysis

The measure of effectiveness used in the cost effectiveness analysis was the time to final surgery.[12] For both consultation modalities, time to surgery (or wait time) was defined as the number of calendar days that elapsed between the initial primary care consultation and the surgical intervention. Taking into account the mean wait times for surgery in both PSTD and the conventional referral system reported in the descriptive study of this project,[9] the cost or saving generated by the increased effectiveness was quantified, or, in other words, the cost-effectiveness of each modality was established using the following formulas:

1. The increment in effectiveness ($\delta t effectiveness)$, defined as the difference between the mean time to surgery in the PSTD system (wait$_{PSTD}$) and in the conventional referral system (wait$_{CONV}$) calculated according to the following formula:

$$\delta t effectiveness = wait_{PSTD} - wait_{CONV}$$

2. The mean cost-effectiveness ratio, a variable that relates the mean cost per patient to the mean wait time for each modality. As the mean time to intervention is a measure of effectiveness with a decreasing absolute value, it was used as the denominator for this ratio (1/wait time) according to the following formula:

$$\text{Mean cost-effectiveness ratio} = \frac{\text{mean cost per patient}}{1/\text{mean wait time}}$$

3. The incremental cost-effectiveness ratio, a variable that relates the increase in cost between the least expensive and the most expensive modality to the increase in effectiveness achieved, providing information about the cost or saving achieved by the new health care delivery system per patient and per unit of effectiveness, that is, per patient and per day of wait time saved. This variable was calculated using the following formula:

$$\text{Ratio} = \frac{\text{mean incremental cost}}{\text{increment of effectiveness}}$$

Statistical significance was set at a level of $P<.05$, and significant differences were determined using the χ^2 test and the t test.

Results

In total, 134 patients were treated using the PSTD system during the 12 months of the study. The mean age of the patients was 70.25 years (95% confidence interval [CI], 67.90-72.60 years; range 31-97 years), and there were more men (61.2%) than women (38.8%).[9] The mean time to surgical intervention for the patients managed by PSTD was 26.10 days (95% CI, 24.51-27.70 days). The patients who were managed using teledermatology made only 1 trip to the hospital. In the group managed using the conventional consult process, mean time to surgery for the patients with nonmelanoma cancer was 60.57 days (95% CI, 56.20-64.93 days; $P<.001$).[9]

The allocation of a specific cost to each of the activities and procedures included in the activity map was the basis of the cost identification analysis. Table 2 shows the detailed unit costs and the total cost of the health care provided to all the patients managed by either PSTD or the conventional referral system. Significant differences were found between the cost of care using PSTD and using the conventional process ($P<.05$) (Table 2).

The cost ratio between the 2 modalities revealed that conventional care was 1.78 times more costly than PSTD. In the group of patients who had no difficulty traveling, conventional care was 1.84 times more costly, while, in the group of those with impediments to travel, conventional care was 1.68 times more expensive than PSTD.

Table 3. Cost-Effectiveness Analysis

	Presurgical Teleconsultation	Conventional Care
Mean cost per patient, €	156.40	278.42
Mean wait time, d	26.10	60.57
1/mean wait time	0.04	0.02
Cost-effectiveness ratio	3910.00	13 921.00
Mean incremental cost, € $\Delta_{tcost} = cost_{PSTD} - cost_{CONV}$	−122.02	
Mean incremental effectiveness, d $\Delta_{teffectiveness} = wait_{PSTD} - wait_{CONV}$	−34.47	
Incremental cost-effectiveness ratio $\Delta_{teffectiveness}$	€3.54/patient/day saved	

Abbreviations: $cost_{CONV}$, unit cost of care using the conventional referral system; $cost_{PSTD}$, unit cost of care using presurgical teledermatology; $wait_{CONV}$, time to surgery in the conventional referral system; $wait_{PSTD}$, time to surgery in the teledermatology system.

Table 4. Cost-Effectiveness Analysis in Patients with Impediments to Travel

	Presurgical Teleconsultation	Conventional Care
Mean cost per patient, €	244.77	412.62
Mean wait time, d	26.10	60.57
1/mean wait time	0.03	0.01
Cost-effectiveness ratio	8159	41 262
Mean incremental cost, € $\Delta cost = cost_{PSTD} - cost_{CONV}$	−167.85	
Mean incremental effectiveness, $\Delta effectiveness = wait_{PSTD} - wait_{CONV}$	−34.47	
Incremental cost-effectiveness ratio $\Delta cost/\Delta effectiveness$	€4.87/patient/day saved	

Abbreviations: $cost_{CONV}$, unit cost of care using the conventional referral system; $cost_{PSTD}$, unit cost of care using presurgical teledermatology; $wait_{CONV}$, time to surgery in the conventional referral system; $wait_{PSTD}$, time to surgery in the teledermatology system.

Table 5. Cost-Effectiveness Analysis in Patients Without Impediments to Travel

	Presurgical Teleconsultation	Conventional Care
Mean cost per patient, €	127.53	234.57
Mean wait time, d	26.1	60.57
1/mean wait time	0.04	0.02
Cost-effectiveness ratio	3188.25	11 728.5
Mean incremental cost, € $\Delta cost = cost_{PSTD} - cost_{CONV}$	−107.04	
Mean incremental effectiveness, d $dt effectiveness = wait_{PSTD} - wait_{CONV}$	− 34.47	
Incremental cost-effectiveness ratio $\Delta cost/\Delta effectiveness$	€3.10/patient/day saved	

Abbreviations: $cost_{CONV}$, unit cost of care using the conventional referral system; $cost_{PSTD}$, unit cost of care using presurgical teledermatology; $wait_{CONV}$, time to surgery in the conventional referral system; $wait_{PSTD}$, time to surgery in the teledermatology system.

Cost-Effectiveness Analysis

Using the time to surgery, that is the mean wait time that elapsed between the initial primary care consultation and the eventual surgical intervention, as a measure of effectiveness, the relationship between these measures of effectiveness and the cost incurred to achieve these effects are described in Tables 3, 4, and 5.

Since the mean time to surgery is a measure of effectiveness with an absolute value that decreases as effectiveness increases, this variable was used as the denominator for the cost-effectiveness ratios (1/wait time). PSTD was found to be more cost-effective than the conventional consult process, with a saving of €3.54 per patient and per day of wait time avoided for PSTD as compared to the conventional referral system (Table 3). This saving was greater in patients with impediments to travel than in patients who had no difficulty traveling to the hospital (€4.87 compared to €3.10; *P*<.05) (Tables 4 and 5).

Discussion

The economic analysis provides information from a study of a series of patients whose routine care was carried out using a store-and-forward teledermatology system for presurgical assessment in a public health care setting equipped with telecommunications infrastructure (corporate intranet).[9]

In the context of the regional hospital setting and the societal perspective adopted in the analysis, this study shows store-and-forward teledermatology to be both an economically advantageous and cost effective platform for the processes involved in the presurgical management of patients with nonmelanoma cancer. Overall, PSTD was 1.78 times more economical than the conventional referral system as a method for managing patients with nonmelanoma cancer (€156.40/patient compared to €278.42/patient) (Table 2). The cost also decreased substantially in patients with a physical limitation that made it difficult for them to travel to the hospital, making PSTD 1.68 times less costly than conventional care (€244.77/patient compared to €412.62/patient) (Table 2). Patients with physical handicaps generally required medical transport to attend consultations and this situation generated a much higher cost than that associated with public or private transport (Table 2). This reduces the cost ratio in this group of patients because, while the overall number of trips was reduced, the higher cost of the medical transport required for these patients gives rise to a reduction in the difference between the 2 modalities. Furthermore, the care of bedridden patients was also made more expensive by the home visits required by these patients in the early phases of the process.

Although there has been no prior experience with the use of teledermatology in presurgical assessment and management, the economic results of the use of teledermatology has been analyzed in earlier studies.[16-18] The results most similar to those obtained in this study were reported for a store-and-forward teledermatology system shown to be 1.70 times more expensive than conventional care, but with a better cost-effectiveness ratio than the traditional system.[19]

The incremental cost-effectiveness ratio revealed a substantial saving both for patients without impediments to travel and for those with reduced mobility (€3.10 and €4.87 per patient and per day of wait time avoided, respectively). In this case, however, in contrast to the cost ratio, the saving was greater in the patients with impediments to travel because the calculation of the incremental cost-effectiveness ratio is based on the most important measure of effectiveness, that is, the reduction in wait time, which was the same for both subgroups.

In addition to the savings in the cost of patient care achieved with PSTD, the saving in travel is also notable, not only in economic terms but also in the quality of care as perceived by the patients and by the family and carers of elderly bedridden patients. In this group, the transfer of a patient, whether in a private vehicle or an ambulance, represents a substantial disruption of the patient's daily routine. The use of teleconsultation as a referral system reduces the need to physically move the patient to a minimum, that is, once on the day of the surgical intervention. In these patients, preoperative testing and postoperative wound care are carried out in the patient's home by nursing personnel, thus optimizing the use of primary care resources already in place, such as home care services and programs for monitoring oral anticoagulant treatment.

The significant difference between the 2 modalities in time to surgical intervention (60.57 days versus 26.10 days; *P*<.001) is the chief factor in the improvement found in cost-effectiveness when teledermatology was used as a presurgical tool.[9] Although the time to surgery is not a final outcome directly related to the clinical course of the disease, it is deemed to be an appropriate intermediate outcome that can be used as a measure of clinical effectiveness in economic analyses.[1,12,19]

It should be noted that the time to intervention is defined as the interval between a patient's initial consultation in primary care and the day of the surgical intervention in the hospital. In the case of PSTD, the period that was actually shortened significantly was the interval between the initial primary care consultation and first contact with a dermatologist,[1,8] because preoperative management takes the same amount of time in both modalities.[1,9]

Finally, the following limitations and considerations should be taken into account in the appropriate interpretation and extrapolation of the results of this study.

1. Since we used an intention-to-treat analysis, costs were included for all patients scheduled for surgery whether or not the operation was eventually performed.
2. The costs were determined using a modeling method in which average costs were used to calculate the nonmedical direct costs. In addition, the cost identification analysis

included a number of estimates because a variety of methods were used to obtain cost information. The cost of travel for a companion was not taken into account in the calculation of the expense associated with travel and lost work time. The unemployment rates in the study population were not taken into account when calculating the number of lost work days. Consequently, lost work time was calculated for all patients irrespective of whether they were retired or disabled. Moreover, given the difficulties involved in gathering information concerning real patient salaries, we based this valuation on the minimum wage in Spain. It should be noted, however, that most of the calculations carried out were optimistic and favored the conventional referral system since they all led to the reduction of the cost of the face-to-face consult process as compared to the PSTD system.

3. The PSTD system evaluated in this study was a specific application of a store-and-forward teledermatology system that had already been implemented and was operative in a public hospital equipped with a corporate intranet. This circumstance made it possible to develop the teledermatology application without incurring any additional overheads in terms of telecommunication structures or equipment purchase.

Conclusion

The results of this study suggest that in a public health care system with a telecommunications infrastructure (corporate intranet), store-and-forward teledermatology applied to the preparation and presurgical planning in patients with skin cancer is more cost-effective than the conventional face-to-face process.

Conflicts of Interest
The authors declare no conflicts of interest.

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