

# Use of Smartphones in Telemedicine: Comparative Study Between Standard and Teledermatological Evaluation of High-Complex Care Hospital Inpatients

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## Abstract

**Background:** It is estimated that there are around 7 billion mobile phone subscriptions worldwide. Considering the availability and convenience, it appears to be a suitable device for store-and-forward (SF) consultations. **Introduction:** Although teledermatology has been suggested as an effective way of reducing costs and providing otherwise inaccessible expert evaluation, most studies have relied on high cost and high technological means. **Materials and Methods:** We conducted a study with inpatients that required dermatological evaluation in a high-complexity university hospital, accessing the correlation between traditional face-to-face evaluation and SF teledermatology, with data and pictures collected by medical students using smartphone cameras and then sent to consultants by e-mail. **Results:** For 2 months, we evaluated 100 patients and, as a result, the total agreement between both consultation modalities was 54%, the partial agreement was 27%, and the disagreement was 19%. **Discussion:** This study points out that SF teledermatology with the use of mobile phone is comparable to traditional face-to-face evaluation. Furthermore, most of the disagreements were probably related to the inexperience of the medical residents. **Conclusion:** Our study suggests that a smartphone-based teledermatology inpatient consultation model could be a reasonable option for hospitals lacking dermatological services. Also, it may be as or more effective than face-to-face consultations, if performed by a more experienced dermatologist. When feasible, photographing training should be performed.

**Keywords:** e-health, dermatology, teledermatology, telemedicine, telehealth

## Introduction

Telemedicine has the potential of improving access to specialist medical services and minimize costs and, because of its visual nature, dermatology appears to be an ideal specialty for telemedicine. Teledermatology can be carried out in real-time using videoconferencing (VC) systems or asynchronously using store-and-forward (SF) systems, a modality in which clinical images are obtained by the physician, stored, and then forwarded to the specialist for later assessment. VC consumes more time and resources and the results can be similar to those of SF teleconsultation, which is considered the most cost effective method of teledermatology.<sup>1-4</sup>

Although dermatology is primarily an outpatient specialty, the value of dermatologists as consultants within the hospital setting is increasing, considering that 20% of the general population have skin diseases,<sup>5</sup> regardless of the condition that led to hospitalization. A prospective study recorded data from hospital dermatology consultation requests over a period of 4 months and evaluated 313 requests.<sup>6</sup> For 169 consultations (54%), complaints were resolved with a single visit and only 39% of the patients required dermatological follow-up after discharge from the hospital, suggesting that most of them had common diseases and a clinical diagnosis was sufficient to enable treatment by the referring physician.

In nearly all of the published studies on the reliability of SF, patient's clinical history and their photographs were not obtained by primary care physicians, but rather by experts.<sup>7</sup> In these studies, pictures were taken by a medical student, under the direction of a dermatologist, by dermatology residents, or by professional photographers.<sup>8-10</sup> Also, almost all studies were conducted using specific software and physicians received training before data collection.<sup>11</sup> A systematic review of Warshaw et al. showed 65% of agreement between SF and face-to-face consultations.<sup>12</sup> Nevertheless, in this review the use of mobile phones was considered ineligible.

In our study, we intended to evaluate the reliability of SF teledermatology in inpatient dermatological consultations at a high-complexity university hospital, using mobile phone camera and no previous training, with a realistic, inexpensive,

and easily reproducible teledermatology model. We created a situation in which nondermatologists, with no previous dermatological photographing practice, sent pictures to be evaluated by dermatologists, simulating the inpatient consultation service, where the evaluations are requested by other specialties.

Materials and Methods

The study was conducted between January and April 2015 at the Hospital das Clínicas of the University of São Paulo. We included inpatients visited by the traditional face-to-face consultation performed by dermatology residents. Traditional consultation services are carried out by three third-year dermatology residents in this hospital. After observing all patients, the residents usually discuss their clinical impressions with a more skilled dermatologist. We collected the residents' first formulated clinical hypotheses before discussion. Patients were also visited by two medical students of the last year, with only graduation dermatological knowledge who collected selected clinical data (Table 1) and pictures of their skin lesions, using mobile phone camera. A Samsung Galaxy s4 and an Apple iPhone 4, with cameras of 13 and 5 megapixels (MPs), respectively, were used without prior technical instruction. No description of dermatological examination was provided. The full resolution pictures and clinical data were then sent to an e-mail provided by the information technology division of our hospital. Two senior dermatologists that were not involved in the traditional inpatients consultation service later evaluated and formulated the clinical hypothesis.

The correspondence between the hypothesis from the traditional consultant service and SF teledermatology was established by a third dermatologist as in "total agreement," "partial agreement," or "nonagreement" with regard to the

traditional consultation. A "total agreement" was considered when all the hypotheses from the traditional consultation were considered by the SF evaluation. If some, but not all the hypotheses were considered, the case was ranked as "partial agreement." In case of no matching hypotheses, the evaluations were classified as "nonagreement." The third dermatologist attempted to explain the reason for disagreement, by pointing out poor technical quality of the photographs, lacking of clinical data or ancillary tests, or possible misdiagnosis of the traditional consultant service.

Patients without skin lesions by the time of clinical evaluation or those who were not evaluated in time both by the face-to-face and SF team, due to discharge or death, were considered ineligible for this study. This study was approved by the Human Research Ethics Committee (CAPPesp). Patients consented to be a part of the present study and they were diagnosed and treated by the traditional face-to-face consultation team, irrespective of the decisions made as part of this study.

Results

We evaluated 100 eligible patients from 27 different hospital sectors including emergency and wards. The most frequent requesting units were Internal Medicine (23%), Rheumatology (10%), Hematology (9%), Cardiology (7%), Infectious disease (6%), Neurology (6%), and Psychiatry (5%) (Table 2). Three patients were held in intensive care units.

Comparing the diagnoses proposed by traditional face-to-face consultation and SF, there were 54 total agreement (Supplementary Table S1; Supplementary Data are available online at www.liebertpub.com/tmj), 27 partial agreement (Supplementary Table S2), and 19 nonagreement evaluations. Considering all cases when at least one of the differential diagnoses was concordant, we had 81% of compatibility.

The third senior dermatologist suggested as the main reason for the 19 disagreement diagnoses, the possibility of traditional consultation incorrect diagnoses in 11 cases, lacking of clinical information and ancillary tests in 3 patients, and poor quality of the picture provided in 5 cases (Table 3).

Among those 19 incompatible cases, four of them were submitted to skin biopsy. The histopathological exam confirmed the SF hypothesis in three of them, and one was inconclusive. The diagnoses proposed by traditional and SF in those cases are shown in Table 4. In the majority of the incompatible cases (n = 15) the initial approach or treatment would be distinguished.

Considering the total and partial agreement cases, the most common diagnoses were infectious diseases (21%), followed

Table 1. Clinical Data Collected by the Medical Students
REQUEST FOR TELEDERMATOLOGY EVALUATION
Specialty responsible for the hospitalization
Reason for the dermatological consultation request
Estimated time of onset of the lesions
Associated symptoms
Reason for hospitalization
Comorbidities
Current pharmacological treatment and estimated time of onset

**Table 2. Distribution of the Evaluation Requests Among the Hospital Units**

REFERRAL SERVICES	N (%)
Internal Medicine	23 (23)
Rheumatology	10 (10)
Hematology	9 (9)
Cardiology	7 (7)
Infectious Diseases	6 (6)
Psychiatric	5 (5)
Endocrinology	5 (5)
Neurology	6 (6)
Pediatrics	4 (4)
Obstetrics	4 (4)
Nephrology	3 (3)
Renal Transplantation Unit	3 (3)
Geriatrics	2 (2)
Otorhinolaryngology	2 (2)
Surgery Emergency	2 (2)
Liver Transplantation Unit	2 (2)
Pediatric Urology	1 (1)
Pneumology	1 (1)
Orthopedics	1 (1)
Anesthesiology Intensive Care	1 (1)
Vascular Surgery	1 (1)
Ophthalmology	1 (1)
Gastroenterology	1 (1)

by eczemas (10%), and cutaneous adverse drug reaction (9%) (Table 5).

## Discussion

The role of telemedicine in healthcare has progressively increased. As dermatology consultation basically relies on visual elements, this technology can be especially useful in this area. In developing countries, where the access to dermatologists can be limited, teledermatology could be useful for triage purposes, reducing unnecessary in-person visits and costs. Easily captured mobile phone images can be sent by e-mail and make this care model very convenient.

The International Telecommunications Union estimates that there are 7 billion mobile phone subscriptions worldwide. Even in developing countries, mobile cellular penetration is

**Table 3. Reason Suggested for the Disagreement Diagnoses**

REASON FOR DISAGREEMENT	HYPOTHESES (TRADITIONAL CONSULTATION × SF TELEDERMATOLOGY)
Poor quality of pictures	
1	Seborrheic dermatitis and poikiloderma × dermatomyositis
2	Herpes simplex × herpes zoster
3	Herpes simplex × herpes zoster
4	Acne × without lesions
5	Seborrheic keratosis × senile purpura
Lacking of data or ancillary tests	
6	Pediculosis × seborrheic dermatitis
7	Residual lesions × lichen sclerosus et atrophicus or scleroderma
8	Septic vasculitis × leukocytoclastic vasculitis and blistering diseases
9	Lichen simplex chronicus × nummular eczema
10	Seborrheic dermatitis × vitiligo
11	Miliaria × hypersensitivity reaction
12	Xerosis × digital ulcer related to lupus
SF correct diagnosis	
13	Proteus syndrome × epidermal nevus
14	Residual eczema × drug-induced reaction
15	Dermatophytosis × impetigo
16	Cutaneous metastasis × lymphoma
17	Epidermal cyst × fistula
18	Granular parakeratosis × Gougerot and Carteaud papillomatosis
19	Lichen simplex chronicus × tinea or intertrigo
SF, store-and-forward.	

more than 90%. Considering its availability, low weight, good quality of cameras, no need of previous training, easy multi-media sharing through Internet, and lower cost, mobile phone use has many advantages when compared to standard digital cameras, and it can be a very good tool to be used in SF consultations.<sup>13</sup>

In Brazil, there are some teledermatology projects involving strategies for long-distance education, tele-assistance, and teleconsultation.<sup>14</sup> In a recent Brazilian telemedicine study, 20% of all requests involved dermatological complaints. Most of them originated from small cities and were requested by

**Table 4. Incompatible Cases Submitted to Skin Biopsy**

TRADITIONAL VS. SF HYPOTHESES	HISTOPATHOLOGY
Cutaneous metastasis vs. lymphoma	Lymphoma
Epidermal cyst vs. fistula	Fistula
Granular parakeratosis vs. Gougerot and Carteaud papillomatosis	Gougerot and Carteaud papillomatosis
Septic vasculitis vs. leukocytoclastic vasculitis or bullous pemphigoid or other blistering diseases	Inconclusive

nonmedical health professionals, indicating lack of access to physicians, a common problem in developing countries.<sup>15</sup>

Although the criteria for agreement differs significantly between studies comparing SF with traditional consultation, many of them show very high agreement rates, usually more than 65%.<sup>11,16–18</sup> Those high rates could be a reflection of the fact that pictures were taken by dermatologist residents or photographers previously trained to take standardized photos using specific apps and cameras.<sup>7,19–21</sup> Considering that our study was conducted without such conditions, one could easily assume that the main reason for lower agreement rates would be lack of training or adequate equipment.

Nonetheless, in the present study, the main reason pointed by the third senior dermatologist for disagreement was the possibility of incorrect diagnosis by the traditional consultant

**Table 5. The Most Common Diagnoses Established, Considering the Total and Partial Agreement Cases**

MOST COMMON DIAGNOSES	N (%)
Infectious diseases	21 (25.9)
Eczema/dermatitis	10 (12.3)
Cutaneous adverse drug reaction	9 (11.1)
Psoriasis	5 (6.2)
Vasculopathy diseases	4 (4.9)
Panniculitis	4 (4.9)
Adnexal diseases	4 (4.9)
Nonmelanoma skin cancer	3 (3.7)
Connective tissue disease	2 (2.5)
Benign cutaneous neoplasm	2 (2.5)
Immunobullous disorders	2 (2.5)
Urticaria/angioedema	1 (1.2)
Others	14 (17.3)

service rather than by SF consultation in 11 cases. Indeed this could be observed in three of the discordant cases that, after histopathological exam, were proved to be compatible with the SF hypothesis (cases 16, 17, and 18 in *Table 3*), reinforcing this assumption. In eight other cases (9, 10, 11, 12, 13, 14, 15, and 19) the clinical pictures supported the SF hypothesis.

The third senior dermatologist was not able to determine which diagnosis was correct in eight cases. Among those, five cases had pictures that were considered to be of bad quality or nonrepresentative of the disease, and three patients demanded in-person evaluation or ancillary tests to establish the correct diagnosis. Probably the resolution of the pictures was not responsible for the disagreements, considering that 15 of the 19 incompatible cases were photographed with the 13 MP camera. In two cases of disagreement, herpes simplex and herpes zoster were considered (cases 2 and 3), but lack of photographs representing the characteristic distribution of lesions possibly led to a misdiagnosis. Another reason for disagreement was the fact that the traditional team diagnosed other skin lesions apart from those originally requested to be evaluated (cases 1 and 5), so some patients lack pictures of them and were not examined for the same lesions by SF. Residual lesions or mild manifestations can be difficult to evaluate by pictures (case 4). Cases 6, 7, and 8 lack additional information or clinical tests to be conclusive. The definitive diagnosis of case 8 was not established.

The most frequent diagnoses in our study were infectious diseases, eczemas, and drug reactions, respectively. In other epidemiological inpatient studies, the three most frequent diagnoses were the same, but eczema was more common than infectious diseases.<sup>5,6</sup>

Infectious diseases are common in outpatients, especially superficial mycosis and bacterial infections. In our study, it was even more frequent considering it was conducted in a high-complexity care university hospital, with some immunosuppressed and critical patients. Eczema is a prevalent disease and is also frequently diagnosed in inpatients, as they stay bedridden longer, and have catheters, adhesive tapes, diapers, dressing occlusions, body creams, and topical drugs in contact to their skin. Drug reaction is a particularly common inpatient complication, related to the amount of drugs initiated during hospitalization, as symptomatic analgesics and nonsteroidal anti-inflammatory drugs and pharmacological interaction.

As well as other published studies, most requests came from Internal Medicine. This is probably related to the greater number of patients admitted to their care when compared to other units.<sup>5,6</sup> In our study, there was a significant number of Hematology requests, related to immunosuppression leading

to infectious diseases. All nine patients were immunosuppressed, being four of them previously submitted to bone marrow transplantation, four under induction therapy previous to bone marrow transplantation, and one was under specific chemotherapy for aplastic anemia.

Neurology is also a common referral service. This can be explained by a greater number of bedridden patients, favoring infectious diseases and eczemas, and the use of neuroleptics usually implied in cutaneous reactions. Another ward that most requested dermatological consultation was Rheumatology, reflecting the prevalence of connective tissue diseases with cutaneous manifestations.

The limitations of our study include the different resolutions of the pictures taken by the medical students. Also, teledermatologists had distinct degrees of experience. Finally, the process of determining the cause for the disagreement using a single person was subjective. Besides, the in-person evaluation was performed by residents, and the teledermatological by senior dermatologists. A study performed by seeing a patient through a teledermatology consult system and the same dermatologist seeing the same patient face to face in a dermatology clinic at a tertiary medical center showed a diagnostic correlation between teledermatology and in-person consultation of 70% for complete agreement, 20.6% for partial agreement, and 9.4% for disagreement.<sup>22</sup> Our lower total agreement rate could be explained by the different accuracy of diagnoses performed by the residents when compared to the dermatologists. A prior study reported a 53% concordance between the diagnoses performed by residents and attending dermatologists responding to SF teledermatology consults submitted by primary care.<sup>23</sup>

## Conclusions

The results of our study showed evidence that probably a smartphone-based teledermatology model is comparable to the ones using high-cost and high technological cameras. Regarding the human resources, a previous basic orientation could improve the feasibility of SF teledermatology, considering that some cases were improperly evaluated because of the lack of pictures that represented accurately the disease. Probably more embracing images, including scalp, nails, mucosa, and full-body pictures would enable SF to visualize, besides the elementary lesion, its pattern of distribution and achieve a correct diagnosis.

Furthermore, it is possible that a SF teledermatology inpatient consultation performed by senior dermatologists could be as or more effective than traditional evaluation performed only by inexperienced residents. Therefore, in a university hospital, this model of SF could also be a tool to assist the senior

dermatologist in supervising the inpatient consultations performed by the residents, avoiding possible misdiagnoses and sorting the patients who should be evaluated by the assistant in person. This would be beneficial especially in those cases where inpatients are discharged before completion of dermatological evaluation.

Also, SF smartphone-based teledermatology could be implemented in hospitals without a dermatological inpatient evaluation service. In this scenario, referring physicians would send pictures and clinical data to a skilled dermatologist that would be responsible for deciding whether to introduce dermatological treatment or recommend an in-person consultation.<sup>24</sup> The present study supported previous epidemiological data regarding dermatological disease prevalence among inpatients of specific clinic units of a high-complex hospital. Therefore, it reinforces the need of a dermatological evaluation of these patients. In the current work, we suggested that this assessment could be provided by SF teledermatology even when a dermatologist is available at this setting,<sup>25</sup> leading to a better outcome and better use of the capacity of specialist personnel. We hope that in the future, this pilot study will inspire more research in the area, embracing more services and for a longer period of time to validate the present findings.

## Disclosure Statement

No competing financial interests exist.

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