Use of teledermatology by dermatology hospitalists is effective in the diagnosis and management of inpatient disease

Colleen K. Gabel, BS,[a] Emily Nguyen, BS,[a] Ryan Karmouta, MD, MBA,[b] Kristina J. Liu, MD, MHS,[c] Guohai Zhou, PhD,[d] Allireza Alloo, MD,[e] Ryan Arakaki, MD,[f] Yevgeniy Balagula, MD,[g] Alina G. Bridges, DO,[h] Edward W. Cowen, MD, MHSc,[i] Mark Denis P. Davis, MD,[h] Alisa Femia, MD,[j] Joanna Harp, MD,[k] Benjamin Kaffenberger, MD,[l] Jesse J. Keller, MD,[m] Bernice Y. Kwong, MD,[n] Alina Markova, MD,[o] Melissa Mauskar, MD,[p] Robert Micheletti, MD,[q] Arash Mostaghimi, MD, MPH,[d] Joseph Pierson, MD,[r] Misha Rosenbach, MD,[q] Zachary Schwager, MD,[s] Lucia Seminario-Vidal, MD, PhD,[t] Victoria R. Sharon, MD, DTMH,[e] Philip I. Song, MD,[u] Lindsay C. Strowd, MD,[v] Andrew C. Walls, MD,[d] Karolyn A. Wanat, MD,[w] David A. Wetter, MD,[h] Scott Worswick, MD,[x] Carolyn Ziemer, MD, MPH,[y] Joseph Kvedar, MD,[a] Anar Mikailov, MD,[z] and Daniela Kroshinsky, MD, MPH[a]

Boston and Burlington, Massachusetts; Los Angeles, San Francisco, Stanford, and Palo Alto, California; New Hyde Park, Bronx, and New York, New York; Rochester, Minnesota; Bethesda, Maryland; Columbus, Ohio; Portland, Oregon; Dallas, Texas; Philadelphia, Pennsylvania; Burlington, Vermont; Tampa, Florida; Winston-Salem and Chapel Hill, North Carolina; and Milwaukee, Wisconsin

Background: Patient outcomes are improved when dermatologists provide inpatient consultations. Inpatient access to dermatologists is limited, illustrating an opportunity to use teledermatology. Little is known about the ability of dermatologists to accurately diagnose disease and manage inpatients with teledermatology, particularly when using nondermatologist-generated clinical data.

Methods: This prospective study assessed the ability of teledermatology to diagnose disease and manage 41 dermatology consultations from a large urban tertiary care center, using internal medicine referral documentation and photographs. Twenty-seven dermatology hospitalists were surveyed. Interrater agreement was assessed by the κ statistic.

Results: There was substantial agreement between in-person and teledermatology assessment of the diagnosis with differential diagnosis (median κ = 0.83), substantial agreement in laboratory evaluation

From the Department of Dermatology, Massachusetts General Hospital, Boston[a]; Division of Dermatology, University of California—Los Angeles[b]; Department of Dermatology[c] and Center for Clinical Investigation,[d] Brigham and Women's Hospital, Boston; Department of Dermatology, Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, New Hyde Park[e]; Department of Dermatology, University of California—San Francisco[f]; Department of Medicine, Division of Dermatology, Montefiore Medical Center, Bronx[g]; Department of Dermatology, Mayo Clinic, Rochester[h]; Dermatology Branch, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, Bethesda[i]; Department of Dermatology, New York University School of Medicine[j]; Department of Dermatology, Weill Cornell Medicine, New York[k]; Division of Dermatology, Department of Internal Medicine, The Ohio State University, Columbus[l]; Department of Dermatology, Oregon Health & Science University, Portland[m]; Department of Dermatology, Stanford University School of Medicine[n]; Department of Dermatology, Memorial Sloan Kettering Cancer Center, New York[o]; Department of Dermatology, University of Texas Southwestern Medical Center, Dallas[p]; Department of Dermatology, University of Pennsylvania School of Medicine, Philadelphia[q]; Dermatology Division, University of Vermont Medical Center, Burlington[r]; Department of Dermatology, Lahey Hospital and Medical Center, Burlington[s]; Department of Dermatology and Cutaneous Surgery, University of South Florida Morsani College of Medicine, Tampa[t]; Department of Dermatology, Palo Alto Medical Foundation[u]; Department of Dermatology, Wake Forest Baptist Health, Winston-Salem[v]; Department of Dermatology, Medical College of Wisconsin, Milwaukee[w]; Department of Dermatology, Keck School of Medicine at the University of Southern California, Los Angeles[x]; Department of Dermatology, University of North Carolina, Chapel Hill[y]; and Department of Dermatology, Beth Israel Lahey Health, Burlington.[z]

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Correspondence to: Daniela Kroshinsky, MD, MPH, Department of Dermatology, Massachusetts General Hospital, 50 Staniford St, 2nd Floor, Boston, MA 02114. E-mail: dkroshinsky@partners.org.

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decisions (median κ = 0.67), almost perfect agreement in imaging decisions (median κ = 1.0), and moderate agreement in biopsy decisions (median κ = 0.43). There was almost perfect agreement in treatment (median κ = 1.0), but no agreement in follow-up planning (median κ = 0.0). There was no association between raw photograph quality and the primary plus differential diagnosis or primary diagnosis alone.

Limitations: Selection bias and single-center nature.

Conclusions: Teledermatology may be effective in the inpatient setting, with concordant diagnosis, evaluation, and management decisions. (J Am Acad Dermatol 2021;84:1547-53.)

Key words: dermatology consultations; dermatology hospitalists; inpatient dermatology; store-and-forward; teledermatology; telemedicine.

BACKGROUND

Teledermatology is the remote dermatologic assessment of patients in real time ("live interactive"), by accessing stored data ("store and forward"), or a combination of the 2 ("hybrid"), with worldwide applications.[1] Teledermatology has been studied in general triage, consultation in remote locations, and monitoring of chronic skin conditions.[1] In addition to increased access to dermatologists, potential benefits of store-and-forward teledermatology include cost reduction because of fewer face-to-face consultations,[2] reduced travel time and opportunity cost caused by missed work,[3-5] and reduced contagion spread amid infectious disease outbreaks.

CAPSULE SUMMARY

- Inpatient access to dermatologists is limited, highlighting an opportunity to use teledermatology within the inpatient setting.
- Teledermatology in the inpatient setting may be a clinically acceptable option for diagnosis, evaluation, and management. This may represent a novel and effective option for hospitals.

Significant clinical evidence supports the outpatient use of store-and-forward teledermatology.[2-10] In contrast, teledermatology has been studied in the inpatient setting to a limited degree. A significant practice gap exists between the demand for inpatient dermatology services and access to dermatologists,[11,12] often a source of frustration for inpatient providers and patients. Dermatology hospitalists represent a clinical group with expertise in complex medical dermatology and the diagnosis and management of skin diseases affecting hospitalized patients. Involvement of dermatology hospitalists in the care of hospitalized patients has been found to improve patient outcomes.[13] In a subset of cases, inpatient teledermatology reduces time for the primary medical team to receive a response for a dermatology consultation.[14]

Dermatologist interest in inpatient teledermatology is high. A survey of attending physicians demonstrated that 61.5% of these dermatologists agreed or strongly agreed that teledermatology helps inpatient care.[15] Another study found that 95% of hospital and emergency department practitioners would use a teledermatology consultation service if available; however, only 5% believed that teledermatology would be equivalent to a face-to-face consultation.[16] This finding supports the need for additional studies evaluating inpatient teledermatology, which may shift perception and encourage adoption of inpatient teledermatology.

This study investigates the diagnostic and management agreement between inpatient face-to-face and store-and-forward teledermatology evaluations using remote digital evaluations for hospital-based dermatology consultations.

METHODS

Eligible patients for this study were admitted to Massachusetts General Hospital between July and August 2013 and had a dermatology consultation staffed by a dermatology hospitalist with more than 6 years of inpatient experience, defined as the primary dermatologist. This yielded a sample of 108 patients. Only consultations with digital images and nondermatologic evaluations involving the dermatologic complaint were included. Cases were selected if the accuracy of the primary dermatologist's diagnosis was able to be confirmed according to testing, response to therapy, and final diagnosis at discharge. In accordance with these inclusion criteria, a total of 42 patients were initially included (Fig 1). One case was excluded from analysis to preserve the generalizability of study results[17] because this patient presented with multiple concomitant dermatologic complaints and the

Abbreviations used:

CI: confidence interval
IQR: interquartile range

documentation did not specify the focus of the dermatology consultation.

For teledermatology review, data abstractors not involved in the care of the included patients packaged patient data into surveys by unique numeric patient identifiers. Each survey set contained 7 individual cases, randomly assigned to each survey set from the total case pool. Each case contained the relevant history and physical examination notes generated by a nondermatologic internal medicine or emergency medicine provider. In addition, all data such as laboratory studies, imaging, microbiology, pathology, and digital images up to the day of the consultation that would have been available to the primary dermatologist were included. Finally, a diagnosis/management questionnaire was included. The order of case examination within each survey set was fixed across all teledermatologists. Patient identifiers were uniquely created and stored safely.

Only nondermatologic patient history and physical examination notes were included to mimic actual settings. Photographs were captured primarily by dermatology residents from the Harvard Combined Dermatology Residency. Camera use was heterogenous and included Sony (Tokyo, Japan) NEX5N 12MP and 5MP iPad Mini (Apple, Cupertino, CA). Images were obtained by using both the original digital images and screen images from the electronic medical record. Study data were collected and managed with Research Electronic Data Capture tools (version 9.5.23) hosted at Partners.[18,19]

The packaged cases were sent to 27 experienced dermatology hospitalists in order of response to request for participation at various academic institutions across the United States. Each remote teledermatologist received 6 to 7 cases within a secure Research Electronic Data Capture survey (Supplemental Fig 1, available via Mendeley at https://doi.org/10.17632/rnk3pyk24g.1). Each clinical case was evaluated by 4 to 5 teledermatologists.

The surveys included the option to list a primary diagnosis as well as a maximum of 3 differential diagnoses. The evaluation and management plans offered were as follows: biopsy; topical therapy; systemic/oral therapy; microbiology; laboratory evaluations; transfer to the burn unit, if not already there; recommend continued patient monitoring as an inpatient; and recommend follow-up as outpatient for dermatologic condition. Once the teledermatologist selected a treatment plan, he or she was prompted for free-text details. Both the correct mode and type of therapy were assessed. If the selected treatment differed between the primary dermatologist and the teledermatologist but both options were within the accepted standard of care for that disease, these treatments were considered concordant. This was to minimize the effect of stylistic practice differences in grading appropriateness.

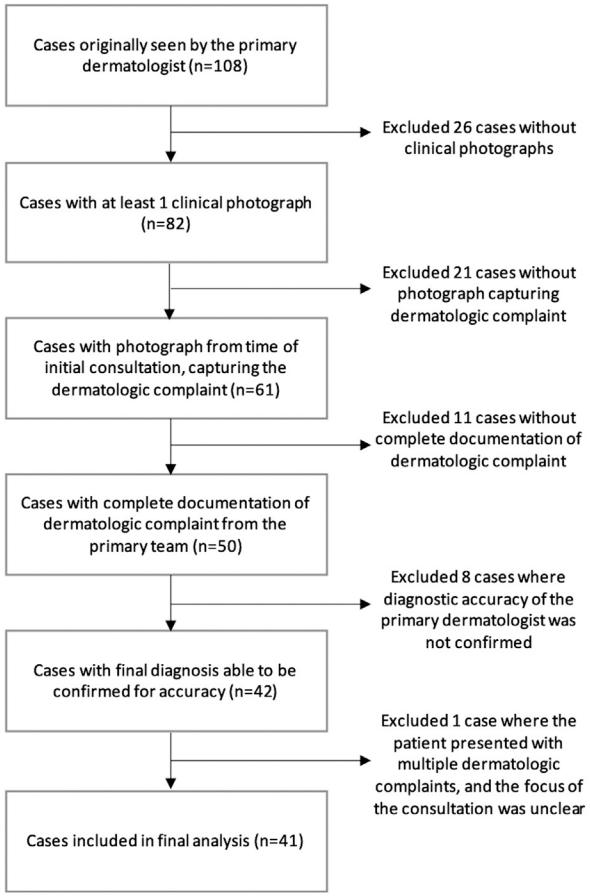

Fig 1. Selection criteria for cases to include in study.

The follow-up plan options were sign off and no need for follow-up as either an inpatient or outpatient; outpatient follow-up, no need for additional inpatient dermatology evaluations ("sign off"); no need to consult with the patient tomorrow, but evaluate whether the primary team requests it and ensure outpatient follow-up is planned; and consult with the patient tomorrow and follow closely. Teledermatologists rated their degree of comfort in managing the case as a dermatologist, as well as the quality of each image.

Outcomes measured were concordance between the primary dermatologist and the teledermatologists for the following: primary diagnosis, primary diagnosis plus differential diagnosis, decision to

biopsy, laboratory evaluation, imaging, treatment, and follow-up plan. Primary outcomes were defined as primary plus differential diagnostic concordance as well as management plan concordance, the rationale of which was to assess whether teledermatology could result in an appropriate evaluation and management leading to an effective outcome for the patient. Secondary outcomes were primary diagnostic concordance alone, as well as concordance in evaluation.

Primary diagnostic concordance was defined as agreement between the primary diagnosis provided by the primary dermatologist and the teledermatologist. Primary diagnostic plus differential diagnostic concordance was defined as the primary dermatologist's diagnosis being among the differential diagnosis of the teledermatologists in cases in which the primary diagnosis was discordant. The diagnoses themselves, and not diagnostic family, were used in calculating diagnostic concordance.

Statistical analysis

We calculated the prevalence-adjusted bias-adjusted κ[20] to quantify the concordance between the teledermatologists' and primary dermatologist's primary diagnosis, teledermatologists' primary diagnosis plus differential diagnosis and primary dermatologist's primary diagnosis, and teledermatologists' and primary dermatologist's management plan (separately for each of the 5 domains: biopsy, evaluation, imaging, treatment, and follow-up). The following criteria were used to assess significance: values less than or equal to 0 as indicating no agreement, 0.01 to 0.20 as none to slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as substantial, and 0.81 to 1.00 as almost perfect agreement.[21] We evaluated the associations of the calculated concordance with teledermatologists' years of experience and the reported photograph quality rating with the Pearson correlation coefficient. We also evaluated the associations of teledermatologists' level of comfort managing patients (with photographs and story alone) with photograph quality and teledermatologists' years of experience with the Wilcoxon's rank sum test. All were conducted with R (version 3.6.1, https://www.r-project.org/).

RESULTS

Table I depicts the characteristics of the patients included in the study surveys. The mean age was 54.1 years (standard deviation 23.7 years), 43.9% were women, 75.6% identified as white, and 68.3% identified as non-Hispanic or Latino. The final diagnoses are provided that were used to evaluate

Table I. Demographic characteristics of patients included in this study

Patient characteristics	Total (n = 41)
Age, mean (SD), y	54.1 (23.7)
Sex	
Women	18 (43.9)
Race	
Asian	2 (4.9)
Black	4 (9.8)
White	31 (75.6)
Unknown	4 (9.8)
Ethnicity	
Hispanic or Latino	0
Not Hispanic or Latino	28 (68.3)
Unknown	13 (31.7)
Dermatologic consultation characteristics	
Chronology of skin findings, median (IQR), d	4.0 (2.0—14.0)
Medications, mean (SD)	7.0 (3.7)
Final diagnostic categories	
Hypersensitivity	12 (29.3)
Contact dermatitis (4)	
Drug hypersensitivity (6)	
Erythema nodosum	
Urticaria	
Vascular	8 (19.5)
Calciphylaxis	
Henoch-Schönlein purpura	
Leukocytoclastic vasculitis	
Lipodermatosclerosis	
Small vessel vasculitis	
Stasis dermatitis (3)	
Infectious	7 (17.1)
Atypical mycobacterial infection	
Bullous impetigo	
Eczema herpeticum	
Herpes simplex virus	
Erythema chronicum migrans (2)	
Varicella zoster virus	
Inflammatory	7 (17.1)
Atopic dermatitis	
Gout	
Granulomatous disease	
Hidradenitis suppurativa	
Miliaria rubra	
Pyoderma gangrenosum (2)	
Neoplastic	3 (7.3)
Carcinoma erysipeloides	
Kaposi sarcoma	
Nevus lipomatosus	
Iatrogenic	2 (4.9)
Steroid acne	
Warfarin skin necrosis	
Traumatic	2 (4.9)
Bateman purpura	
Neurotic excoriations	

Data are presented as No. (%) unless otherwise indicated.
IQR, Interquartile range; *SD*, standard deviation.

diagnostic concordance. Diagnoses fell under a diverse set of diagnostic families, consisting of hypersensitivity reactions (29.3%), vascular (19.5%), infectious (17.1%), inflammatory (17.1%), neoplastic (7.3%), iatrogenic (4.9%), and traumatic (4.9%).

The teledermatologists were 40.7% women and practiced in diverse academic institutions from all geographic regions of the United States. The mean number of years' experience of each of the teledermatologists was 7.0 (standard deviation 1.2) (Table II). Out of all cases, 45.1% of teledermatologists were comfortable managing the case as teledermatologists. The mean number of differential diagnoses per teledermatologist per individual case was 2.6 (standard deviation 0.4).

There was fair concordance between primary dermatologist and teledermatologist primary diagnosis alone (median concordance 66.7%, interquartile range [IQR] 57.1%-78.6%; median κ = 0.33, IQR 0.14-0.57), with substantial agreement between primary dermatologist and teledermatologist primary plus differential diagnosis (median concordance 91.7%, IQR 85.7%-92.9%; median κ = 0.83, IQR 0.71-0.86). There was substantial agreement in pursuing additional laboratory evaluation (median concordance 85.7%, IQR 85.7%-92.9%; median κ = 0.67, IQR 0.43-0.79), and almost perfect agreement in imaging decisions (median concordance 100%, IQR 50.0%-100.0%; κ = 1.0, IQR 0.0-1.0). There was moderate agreement in the decision to biopsy (median concordance 71.4%, IQR 53.6%-85.7%; median κ = 0.43, IQR 0.07-0.71). There was almost perfect agreement in treatment plans (median concordance 100%, IQR 85.7%-100.0%; median κ = 1.0, IQR 0.67-1.0). There was no agreement in the follow-up plan (median concordance 50.0%, IQR 42.9%-66.7%; median κ = 0.0, IQR −0.14 to 0.14). Fig 2 depicts the distribution of κ values for agreement between the teledermatologists' and the primary dermatologist's primary diagnosis (Fig 2, *A*) and primary plus differential diagnosis (Fig 2, *B*).

There was no association between experience of the teledermatologist and primary plus differential diagnostic concordance (correlation = −0.27; 95% confidence interval [CI] −0.59 to 0.12, scatter plot in Supplemental Fig 2, corresponding Supplemental Table I) or primary diagnostic concordance (correlation = −0.27; 95% CI −0.59 to 0.12). There was also no association between years' experience of the teledermatologist and decision to pursue laboratory evaluation (correlation = −0.19; 95% CI −0.53 to 0.21), biopsy (correlation = −0.32; 95% CI −0.62 to 0.07), imaging (correlation = −0.19; 95% CI −0.53 to 0.21), treatment decisions (correlation = −0.18; 95% CI −0.53 to 0.21), and follow-up planning (correlation = −0.06; 95% CI −0.33 to 0.43).

There was no association between either raw photograph quality and the primary plus differential diagnosis (correlation = 0.008; 95% CI

Table II. Characteristics of the surveyed teledermatologists

Characteristic	Total (n = 27)
Sex, No. (%)	
Women	11 (40.7)
Geographic distribution, No. (%)	
Northeast	13 (48.2)
Midwest	5 (18.5)
West	5 (18.5)
Southeast	3 (11.1)
Southwest	1 (3.7)
Years of experience, mean (SD)	7.0 (1.2)

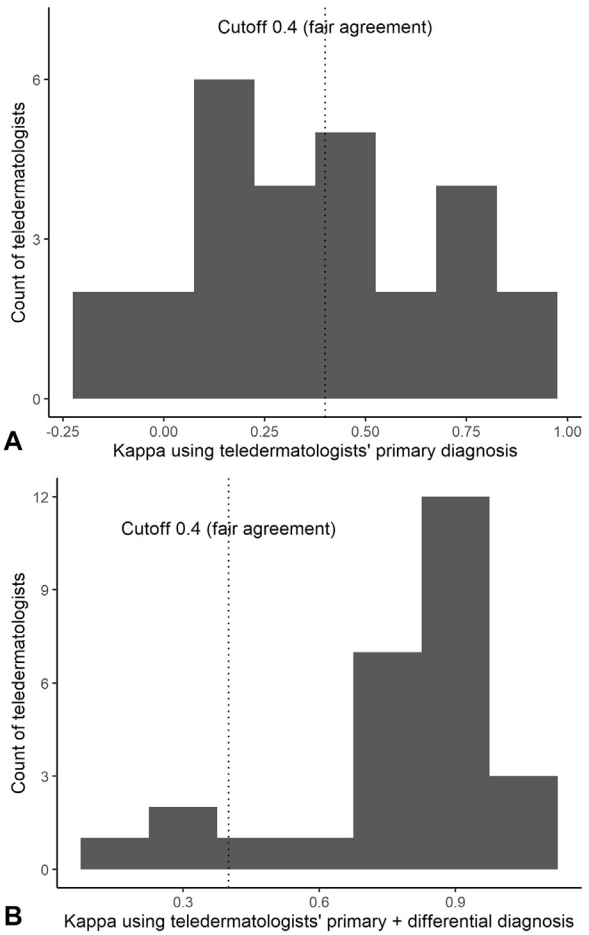

Fig 2. Distribution of κ values for agreement between the teledermatologists' and the primary dermatologist's primary diagnosis (**A**) and primary plus differential diagnosis (**B**).

−0.18 to 0.19) or primary diagnostic concordance alone (correlation = −0.07; 95% CI −0.12 to 0.25). The Wilcoxon's rank sum test of the teledermatologists' comfort with managing the case and years of experience indicated that teledermatologists with fewer years of experience were more likely to be comfortable managing the patients as teledermatologists (P = .04).

DISCUSSION

This study illustrates that store-and-forward teledermatology may be reliable in the academic inpatient setting, with strong agreement between primary dermatologist and teledermatologist for diagnosis, evaluation, and management.

The high concordance of primary plus differential diagnosis is in line with previous outpatient literature,[8,22] with studies demonstrating diagnostic concordance ranging from 41% to 100% for store-and-forward cases.[2] This finding builds on limited studies evaluating the use of teledermatology in the inpatient setting.[12,23,24] As with a previous study,[2] diagnostic concordance improved when the differential diagnosis was taken into account.

The decision by teledermatologists to pursue evaluation in this study was highly concordant, with substantial agreement in the laboratory evaluation desired. However, there was only moderate agreement in the decision to biopsy, which is in contrast with a previous inpatient teledermatology study finding a greater than 95% concordance in assessing need for biopsy.[12] This may be due to stylistic practice differences or individual comfort level.

The treatment plans offered by the teledermatologists were highly concordant with those of the primary dermatologist, suggesting that the outcomes of each patient may have been the same if managed by teledermatology, even in cases in which the primary diagnosis differed. This may be due to the high concordance of primary plus differential diagnosis, leading to treatment plans applicable to multiple diagnoses.

The baseline interdermatologist variability that occurs even with face-to-face consultations must also be taken into consideration because a previous study of face-to-face, clinic-based dermatologists found diagnostic testing to be 85% concordant, medical-based therapy to be 85% concordant, and clinic-based therapy 77% concordant.[22] Thus, some degree of discordance may be expected.

The lack of concordance between teledermatologists and the primary dermatologist for follow-up plans suggests that in-person evaluation may be needed before disposition planning. Stylistic differences also likely played a role. Patient-specific factors may have a role in disposition planning, such as access to resources and health literacy, which may contribute to the discordance between the primary dermatologist and the teledermatologists. Further study of follow-up planning is needed to elucidate whether teledermatology may be reliable for this use.

Photograph quality was not associated with primary diagnostic concordance or primary plus differential diagnostic concordance. This suggests that even in cases in which image quality is suboptimal, the reliability of teledermatology may not be affected. However, although the authors used images from heterogeneous sources, many photographs used in the study surveys met the minimum standards recommended for teledermatology.[25] Additionally, assessment of image quality was not broken down into detailed components, such as lighting, focus, or capture of clinically relevant information. Photograph quality and training in obtaining photographs may be needed to ensure good capture of the relevant areas when teledermatology is implemented because the study photographs were captured by dermatology resident physicians.

There was no association between experience of the teledermatologist and diagnostic concordance, illustrating the generalizability of teledermatology across all ages of practicing dermatologists.

There appeared to be a lack of agreement between concordance and the teledermatologists' level of comfort in managing each case as teledermatologists. The teledermatologists considered themselves comfortable less than half of the time; however, their survey responses often aligned with that of the primary dermatologist. This may be in part due to the novelty of teledermatology. The teledermatologists with fewer years of experience were more likely to be comfortable managing the case, aligning with previous literature,[26] reflecting an opportunity to use teledermatology even in novice practice settings. Similarly, teledermatology exposure in residency may correlate with comfort of use,[27] suggesting that early incorporation of teledermatology in training may facilitate its implementation.

One of the greatest strengths of this study is the large sample size of teledermatologists, mimicking the heterogeneity of applying teledermatology to actual practice settings. The distribution of diagnoses included in this study reflects that of common dermatology consultations.[13] Limitations of this study include its single-center nature and the fact that dermatology residents captured the clinical photographs. The dermatology residents may have

had a more thorough understanding of how to obtain a high-quality dermatology photograph than nondermatology staff, who would be submitting the teledermatology consultation in actual practice. Training of nondermatology staff in obtaining high-quality images may be needed. On the other hand, camera technology has likely improved and may lead to heightened quality of photographs in today's use of teledermatology. Further study is needed to determine best practices for implementing an inpatient teledermatology program.

In conclusion, teledermatology may be effective for managing dermatologic disease in the inpatient setting and leads to highly concordant diagnostic, evaluation, and management decisions when performed by experienced inpatient dermatologists. This may represent a novel and effective option for community hospitals and may be particularly applicable during times of concern for spread of infectious disease, such as during the 2019-2020 outbreak of the severe acute respiratory syndrome coronavirus 2.

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