Dermatological Diagnostic Acumen Improves with Use of a Simple Telemedicine System for Underserved Areas of South Africa

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Abstract

Objective: Telemedicine holds promise as a tool for improving the delivery of specialty care, especially in underserved regions, including those in South Africa. However, data that demonstrate the extent of its sustainable benefits to referring providers are currently insufficient. This study investigates whether utilization of a teledermatology network enhances the diagnostic acumen of primary care providers (PCPs) in underserved areas of South Africa.

Materials and Methods: A longitudinal descriptive pilot study was conducted after establishing a telemedicine network linking University of Cape Town dermatology consultants to six providers from five underserved primary care sites using store-and-forward technology between October 2004 and January 2007. Of 120 total referrals, trend analysis was performed using 72 sets of patient histories, digital images, and corresponding consultant responses to evaluate the diagnostic concordance between six PCPs and teleconsultants over 12 consecutive referrals. **Results:** Strong positive Spearman rank-order correlations were observed between the number of referrals sent per PCP and proportion of primary diagnostic agreement with teledermatologists, $r_s=0.86$ ($p < 0.001$). The mean primary diagnostic concordance trend that started at 13% for the first four referrals increased nearly fourfold after referring as few as nine patients to the network. **Conclusions:** If a simple and inexpensive teledermatology solution is carefully implemented in a resource-limited setting, an improvement of PCP diagnostic acumen can be achieved with a relatively small number of referrals. This educational benefit to referring PCPs could be sustainable and would ultimately enhance the quality of dermatological care in these underserved regions.

Key words: teledermatology, distance learning, dermatology

Introduction

Sub-Saharan Africa has long suffered from a huge burden of disease and limited resources. Significant deficiencies in access to basic healthcare, let alone specialty care, exist in many areas.^{1,2} In the 1980s, the human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) pandemic brought a bewildering twist to overburdened healthcare providers. At the end of 2007, 18.1% of adults aged 15–49 in South Africa were HIV infected.³ Skin diseases in this region, already a cause of significant morbidity and mortality before HIV/AIDS, had now become more prevalent, complex, and stigmatizing. Because of the skin's role in immunologic protection, it is no surprise that studies have shown that at least 90% of HIV-infected patients will develop skin disease during the course of their infection.⁴ A skin condition is commonly the first sign of HIV infection.⁴ Once HIV infection is established, the kind and number of cutaneous diseases can be used to gauge the stage of infection.⁴ Cutaneous conditions are often multiple, severe, and recalcitrant to standard therapy. As a result, a significant proportion of primary care providers (PCPs) in one U.S. study were unable to recognize skin signs associated with HIV infection.⁵

In contrast to widely available specialty care in the United Kingdom, Europe, and North America, medical care from specialists in sub-Saharan Africa is scarce.⁶ In South Africa, there is an average of one dermatologist to two million people within the public sector of healthcare that serves the majority of patients in the country.⁷ With such scarcity of dermatologists, a PCP who needs help with a skin-diseased patient often finds referral to a dermatologist impossible to deliver, owing to geographic distance and lack of funds to travel.

Despite the lack of specialty healthcare, information and communication technology continues to grow and reach more people in South Africa.⁸ For example, when this study was carried out in 2005, South Africa ranked 37th in the world in Internet use and 20th for cell phone users, despite a world ranking for gross domestic product (GDP) per capita of 94 (est. 2007).⁹ Many basic health centers are able to transmit digital images and clinical data securely via the Internet. Therefore, the availability of virtual medical support and education could significantly benefit PCPs in these underserved areas.

Teledermatology utilizing convenient and inexpensive store-and-forward (S&F) technology involves capturing patient images and electronically transmitting them asynchronously to a specialist who can render an opinion. As most dermatological consultation is not urgent, a turnaround of the consultant's opinion within 3–5 days was

very acceptable for the referring provider and the patient, particularly given the savings in travel cost and time to referral.^{10,11}

The real test of teledermatology will be in underserved regions, where provision of teledermatology services could have its greatest impact.¹² However, does shifting dermatological care from a busy PCP to a busy specialist, either in-person or via telemedicine, really unburden healthcare? Dermatologists are able to evaluate and diagnose skin conditions more efficiently and accurately, and a reasonable extension is that this leads to more directed and effective therapies.¹³ In resource-limited areas, better diagnostic acumen could minimize empirical treatments and reduce the need for repeated patient visits and depletion of limited medical resources. If PCP diagnostic acumen could be enhanced by using a network with prompt feedback by a specialist, this effect could be sustained beyond the involvement of the teleconsultative service.

In this study, we investigate whether utilization of a low-cost S&F teledermatology network enhances the diagnostic acumen of PCPs in underserved areas of South Africa.

Materials and Methods

This study was a pragmatic analysis comparing diagnostic concordance between referring PCPs and receiving teledermatologists from the beginning of network use to beyond the 12th referral. The study was approved by the University of Washington Institutional Review Board/Human Subjects Review Committee in Seattle, WA, and the University of Cape Town Ethics Committee in Cape Town, South Africa, and carried out under the advisement of the Medical Research Council of South Africa's Telemedicine Lead Program. All patients and PCP study participants provided written informed consent.

IDENTIFICATION OF HEALTHCARE SITES AND PROVIDERS

A sample of five teledermatology network referring sites were identified and established in underserved areas of South Africa. Site selection commenced on September 1, 2004, with the first referral sent in October 2004 and the last referral collected in January 2007. Inclusion criteria for the selected sites were lack of public sector face-to-face dermatological services in the area, a personal computer running Windows 98 or later operating system with password-protected e-mail access, an onsite healthcare provider with basic computer skills agreeing to use a telereferral system for dermatological problems, and a facility for securing electronic equipment and confidential medical information. PCPs self-selected to use the network. For practical reasons, a control group of network nonusers was not recruited and therefore not included in the analysis.

PROCEDURE AND EQUIPMENTS USED FOR S&F TELEDERMATOLOGY

The procedure for implementing this network and assessing its quality involved setting up digital imaging equipment and training appropriate PCPs at health centers or hospitals where in-person dermatological consultation was unavailable. Each site was provided an identical digital camera, the Canon PowerShot A430 (4-megapixel

resolution). After the providers received training in basic dermatological photography and image file handling, they transmitted images of their skin-diseased patients, relevant medical history, their clinical assessments, and the specific referring questions via password-protected, encrypted e-mail between the provincial departments of health Intranet to the teleconsultant's password-protected, encrypted e-mail address. An electronic clinical referral template was provided to each referring PCP to standardize information gathering. Not all providers chose to use this referral template for every referral. A teledermatologist in Cape Town (R.C.) reviewed the images and clinical information and sent back to the PCP his diagnostic opinion, management recommendations, feedback, and any relevant references using a template Teleconsultant Response form (*Supplementary Tables S1–S3*; Supplementary Data are available online at www.liebertonline.com/tmj). When appropriate, the teleconsultant recommended further confirmatory tests, such as tissue biopsies, skin scrapings, and serologies, to be performed and the follow-up findings to be reported. The follow-up results were then used to compare the teleconsultant's primary diagnoses that were offered at the time of initial response. Computing equipment for the receiving teleconsultant consisted of a standard desktop computer running the Windows XP operating system with a 19-inch cathode ray tube monitor, provided by the University of Cape Town Faculty of Health Sciences. The images were most often viewed using the Windows Fax and Image Viewer, a standard feature on Windows XP that allowed digital zoom and reorientation of images.

PATIENT AND PROVIDER QUESTIONNAIRES

A satisfaction questionnaire was used to assess qualitative and descriptive outcome measures that focused on patient and provider overall satisfaction, convenience, comfort level, educational value, and clinical improvement of the skin condition using the teledermatology system. Responses were categorized on a five-point Likert-type scale, ranging from strong agreement to strong disagreement. The surveys were administered in paper format and were adapted from ones previously used and validated by Williams et al.¹⁰ Both PCPs and patients were asked to complete the surveys presented at the time of initial patient visit and at the time of the follow-up visit.

TREND ANALYSIS

Trend and correlational analyses were performed on measures of both complete and partial diagnostic agreement. Complete agreement examined primary diagnoses as the single most likely assessment presented by PCPs and teledermatologists, and partial agreement included evaluation of differential diagnoses provided by the PCPs.

In evaluating complete agreement, primary diagnoses of presenting skin conditions were compared between PCPs and teledermatologists to assess changes in PCP diagnostic acumen with increasing use of the teledermatology service. Primary diagnoses, as reported on the referring providers' clinical histories, were used to analyze the educational trend, because, in a resource-limited setting, PCPs would most likely depend on their primary assess-

ment for patient management if they were unable to seek additional recommendations from specialists. A dichotomous variable (1 or 0) was used to categorize the agreement of primary diagnoses: a score of 1 was assigned if primary diagnosis provided by PCP agreed with that of teledermatologist, as reported on the Teleconsultant Response form, and a score of 0 was assigned if primary diagnosis did not agree or if the PCP did not provide an assessment. In assessing partial agreement, criteria set for complete agreement above was used and a score of 0.5 was assigned if PCP differential diagnoses agreed with primary diagnosis of teledermatologist.

For each provider, the first 12 consecutive referrals were analyzed for diagnostic concordance. Trends in diagnostic acumen were assessed by first calculating the average diagnostic score across all six providers for each referral. Next, nonparametric Spearman rank correlation was analyzed to find associations between diagnostic concordance and the number of referrals sent by the PCPs. The Spearman rank correlation is interpreted similarly to its parametric equivalent, the Pearson r , but does not assume that the populations of the assessed variables are normally distributed. This represents a conservative approach to analyze these data but one that is sufficiently robust and decreases the likelihood of unintended biases. Referral trend was also evaluated to detect changes in average number of dermatologic referrals sent by PCPs over time. Statistical Package for the Social Sciences version 15.0 was used for all statistical analyses.

Results

STUDY SITES AND PARTICIPANT CHARACTERISTICS

Six PCPs (five primary care physicians and one dermatology-trained nurse) from five network referring sites in South Africa sent 120 patient cases that were evaluated for the trend study. The established primary care sites were located in the towns of George (2 PCPs, 32 and 12 referrals) and Hermanus (1 dermatology-trained nurse, 26 referrals) in the Western Cape Province, Mthatha (1 PCP, 18 referrals) in the Eastern Cape, and Polokwane (1 PCP, 17 referrals) and Tzaneen (1 PCP, 15 referrals) in the province of Limpopo.

Table 1. Patient Characteristics

CHARACTERISTIC	MEAN ^a	
	N= 120	N= 72
Age, year (range)	35 (0–84)	35 (0–84)
Female, %	61	57
Adult (≥ 17 years), %	77	75
Known HIV-positive status, %	21	28

^aMean values were separately calculated for 120 total referrals and 72 referrals used for trend analysis.

HIV, human immunodeficiency virus.

Table 2. Digital Images Sent by Primary Care Providers

CHARACTERISTIC	MEAN ^a	
	N= 120	N= 72
Number of images per referral (95% CI)	4.0 (3.4–4.6)	4.4 (3.6–5.3)
Size (megabytes) per image (95% CI)	0.7 (0.6–0.8)	0.7 (0.6–0.8)
Quality: very good to excellent, %	79	75

^aMean values were separately calculated for 120 total referrals and 72 referrals used for trend analysis.

CI, confidence interval.

Patient characteristics, digital image evaluation, and other referral information are presented in *Tables 1–3*, separated by mean values calculated for the entire 120 referrals and 72 referrals used for trend analysis. Overall, both sets of values are comparable without apparent discrepancy. Characteristics of the patient population who participated in the teledermatology network are described in *Table 1*. For the 120 total referrals, the referred patients were 77% adults and 61% female. Most (82%) had darker skin types (Fitzpatrick photo-types IV–VI), a factor in the diagnosis of inflammatory skin conditions, which can present more subtly in more darkly pigmented skin than fairer skin.¹⁴ The skin conditions in question were mostly (95%) inflammatory or infectious lesions, with the remainder being solitary skin growths. Known HIV seropositive status of the patient population was 21%. HIV infection was uncovered in small number of patients referred.

DIGITAL IMAGE INFORMATION

Because bandwidth and large file size can be limiting factors in remote and underserved areas, we evaluated digital image informa-

Table 3. Referral Information Sent by Primary Care Providers

CHARACTERISTIC	MEAN ^a	
	N= 120	N= 72
Sufficient history provided, %	78	77
Primary diagnosis provided, %	78	80
Primary diagnostic concordance, % (95% CI) ^b	33 (25–42)	30 (19–40)
PCP referral form used, %	27	24

^aMean values were separately calculated for 120 total referrals and 72 referrals used for trend analysis.

^bMean primary diagnostic agreement was calculated between PCPs and teledermatologists.

PCP, primary care provider.

tion (Table 2). For every referral, an average of four images were sent with mean image size of 0.7 (95% confidence interval [CI], 0.6–0.8) megabytes per image. Most (79%) of the digital images sent were rated as very good or excellent in quality by the teledermatologists, 15% were fair or mixed quality, and 6% of the images were not interpretable, generally because the image was out of focus. Overall, resolution of images captured by the 4-megapixel digital cameras was considered satisfactory for the teledermatology system.

REFERRAL INFORMATION AND TELEDERMATOLOGIST RESPONSE TIME

An evaluation of clinical histories showed that sufficient medical histories and primary diagnoses were submitted by referring providers in most (78%) of the cases (Table 3). However, despite its availability, the clinical referral template provided by the teledermatology network was used in a minority (27%) of referrals and was perceived as requiring more time to complete. The site staffed solely by a nurse consistently used this template, whereas doctors continued to use a more informal history reporting style in the body of the e-mail sent. Delivery of responses by the teledermatologists to the referrals was 100%, and the average time of response was 4.7 days (95% CI, 3.7–5.7 days), which included weekends and time away on leave.

CONFIRMATORY TESTS FOR DIAGNOSTIC ACCURACY

To assess the diagnostic accuracy of the teledermatologist's opinion, PCPs were asked to obtain confirmatory tests, such as histopathologic findings of tissue biopsies, skin scrapings, and serologies, whenever appropriate, and were asked to provide the test results to the teleconsultant. This produced a total of nine follow-up responses. Evaluation of the confirmatory test results revealed that eight of nine (89%) cases agreed with the initial primary diagnoses offered by the teledermatologist.

SATISFACTION QUESTIONNAIRES

The patients and referring providers were also asked to complete a set of satisfaction questionnaires at the initial patient visit and at the time of follow-up visit. The response rate was low on the surveys, which were administered in paper format. We received by postal mail a total of 25% of the patient surveys and 15% of the PCP surveys for both the initial patient visit and the follow-up visit. Although results derived from a low number of survey respondents could introduce biases, a review of all of the returned questionnaires revealed a high level of patient and provider satisfaction with use of the teledermatology network. The referring providers indicated a strong level (100%) of overall satisfaction, convenience, improved patient outcome, and enhanced learning from the teleconsultation. Similarly, patients reported a high level of overall satisfaction (97%), convenience (100%), comfort with photography (80%), and improvement of the skin condition (100%) on their return visit. A face-to-face dermatology consultation was preferred by PCPs in 28% of surveys and by patients in 17% of surveys at the initial visit.

DIAGNOSTIC CONCORDANCE AND TRENDS

To determine whether PCPs who used the teledermatology network showed improvement with continued network usage, we analyzed changes in diagnostic concordance between PCPs and teledermatologists. Of 120 total cases, trend analysis was performed on the first 12 consecutive referrals from each of the six PCPs, resulting in inclusion of 72 referrals. As not all six providers referred more than 12 cases, the dataset was limited to be able to carry out analysis of the entire group without introducing bias related to discontinuation of network use by individual providers. Before evaluating for trends, the mean primary diagnostic concordance between PCPs and teledermatologists was separately calculated for the entire 120 referrals and the 72 referrals used for trend analysis, which showed statistically similar results of 33% (95% CI, 25%–42%) and 30% (95% CI, 19%–40%) agreement, respectively. For trends, Spearman rank correlations were used to explore associations between diagnostic concordance and the number of referrals made across time. A strong positive correlation of $r_s = 0.86$ ($p < 0.001$) was observed between the rank order of the referral sent per PCP ($n = 1$ st through 12th referral) and rank order of the complete diagnostic agreement, which considered only primary diagnoses (Fig. 1A). This relationship illustrated that the proportion of primary diagnostic concordance with teledermatologists started at an average of 13% for the first four referrals sent per referring clinician but increased to 50% by the 9th through 12th referral, showing a nearly fourfold increase. Moreover, another strong positive correlation of $r_s = 0.73$ ($p = 0.007$) was observed between the rank order of the first 12 referrals and the rank order of the partial agreement that considered concordance of both primary diagnoses and differential diagnoses (Fig. 1B). Concordance of partial agreement started at an average of 33% for the first four referrals and increased to 60% by the 9th through 12th referral. A moderate negative correlation of $r_s = -0.58$ ($p = 0.016$) was observed between the rank order of the average number of referrals sent by providers and collection month ($n = 1$ –17 months). Considered jointly, these findings provide preliminary evidence that diagnostic agreement increases with increased utilization of teledermatology service and the number of referrals decreases over time.

Discussion

This study demonstrates that use of a simple and inexpensive S&F teledermatology network is associated with a significant enhancement of the PCP diagnostic acumen in a relatively small number of referrals. A nearly fourfold improvement of PCPs' mean primary diagnostic agreement with the consulted teledermatologists occurs after referring as few as nine patients to the network. Although two studies from Australia evaluated diagnostic concordance between teledermatologists and general practitioners noting variable concordance rates of 35% and 49%, these values were averaged over the entire study period and did not show how the diagnostic agreement changed over time or with consistent use of the teledermatology service.^{15,16} Our study analyzes diagnostic concordance trends that

Fig. 1. Trend analysis of diagnostic concordance between primary care providers (PCPs) and teledermatologists with increased utilization of teledermatology service. Strong positive Spearman rank correlations are observed between the rank order of the referrals sent per PCP and proportion of **(A)** the complete diagnostic agreement, which considers only primary diagnoses ($r_s=0.86$, $p<0.001$), and **(B)** the partial diagnostic agreement, which includes both primary diagnoses and differential diagnoses ($r_s=0.73$, $p=0.007$). Each data point reflects an arithmetic average of diagnostic concordance across six PCPs

have not been published to date and investigates how S&F teledermatology service can provide needed educational and practice benefits to the referring PCPs.

One explanation for the findings in our study is that relevant, timely, patient-centered feedback from a specialist improves PCPs' pattern recognition and recall of previous dermatologic training. This is a major way that medical students and nurses learn clinical medicine: through apprenticed, patient-based experience that incorporates feedback, testing, evaluation, and role modeling. In addition, feedback and educational resources provided through the network could have stimulated self-directed learning specific to dermatology, thereby raising interest in the referring PCPs and promoting effectiveness in their clinical practice. A valid way to assess this expla-

nation would be to offer a pre- and post-network use test of the PCPs' diagnostic and management abilities using representative clinical examples of conditions likely to be seen in their practices. Although such testing was not offered in this study, developing a pragmatic and appropriate tool for evaluating the changes in PCP diagnostic and management abilities is an important consideration for future investigation.

As this study analyzed data from a proof-of-concept project, a number of limitations exist. A control group of PCPs who did not use the network over the same period of time with a comparison of concordance before and at the end of the study period would have added strength to the present analysis. A larger number of PCPs using the network over a longer period of time and sending a greater number of referrals would allow subgroup analysis. For example, a comparison in concordance change among physicians versus nurses would be relevant for selection of future sites to the network. Future assessment of this and similar networks in underresourced areas could consider these elements for study design.

Also, because of the descriptive nature of the study, a number of biases are possible. One possibility is selection bias. The PCPs may have selected cases for which they had higher confidence in their diagnostic impression. This could have contributed to apparent diagnostic enhancement. However, this is an unlikely factor as the administrative burden for referring a patient to the network in a resource-limited setting would discourage referrals where the PCP already had confidence in his or her diagnosis and treatment strategy. In fact, referring questions by the PCPs trended toward greater complexity and difficulty over time, as assessed by the teleconsultants.

Receiver bias is another consideration. The teleconsultant could have progressively agreed with the PCPs, as the PCPs improved their photographic technique or their use of dermatologic descriptive language over time. An assessment of the quality of digital images submitted by each referring PCP showed consistent quality throughout the study, with no detectable change across referrals (data not shown); therefore, the change observed in diagnostic concordance is not likely dependent on the change in photographic technique and image quality. In addition, the teledermatologist typically evaluated the digital images first for clinical pattern and morphology of the conditions and established differential diagnoses prior to reviewing the clinical histories provided by the PCPs. The differential diagnoses were then modified by patient history, with minimal influence from the referring clinician's description and impression of the skin condition. Further, most referrals were reviewed with other dermatology consultants after the response was returned to the PCPs to assess concordance between consultants. Therefore, receiver bias is not likely contributing to the apparent enhancement in diagnostic acumen seen in this study.

Can teledermatologists' assessments serve as a pragmatic gold standard? We assessed diagnostic accuracy of teledermatologists by comparing their primary diagnoses against follow-up results of all available biopsy and reference standard tests that were provided by

the PCPs postteleconsultation. Histopathologic results of biopsied tissues and findings from other reference standard tests (e.g., laboratory tests and skin scraping findings) showed that eight of nine (89%) cases agreed with teledermatologists' initial primary diagnoses. Although the sample size is small, this result is consistent with previously published data that used biopsy and other reference standard tests to demonstrate that both traditional clinic-based and SAF teledermatology consultations result in accurate diagnostic outcomes.^{17,18} Moreover, a recent randomized, controlled trial revealed that SAF teledermatology consultations produce similar clinical outcomes when compared with conventional clinic-based consultations.¹⁹ Taken together, evidences suggest that opinions of teledermatologists utilizing SAF technology could appropriately be used as a pragmatic gold standard.

One of the interesting correlations found in this study is the PCP referral trend. Data measured over a 17-month period showed a decline in number of referrals sent per PCP. Reasons for this decline are difficult to define, especially because the results of our PCP and patient satisfaction surveys are inconclusive. Whether the referral pattern depended on enthusiasm and novelty of teledermatology program that diminished over time or it depended on other administrative reasons needs investigation. However, a viable explanation to consider is that successful knowledge transfer from teledermatologists to the referring providers led to a decreased need to refer patients over time. One study assessed referral patterns in a global SAF telemedicine system and found similar trend of declining referral rates over a 4-year period.²⁰ The authors also reported some evidence that in recent years, the growth in global demand for telemedicine has been exponential, whereas the growth in available resources such as specialists has been linear. If the decline in referral trend observed in this study is attributable to true knowledge transfer, then the expansion of teledermatology practice could help alleviate the foreseeable imbalance in high service demand and low supply of dermatologists in our healthcare system worldwide. While logistical and cultural challenges in the developing world limit stringent research investigation, carefully implemented teledermatology solutions could help to create better access to healthcare with a lasting effect.

Ultimately, locally practicing PCPs play a key role in determining the quality of healthcare practice in underserved areas and need appropriate support. At the same time, limited resources in developing nations compel us to seek out pragmatic yet innovative strategies to deliver healthcare. Our study addresses these considerations and presents evidence that continued use of a simple and low-cost S&F teledermatology system improves the diagnostic acumen of referring PCPs. This educational and practice benefit to the referring providers could be sustainable and would enhance the dermatological care in various underserved regions.

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Disclosure Statement

No competing financial interests exist.

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