


## Original Investigation

# Cost and Utility Analysis of a Store-and-Forward Teledermatology Referral System

## A Randomized Clinical Trial

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**IMPORTANCE** The costs and utility of teledermatology are important features of implementation. Such an analysis requires a description of the perspective of the entity that will bear the cost.

**OBJECTIVE** To assess the costs and utility of a store-and-forward teledermatology referral process compared with a conventional referral process from the perspectives of the Department of Veterans Affairs (VA) and society.

**DESIGN, SETTING, AND PARTICIPANTS** Three hundred ninety-one randomized participants were referred from remote sites of primary care to the dermatology services of 2 VA medical facilities for ambulatory skin conditions from December 2008 through June 2010, and follow-up was completed in March 2011. The time trade-off utility measures and costs were collected during a 9-month period among participants in a 2-site parallel group randomized clinical trial. The perspectives of the VA and society were evaluated. The multiple imputation procedure or weighted means were used for missing data elements. Data were analyzed from January to July 2014.

**INTERVENTIONS** Referrals were managed using store-and-forward teledermatology or a conventional text-based referral process.

**MAIN OUTCOMES AND MEASURES** Total costs from the perspectives of the VA and society incurred during the 9-month follow-up were used to derive per-participant costs. Utility, using the time trade-off method, was the measure of effectiveness.

**RESULTS** From the VA perspective, the total cost for conventional referrals was \$66 145 (minimum, \$58 697; maximum, \$71 635), or \$338 (SD, \$291) per participant (196 participants); the total cost for teledermatology referrals was \$59 917 (minimum, \$51 794; maximum, \$70 398), or \$308 (SD, \$298) per participant (195 participants). The \$30 difference in per-participant cost was not statistically significant (95% CI, -\$79 to \$20). From the societal perspective, the total cost for conventional referrals was \$106 194 (minimum, \$98 746; maximum, \$111 684), or \$542 (SD, \$403) per participant (196 participants); the total cost for teledermatology referrals was \$89 523 (minimum, \$81 400; maximum, \$100 400) or \$460 (SD, \$428) per participant. This \$82 difference in per-participant cost was statistically significant (95% CI, -\$12 to -\$152). From baseline to the 9-month follow-up, the time trade-off utility value improved by 0.02 in the conventional referral group and 0.03 in the teledermatology group. This difference was not statistically significant ( $P = .50$ ).

**CONCLUSIONS AND RELEVANCE** Compared with conventional referrals, store-and-forward teledermatology referrals were performed at a comparable cost (VA perspective) or at a lower cost (societal perspective) with no evidence of a difference in utility as measured by the time trade-off method.

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Despite its relevance to delivery of health care, the economic impact of store-and-forward teledermatology has only modest representation in the medical literature. Understanding the economic impact of teledermatology is a valuable, if not an essential, feature for planning and ongoing evaluation of a teledermatology program. When reporting costs associated with a particular intervention, the perspective(s) of that analysis should be described. In terms of cost, *perspective* refers to those cost elements that affect, or are borne directly, by a particular entity (eg, health care systems, insurers, society).<sup>1,2</sup> In this study, we took the perspective of our setting, the US Department of Veterans Affairs (VA), and a societal perspective. Both perspectives were included because the Panel on Cost Effectiveness in Health and Medicine (hereinafter referred to as the Panel)<sup>1</sup> recommends conducting economic analyses that take into consideration the more comprehensive societal perspective, although analyses often include the point of view of relevant specific interests—the VA perspective in this case. When different perspectives are presented in an analysis, the Panel further recommends that results be compared side by side.<sup>1</sup>

The Panel also recommends using utility weights, numerical representations of preferences for different health conditions or outcomes, as the effectiveness component of cost-effectiveness analyses.<sup>1</sup> For the utility measure, we used the time trade-off method, a formal technique that was developed specifically for health care.<sup>3,4</sup> The time trade-off method determines whether an individual would trade a shorter portion of their life expectancy to be in perfect health compared with a longer period in their current health state. The utility weight that a person has for his or her current health state is reached when he or she is indifferent between the 2 alternatives. The time trade-off method is the preferred utility measure used to assess disease burden among dermatologic conditions.<sup>5</sup> In the context of a randomized clinical trial that also assessed quality of life and clinical course, we collected cost and utility data that compared a store-and-forward teledermatology referral process with a conventional referral process.

## Methods

### Design

The study consisted of a 2-site, parallel-group, randomized clinical trial that compared a store-and-forward teledermatology referral process with a conventional referral process. A simple randomization scheme, stratified by site, was used after a prerandomization checklist was completed by enrolling sites. The coordinating center generated the random allocation sequence and provided the randomization assignment to the enrolling sites after verification of the prerandomization checklist. The study intervention prevented masking to the randomization assignment. A copy of the trial protocol is found in the [Supplement](#).

As previously reported,<sup>6,7</sup> the study assessed the quality of life and clinical course as primary and secondary outcomes, respectively, with sample size estimates being based

on quality-of-life outcomes. In the present report, we focus on economic and utility outcomes. We collected incurred costs during the 9-month follow-up and the time trade-off utility method (as a measure of effectiveness). The study was approved by the institutional review boards of the Harry S. Truman Memorial Veterans' Hospital, Minneapolis Veterans Affairs Health Care System, Durham Veterans Affairs Medical Center, and Edward Hines Jr Veterans Affairs Hospital, and all participants provided written informed consent.

### Setting

The sites of dermatology care were the Harry S. Truman Memorial Veterans' Hospital in Columbia and the Minneapolis Veterans Affairs Health Care System in Minneapolis. Study participants were recruited from remote sites of primary care that refer patients for dermatology care to the dermatology services of these 2 facilities. Remote sites included 2 primary care sites located 25 and 27 miles from the Columbia facility and 1 primary care site located 66 miles from the Minneapolis facility. Eligibility criteria have been described previously.<sup>6,7</sup>

### Interventions

Study interventions, including the teledermatology and conventional referral processes, have been presented in detail previously.<sup>6,7</sup> In brief, consenting participants who were referred from 1 of the sites of primary care to 1 of the dermatology services were randomized to a teledermatology referral (teledermatology group) or a conventional referral (conventional referral group). The conventional referral process consisted of the referring clinician generating a text-based consultation to the dermatology service using the VA Computerized Patient Record System. The dermatology services typically schedule patients for a visit after receiving these consultations, thus requiring the patients to travel to the Columbia or Minneapolis facility. For participants randomized to teledermatology, the addition of a digital image set and standardized history were included with the electronic consultation. On review of a teledermatology referral, the participant was scheduled for an in-person dermatology clinic visit, or a diagnosis and/or management plan was provided to the referring clinician without scheduling an in-person visit to the dermatology clinic.

### Measurements and Outcomes

Participants were enrolled from December 2008 through June 2010. Participants were followed up and data were collected for 9 months after study enrollment, until March 2011. Incurred costs during the 9-month period related to the care of their referred dermatologic condition were recorded. A close-out visit was scheduled at month 9 for the purpose of collecting final data, including the time trade-off utility evaluation.

### Cost Elements and Economic Perspective

Cost elements were considered to be VA-incurred and other incurred costs. The VA-incurred costs represent the VA economic perspective, and the sum of VA-incurred and other incurred costs approximate a societal economic perspective. The cost elements from the VA perspective included (1) the teleder-

matology intervention or referral, (2) referral and follow-up visits to the dermatology clinic, (3) dermatologic medications prescribed, (4) travel cost reimbursement to patients paid by the VA, and (5) dermatology-related hospitalizations. To approximate the societal perspective, other incurred costs were added to the VA-incurred costs. Other incurred costs were represented by cost elements that included (1) dermatologic care sought outside of the VA system, (2) travel costs in seeking health care if not reimbursed by the VA, and (3) work or productivity loss owing to the patient missing work or losing productivity in seeking health care. For each perspective, the cost elements defined above were summed to generate a total cost with minimum and maximum values. The total cost and the ranges were used to generate per-participant costs resulting from the bootstrapped analysis as described below.

### VA-Incurred Costs

#### Intervention Costs

Because the per-participant cost for using the camera and flash to obtain images is negligible, we did not include the equipment cost in the total teledermatology intervention cost. The teledermatology intervention cost consists of labor input required to generate and review the teledermatology referrals. To obtain these data, we performed a 2-month (at the trial midpoint) time study on 22 participants. Imagers at each site logged the time needed to generate and review the images, obtain the standardized history, and upload the consultation information into the electronic medical record. Clinicians at the 2 medical centers logged the time needed to review the teledermatology consultation for the resident and the attending physician. These times were multiplied by the respective wage rates, including fringe benefits, to derive labor cost. Ranges of times and wage values observed at the Columbia and Minneapolis VA facilities were used to generate a weighted mean intervention cost, with observed minimum and maximum values, for each site and applied to the participants at their respective sites. In the provision of health care, other costs such as custodial services, utilities, and administrative costs that cannot be attributed directly to specific health care services (indirect costs) are also incurred. We used the VA's Decision Support System (DSS) administrative data set to collect total annual direct and indirect costs incurred by the dermatology clinics at the Columbia and Minneapolis sites to calculate a direct-to-indirect cost ratio. We applied this ratio to the per-patient labor cost to derive the per-patient teledermatology intervention cost. For participants in the conventional referral group, we used the initial dermatology clinic visit cost observed in the DSS data set as the intervention cost.

#### Dermatology Visit Costs

We collected information on the number of visits for each participant during the study period. The DSS allows each VA facility to report costs using its own methods, which allows for the possibility of site-to-site variation. For participants at the Minneapolis site, we observed a wide range of reported costs with several high outliers. Participants at the Columbia site,

on the other hand, incurred 1 of 2 possible costs. Therefore, we calculated a weighted mean cost using the frequency of observed costs, representing the minimum and maximum values, of Columbia participants and applied this cost to referral visits for all participants. This strategy standardized the cost of referral visits between sites and provided a value analogous to the reimbursement rates of the Centers for Medicare & Medicaid Services for clinic visits.<sup>8</sup>

#### Dermatology Medication Costs

To derive medication costs, we identified all drug class codes related to dermatology in the DSS Pharmacy Extract. The DSS Pharmacy Extract includes the cost of medication acquisition and dispensing. For medications that are mailed, mailing cost is reflected in the dispensing cost. A simplifying assumption stated that all identified drug classes dispensed among our participants were used for dermatology care of the referred condition. Biological agents were the exception because they are a high-cost item and their rare use made medical record review feasible. A medical record review was performed for each of the 4 biological drug class codes in the DSS, and costs were included only if the indication was for the consulted skin condition.

#### Reimbursed Travel Costs

For eligible patients, the VA reimbursed travel costs to seek medical care at VA facilities. Through self-report, participants indicated whether or not they received travel reimbursement from the VA and, if so, the amount of reimbursement they received. This dollar amount included the cost of round-trip travel to seek primary and dermatology care.

#### Other Incurred Costs

##### Travel Cost

Participants who did not report receiving VA travel reimbursement had their mileage estimated using distance in miles between the zip codes of their home address and the site of dermatology care. This mileage was multiplied by the total number of dermatology clinic visits made to derive the round-trip distance traveled. To monetize travel cost, we multiplied total distance traveled by \$0.235 per mile, which is the 2011 mileage rate the Internal Revenue Service allowed for deducting medical travel expenses.<sup>9</sup>

##### Loss of Productivity Cost

We asked participants to self-report how many hours were required to attend a dermatology clinic visit, including travel to and from the clinic, wait time, and time spent with physicians. The participants were given a dichotomous choice of 4 or 8 hours. To account for missing data, we calculated a weighted mean value from the reporting participants and substituted this value (4.7 hours) for nonreporting participants. Implicit in this assumption is that an opportunity cost in seeking health care could be spent on some other productive endeavor, such as employment. To monetize productivity loss, we multiplied the time required to seek dermatology care by the US mean hourly earnings of all employees as of June 2011, seasonally adjusted, for an unrevised value of \$23.04.<sup>10</sup>

## Dermatology Care

Participants were also asked to self-report if they sought dermatology care outside the VA system. To monetize care sought outside the VA system, we used the Centers for Medicare & Medicaid Services reimbursement rates of \$97 for first visits and \$65 for any subsequent follow-up visits.<sup>8</sup>

## Utility Measurement

To measure effectiveness, we used the time trade-off method to assess utility at baseline and at the 9-month follow-up. Time trade-off is a means of determining the quality of life one experiences in a given health state by assessing the equivalence point between living a longer life with the medical condition of interest vs a shorter life in perfect health. We asked participants to consider perfect health vs the skin condition that resulted in their referral to the dermatology clinic. Specifically, questioning began with the following: "If you could live the next 20 years with your current skin condition or 19 years with perfect health, which would you choose?" Bids were presented in 1-year decrements until the participant was no longer willing to trade off time to be in perfect health. The utility of a given skin condition was calculated as the ratio of the fewer years of perfect health they were willing to trade off to avoid spending 20 years with their skin condition. For example, if a participant was willing to spend 16 years with perfect health rather than 20 years with their skin condition, the utility value for their skin condition was 0.8 (16/20). Thus, the greater burden that the skin condition had on the participant's health produced a lower utility ratio.

## Statistical Analysis

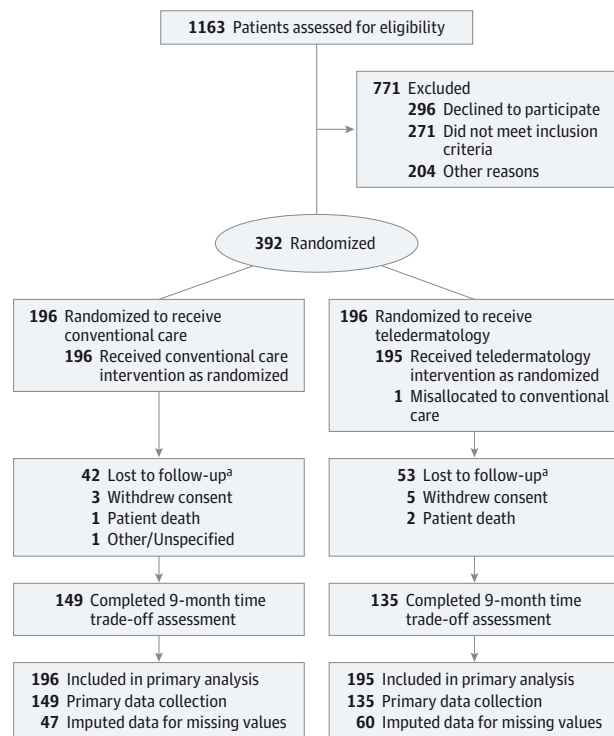
Data analysis was performed from January to July 2014. We applied standard descriptive statistics to the cost and utility measures. We calculated paired, 2-tailed *t* statistics ( $\alpha = .05$ ) to test for statistical significance in group mean differences. These analyses were conducted via spreadsheets using Microsoft Excel 2010 (Microsoft Corporation). We conducted bootstrapped analyses with 5000 iterations of the cost and utility measures using SAS statistical software (version 9.2; SAS Institute Inc) to generate CIs around the cost and utility point estimates.<sup>11</sup> We used the multiple imputation procedure in the SAS software to impute missing utility values.

## Results

### Recruitment and Participant Characteristics

Recruitment was conducted from December 2008 through June 2010 and was terminated when the scheduled enrollment deadline was met. Three hundred and ninety-two participants were randomized from the 1163 patients assessed for eligibility in the clinical trial (Figure). Costs incurred by 391 participants (196 in the conventional referral group and 195 in the teledermatology referral group) were included in the analysis, excluding 1 participant who was misrandomized to conventional care. The mean age of participants was 62.3 years. Three hundred and eighty-two participants (97.7%) were male, and 373 participants (95.4%) were non-Hispanic white with no

Figure. CONSORT Diagram



<sup>a</sup> Includes those participants who could not be located and those who could not be contacted or were unwilling to attend.

difference in baseline characteristics between randomization groups, as previously reported.<sup>6</sup>

## Cost

### Total Cost by Randomization Group

Participants in the conventional referral group had 303 dermatology clinic visits (mean cost, \$45 353) and those in the teledermatology referral group had 214 dermatology clinic visits (mean cost, \$32 032). The teledermatology group incurred a mean of \$5120 in referral cost. These intervention costs incurred for both randomization groups, with observed minimum and maximum values, are shown in Table 1.

Table 2 adds the cost of travel reimbursement by the VA, medication costs, travel costs, productivity loss costs, and costs of care sought outside the VA system to the intervention costs from Table 1. The weighted mean travel time of 4.7 hours was used for missing self-reports for 74 participants in the teledermatology group and 64 participants in the conventional referral group. Lower costs were incurred for the teledermatology group compared with the conventional referral group from the VA and societal perspectives.

### Per-Participant Cost

We calculated per-participant cost estimates using the bootstrap procedure to assess precision around the point estimates (Table 3). Participants in the conventional referral group incurred a mean VA-perspective cost of \$338 (SD, \$291), whereas participants in the teledermatology group incurred a mean cost of \$308

**Table 1. Intervention Costs Incurred by Referral Group**

Cost Element	Referral Group, Cost, \$					
	Conventional (n = 196)			Teledermatology (n = 195)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Teledermatology referrals	NA	NA	NA	5120	2258	11 724
Dermatology clinic visits	45 353	37 905	50 843	32 032	26 711	35 909
Intervention costs	45 353	37 905	50 843	37 152	28 969	47 633

Abbreviation: NA, not applicable.

**Table 2. VA Perspective and Societal Perspective Total Costs by Randomization Group<sup>a</sup>**

Cost Element	Referral Group, \$	
	Conventional	Teledermatology
VA perspective		
Intervention, mean (minimum/maximum)	45 353 (37 905/50 843)	37 152 (28 969/47 633)
Travel reimbursement	3591	3072
Dermatology medication	17 201	19 693
Total (minimum/maximum)	66 145 (58 697/71 635)	59 917 (51 794/70 398)
Other incurred		
Travel	6460	5732
Productivity	32 600	22 643
Care sought outside the VA	989	1231
Total	40 049	29 606
Societal perspective		
Total, mean (minimum/maximum)	106 194 (98 746/111 684)	89 523 (81 400/100 400)

Abbreviation: VA, Department of Veterans Affairs.

<sup>a</sup> Unless otherwise indicated, data are expressed as mean costs.

(SD, \$298). From the VA perspective, the per-participant cost was \$30 lower for the teledermatology group, but this difference was not statistically significant (95% CI, -\$79 to \$20). From a societal perspective, the mean per-participant cost was lower by \$82 for the teledermatology group, and this difference was statistically significant (95% CI, -\$152 to -\$12).

**Effectiveness**

Missing utility values were imputed for 47 of the 196 participants in the conventional referral group and 60 of 195 participants in the teledermatology group. At baseline, mean (SD) utility values for the conventional referral and teledermatology groups were 0.90 (0.18) and 0.90 (0.21), respectively. At 9 months, the mean (SD) utility values for the conventional referral and teledermatology groups were 0.92 (0.15) and 0.93 (0.12), respectively. Utility change scores are shown in Table 3. The 0.03 utility gain among the participants in the teledermatology group compared with the 0.02 gain among those in the conventional referral group was not statistically significant ( $P = .50$ ).

**Discussion**

A prior study performed in a VA<sup>12</sup> setting resulted in cost findings contrary to our findings. In that study, store-and-

**Table 3. Per-Participant Cost and Utility Change Score by Randomization Group**

Randomization Group	Perspective Cost, Mean (SD), \$		Change in Utility Score, Baseline to Month 9, Mean (SD) <sup>c</sup>
	VA <sup>a</sup>	Societal <sup>b</sup>	
Conventional	338 (291)	542 (403)	0.02 (0.18)
Teledermatology	308 (298)	460 (428)	0.03 (0.19)

Abbreviation: VA, Department of Veterans Affairs.

<sup>a</sup> The \$30 cost savings for teledermatology was not statistically significant (95% CI, -\$79 to \$20).

<sup>b</sup> The \$82 cost savings for teledermatology was statistically significant (95% CI, -\$152 to -\$12).

<sup>c</sup> Both randomization groups had a gain utility, but the difference between groups was not statistically significant ( $P = .50$ ).

forward teledermatology was the more costly alternative, with the mean cost per participant for teledermatology of \$36.40 vs \$21.40 for conventional referral from the VA perspective. From the societal perspective, the mean cost per participant was \$40.35 for teledermatology vs \$26.50 for conventional referral. The previous study<sup>12</sup> was limited by a design that only modeled a site-to-site referral process, because the sites of primary care and dermatology care were the same medical facility. Assessing costs in a true site-to-site referral system was a major rationale for the present study. The difference in magnitude in mean costs can be attributed to different cost-accounting mechanisms, more comprehensive cost accounting in the present study, and differing transportation costs. Another study performed in a Department of Defense setting<sup>13</sup> showed mean costs that were closer in magnitude to the present findings. In that study, mean direct costs per participant were \$294 for store-and-forward teledermatology referrals vs \$283 for conventional referrals. When lost productivity costs were included, the cost favored teledermatology, with a mean cost of \$340 compared with \$372 for conventional referral.

Our utility assessment found that participants were willing to trade some life expectancy to be rid of their skin condition. In both randomization groups, at baseline, the trade-off was approximately 2 years based on a 20-year life expectancy. From baseline to the 9-month follow-up, the amount of time participants in the teledermatology group were willing to trade was approximately 7 months fewer than at baseline, and participants in the conventional referral group were willing to trade approximately 4 fewer months, with both values representing a gain in utility. Prior studies of various skin conditions<sup>5,14-16</sup> have resulted in utility values similar to ours, although none included a teledermatology intervention. Using



the time trade-off technique among patients with melasma and based on a 30-year life expectancy,<sup>14</sup> a utility value of 0.96 was found that represented a willingness to trade 14 months of life. Time trade-off utility values for acne in an adolescent population<sup>15</sup> ranged from 0.965 to 0.978, depending on the degree of resolution and the presence or absence of scarring. Based on a 30-year life expectancy, another study<sup>16</sup> found the time trade-off utility value to be 0.88 for psoriasis and 0.93 for atopic eczema. In a comprehensive review of time trade-off utilities for dermatologic conditions,<sup>5</sup> utility values were found to range from 0.64 for bullous disease to 1.0 for urticarial and cosmetic conditions, with most of the skin conditions resulting in utilities in a range similar to our results (0.91-0.99).

Our study design and results have limitations. The generalizability of our findings may be constrained by the demographics of our study population and, therefore, the representative skin conditions. Simplifying assumptions, such as designating the identified drug classes dispensed as being used for the skin condition of interest, may have overestimated total drug costs. We imputed time trade-off values when data were missing. Our method of imputation may not represent the actual views of those participants if they had participated in the time trade-off evaluation. However, because our utility values are similar to those for a large number of skin conditions in the existing literature, we believe that the imputation's effect on our utility values was unlikely to exert a material influence on its magnitude. Also, baseline utility values of the missing sample did not differ from those of the nonmissing sample. Other missing data imputations, such as time to travel to and from the clinics, could have resulted in similar issues with the results. However, because these data were collected in the context of a randomized clinical trial, any potential bias is more likely to influence absolute values rather than incremental differences. Finally, absolute costs in a VA setting do not necessarily represent the absolute costs incurred in other settings (eg, non-VA health care system costs). However, because this study is a randomized clinical trial that compared

2 methods of referral, the incremental difference between randomization groups is the relevant metric.

One strength of this study is its conduct in the context of a true site-to-site setting of primary care to dermatology referral. Participants were seen at sites of primary care that lacked on-site dermatology services. Therefore, our data reflected issues such as distance traveled to and from clinics with attendant travel cost, productivity loss, and VA-reimbursed travel costs as actually experienced by the participants. We did not include in the analysis the cost (\$9615) of the 1 patient in the conventional referral group who experienced an inpatient admission based on the referred skin condition. This cost was not included because it was a singular event and served to increase the cost differential between teledermatology and conventional referral that already favored teledermatology.

## Conclusions

Our study provides important and comprehensive information regarding the cost and utility of a store-and-forward teledermatology referral system as used in a VA setting. In the context of a randomized trial, we found that teledermatology was comparable in cost from the VA perspective and less costly from the societal perspective than the conventional referral process. No evidence suggests a difference in utility, as measured by a time trade-off utility assessment, between randomization groups. This finding indicates that the difference (gain) in utility between entry to and exit from the study was not influenced by the method of referral. When the effectiveness of competing interventions is not different, or is otherwise considered equivalent, cost-effectiveness analysis reduces to a cost-minimization analysis, meaning that the economic assessment relies on an analysis of cost.<sup>1</sup> As such, our cost-minimization analysis found a nonstatistically significant lower cost with teledermatology from the VA perspective and a statistically significant lower cost for teledermatology from the societal perspective.

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the integrity of the data and the accuracy of the data analysis.

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## NOTABLE NOTES

### John Templeton Bowen

Harleen Arora, BS; Simran Arora; Vidhi Shah, BA; Keyvan Nouri, MD

Quiet and aloof, Dr John Templeton Bowen could be found poring over pathology slides in private rather than engaging others in the hospital. Bowen is considered a pioneer of dermatopathology at Massachusetts General Hospital (MGH).<sup>1</sup> Prior to his career at MGH, American dermatologist Bowen graduated from Harvard Medical School (HMS) and studied in Germany and Austria before returning to America in 1889.<sup>1</sup> He began his career as "assistant physician to outpatients with disease of the skin" at MGH and became chief of the dermatology service by 1911.<sup>1</sup> He also was the first professor of dermatology at HMS.<sup>1</sup> Because of his interest in skin histopathology, he was prolific in his analysis and description of dermatologic conditions, including his namesake: Bowen disease.

In his 1912 publication, Bowen described precancerous dermatoses that histologically and physically resembled other precancerous conditions, due to epithelial hypertrophy and hyperkeratosis.<sup>2</sup> In 1914, French dermatologist Jean Darier wrote to Bowen about encountering

patients with lesions similar to those he described.<sup>3</sup> Later, in his book, Darier accredited Bowen with the discovery.<sup>3</sup> Today, Bowen disease has been more extensively studied and is synonymous with squamous cell carcinoma in situ.<sup>2</sup>

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