JMIR Dermatology

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Volume 5 (2022), Issue 4   ISSN 2562-0959   Editor in Chief: Robert Dellavalle, MD, PhD, MSPH

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A 9-Year Teledermoscopy Service in New Zealand: Retrospective Service Review

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Abstract

Background: A teledermoscopy service was established in January 2010 wherein patients attended nurse-led clinics for the imaging of lesions of concern and remote diagnosis by a dermatologist.

Objective: This study aims to review the number of visits, patient characteristics, the efficiency of the service, and the diagnoses made.

Methods: We evaluated the waiting times and diagnoses of skin lesions for all patient visits from January 1, 2010, to May 31, 2019. The relationships between patient characteristics and the diagnosis of melanoma were specifically analyzed.

Results: The teledermoscopy clinic was attended by 6479 patients for 11,005 skin lesions on 8805 occasions. Statistically significant risk factors for the diagnosis of melanoma and melanoma in situ were male sex (*P*<.001), European ethnicity (*P*=.001), an age of 65 to 74 years (*P*=.001), and Fitzpatrick skin type 2 (*P*=.001). Attendance was maximal during 2015 and 2016. The seasonal variations in visits from 2011 to 2018 revealed a consistent peak at the end of summer and a dip at the end of winter. In the year 2010, a total of 306 patients attended the clinic; 76.1% (233/306) of these patients were discharged to primary care, and 23.9% (73/306) were referred to a hospital for a specialist assessment. For patients who were diagnosed with suspected melanoma by a dermatologist from January 1, 2010, to May 31, 2019, the median waiting time for an imaging appointment was 44.5 (mean 57.9; range 8-218) days. The most common lesions diagnosed were benign naevus (2933/11,005, 26.7%), benign keratosis (2576/11,005, 23.4%), and keratinocytic cancer (1707/11,005, 15.5%); melanoma was suspected in 4.6% (507/11,005) of referred lesions. The positive predictive value of melanoma and melanoma in situ was 61.1% (320 true positives and 203 false positives). The number needed to treat (ie, the ratio of the total number of excisions to the number with a histological diagnosis of melanoma or melanoma in situ) was 2.02.

Conclusions: A teledermoscopy service offered by nurse-led imaging clinics can provide efficient and convenient access to dermatology services by streamlining referrals to secondary care and prioritizing patients with skin cancer for treatment.

(JMIR Dermatol 2022;5(4):e36351) doi:10.2196/36351

KEYWORDS

dermatology; dermoscopy; telemedicine; skin neoplasms; melanoma

Introduction

New Zealand had the second highest rate of melanoma worldwide in 2018, following Australia [1]. In 2017, the New Zealand Cancer registry recorded 2553 cases of melanoma, with an age-standardized incidence rate of 35.1 per 100,000 people, and melanoma was one of the top 10 causes of cancer death among both women and men in 2016, 2017, and 2018 [2]. It was predicted that 90,400 New Zealanders would be diagnosed with at least one in situ or invasive keratinocytic cancer (also known as *nonmelanoma skin cancer*) in 2018 [3]. Diagnostic uncertainty results in high rates of referrals to dermatologists.

Access to dermatology outpatient clinics in New Zealand is limited by a shortage of dermatologists [4,5], resulting in unnecessary excisions of benign lesions in primary care and, potentially, the late diagnosis of melanoma [6]. The New Zealand Ministry of Health's Faster Cancer Treatment targets include a 2-week indicator for ensuring that patients with a high suspicion of cancer are seen by a specialist service within 2 weeks of being referred; however, these targets have been difficult for district health boards to achieve. For patients with a low suspicion of cancer, the expected waiting time is 45 days for a semiurgent outpatient clinic appointment and 120 days for a routine outpatient clinic appointment [7].

There has been rapid growth in the use of store-and-forward teledermoscopy globally, and it has proven to be a valuable service for both clinicians and patients worldwide. A 14-year study of UK teledermatology services showed 68% diagnostic concordance and an 82% satisfaction rate for 40,201 teleconsultations [8]. Another study in Spain showed improved access to dermatologists through a teledermoscopy service [9]. The use of teledermoscopy has allowed skin lesions to be diagnosed at remote locations and has reduced the need for face-to-face consultations. Following a proof-of-concept study that was conducted in 2008 to confirm whether skin lesions could be diagnosed from high-quality digital photographs [10], a teledermoscopy service was established at our center in January 2010. This teledermoscopy service is a collaboration between a public hospital and an established private teledermoscopy company. In an earlier trial of 200 patients who used a similar service that was provided at another center in New Zealand, the service resulted in potential financial savings and shorter waiting times [11].

Through our service, patients referred from primary care for the assessment of 1 to 5 skin lesions may be scheduled for an appointment at an imaging clinic in 1 of 3 towns. Information, including digital images, is collected at these clinics. A specially trained nurse (ie, a melanographer) collects demographic and medical information and captures regional, close-up, and dermoscopic images of the skin lesions that were identified in the referral for later remote diagnosis by a teledermatologist. Additional skin lesions of patient or nurse concern can also be imaged. Total body skin examinations were not offered during the time covered by this study.

This study aims to record the number of visits over a 9-year and 7-month period, patient characteristics, the efficiency of the service, and the diagnoses made.

Methods

Ethical Considerations

New Zealand Health and Disability Ethics Committee approval was not required for this research, as it was a low-risk retrospective service review.

Recruitment

All patient visits to the teledermoscopy clinic from January 1, 2010, until May 31, 2019, were included in this study. We also performed analyses on subsets of patients (ie, patients with confirmed melanoma and patients who attended the clinic from January 2010 until December 2010).

Regional images were captured by using a Nikon D3300 (Sendai Nikon Corporation), and macroscopic and dermoscopic images were captured by using a DermLite Cam v01 (3Gen LLC) and DermLite Cam v02 (3Gen LLC); other cameras were used in the first few years. Files were uploaded by using a virtual private network for storage on a secure server. The files were downloaded remotely to be viewed, using proprietary software. Each case was assessed by a dermatologist, who made a diagnosis and formulated a management plan. The referring primary care physicians and patients expected to receive a diagnosis report within 7 to 10 working days after the patients' appointments.

The dates of imaging, patient-related data, and lesion-specific data were extracted from the service database. The recorded demographic information (age, sex, and ethnicity) and data on melanoma risk factors, such as Fitzpatrick skin type (1: pale, burns easily; 2: fair, burns easily; 3: darker white, tans easily; 4: brown, tans easily; 5-6: dark brown or black, always tans), eye and hair color, a personal and family history of melanoma, outdoor occupation, and a history of sunburn, were collected. The diagnosis software was accessed to review the dates of referrals, patients' medical and lesion histories, and skin lesion assessments. Patients' hospital electronic health records were accessed to obtain histopathology results following the excision of suspected melanoma.

Statistical Analysis

Risk Factors for Melanoma

Patient characteristics and risk factors were analyzed for a subset of patients with confirmed melanoma. Statistical tests (Z test, Pearson chi-square test, and Fisher exact test) were conducted to determine the significance of patient characteristics and the occurrence of melanoma.

A Z test was used to compare the statistical significance of the relationship between sex and the occurrence of melanoma. A Pearson chi-square test was used to compare the relationships among age, ethnicity, skin type, risk factors, and the occurrence of melanoma for sample sizes of <5, and a Fisher exact test was used to calculate the P value. Patients with "unsure" responses were excluded from the analysis.

Trend and Timeline

The number of visits over 2010 to 2018 and the number of visits for all months over this 9-year period were calculated. Visits in the year 2019 were excluded, as the data were only collected up to May 31, 2019. The number of patients with confirmed melanoma (in situ and invasive) were compared with the number of patient visits each month. A linear regression model was used to analyze the relationships among months, the number of visits, and the occurrence of melanoma over the 9-year period. The R^2 value was calculated to predict how well the data fit the regression model.

Efficiency of the Service

We analyzed a subset of patients who were seen in the clinic from January until December 2010. The percentage of patients who were referred to a hospital for a specialist assessment was calculated. The waiting time for an appointment was based on the difference between the date of the referral and the date of imaging. Wait times for treatments (excision or discharge) were determined for a subset of patients.

Diagnoses

Skin lesions were classified via teledermoscopic diagnosis. Skin cancers were compared to the total number of skin lesions ([melanoma + keratinocytic cancer]/total lesions × 100). The percentages of benign and premalignant lesions were calculated. Based on the subset of skin lesions for which excision was recommended, the percentage of confirmed melanoma or melanoma in situ (based on histology), the number needed to treat (NNT), and positive predictive value (PPV) were also determined.

Quality Standards

Aspects of the teledermoscopy service were compared with the 2011 Quality Standards for Teledermatology by the British Association of Dermatologists [12].

Results

Recruitment

Between January 1, 2010, and May 31, 2019, a total of 6479 patients attended the teledermoscopy clinic on 8805 occasions (female: 4087/6479, 63.1%; male: 2392/6479, 36.9%). The majority of visits were of physician concern (5608/8805, 63.7%), and the remainder (3202/8805, 36.3%) were referred due to patients' concerns. Images were taken of 11,005 unique skin lesions.

The median age of the 6479 patients was 57 years (mean 53.67 years; range 2 months to 100 years). As per Table 1, most patients self-identified as New Zealand European (5800/6479, 89.5%). The remaining patients self-identified as Maori (321/6479, 5%), Pacific Islander (29/6479, 0.4%), Asian (158/6479, 2.4%), and other (160/6479, 2.5%).

Among the 6479 patients, the Fitzpatrick skin type was recorded as type 1 for 437 (6.7%) patients, type 2 for 4022 (62.1%) patients, type 3 for 1478 (22.8%) patients, type 4 for 503 (7.8%) patients, and type 5 or 6 for 25 (0.4%) patients. The skin type of 14 (0.2%) patients were not recorded.

Table 1. Demographic characteristics of patients who attended the teledermoscopy service.

Demographic characteristics	All patients (N=6479)	Patients with histologically confirmed melanoma (n=330)
Age (years), median	57	68
Number of male patients:number of female patients (ratio)	2392:4087 (0.59)	176:154 (1.14)
Ethnicity, n (%)		
European	5800 (89.5)	330 (100)
Māori or Pacific Islander	350 (5.4)	0 (0)
Asian	158 (2.4)	0 (0)
Other[a]	160 (2.5)	0 (0)

[a]Mixed, Mediterranean, other White, and other Black patients.

Risk Factors for Melanoma

The median age of 330 patients with histologically confirmed melanoma was 68 (mean 73.5; range 20-93) years. There was a statistically significant higher incidence of melanoma in men (176/330, 53.3%; SD 0.0175; P<.001). The 65 to 74 years age group had the highest occurrence of histopathologically confirmed melanoma (P=.001); all self-identified as European.

Trend and Timeline

Clinic visit numbers were maximal in the years 2015 and 2016. The seasonal variations in visits from 2011 to 2018 revealed a consistent peak between March and April—the end of summer in New Zealand—and a dip between August and September—the end of winter. A linear regression model was used to demonstrate a statistically significant linear relationship among the variables (P<.001).

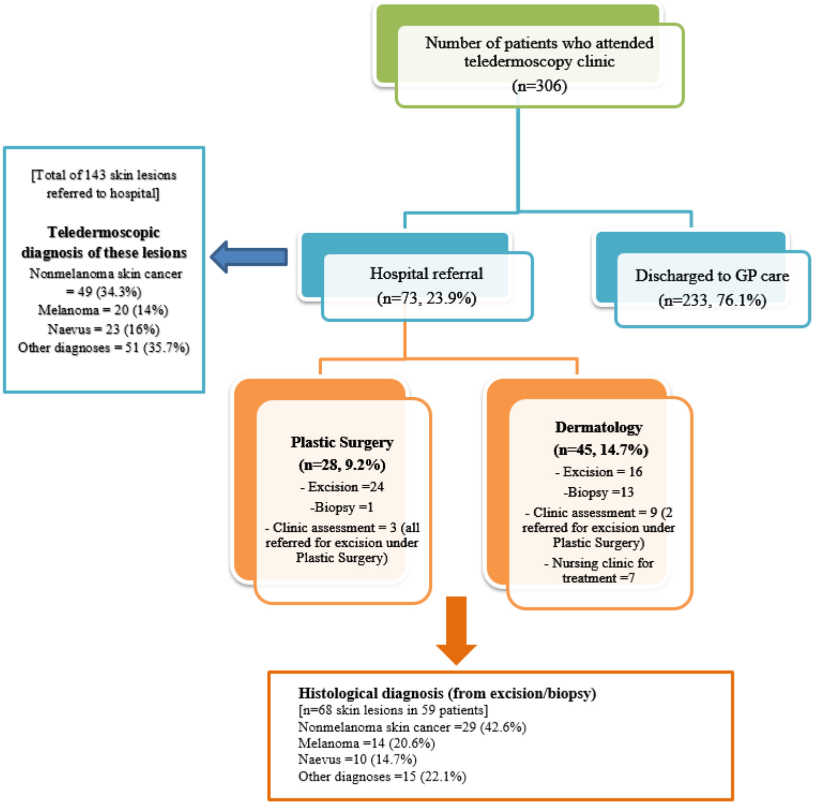
The lowest proportion of histologically confirmed melanomas was found in winter (72/1969, 3.65%; from June to August), and the highest was 4.37% (91/2082) in spring (from September to November). However, the R^2 value was 0.22 when including outliers and 0.3 when not including outliers; hence, it is a poor sign that the predictive models and chi-square distribution test showed no statistically significant relationship between the months and the occurrence of melanoma (P=.65).

Efficiency of the Service

Figure 1 shows the flowchart of patients who attended the teledermoscopy clinic from January to December 2010. Of the 306 patients seen during this period, 23.9% (n=73) subsequently required a hospital specialist appointment. Biopsy or excision was recommended for 59 (19.2%) patients with 68 lesions. In total, 76.1% (n=233) of patients were discharged back to primary care.

Between January 2010 and May 2019, melanoma was strongly suspected in 463 patients; they had a median waiting time of 44.5 (mean 57.9; range 8-218) days for imaging and a median waiting time of 63 (mean 63.2; range 28-94) for the first treatment received.

Figure 1. Flowchart of patients who attended the teledermoscopy clinic from January to December 2010. Other diagnoses included benign keratosis, vascular lesions, inflammatory lesions, collisions, other benign lesions, dermatofibroma, and uncertain diagnoses. GP: general practitioner.



Diagnoses

The teledermatologist suspected skin cancer in 20.1% (2214/11,005) of the lesions (nonmelanoma skin cancer [keratinocytic]: 1707/11,005, 15.5%; melanoma: 507/11,005, 4.6%).

The most common benign diagnosis was benign melanocytic naevus (2933/11,005, 26.7%); naevi were classified as atypical or dysplastic in 236 of these cases. Other diagnoses included benign keratosis (2576/11,005, 23.4%), premalignant skin lesions (1132/11,005, 10.3%), other benign lesions (707/11,005, 6.4%), vascular lesions (325/11,005, 3%), inflammatory conditions (187/11,005, 1.7%), dermatofibromas (187/11,005, 1.7%), and nail abnormalities (125/11,005, 1.1%).

There were 291 skin lesions with no specific diagnosis (did not require further assessment), 206 nondiagnostic skin lesions (required face-to-face outpatient clinic appointments), 96 lesions that had resolved prior to imaging, 18 collision lesions with more than 1 diagnosis, and 8 treatment-related lesions.

The diagnosing dermatologist recommended excision for 744 lesions due to a high suspicion (523/744, 70.3%) or mild suspicion (221/744, 29.7%) of melanoma. Of the 523 with a high suspicion of melanoma, 320 were confirmed based on histology (melanoma in situ: n=209; invasive melanoma: n=111). The PPV of melanoma and melanoma in situ in this study was 61.1% (320 true positives and 203 false positives); in other words, there was 61.1% diagnostic agreement between the teledermatologist and the histopathology. Among the 744 excised lesions, there were 367 (49.3%) confirmed melanomas; 243 (243/367, 66.2%) were melanoma in situ and 124 (124/367, 33.8%) were invasive melanoma. The ratio of melanoma in situ to invasive melanoma (243:124) was 1.96. The ratio of the total number of excisions to the number with a histological diagnosis of melanoma or melanoma in situ was the NNT (2.02).

Quality Standards

Our teledermoscopy service met 6 of the 8 British Primary Care Commissioning's Quality Standards for Teledermatology [12].

There were clear guidelines on referral pathways for general practitioners, and only patients with skin lesions suspicious of cancer were referred. Informed consent was obtained from all patients. All images were taken by competent staff, and diagnoses were made by dermatologists who had experience in teledermatology.

The median waiting time for patients with suspected melanoma has exceeded the 2-week waiting time target. The Quality Standards for Teledermatology recommend that 1 audit and 1 patient survey be conducted every 12 months. We have conducted several partial audits over the years (some are included in this paper) but only conducted a single, limited patient survey [11].

Discussion

The teledermoscopy service was able to deliver more efficient health care and improved access to specialist diagnoses.

Principal Results

We have shown that community-based teledermoscopy clinics can reduce the need for dermatology outpatient appointments. The preponderance of women who attended the clinic

(4087/6479, 63.1%) corresponds with the greater utilization of primary health care services by women [13]. The highest rate of melanoma was found in men and in the 65 to 74 years age group. Our figures confirm the prevalence of melanoma in fair-skinned individuals who are predominantly of European ancestry. The high risk of melanoma in this population can be explained through genetic predisposition and risk behavior [14]. Our sex and age group findings were comparable to the New Zealand Cancer Registry data from 2015 to 2017, in which a melanoma diagnosis is most common in men and in the 70 to 74 years age group. Further, 89.5% (5800/6479) of patients who attended clinic self-identified as New Zealand European in our study; however, Statistics New Zealand reported that the New Zealand population has a smaller proportion of New Zealand European individuals (74%) [15].

Seasonal variations in visits showed peaks in referrals and imaging at the end of summer and may have been due to (1) high lesion visibility during summer due to light clothing and (2) high skin cancer awareness during summer months. This is consistent with melanoma incidence data for New South Wales, Australia [16].

In terms of efficiency, the important outcomes were the reductions in waiting times and the streamlining of referrals. The median waiting time for patients with suspected melanoma exceeded the 2-week waiting time target. This may have been due to delays in the receipt and triage of general practitioner referrals, delays in sending out appointment letters, or high patient workloads. Most patients (233/306, 76.1%) were discharged or referred back to primary care.

The PPV of 61.1% and NNT of 2.02 show strong diagnostic concordance for melanoma. The melanoma in situ to invasive melanoma ratio of 1.96 indicates a high sensitivity for the diagnosis of melanoma. The high percentage of benign lesions diagnosed is encouraging, as without an expert opinion, many of these may have been subjected to unnecessary diagnostic procedures. The clinical photographs that were taken by a trained nurse (ie, a melanographer) using standardized equipment were of consistently high quality, allowing confident diagnoses to be made by our experienced dermatologists.

The results above are important in terms of improving health care access and delivery for the wider population. Our recommendations for current services include increasing the number of locations for imaging clinics, recruiting nurses with an appropriate level of training, and developing fast-tracked referral guidelines for high-risk individuals.

Comparison With Prior Work

The diagnostic classifications in this study were comparable to those of other large teledermoscopy services. Mehrtens et al [8] reported benign naevus, seborrheic keratosis, and keratinocytic cancer in 25%, 22%, and 23% of 40,201 patients who attended a teledermoscopy service in the United Kingdom, respectively. Moreno-Ramirez et al [9] reported benign naevus, seborrheic keratosis, and keratinocytic cancer in 23%, 23.8%, and 10.4% of 34,553 patients who attended a teledermoscopy service in Spain, respectively.

Limitations

Through our service, imaging is offered in 3 locations, so patients must travel beyond their primary care facility to access the service. The main concern has been prolonged delays prior to imaging.

Referrals to the service described herein decreased from mid-2017 onward, that is, after the introduction of an electronic referral pathway for suspected skin cancer that encourages referrers to attach their own clinical and dermoscopic images.

We have not undertaken a formal retrospective review of the lesions that were diagnosed as benign via teledermoscopy, so we cannot report the false-negative rate. However, the high percentage of benign lesions diagnosed in this study is encouraging. A systematic review of the data for the Auckland service reported a negative predictive value of 96%, with 2 false-negative diagnoses of melanoma [10].

Conclusions

The teledermoscopy imaging service we have described has provided accurate diagnoses, thereby minimizing unnecessary visits to outpatient clinics, so that patients with confirmed skin cancer can be prioritized for surgery.

Acknowledgments

We would like to acknowledge MoleMap New Zealand—the provider of the imaging service—on behalf of Waikato District Health Board. We also thank the melanographers at Anglesea Clinic, the patients who gave permission for their photographs to be used for publication, Thames and Te Kuiti Hospitals, the diagnosing dermatologists at Waikato Hospital (AO, Dr Marius Rademaker, and Dr Anita Eshraghi), and the service data analyst for their assistance in locating some of the data (Vijen Reddy).

No external funding was received for this study.

Authors' Contributions

NSCT conducted the data analysis during their research for a final-year student elective (2019) and authored this paper. AO was responsible for the concept of this study, data collection, and the supervision of students and authored this paper.

Conflicts of Interest

AO is paid a service fee by MoleMap New Zealand to diagnose their private patients but has no financial interest in the company.

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Abbreviations

NNT: number needed to treat
PPV: positive predictive value

Edited by R Dellavalle; submitted 11.01.22; peer-reviewed by S Sabarguna, M Hofford, D Madhusudhan; comments to author 07.05.22; revised version received 30.08.22; accepted 17.09.22; published 06.10.22.

Please cite as:
Teoh NSC, Oakley A
A 9-Year Teledermoscopy Service in New Zealand: Retrospective Service Review
JMIR Dermatol 2022;5(4):e36351
URL: https://derma.jmir.org/2022/4/e36351
doi:10.2196/36351
PMID:37632888

Original Paper

Concordance and Accuracy of Teledermatology Using Mobile Phones in the Outpatient Clinic of Jose R Reyes Memorial Medical Center: Cross-sectional Study

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Abstract

Background: Dermatologists rely on visual findings; thus, teledermatology is uniquely compatible to providing dermatologic care. The use of mobile phones in a store-and-forward approach, where gathered data are sent to a distant health provider for later review, may be a potential bridge in seeking dermatologic care.

Objective: This study aimed to determine the agreement between face-to-face consultations and teledermatologic consultations through the store-and-forward approach using mobile phones and its accuracy compared to a histopathologic diagnosis.

Methods: The study design was a cross-sectional study of participants consecutively recruited from dermatology patients who presented with skin or mucosal complaint and without prior dermatologist consultation. Photographs were taken using a standard smartphone (iPhone 6s Plus), and a 4-mm skin punch biopsy was taken on each patient—the gold standard to which the study result was compared to. The photographs were sent to 3 consultant dermatologists using a store-and-forward approach, for independent diagnosis and treatment plan.

Results: A total of 60 patients were included, with a median age of 41 years. There was moderate-to–almost perfect agreement in terms of final diagnosis between the face-to-face dermatologic diagnosis and teledermatologic diagnoses. The third teledermatologist had the highest agreement with the clinical dermatologist in terms of final diagnosis (κ=0.84; P<.001). Among the 3 dermatologists, there was moderate-to–almost perfect agreement as well. Agreement between pairs of teledermatologists ranged from 0.45 to 0.84. The 3 teledermatologists had moderate-to-substantial agreement with the biopsy results, with the third teledermatologist having the highest accuracy (κ=0.77; P<.001). Overall, there was a moderate agreement in the diagnosis of patients across raters.

Conclusions: Teledermatology is a viable alternative to face-to-face consultations. Our results show moderate-to-substantial agreement in diagnoses from a face-to-face consultation and store-and-forward teledermatology.

(JMIR Dermatol 2022;5(4):e32546) doi:10.2196/32546

KEYWORDS

teledermatology; telemedicine; store-and-forward approach; dermatology; virtual consultation; histopathological diagnosis; skin; telehealth; mobile phones; cross-sectional study; dermatologists; dermatologic care; mucosal

Introduction

Telemedicine, a subset of eHealth, refers to the use of electronic communications technology for the intention of health management and education [1]. The predominant visual component of the practice of dermatology may translate to a suitable use of telemedicine—hence, the current practice of teledermatology, defined as the use of information and communications technology for the purpose of diagnosis, monitoring, treatment, prevention, research, and education over a distance [2]. This practice is delivered using 2 methods: (1) the store-and-forward method, in which the gathered data are sent to a distant health provider for later review; and (2) the live method, which uses videoconferences to allow consultation in real time between a patient or provider and a distant provider [1].

Telemedicine has been in use since the early 1900s, during which ship captains used the radio to seek medical advice [2]. In modern times, teledermatology has been successfully used with the store-and-forward method, such as in the Africa Teledermatology Project, the Swinfen Charitable Trust, the Médecins Sans Frontières Telemedicine Network, and the Réseau Afrique Francophone de Télémédecine project [1]. The African Teledermatology Project connected sub-Saharan countries to dermatologists from resource-rich countries to provide dermatologic care [3]. In Mongolia, Byamba et al [4] assessed the costs and efficiency of teledermatology against face-to-face consultations. It lessened the costs and time of travel, decreased the time to seek dermatologic care, and improved patient satisfaction.

Applications of teledermatology includes teletriage, primary care–to-dermatology consultation, specialists-to-dermatology consultation, dermatologist-to-dermatologist consultation, telepathology, long-term management, care coordination, and dermatology education [1]. The success of such applications was found to be due to satisfactory skin diagnosis and disease management, its diagnostic concordance with face-to-face visits, and the satisfaction of both patient and health provider with the format [3-11].

With only 1063 board-certified dermatologists in the Philippines, the ratio of dermatologists to the total population is still low. There is limited distribution of dermatologists to rural areas. With skin diseases as one of leading causes of disability worldwide, traditional methods of consultation have been a challenge; thus, there is a need for innovative methods and platforms to provide adequate care over a great distance. In recent advances in teledermatology, several studies have dealt with the use of mobile devices such as smartphones as a tool to convey clinical information [3,5-12]. Out of a total population of 100 million Filipino people, 70 million own a mobile phone [5]. Mobile phones may serve as a bridge to other areas lacking dermatologic care, providing a solution to the challenges of the lack of health provider and distance.

In a resource-limited country, specialist care is not readily available to many patients. There is a great disproportion of specialists to the overall population. Compared to resource-rich countries, there is less effort to promote the use of telemedicine due to a smaller return of investment and lack of technical infrastructures necessary to provide care for our patients [6].

Teledermatology should be implemented in a way that is sensitive to the culture and unique needs of the local setting, bearing in mind limitations of resources. Teledermatology comes with its own challenges such as sustainability in terms of setting up the platform, the computer literacy of patients and health care providers, the regularity and availability of internet access and mobile network connectivity, the sensitivity of patients wherein their preference is face-to-face contact or they have resistance to being photographed, patient privacy and data security, as well as the setup for payment [7].

Teledermatology is deemed to be the future of the practice of dermatology as evidenced by the number of available dermatologists and their practices being commonly clustered around urban localities [7]. Its practice is even more relevant due to the COVID-19 pandemic, wherein physical distancing is one of the key components of transmission prevention. The use of eHealth through teledermatology can ease the anxiety experienced by patients when faced with the possibility of needing a face-to-face consultation as well as stemming the overwhelming need for specialty consultations in remote rural municipalities. Teledermatology can thus provide a means of getting consultations while maintaining public health safety. Beyond practicing amid a pandemic, teledermatology may increase the access of the population to specialists who are physically too far away. This study aimed to determine the agreement and the accuracy of face-to-face consultations and teledermatologic consultations with the store-and-forward approach using a mobile phone. Additionally, we aimed to determine interrater concordance (ie, statistical agreement) between the clinical face-to-face dermatologist and teledermatologists in diagnosis, the interrater concordance in diagnoses among the teledermatologists, and the accuracy of teledermatologic diagnoses with the histopathology diagnosis.

Methods

Study Design and Setting

This was a cross-sectional study conducted at the outpatient department (OPD) of the Jose R. Reyes Memorial Medical Center from August 1 to September 30, 2018. Face-to-face consultations were done at the dermatology clinic of the OPD, whereas teledermatology diagnoses were performed independently by 1 or 2 dermatologists.

Ethics Approval

Prior to implementation, the study was approved by the hospital institutional review board (protocol number 18-015) and adhered with the ethical standards of the committee on human experimentation with the Helsinki Declaration of 1975.

Participants

The primary investigator consecutively recruited dermatology patients—Filipino patients of any age and sex who presented with any skin or mucosal complaint during their first consultation for that specific complaint. Patients who came in for a follow-up check-up, had previously been biopsied for the same skin lesion, who came in with a diagnosis already previously known to the patient, or had previously been evaluated by a dermatologist for the same skin or mucosal lesion were excluded from the study.

Data Collection

All patients received a face-to-face clinical evaluation by a supervising clinical dermatologist (CD) that was assisted by the primary investigator according to the standard procedure at the OPD. After evaluation, the patients were invited to participate in the study. Written informed consent was obtained from adults and parents of pediatric patients. If the patient, or legal guardian for a minor patient, consented to participate in the study, the primary investigator then proceeded to conduct a protocol-based dermatologic evaluation for this study. The skin or mucosal lesions were photographed using an iPhone 6s Plus with a 12-megapixel back camera. Photographs were taken 4 inches (10 cm) away, perpendicular to the lesion under ambient lighting. The primary investigator obtained a 4-mm skin punch biopsy on the skin or mucosal lesion of interest. The patients were prescribed treatment based on the clinical diagnosis made from this face-to-face clinical evaluation.

Diagnosis From Teledermatology

The photographs from the iPhone 6s Plus were viewed separately by 3 teledermatologists. They were provided with the patient's age and sex, a brief description of the patient's medical history, and high-resolution images of the skin lesion(s). The teledermatologists gave their clinical diagnosis and proposed a treatment plan for each patient.

Statistical Analysis

A minimum of 56 study participants were required for this study, assuming an 18% probability of disagreement between the CD and teledermatologist, a 95% CI of plus or minus 0.10, and 5% level of significance, based on Lamel et al [8] and Machin et al [9].

Descriptive statistics were used to summarize the general and clinical characteristics of the participants. Frequency and proportion were used for nominal variables, median and range for ordinal variables, and mean and SD for interval or ratio variables. Cohen κ was used to determine statistical agreement between the diagnoses of the CD and teledermatologists. All valid data were included in the analysis. Missing variables were neither replaced nor estimated. Null hypothesis was rejected at .05 α-level of significance. Stata statistical software (version 15.0; StataCorp) was used for data analysis.

Results

Patient Demographics and Disease Categories

A total of 60 patients were included in the study, with a median age of 41 (range 4 months to 75 years) years, and 50% (n=30) were female (Table 1).

There were 57 dermatologic diagnoses identified from both the CD and 3 teledermatologists. The 3 teledermatologists were board-certified dermatologists who have been practicing for 3 to 7 years. The diagnoses from face-to-face dermatology and teledermatology are enumerated on Figure 1.

The diagnoses confirmed by histopathology were classified by standard disease categories (Table 2). A majority (n=31, 52%) of the diseases fell under the inflammatory disease category, followed by benign neoplasms (n=11, 18%). Other disease categories include infectious diseases, vascular diseases, and malignant neoplasms.

Table 1. Demographic and clinical profile of patients (N=60).

Characteristic	Value
Age (years), median (range)	41 (0.33-75)
Sex, n (%)	
Male	30 (50)
Female	30 (50)
Comorbidities, n (%)	
Hypertension	3 (5)
Benign prostate hypertrophy	2 (3)
Diabetes	2 (3)
Dyslipidemia	2 (3)
Allergy	1 (2)
Heart disease	1 (2)

Figure 1. Cluster dendogram comparing face-to-face dermatologic diagnoses versus teledermatologic diagnoses and differentials. ACD: allergic contact dermatitis; CA: carcinoma; DHR: dermal hypersensitivity reaction; ICD: irritant contact dermatitis; LSC: lichen simplex chronicus; PLEVA: pityriasis lichenoids et varioliformis acuta; PLC: pityriasis lichenoides chronica; PPD: pigmented purpuric dermatosis; SCCA: squamous cell carcinoma; SCPD: subcorneal pustular dermatosis; SLE: systemic lupus erythematosus.

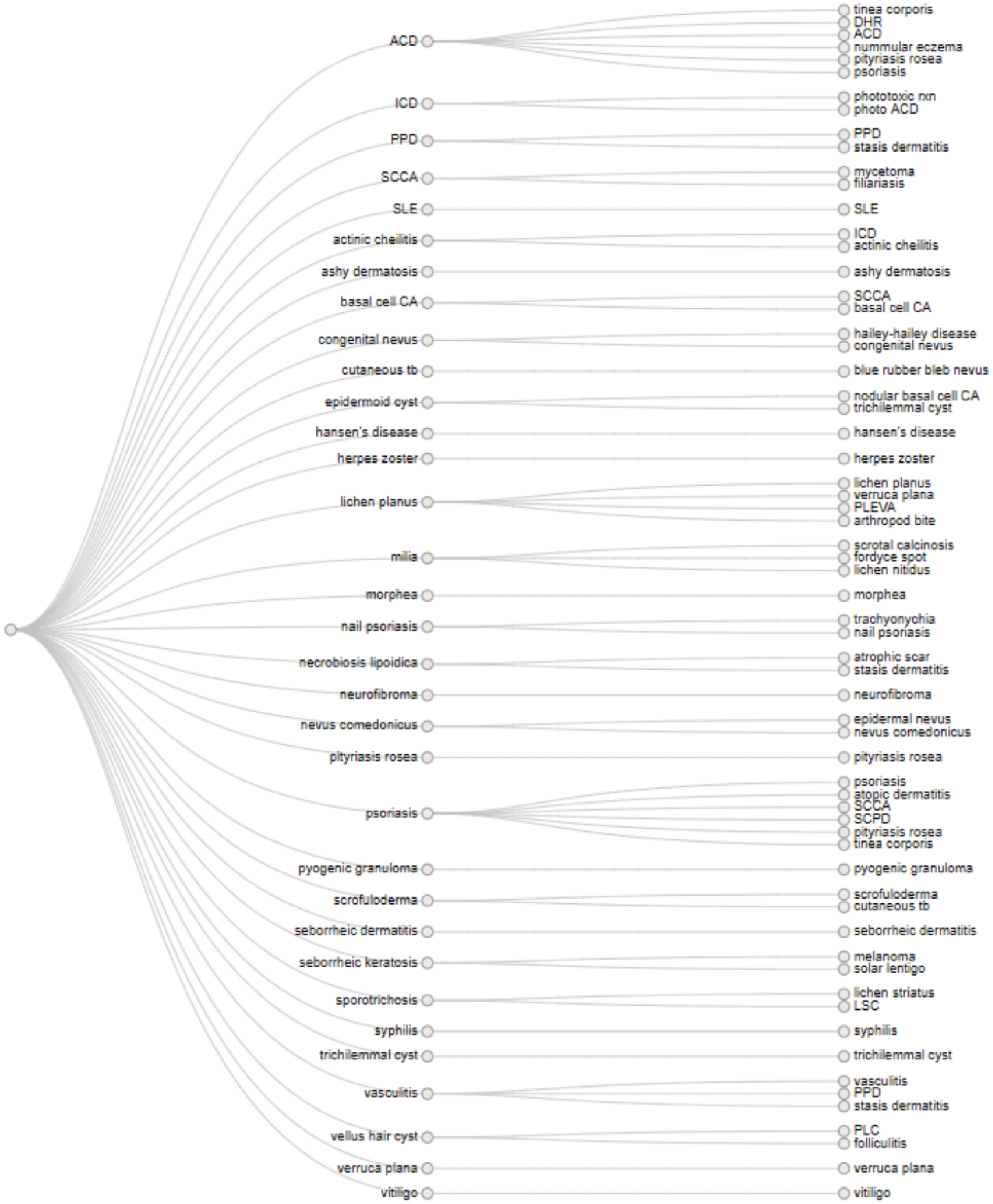

Table 2. Disease categories based on biopsy (N=60).

Dermatologic disease category	Diagnosis, n (%)
Inflammatory	31 (52)
Benign neoplasm	11 (18)
Infectious	8 (13)
Vascular	6 (10)
Malignant neoplasm	4 (7)

Face-to-Face Dermatologic Diagnosis Versus Teledermatologists' Diagnoses

The concordance rates between the CD and teledermatologists were from 57.1% to 86.7%. There was moderate-to–almost perfect agreement in terms of final diagnosis between the face-to-face dermatologic diagnosis and teledermatologic diagnoses (Table 3). Teledermatologist 3 had almost perfect agreement with the clinical dermatologist in terms of final diagnosis (κ=0.84; *P*<.001).

Table 3. Agreement between clinical dermatologist and teledermatologists based on final diagnosis (N=60).

Agreement	Concordance (%)	κ value[a]	Interpretation	*P* value
CD[b] vs T1[c]	57.1	0.55	Moderate agreement	<.001
CD vs T2	60.4	0.58	Moderate agreement	<.001
CD vs T3	86.7	0.84	Almost perfect agreement	<.001

[a]κ interpretation: ≤0, poor; 0-0.2, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect.

[b]CD: clinical dermatologist.

[c]T: teledermatologist.

Agreement Across Teledermatologists

The concordance rates among the teledermatologists were from 46.8% to 86.7%. Among the 3 dermatologists, there was moderate-to–almost perfect agreement as well (Table 4). Agreement between pairs of teledermatologists ranged from 0.45 to 0.84. Teledermatologists 1 and 3 had an almost perfect agreement (κ=0.84; *P*<.001).

Table 4. Agreement among teledermatologists based on final diagnosis (N=60).

Agreement	Concordance (%)	κ value[a]	Interpretation	*P value*
T1[b] vs T2	46.8	0.45	Moderate agreement	<.001
T1 vs T3	86.7	0.84	Almost perfect agreement	<.001
T2 vs T3	73.3	0.69	Substantial agreement	<.001

[a]κ interpretation: ≤0, poor; 0-0.2, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect

[b]T: teledermatologist.

Teledermatologists Versus Histopathology

The accuracy rates of the teledermatologists were from 60% to 80%. The 3 teledermatologists had moderate-to-substantial agreement with the biopsy results (Table 5). Teledermatologist 3 had the highest accuracy in diagnosing diseases (κ=0.77; *P*<.001).

Table 5. Agreement between teledermatologists and biopsy based on final diagnosis (N=60).

Agreement	Concordance (%)	κ value[a]	Interpretation	*P* value
Biopsy vs T1[b]	60	0.58	Moderate agreement	<.001
Biopsy vs T2	62.8	0.61	Substantial agreement	<.001
Biopsy vs T3	80	0.77	Substantial agreement	<.001

[a]κ interpretation: ≤0, poor; 0-0.2, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect

[b]T: teledermatologist.

Overall Agreement

The κ values in the present study were from 0.53 to 0.58. The agreement between the teledermatologists and biopsy was the highest. However, there was still a moderate agreement in the diagnosis of patients among raters, based on final diagnosis (Table 6). The overall agreement per specific diagnosis is shown in Multimedia Appendix 1.

Based on the disease categories, the CD and teledermatologists had moderate-to-substantial agreement (Table 7). Vascular diseases, inflammatory diseases, and benign neoplasm showed substantial agreement with κ values from 0.64 to 0.72. Conversely, malignant neoplasm and infectious diseases showed moderate agreement with κ values from 0.58 to 0.60.

Table 6. Summary of overall agreement among raters based on final diagnosis. The number of ratings per subject vary; thus, we could not calculate test statistics (*P* value).

Agreement	κ value[a]	Interpretation
Clinical dermatologist and teledermatologists	0.56	Moderate agreement
Among teledermatologists	0.53	Moderate agreement
Teledermatologists and biopsy	0.58	Moderate agreement

[a]κ interpretation: ≤0, poor; 0-0.2, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect.

Table 7. Agreement of all raters based on disease category. The number of ratings per subject vary; thus, we could not calculate test statistics (*P* value).

Disease category	κ value[a]	Interpretation
Inflammatory	0.64	Substantial agreement
Infectious	0.58	Moderate agreement
Benign neoplasm	0.62	Substantial agreement
Malignant neoplasm	0.60	Moderate agreement
Vascular	0.72	Substantial agreement

[a]κ interpretation: ≤0, poor; 0-0.2, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect.

Discussion

This study aimed to find the agreement and accuracy of face-to-face consultations and teledermatologic consultations with the store-and-forward approach. Overall, there was a moderate agreement in the diagnosis of patients among raters. The concordance rates of teledermatologists with that of face-to-face dermatologist and the accuracy of teledermatologists with the biopsy results were consistent with the previous studies that used mobile phone teledermatology. The accuracy of mobile phone dermatology was low compared to other media in teledermatology [10-12].

Similar results can be found in other studies. For instance, Clark et al [10] reviewed 15 studies that used mobile phones in teledermatology. Concordance is the reliability or agreement between the face-to-face dermatologist and teledermatologist. The diagnostic concordance rates of teledermatology using mobile phones ranged from 40% to 95%, whereas the management concordance rates ranged from 69% to 100%. Varying results have been documented for both diagnostic and management concordance rates in 41% to 94% of cases [11,12]. Despite having high concordance rates, the study concluded that traditional face-to-face dermatology is still superior to mobile phone teledermatology. In this study, both concordance rates showed moderate-to-substantial agreement. Therefore, the results in this study are consistent with the results of the systematic review.

Although the results show that there is a moderate overall agreement in diagnosis, other factors that make up the process must be studied to determine how ready an institution or country is for teleconsultations. However, these results may be useful for exploring the possibility of teleconsultations in other fields. The results may also be used as a reference for learning more about the common practices used in telemedicine that are unique to the community's culture, norms, and needs. Future studies that develop the subject may look into these areas and may also test other populations' readiness. It is recommended to look into other demographic factors that may explain the results, such as the technological access and literacy of patients and health care providers involved in the treatment process.

Other technical factors can affect accurate diagnoses in skin diseases, including, but not limited to, image resolution and image quality (particularly color balance and brightness). Image resolution pertains to the number of pixels in a picture [13]. For this study, the phone used (iPhone 6s Plus) has a camera that generates an image with a 12-megapixel resolution, which entails a pixel resolution of approximately 4290 × 2800 pixels, with 4K HD recording resolution capability of 3840 × 2160 [14]. The American Telemedicine Association requires a minimum of 640 × 360 resolution for pictures and 30 frames per second for videos to see a patient via telemedicine, which makes the smartphone qualified to be used for teledermatology purpose [15]. Image quality, meanwhile, is defined as the accuracy of the image's representation of details stored in pixels [13]. Brightness is the intensity of light reflected from objects, captured by a camera; color balance is the "color temperature" or the relative warmth or coolness of white light in a picture [16]. It was pointed out by Iyatomi et al [17] that accurate color information is important for melanoma diagnoses, and incorrect brightness and color balance adversely impact diagnostic performance. They were able to develop a color calibration filter that automatically adjusts the image quality of a melanoma to help diagnosticians correctly identify melanoma types. The principle of correctly calibrated images can also be applied to other skin diseases. Friedman et al [18] asked 13 dermatologists to anonymously review 13 clinical images of a fungal skin infection and found that the majority of the cases were identified correctly 50% of the time, with only 1 of the cases identified correctly 90% of the time.

Advances in artificial intelligence enables more accurate and faster diagnoses of skin diseases, interfacing with teledermatology. A deep learning system developed by Liu et al [19,20] was able to distinguish 26 common skin diseases, with results considered as noninferior to 3 board-certified dermatologists and superior to primary care physicians and nurse practitioners involved in the study. The data consist of 17,777 deidentified cases collected from a teledermatology service. Another deep learning model developed by Esteva et al [21] was trained with a data set of 129,450 images, consisting of 2032 diseases. Its performance was tested against 21 board-tested dermatologists to perform 2 tasks, which are classifying images correctly as: (1) having keratinocyte carcinomas versus benign seborrheic keratoses, and (2) having malignant melanomas versus benign nevi. The model was able to match the performance of the experts, further showing that artificial intelligence can be leveraged to critically deliver appropriate diagnostic care. Due to the successful compression and optimization achieved by these neural networks, interfacing using apps installed on mobile phones or websites is entirely possible, making access to these tools easier.

It must be noted that this study was conducted prior to the COVID-19 pandemic. Hence, it was in a setting where teledermatology was a "proof of concept" for diagnosis based on phone images, rather than done in a real-life setting, and for which the diagnosticians had no binding physician-patient relationship. It is likely that the practice of teledermatology in more recent times may even perform better now that it is rapidly becoming culturally acceptable in clinical practice. In conclusion, teledermatology is a viable alternative to face-to-face consultations. This study showed moderate-to-substantial agreement in diagnoses from face-to-face consultation and store-and-forward teledermatology.

Acknowledgments

The authors would like to acknowledge the following dermatologists who served as the teledermatologists in this paper: Vanika Celina Y Viardo, MD; Ron Michael P Dagala, MD; and Marie Kris Lin-Mendoza, MD. This study did not receive any specific funding.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Agreement between teledermatologists and biopsy results.

[DOCX File , 15 KB - derma_v5i4e32546_app1.docx]

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Abbreviations

CD: clinical dermatologist
OPD: outpatient department

Edited by R Dellavalle, T Sivesind; submitted 01.08.21; peer-reviewed by J Yu, K Ashack, E Parker; comments to author 03.03.22; revised version received 19.09.22; accepted 13.10.22; published 31.10.22.

Please cite as:
Preclaro IAC, Gulmatico-Flores Z, Tianco EAV
Concordance and Accuracy of Teledermatology Using Mobile Phones in the Outpatient Clinic of Jose R Reyes Memorial Medical Center: Cross-sectional Study
JMIR Dermatol 2022;5(4):e32546
URL: https://derma.jmir.org/2022/4/e32546
doi:10.2196/32546
PMID:37632883

Original Paper

Patient Factors Associated With Teledermatology Visit Type and Submission of Photographs During the COVID-19 Pandemic: Cross-sectional Analysis

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Abstract

Background: The COVID-19 pandemic necessitated the widespread adoption of teledermatology, and this continues to account for a significant proportion of dermatology visits after clinics have reopened for in-person care. Delivery of high-quality teledermatology care requires adequate visualization of the patient's skin, with photographs being preferred over live video for remote skin examination. It remains unknown which patients face the greatest barriers to participating in a teledermatology visit with photographs.

Objective: The aim of this study was to identify patient characteristics associated with type of telemedicine visit and the factors associated with participating in teledermatology visits with digital photographs versus those without photographs.

Methods: We performed a cross-sectional analysis of the University of Pennsylvania Health System electronic health record data for adult patients who participated in at least 1 teledermatology appointment between March 1, 2020, and June 30, 2020. The primary outcomes were participation in a live-interactive video visit versus a telephone visit and participation in any teledermatology visit with photographs versus one without photographs. Multivariable logistic regression was performed to evaluate the associations between patient characteristics and the primary outcomes.

Results: In total, 5717 unique patients completed at least 1 teledermatology visit during the study period; 68.25% (n=3902) of patients participated in a video visit, and 31.75% (n=1815) participated in a telephone visit. A minority of patients (n=1815, 31.75%) submitted photographs for their video or telephone appointment. Patients who submitted photographs for their teledermatology visit were more likely to be White, have commercial insurance, and live in areas with higher income, better education, and greater access to a computer and high-speed internet ($P<.001$ for all). In adjusted analysis, older age (age group >75 years: odds ratio [OR] 0.60, 95% CI 0.44-0.82), male sex (OR 0.85, 95% CI 0.75-0.97), Black race (OR 0.79, 95% CI 0.65-0.96), and Medicaid insurance (OR 0.81, 95% CI 0.66-0.99) were each associated with lower odds of a patient submitting photographs for their video or telephone visit. Older age (age group >75 years: OR 0.37, 95% CI 0.27-0.50) and Black race (OR 0.82, 95% CI 0.68-0.98) were also associated with lower odds of a patient participating in a video visit versus telephone visit.

Conclusions: Patients who were older, male, or Black, or who had Medicaid insurance were less likely to participate in teledermatology visits with photographs and may be particularly vulnerable to disparities in teledermatology care. Further research is necessary to identify the barriers to patients providing photographs for remote dermatology visits and to develop targeted interventions to facilitate equitable participation in teledermatology care.

(JMIR Dermatol 2022;5(4):e38694) doi:10.2196/38694

KEYWORDS

teledermatology; telemedicine; COVID-19 pandemic; healthcare disparities; photographs; virtual; skin examination; dermatology

Introduction

The COVID-19 pandemic necessitated the widespread adoption of teledermatology care across the United States [1]. In response to stay-at-home orders and clinic closures, the Centers for Medicare & Medicaid Services expanded access to telehealth services by removing geographic restrictions and adding reimbursement for asynchronous and telephone encounters [2]. This resulted in a major increase in the use of teledermatology services especially during the early pandemic, and teledermatology has continued to account for a significant proportion of dermatology visits even after clinics have reopened for in-person care [3]. Teledermatology providers may deliver care via live-interactive videoconferencing, store-and-forward asynchronous consultations, audio-only visits, or a combination of these modalities [4]. These remote services have the potential to increase access to dermatologic care in underserved areas, deliver care at a lower cost, and mitigate known barriers to in-person visit attendance [5-9].

However, the existing digital divide has raised concerns about the ability of patients to equitably participate in teledermatology care. Reliable internet access and mobile device ownership vary based on patient age and income [10,11]. Additionally, poor technological infrastructure remains a barrier to telemedicine services in rural areas [12]. Previous studies have demonstrated that older adult patients and non–English-speaking patients were less likely to use teledermatology care compared to in-person care during the COVID-19 pandemic [13,14]. Among patients who do participate in teledermatology, older individuals, racial or ethnic minorities, and those with lower income may be more likely to participate in telephone visits compared to live-interactive video visits [15,16].

Given the visual nature of dermatologic examinations, delivery of high-quality teledermatology care requires adequate visualization of the patient's skin. It can be difficult to properly visualize the skin through live-interactive video, and photographs are preferred for adequate skin evaluation [17]. Previous evaluations of teledermatology care have not assessed whether patients had submitted photographs for their video or telephone visits, which can be an important determinant of the quality of care received. It is unknown which patients face the greatest barriers to participating in teledermatology visits with photographs. Therefore, we aimed to identify patient characteristics associated with telemedicine visit type and the factors associated with participating in a teledermatology visit with and without digital photographs.

Methods

Study Design, Data Source, and Study Population

We performed a cross-sectional study of adult patients (≥18 years old) who participated in at least 1 teledermatology appointment between March 1, 2020, and June 30, 2020, using the University of Pennsylvania Health System electronic health record data. During this period of the COVID-19 pandemic, all nonemergent, nonprocedural dermatologic services were provided remotely. Among the small number of patients who participated in more than 1 teledermatology visit during the study period, only the first visit was evaluated.

Ethical Considerations

This study was determined to be exempt from full review by the institutional review board at the University of Pennsylvania authorized by 45 CFR 46.104, category.

Outcomes

The primary outcome was teledermatology visit type. We specifically compared participation in a live-interactive video visit versus a telephone visit and participation in any teledermatology visit with photographs versus one without photographs (ie, video or telephone visit with digital photos submitted via the electronic patient portal versus without submission of digital photographs).

Covariates

Patient characteristics including age, sex, race and ethnicity, primary language, marital status, insurance, electronic patient portal activation status, and visit diagnosis were extracted from the electronic health record. Race and ethnicity were combined and categorized as follows: non-Hispanic White (reference; hereafter referred to as "White"), non-Hispanic Black (hereafter referred to as "Black"), non-Hispanic Asian (hereafter referred to as "Asian"), Hispanic (any race), or non-Hispanic other race. Educational attainment, poverty level, broadband internet access, and computer access were based on the patient's zip code of residence and obtained from the 2016-2020 American Community Survey 5-year data [18]. Diagnoses associated with teledermatology visits were categorized as follows: inflammatory and autoimmune diseases (including eczema, acne, psoriasis, and other inflammatory skin diseases as well as all autoimmune/immune-mediated skin diseases), benign neoplasms, malignant and premalignant neoplasms, pigmentary disorders, and other dermatologic conditions (including hair or nail disorders, infections, and other diseases not already categorized). The inflammatory and autoimmune diseases category served as the reference diagnosis category. Diagnostic categories were determined based on the distribution and relatedness of individual *International Classification of Disease, Tenth Revision* (ICD-10) codes associated with teledermatology visits included in the study period. Among visits associated with diagnoses across multiple categories, a primary diagnosis was determined based on an estimate of the importance of skin visualization for the diagnosis according to the following hierarchy (from highest to lowest): malignant and premalignant neoplasms, benign neoplasms, inflammatory and autoimmune diseases, pigmentary disorders, and other dermatologic conditions.

Statistical Analysis

Patient characteristics were summarized using descriptive statistics and compared across telemedicine visit types using Wilcoxon rank sum test for continuous variables and χ^2 test for categorical variables. Multivariable logistic regression was performed to calculate odds ratios (ORs) and 95% CIs for the associations between patient characteristics and the study outcomes. A purposeful selection modeling approach was used to build the multivariable model [19]. All covariates with significant ($P<.05$) associations with the outcome on bivariate analyses as well as age and sex were included. For the evaluation of teledermatology visits with photographs versus without photographs, electronic patient portal activation status was not included as a covariate in the multivariable model because use of the electronic portal was required to submit photographs for nearly the entirety of the study period. A sensitivity analysis was also performed including only patient-level variables (excluding educational attainment, poverty level, broadband internet access, and computer access) in the multivariable regression models for each outcome of interest. All analyses were performed using SAS 9.4 (SAS Institute Inc).

Results

In total, 5717 unique patients completed at least 1 teledermatology visit during the study period; 68.25% (n=3902) of these patients had a video visit, and 31.74% (n=1815) had a telephone visit (Table 1). Fewer than one-third of these patients (n=1815, 31.74%) submitted photographs for their video or telephone appointment. The median (IQR) age of the patients was 54 (36-66) years, and most patients were female (n=3712, 64.93%). The racial or ethnic distribution of patients was as follows: 67.73% (n=3872) White, 17.39% (n=994) Black, 3.48% (n=199) Asian, 2.26% (n=129) Hispanic, and 9.15% (n=523) other race. Most patients had commercial insurance (n=2917, 51.02%), and 91.18% (n=5213) had an activated electronic patient portal account that could be used to send messages, documents, or photos electronically to their health care provider. Most visits were associated with a single diagnostic category (n=3349, 58.58%). The most common primary diagnosis category seen during the study period was inflammatory and autoimmune diseases (n=3188, 55.76%), and the most common specific diagnoses were eczema or dermatitis, acne or rosacea, and psoriasis, regardless of visit type.

Table 1. Characteristics of patients who completed video versus telephone teledermatology visits.

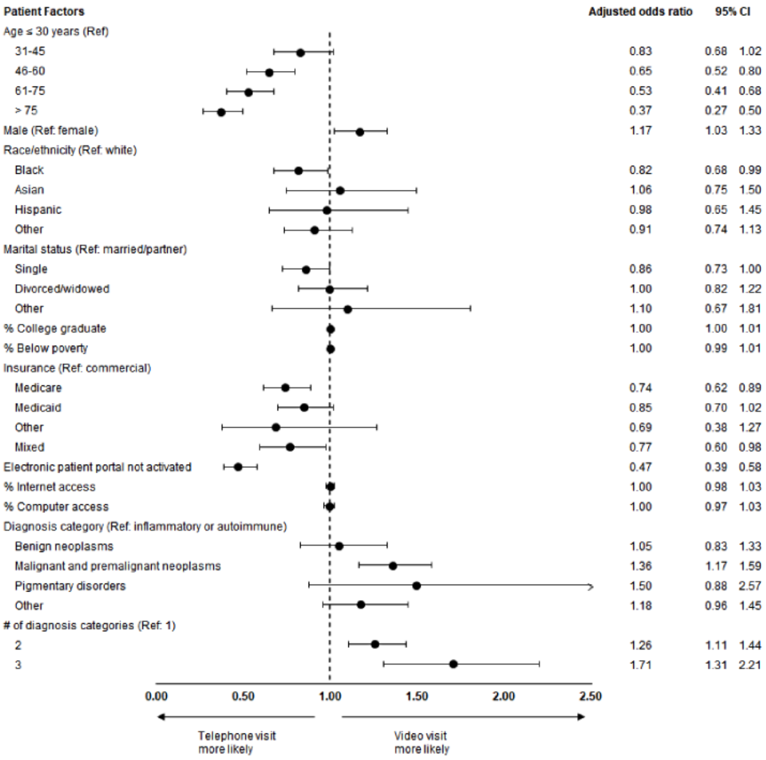
Characteristic	Overall (N=5717)	Video visits (n=3902)	Telephone visits (n=1815)	*P* value
Age (years), median (IQR)	54 (36-66)	52 (35-65)	58 (39-70)	<.001
Age, n (%)				
≤30 years	929 (16.25)	697 (17.86)	232 (12.78)	<.001
31-45 years	1260 (22.04)	917 (23.50)	343 (18.90)	
46-60 years	1374 (24.03)	954 (24.45)	420 (23.14)	
61-75 years	1537 (26.88)	997 (25.55)	540 (29.75)	
75+ years	617 (10.79)	337 (8.64)	280 (15.43)	
Sex, n (%)				
Female	3712 (64.93)	2493 (63.89)	1219 (67.16)	.02
Male	2005 (35.07)	1409 (36.11)	596 (32.84)	
Race/ethnicity, n (%)				
White	3872 (67.73)	2696 (69.09)	1176 (64.79)	<.001
Black	994 (17.39)	615 (15.76)	379 (20.88)	
Asian	199 (3.48)	149 (3.82)	50 (2.75)	
Hispanic	129 (2.26)	90 (2.31)	39 (2.15)	
Other	523 (9.15)	352 (9.02)	171 (9.42)	
Primary language, n (%)				
English	5641 (98.67)	3852 (98.72)	1789 (98.57)	.89
Spanish	24 (0.42)	16 (0.41)	8 (0.44)	
Other	52 (0.91)	34 (0.87)	18 (0.99)	
Marital status, n (%)				
Married/partner	2930 (51.25)	2021 (51.79)	909 (50.08)	.04
Single	2126 (37.19)	1461 (37.44)	665 (36.64)	
Divorced/widowed	574 (10.04)	362 (9.28)	212 (11.68)	
Other	87 (1.52)	58 (1.49)	29 (1.60)	
College graduate (%), median (IQR)	44.20 (27.40-60.0)	45.50 (28.60-61.50)	41.20 (27.10-57.0)	<.001
Living in poverty (%), median (IQR)	7.00 (4.20-13.40)	6.70 (4.10-13.40)	7.30 (4.70-15.10)	.001
Insurance, n (%)				
Commercial	2917 (51.02)	2146 (55.00)	771 (42.48)	<.001
Medicare	1598 (27.95)	956 (24.50)	642 (35.37)	
Medicaid	740 (12.94)	488 (12.51)	252 (13.88)	
Other	48 (0.84)	31 (0.79)	17 (0.94)	
Mixed	344 (6.02)	234 (6.00)	110 (6.06)	
Missing	70 (1.22)	47 (1.20)	23 (1.27)	
Electronic patient portal, n (%)				
Activated	5213 (91.18)	3657 (93.72)	1556 (85.73)	<.001
Not Activated	504 (8.82)	245 (6.28)	259 (14.27)	
With broadband internet (%), median (IQR)	89.90 (83.60-93.00)	90.10 (84.40-93.00)	89.40 (83.00-93.00)	<.001
With a computer (%), median (IQR)	93.80 (90.80-95.80)	93.80 (91.0-95.80)	93.60 (90.40-95.60)	<.001
Primary diagnosis category, n (%)				
Inflammatory or autoimmune	3188 (55.76)	2123 (54.41)	1065 (58.68)	.01
Benign	409 (7.15)	289 (7.41)	120 (6.61)	

Characteristic	Overall (N=5717)	Video visits (n=3902)	Telephone visits (n=1815)	*P* value
Malignant	1501 (26.26)	1072 (27.47)	429 (23.64)	
Pigmentary disorder	78 (1.36)	58 (1.49)	20 (1.10)	
Other	541 (9.46)	360 (9.23)	181 (9.97)	
Number of diagnosis categories, n (%)				
1	3349 (58.58)	2212 (56.69)	1137 (62.64)	<.001
2	1980 (34.63)	1391 (35.65)	589 (32.45)	
≥3	388 (6.79)	299 (7.66)	89 (4.90)	

Video Versus Telephone Visits

In unadjusted analyses, patients who participated in video visits were younger and were more likely to be male, White, and have commercial insurance than were patients who participated in telephone visits; they were also more likely to live in areas with higher income, better education, and greater access to a computer and high-speed internet (Table 1). Notably, patients who participated in video visits were less likely to have Medicare insurance than were those who participated in telephone visits. In adjusted analyses, the following factors were found to be associated with lower odds of a patient participating in a video versus telephone visit: older age (reference age 30 years; age group 46-60 years: odds ratio [OR] 0.65, 95% CI 0.52-0.80; age group 61-75 years: OR 0.53, 95% CI 0.41-0.68; age group >75 years: OR 0.37, 95% CI 0.27-0.50), Black race (OR 0.82, 95% CI 0.68-0.98), Medicare insurance (OR 0.74, 95% CI 0.62-0.89), and nonactivated electronic patient portal account (OR 0.47, 95% CI 0.39-0.58; Figure 1). Male sex (OR 1.17, 95% CI 1.03-1.33), malignant neoplasm primary diagnosis category (OR 1.36, 95% CI 1.17-1.59), and having more than 1 primary diagnosis category (2 categories: OR 1.26, 95% CI 1.11-1.44; 3 categories: OR 1.71, 95% CI 1.31-2.21) were each associated with higher odds of a patient participating in a video versus telephone visit (Figure 1). The results were robust to a sensitivity analysis that included only patient-level variables in the multivariable regression model.

Figure 1. Patient factors associated with video visits compared to telephone visits. Ref: reference group.



Visits With Versus Without Photographs

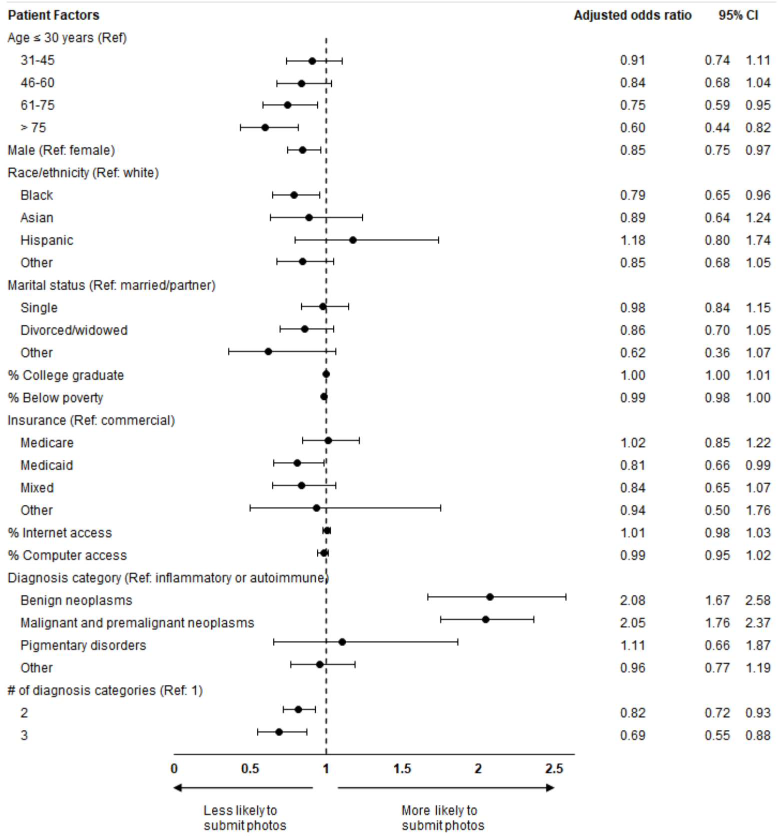
In unadjusted analyses, there were no significant differences in age or sex between patients who submitted photographs for their video or telephone visit versus those who did not (Table 2). However, patients who submitted photographs for their teledermatology visit were more likely to be White, have commercial insurance, and live in areas with higher levels of income, better education, and greater access to a computer and high-speed internet, than were patients who did not submit photographs (Table 2). Additionally, patients who submitted photographs were less likely to have Medicaid insurance than were those who did not submit photographs. In adjusted analyses, the following factors were found to be associated with lower odds of a patient submitting photographs for their video or telephone visit: older age (reference age 30 years; age group 61-75 years: OR 0.75, 95% CI 0.59-0.95; age group >75 years: OR 0.60, 95% CI 0.44-0.82), male sex (OR 0.85, 95% CI 0.75-0.97), Black race (OR 0.79, 95% CI 0.65-0.96), Medicaid insurance (OR 0.81, 95% CI 0.66-0.99), and more than 1 primary diagnosis category (2 categories: OR 0.82, 95% CI 0.72-0.93; 3 categories: OR 0.69, 95% CI 0.55-0.88). The benign neoplasm (OR 2.08, 95% CI 1.67-2.58) and malignant neoplasm (OR 2.05, 95% CI 1.76-2.37) primary diagnosis categories were each found to be associated with higher odds of a patient submitting photographs for their video or telephone visit (Figure 2). These results were also robust to a sensitivity analysis that included only patient-level variables in the multivariable regression model.

Table 2. Characteristics of patients who completed teledermatology visits with photographs versus without photographs.

Characteristic	Visits with photographs (n=1815)	Visits without photographs (n=3902)	*P* value
Age (years), median (IQR)	54 (36-67)	53 (36-66)	.42
Age, n (%)			
≤30 years	292 (16.09)	637 (16.32)	.65
31-45 years	388 (21.38)	872 (22.35)	
46-60 years	437 (24.08)	937 (24.01)	
61-75 years	510 (28.10)	1027 (26.32)	
75+ years	188 (10.36)	429 (10.99)	
Sex, n (%)			
Female	1190 (65.56)	2522 (64.63)	.49
Male	625 (34.44)	1380 (35.57)	
Race/ethnicity, n (%)			
White	1344 (74.05)	2528 (64.79)	<.001
Black	222 (12.23)	772 (19.78)	
Asian	57 (3.14)	142 (3.64)	
Hispanic	43 (2.37)	86 (2.20)	
Other	149 (8.21)	374 (9.58)	
Primary language, n (%)			
English	1798 (99.06)	3843 (98.49)	.14
Spanish	7 (0.39)	17 (0.44)	
Other	10 (0.55)	42 (1.08)	
Marital status, n (%)			
Married/partner	999 (55.04)	1931 (49.49)	<.001
Single	637 (35.10)	1489 (38.16)	
Divorced/widowed	161 (8.87)	413 (10.58)	
Other	18 (0.99)	69 (1.77)	
College graduate (%), median (IQR)	49.30 (30.06-62.20)	41.90 (27.40-58.20)	<.001
Living in poverty (%), median (IQR)	6.40 (4.00-10.30)	7.30 (4.70-14.70)	<.001
Insurance, n (%)			
Commercial	976 (53.77)	1941 (49.74)	<.001
Medicare	514 (28.32)	1084 (27.78)	
Medicaid	179 (9.86)	561 (14.38)	
Other	15 (0.83)	33 (0.85)	
Mixed	103 (5.67)	241 (6.18)	
Missing	28 (1.54)	42 (1.08)	
Electronic patient portal, n (%)			
Activated	1813 (99.89)	3400 (87.13)	<.001
Not activated	2 (0.11)	502 (12.87)	
With broadband internet (%), median (IQR)	90.80 (86.40-93.10)	89.60 (83.00-93.00)	<.001
With a computer (%), median (IQR)	94.30 (91.80-96.00)	93.60 (90.40-95.70)	<.001
Primary diagnosis category, n (%)			
Inflammatory or autoimmune	845 (46.56)	2343 (60.05)	<.001
Benign	178 (9.81)	231 (5.92)	

Characteristic	Visits with photographs (n=1815)	Visits without photographs (n=3902)	*P* value
Malignant	623 (34.33)	878 (22.50)	
Pigmentary disorder	20 (1.10)	58 (1.49)	
Other	149 (8.21)	392 (10.05)	
Number of diagnosis categories, n (%)			
1	1114 (61.38)	2235 (57.28)	.01
2	581 (32.01)	1399 (35.85)	
≥3	120 (6.61)	268 (6.87)	

Figure 2. Patient factors associated with submitting photographs for a virtual visit. Ref: reference group.



Discussion

Principal Findings

In our cross-sectional study of patients who participated in a teledermatology visit during the early COVID-19 pandemic, we found that patients who were older, male, Black, or had Medicaid insurance were less likely to provide photographs for their teledermatology visit after adjusting for sociodemographic factors, diagnosis category, and level of computer and internet access. Patients who were older or Black were also less likely to participate in video visits than in telephone visits. Our study identifies patient populations that may be particularly vulnerable to disparities in teledermatology care.

Previous studies have also found that older patients are more likely to partake in telephone visits than in live-interactive video or asynchronous store-and-forward teledermatology visits [15,16]. Video- and image-based telemedicine encounters require the patient to have access to a smartphone, tablet, or computer; a reliable internet connection; and the ability to follow specific instructions to access and use a telemedicine platform. According to the American Community Survey Reports, people aged 65 years or older have the lowest levels of computer ownership and internet subscriptions [10]. Older adult patients are also more likely to report discomfort with using the internet and have lower electronic health literacy [20]. Many online telemedicine platforms require patients to download a mobile app, sign up for an account, enter demographic information, and memorize a password, all of which can be significant barriers for older patients who may have less experience with this technology or who may be experiencing cognitive decline [21]. Using telemedicine platforms that can be accessed within an existing internet browser, sending direct email or SMS text message links to the appointment, and providing comprehensive appointment instructions ahead of time may help to engage older patients in more teledermatology services [21,22].

In addition to older age, Black race was also associated with a lower likelihood of engaging in a video visit and a lower likelihood of submitting a photograph with any teledermatology visit in this study. A survey of patients' perceptions of medical photography identified that Black patients reported more discomfort with clinical photography and were less likely to agree that it could enhance care [23]. These beliefs are consistent with low levels of trust in the medical system and concerns about personal privacy that stem from a history of racial discrimination in medicine and research [24], and we must be conscientious of this historical context when asking patients to submit sensitive photographs. Another possible explanation for lower photograph submissions is that Black patients may be less likely to enroll in electronic patient portals [25,26]. During this study period, patient portal enrollment was necessary to submit photographs to dermatologists, and this may also contribute to the differences in photograph submission between Black and White patients after adjusting for internet and computer access levels. More broadly, successful enrollment in the electronic patient portal likely represents a patient's overall familiarity with and frequency of technology use, both of which contribute to patients' willingness to participate in video visits [27]. Additionally, the racial differences we have observed likely represent other socioeconomic and infrastructural barriers, such as stable internet connection and personal smartphone or tablet ownership, that were not directly measurable in our study and prevent equitable participation in teledermatology care.

We also identified that having Medicaid insurance was independently associated with a lower likelihood of participating in a teledermatology visit with a photograph. This gap may be the result of decreased access to the technology necessary to capture and submit high-quality photographs to a health care provider. Around one-quarter of adults with household income below US $30,000 report they do not own a smartphone, whereas smartphone ownership is nearly 100% among adults in households earning US $100,000 or more a year [11]. To overcome this financial barrier to remote care, access to a mobile device may need to be considered a medical necessity for low-income, geographically isolated patients [28].

Lastly, there were sex differences in type of teledermatology care received in this study. Prior to the COVID-19 pandemic, research showed that female patients were more likely than males to choose telemedicine visits over in-person appointments [29]. Here, we found that female patients were more likely to participate in telephone visits compared to video visits. This tendency has also been observed in the outpatient cardiology setting [30], while conversely, a study of telemedicine visits in an interventional radiology clinic found that female patients were more likely to complete video visits compared to telephone visits [31]. In our study, females were less likely to use video visits, while they were more likely to submit photographs with their video or telephone appointments. Further investigation is needed to better characterize these sex differences and understand patient preferences for telemedicine modalities.

This study is novel in that we were able to identify patient factors associated with skin visualization with photographs for teledermatology visits. Technologic advances in the resolution of digital photography have made skin visualization through photographs superior to video [32]. Although there are no known studies that directly measure the quality of teledermatology care between audio- or video-only visits to those with photographs, proper visualization of the skin is necessary for dermatologic examination. A recent survey showed that most dermatologists felt that telemedicine video quality was insufficient to provide care equivalent to an in-person visit and that uploading high-quality photographs was needed to supplement the video [33,34]. Therefore, patients relying on audio- or video-only teledermatology may be vulnerable to receiving lower-quality care than those seen via a hybrid method with photographs.

The COVID-19 pandemic has highlighted the longstanding structural inequities that exist in the United States that result in health and health care disparities. Certain populations have been disproportionately affected by COVID-19. For example, Black Americans have a higher burden of disease incidence, hospitalizations, and deaths due to COVID-19 [35,36]. Additionally, patients with public insurance are more likely to be admitted to the hospital for COVID-19–related complications [37]. As we adapt to the ongoing effects of the pandemic, we must ensure that practice changes do not further exacerbate existing disparities in access to and use of health care services. Policies that expand telemedicine access should also be coupled with strategies to broaden access to reliable and high-speed internet and the technological devices needed to participate in high-quality remote care. More funding is needed at the state and national levels to support growing technological infrastructure as are community interventions to promote electronic health literacy and provide access to publicly available electronic resources.

Limitations

This study has several limitations. The data were collected from a single, urban, academic medical center, which may limit the generalizability of the results. We did not have access to patient-level information for income, education, or computer and internet access, so these characteristics were estimated based on each patient's zip code of residence. We did not assess the quality of the photographs provided for the visits, and additionally, we were unable to assess differences in the quality of care received or dermatologic outcomes between visits with video, photograph, or no direct skin visualization. Direct visualization of the skin may not be necessary for all dermatology visits, particularly for established patients with stable, chronic conditions. We were unable to completely account for the reason for visit, which may impact how necessary it is to have skin visualization through video or photographs. Future studies are needed to determine if the modality and quality of skin visualization during a teledermatology appointment impact diagnostic accuracy, need for in-person follow-up visits, or specific skin health outcomes.

Conclusions

This study provides evidence that patients who are older, male, Black, or who have Medicaid insurance are less likely to participate in a teledermatology visit with photographs. Inadequate skin visualization during the virtual dermatologic examination may make this population particularly vulnerable to disparities in teledermatology care. As telemedicine continues to be an integral part of dermatology care delivery after the COVID-19 pandemic, further research is necessary to identify the barriers to sending photographs and to develop targeted interventions to facilitate equitable participation in teledermatology visits.

Conflicts of Interest

JT receives a research grant (to the Trustees of the University of Pennsylvania) from Pfizer Inc and has served as a consultant for Pfizer Inc and Janssen Biotech receiving honoraria. The other authors have no conflicts of interest to declare.

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Abbreviations

OR: odds ratio.

Edited by R Dellavalle, T Sivesind; submitted 12.04.22; peer-reviewed by S Collier, D Madhusudhan; comments to author 18.06.22; revised version received 10.08.22; accepted 13.09.22; published 08.11.22.

Please cite as:
Lamb JE, Fitzsimmons R, Sevagamoorthy A, Kovarik CL, Shin DB, Takeshita J
Patient Factors Associated With Teledermatology Visit Type and Submission of Photographs During the COVID-19 Pandemic: Cross-sectional Analysis
JMIR Dermatol 2022;5(4):e38694
URL: https://derma.jmir.org/2022/4/e38694
doi:10.2196/38694
PMID:37632882

Original Paper

Perspectives and Experiences of Patient-Led Melanoma Surveillance Using Digital Technologies From Clinicians Involved in the MEL-SELF Pilot Randomized Controlled Trial: Qualitative Interview Study

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Abstract

Background: The growing number of melanoma patients who need long-term surveillance increasingly exceeds the capacity of the dermatology workforce, particularly outside of metropolitan areas. Digital technologies that enable patients to perform skin self-examination and send dermoscopic images of lesions of concern to a dermatologist (mobile teledermoscopy) are a potential solution. If these technologies and the remote delivery of melanoma surveillance are to be incorporated into routine clinical practice, they need to be accepted by clinicians providing melanoma care, such as dermatologists and general practitioners (GPs).

Objective: This study aimed to explore perceptions of potential benefits and harms of mobile teledermoscopy, as well as experiences with this technology, among clinicians participating in a pilot randomized controlled trial (RCT) of patient-led melanoma surveillance.

Methods: This qualitative study was nested within a pilot RCT conducted at dermatologist and skin specialist GP–led melanoma clinics in New South Wales, Australia. We conducted semistructured interviews with 8 of the total 11 clinicians who were involved in the trial, including 4 dermatologists (3 provided teledermatology, 2 were treating clinicians), 1 surgical oncologist, and 3 GPs with qualifications in skin cancer screening (the remaining 3 GPs declined an interview). Thematic analysis was used to analyze the data with reference to the concepts of "medical overuse" and "high-value care."

Results: Clinicians identified several potential benefits, including increased access to dermatology services, earlier detection of melanomas, reassurance for patients between scheduled visits, and a reduction in unnecessary clinic visits. However, they also identified some potential concerns regarding the use of the technology and remote monitoring that could result in diagnostic uncertainty. These included poor image quality, difficulty making assessments from a 2D digital image (even if good quality), insufficient clinical history provided, and concern that suspicious lesions may have been missed by the patient. Clinicians thought that uncertainty arising from these concerns, together with perceived potential medicolegal consequences from missing a diagnosis, might lead to increases in unnecessary clinic visits and procedures. Strategies suggested for achieving high-value care included managing clinical uncertainty to decrease the potential for medical overuse and ensuring optimal placement of patient-led teledermoscopy within existing clinical care pathways to increase the potential for benefits.

Conclusions: Clinicians were enthusiastic about the potential and experienced benefits of mobile teledermoscopy; however, managing clinical uncertainty will be necessary to achieve these benefits in clinical care outside of trial contexts and minimize potential harms from medical overuse.

Trial Registration: Australian and New Zealand Clinical Trials Registry ACTRN12616001716459; https://anzctr.org.au/Trial/Registration/TrialReview.aspx?id=371865

(JMIR Dermatol 2022;5(4):e40623) doi:10.2196/40623

KEYWORDS

melanoma; self-surveillance; teledermatology; teledermoscopy; mHealth; high-value care; digital technologies; surveillance; lesion; clinicians; care; mobile; technology; skin

Introduction

The incidence of cutaneous melanoma continues to increase globally [1,2]. In Australia, a country with high melanoma burden [3] and an aging population [4], this continued increase is largely driven by the increased diagnosis of stage 0-2 localized melanoma, as defined by the American Joint Committee on Cancer (AJCC). After excision of the localized melanoma, patients require long-term clinical surveillance, as they are at high risk of developing a recurrent or a subsequent new primary melanoma [5]. Increasing demand for such dermatology services, a shortage of dermatologists [6], and the proliferation of mobile technologies have prompted consideration of changes to traditional face-to-face modes of clinical surveillance [7]. The COVID-19 pandemic has increased the adoption of store-and-forward or real-time video teledermatology [8], with increased use of "virtual melanoma checks" for triaging whether a biopsy or face-to-face review is needed [9]. Additionally, as many melanomas are initially detected by the patient themselves or a family member [10], patient-performed teledermatology (including teledermoscopy) among people with a personal history of melanoma may allow the early detection of a subsequent melanoma [11]. Teledermatology could both increase patient access to a dermatological opinion and reduce the need for routinely scheduled clinic visits. This may especially benefit patients living in rural and remote areas [12], reduce the burden on the health care system, and free up clinician time [13].

Teledermatology smartphone apps that allow patients to send macroscopic images of concerning lesions to skin specialists have become more readily available to consumers since 2012 [14,15]. Commercial teledermatology services offer a store-and-forward modality of teledermatology as part of remote service delivery models where there is no prior patient-doctor relationship and without referral [14-17]. More recently, store-and-forward teledermoscopy has become available in clinical trial settings, whereby patients take dermoscopic images of concerning lesions using a mobile dermatoscope attached to their smartphone camera and transmit these securely to a dermatologist via a smartphone app [18-21]. If shown to be safe, cost-effective, and acceptable to patients, acceptance by teledermatologists assessing images and by treating doctors is also needed before this new model of care is adopted into routine practice [7,22]. Clinicians' acceptance is a key factor in the adoption and long-term use of digital technologies in clinical practice [23,24].

We recently conducted the MEL-SELF pilot randomized controlled trial (RCT) of patient-led surveillance using a mobile dermatoscope and app in addition to usual care (intervention) compared to clinician-led surveillance (usual care). We found that patient-led surveillance including teledermoscopy may be a useful addition to routinely scheduled clinic visits [11,25]. This report presents findings from a nested qualitative study conducted with the trial's teledermatologists, treating dermatologists, and treating skin specialist general practitioners (GPs), referred to collectively as clinicians. We undertook interviews to explore clinicians' views on teledermatology and patient-conducted teledermoscopy and their experiences using these during the pilot trial.

Methods

MEL-SELF Pilot Trial

The MEL-SELF pilot trial ran from November 2018 to January 2020, and a detailed report of the study findings has been published [11]. A total of 100 patients previously treated for melanoma were recruited from specialist-led and GP-led private clinics in Sydney and Newcastle, New South Wales, Australia, and randomized to control (n=51, 51%) or intervention (n=49, 49%). Three treating dermatologists and 6 skin specialist GPs recruited patients, provided routine skin checks, and reviewed lesions as prompted by the intervention, while images submitted from patients by teledermatology were sent to and reviewed by 3 dermatologists located in Sydney, Brisbane, and Melbourne (1 of whom also recruited patients and provided their ongoing care). The model of teledermatology in the MEL-SELF pilot trial was one in which the teledermatologist was not the patient's treating doctor. Treating doctors did not assess images submitted by teledermatology.

Patients in the intervention group were guided on skin self-examination (SSE) through online videos [26] and were provided with a mobile dermatoscope and smartphone app. Patients took dermoscopic images and submitted these for teledermatology review, together with self-reported history (ie, lesion location, history of change, melanoma history of themselves and family, number of moles, skin type, and patient age). If the teledermatologist assessed the lesion as suspicious for melanoma and recommended urgent clinical review in their report, the patient made a fast-tracked, unscheduled appointment with their treating doctor (facilitated by research staff). Teledermatology technologies were provided by MetaOptima Technology Inc (Vancouver, Canada) [27], including a mobile dermatoscope (MoleScope I) that integrates with MoleScope (a smartphone-based skin imaging app) [28] and DermEngine (a digital software system that facilitates the capture, storage, communication, and analysis of skin images by dermatologists) [29].

Clinicians were eligible to participate in this qualitative study if they were involved in screening and recruiting patients for the MEL-SELF pilot RCT and/or reading submitted images and providing reports via teledermatology.

Ethics Approval

This study was approved by the Human Research Ethics Committees at the University of Sydney (X15-0445) and the Royal Prince Alfred Hospital (HREC/15/RPAH/593). All participants provided informed consent. The design, conduct, and reporting of this study follow the SRQR (Standards for Reporting Qualitative Research) guidelines [30].

Data Collection and Analysis

An interview topic guide was developed by the authors to cover views on and experiences of patient-led melanoma surveillance, teledermatology, patient-performed teledermoscopy, and components of trial implementation relevant to each clinician depending on the role they played (Multimedia Appendix 1). The topic guide was flexible enough to adapt to the specific role of each clinician in the pilot trial, and discussions beyond their experiences in the pilot trial were also encouraged. Semistructured phone interviews were conducted by 1 researcher (author DD) who is trained in qualitative interviewing and was not known to any of the clinicians before the study. Interviews lasted between 19 and 77 minutes, with a median time of 23.5 minutes. Interviews were audio recorded and transcribed verbatim by 2 researchers (authors DD and EH). Identifying details were removed from the data at the transcription stage. Interview summaries were written immediately following each interview. Discussions between authors DD and EH considered emerging analytical ideas and opportunities to refine the topic guide and approach. Preliminary codes were developed inductively from the interview summaries by DD and EH. Both authors tested these by separately coding 4 transcripts. A coding framework was then agreed upon by DD and EH and applied to the rest of the data. Key themes and interpretations were identified through coding, memo writing, and analytical discussions [31] involving authors DD, EH, JH, and KJLB. Our emerging theoretical framework had clear resonance with 2 concepts pertinent to the assessment, improvement, and prioritization of health care service delivery: high-value care and medical overuse. High-value care refers to necessary health care that is supported by evidence showing it benefits patients [32]. Conversely, medical overuse is unnecessary health care that is unlikely to benefit patients but may cause them harm [33,34]. We used these concepts to further organize and interpret the data. Coding and initial organization of codes were done in NVivo 12 software (QSR International), and a data matrix was exported to Microsoft Excel (IBM Corp) to aid thematic analysis.

Results

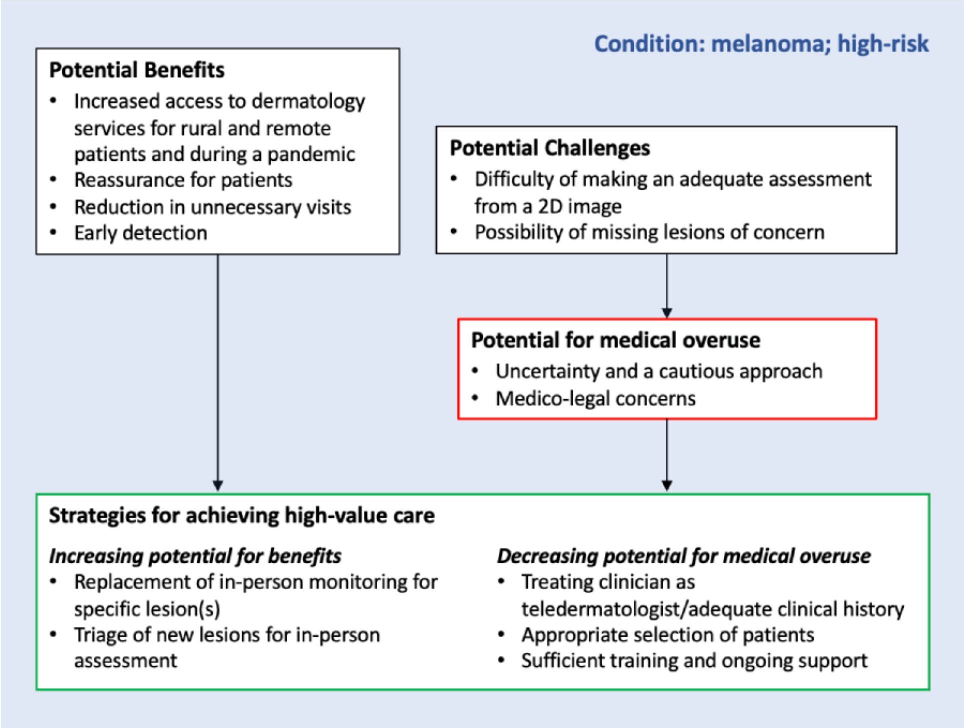
Sample and Overview

All 11 clinicians who were involved in the MEL-SELF trial were invited to participate in an interview. Three clinicians did not reply to the initial or follow-up invitation email, while 8 clinicians agreed to participate and were interviewed between October and November 2020. These included 6 treating clinicians (2 dermatologists, 1 of whom also provided teledermatology, along with 1 surgical oncologist and 3 skin specialist GPs) and 2 dermatologists who provided teledermatology only. Five clinicians were female and 3 were male. Clinicians' experience in managing melanoma patients ranged from 15 to 20 years.

All clinicians had experience using teledermatology; however, due to the novelty of patient-led teledermoscopy in the MEL-SELF pilot trial, experience reviewing dermoscopic images taken by patients (especially those who were not under their care) was more limited. Only 1 clinician (a teledermatologist) had extensive experience reporting on dermoscopic images taken by patients in research settings. All had experience providing second-opinion reviews of dermoscopic images taken by clinical staff in both clinical and research settings. Along with their experiences in the pilot trial, clinicians discussed their experiences of teledermatology outside of it, and these accounts were included in the analysis.

The results of the thematic analysis are summarized in Figure 1. For patient-conducted teledermoscopy to deliver high-value care, strategies are needed to both facilitate potential benefits and inhibit potential harms (particularly from medical overuse). Themes and their relationships to each other are explained in the subsequent sections, supported by illustrative quotes. Additional quotes are included in Multimedia Appendix 2.

Figure 1. Strategies for patient-led surveillance to achieve high-value care.



Perceived Benefits of Patient-Led Surveillance and Patient-Performed Teledermoscopy

There was an agreement among clinicians that patient-led surveillance is a good idea. Clinicians said that patients should be encouraged to get to know their skin and be educated in self-monitoring, noting, however, that not all patients are interested in doing so. Teledermatology was thought to increase access to dermatology services for rural and remote patients and enable continuity of care for all patients during the COVID-19 pandemic, thereby facilitating the early detection of melanomas. Teledermoscopy was thought to make shared monitoring of particular lesions of concern more convenient for high-risk patients living at a distance from dermatology services. Clinicians said that teledermoscopy enables quick feedback for lesions that the patient thinks are potentially concerning, either facilitating prompt review in the clinic if necessary or otherwise alleviating worry and a potentially long period of anxiety ahead of the next routinely scheduled visit. They also thought it may be useful for monitoring lesions that the clinician thinks are potentially concerning. For this use, remote monitoring was thought to have beneficial potential by reducing the frequency of routinely scheduled clinics for monitoring particular lesions.

Perceived Challenges and Potential Harms of Teledermoscopy and Teledermatology

Making Judgments From a Digital Image

Of the 6 treating clinicians, 5 emphasized that any images taken by patients needed to be of good quality, but in their experience inside and outside of the pilot trial, these were often of suboptimal quality, making clinical decisions difficult. While most of the treating clinicians were not assessing dermoscopic images during the pilot trial, they were able to view the images taken by their own patients. One treating clinician commented about the poor quality of dermoscopic images submitted during the pilot trial by 1 of their patients, which resulted in an unnecessary clinic visit. Four of the 6 clinicians who recounted experiences assessing dermoscopic images taken by patients or by other clinicians said that assessing lesions from a dermoscopic image (even if high quality) without seeing the patient in person was difficult and not always possible.

> *And some lesions are just impossible to assess, I think, via telehealth adequately, particularly if patients are high risk, you know…so I think we all feel a bit more comfortable seeing that patient face to face.* [Clinician #6, teledermatologist]

Similarly, 2 treating clinicians described difficulty making judgments about lesion management from images sent to them by patients, as they were unable to assess the lesion's texture and how the lesion responds to moving the skin.

Conversely, 2 clinicians said that assessing dermoscopic images taken by patients did not pose a problem for them. One was a treating clinician who, speaking hypothetically, said it would be just like having a patient in the consultation room, on the condition that the images were of good quality and of their own patients. The second clinician, a teledermatologist who had many years of experience in reporting dermoscopic images without seeing the patient clinically, emphasized the importance of adequate clinical history to make recommendations based on dermoscopic images.

Possibility of Missing Other Lesions of Concern

Clinicians discussed a hypothetical scenario where patient-led surveillance replaces some routine clinical visits (rather than being implemented in addition to routine visits, as was the case in the pilot RCT). Regarding this scenario, 4 clinicians expressed concern about whether patients were able to correctly identify suspicious lesions or would miss changes in areas of their body that are not easily observable. They were concerned that teledermatology could give patients false reassurance due to their selection of lesions to image, and that this could lead to deferring a clinic visit where a melanoma they were not aware of might have been identified.

> *…You can do more opportunistic checks and maybe you find something else, while if the patient only sends you a photo of the lesion that is concerning them, maybe that one is nothing but maybe next to it there is a melanoma sitting there.* [Clinician #2, treating clinician]

Potential for Medical Overuse

Uncertainty and a Cautious Approach

Among the treating clinicians, 2 explained their experiences of how uncertainty when assessing digital images can result in an overcautious approach, which in turn has the potential to result in medical overuse (ie, unnecessary visits and unnecessary biopsies or excisions) if the clinician is not able to act as the gatekeeper for these.

> *…Overall, you're going to be a bit overcautious and you know, overcall things to be on the safe side…when you're just looking at an image, you actually change your threshold to be more inclusive so that you don't miss anything…as a teledermatologist, you are going to be more cautious, so normally in your clinical practice…there's a thing called a number needed to treat, so the number of benign lesions you cut out to find one melanoma, and my average is something like 2.5 to 3, so 2.5 to 3 lesions that I cut out to pick up one melanoma; if I was going off photos and teledermatology, that number may double, it might be 5 or 6 or 7 to 1.* [Clinician #3, treating clinician]

Because the teledermatologist was not the patient's treating doctor, they assessed submitted images without information about the patient's clinical management and sometimes without an image to compare to. Therefore, at times, they advised the patient to make an urgent appointment with their treating doctor for lesions that were already being monitored by the treating doctor. This caused confusion and anxiety for the patient, difficulty for the treating clinician who had to delicately explain the situation, and unnecessary urgently scheduled clinic visits. Treating clinicians also tended to act on the teledermatologist's report if it suggested that biopsy or excision may be necessary to ease anxiety that the urgent messaging on the report had caused the patient, potentially resulting in unnecessary biopsies and excisions.

> *…Probably a little bit of anxiety for the patient, thinking oh no there's something wrong, but because it didn't take long, they were in [to the clinic] within the week …they were reassured, yep no, this is ok, we'll do the biopsy anyway, but it should be fine, etc.* [Clinician #3, treating clinician]

Medicolegal Concerns

Four clinicians perceived medicolegal issues associated with teledermatology for management of skin lesions. They suggested that the possibility of litigation for a missed or delayed melanoma diagnosis could be another reason why clinicians may "overcall" a lesion as concerning when it is not, due to the clinician's tendency to err on the side of caution in their assessment. They explained that providing teledermatology for high-risk melanoma patients should be approached with caution outside a trial context and that some skin specialists prefer not to offer teledermatology for melanoma patients at all.

Strategies for Achieving High-Value Care

Decreasing the Potential for Medical Overuse

Adequate Clinical History

All clinicians discussed the difficulty and uncertainty associated with reviewing images "out of context" and stressed the importance of having sufficient lesion and patient history to help them make adequate assessments of dermoscopic images to inform management decisions. Further, they explained that the teledermatologist's report needs to be considered by the treating doctor as a recommendation; the final decision regarding the management of the lesion is for the treating doctor to make, as they have the most comprehensive knowledge of the patient's skin.

> *…You need a history, you need to know where the lesion is, you need to know a little bit about the patient and what the rest of their skin is like. Sometimes what appears to be an abnormal naevus might just be the patient, they actually have all abnormal naevi, and they all look the same, so…there's not as much concern.* [Clinician #5, treating clinician]

Suitable Patients

To ensure the most effective use of teledermoscopic technologies, clinicians suggested carefully selecting good candidate patients, such as offering them to patients who are at risk of developing a new or recurrent melanoma but only have a small or moderate number of skin lesions to monitor, are comfortable using smartphone apps, have someone to help them take the images, and are interested in actively taking part in their own skin surveillance. Some clinicians also mentioned that patients should be younger (eg, 60 years and under), as these patients are usually more open to monitoring their own skin and are more accustomed to using digital technology. However, this was balanced by the suggestion that exclusion should not be based simply on age because some older people regularly use digital technologies or have someone to help them.

Training and Ongoing Support

Providing training, instruction resources, and ongoing support to patients were highlighted as important when delivering a teledermoscopy service. One clinician discussed their experience of patient-performed teledermoscopy in another study:

> *Our experience has been that when you explain and demonstrate to the patient how to take the photo…and you show them the video. After 3 months, you need*

to contact them to tell them to look at the video again…so it's really holding the hand of the patient, and we have quite a lot of phone calls and emails but mostly the videos have been really really useful. [Clinician #1, treating clinician]

Increasing the Potential for Benefits

Replacement of In-Person Monitoring of Specific Lesions

Due to the difficulty of determining with high certainty whether a lesion imaged by a patient is a melanoma or not and the possibility of missing a melanoma, most clinicians felt patient-led teledermoscopy may only partially replace in-person checks. They suggested that patient-led teledermoscopy could be used for patients who would otherwise need to come into the clinic for monitoring particular lesions in between their 6 monthly or annual routinely scheduled in-person checks.

…When we see them, we see some lesions that are not clear-cut melanoma, we don't want to cut but we are still a little bit worried because it has been changing with the total body photography or the patient has told us it is itchy, but we can't see anything, there is a lot of good reason to organize monitoring. And so instead of them coming in 3 months afterwards and taking a photo with the photographer and then going home because it's fine, we just tell them to take the photo at home and send us the photo with MoleScope. [Clinician #1, treating clinician]

Triage of New Lesions

Clinicians also suggested that patient-led teledermoscopy is well suited for use as a triage tool to decide whether clinical review is necessary when patients identify a lesion they think is suspicious.

So we cannot do a complete check with a dermoscope through Skype or Zoom, but we can triage a lesion quite well, and when we tell them how to send a photo even if they don't have a dermoscope, most of the time we can tell if we need to intervene now or if it is an age spot that is most likely fine and we review that when they come back in 4 months, or if it's something that we do need to see because we don't know it, if it's too difficult to tell. So, we know how to manage the patient. [Clinician #1, treating clinician]

Discussion

Principal Findings

This qualitative interview study provides important insights into the experiences and perspectives of a highly specialized group of clinicians (dermatologists and GPs specializing in skin cancer care) who participated in a pilot RCT of patient-led melanoma surveillance using mobile teledermoscopy. Clinicians identified several potential benefits of such an intervention, including additional monitoring and early diagnosis, reassurance for patients, increased access to care, and a reduction in unnecessary clinic visits. Clinicians also discussed several challenges that may increase clinical uncertainty and lead to medical overuse, as well as potentially harming patients. These included receipt of low-quality images from patients (also highlighted by Kozera et al [35]), limitations to assessment of lesions from a dermoscopic image, potential for the patients to miss lesions of concern, and perceived medicolegal risks.

We found that to decrease the potential for medical overuse when implementing patient-led surveillance using teledermoscopy, it is necessary to manage the clinicians' uncertainty. Uncertainty could be reduced by providing teledermatologists with adequate clinical history, offering the intervention to patients who have been screened for the capacity to use app and photo functions of their smartphone with ease and have someone to help them take dermoscopic photos, and providing patients with sufficient training and ongoing support. For the potential benefits of the intervention to be realized, it is important to ensure its optimum placement within the clinical care pathway. Clinicians suggested that the intervention may be able to replace scheduled monitoring visits for some patients and that the intervention could be used as a triage tool to decide whether in-person assessment is necessary for new lesions. These strategies may ensure that the intervention is most likely to deliver benefits without causing harm.

Possible Mechanisms and Implications

Although there is potential for the intervention to deliver high-value care, during the pilot trial, several interacting factors resulted in some instances of medical overuse, including unnecessary unscheduled visits and biopsies. Our findings suggest that sometimes teledermatologists (who, as per the trial design, were separate from the treating clinicians) recommended that patients make a fast-tracked unscheduled visit to review lesions that they considered suspicious because they did not have enough information about the lesion or the patient or the image was of poor quality. These decisions may reflect risk aversion, intolerance of uncertainty, and fear of malpractice and litigation, factors that may drive medical overuse [36,37]. In these instances, the treating clinician may have ordered unnecessary biopsies that they otherwise would not have to reassure the patient following an alarming teledermatology report. It is also well known that patients experience significant anxiety concerning their melanoma diagnosis [38], so perceived patient desire for clinical action by clinicians wishing to relieve patient anxiety and prioritize maintenance of the doctor-patient relationship could result in decisions to undertake biopsies even if they think this is clinically unnecessary [39]. Some of these issues may be avoided if patient-led surveillance is implemented with the patient's treating doctor as the teledermatologist. Where this is not possible, sufficient clinical information needs to be provided to the teledermatolgist.

Underlying the cautious approach taken by teledermatologists and treating clinicians is that patients who participated in the MEL-SELF trial had a personal history of melanoma and were thus at high risk of a subsequent melanoma. The framework by Greenhalgh et al [40] for considering influences on the adoption, scale-up, spread, and sustainability of patient-facing health care technologies considers the nature of the condition as the first domain in theorizing the success or failure of interventions. The diagrammatic depiction of our findings (Figure 1) suggests the ever-present influence of the high-risk nature of melanoma surveillance on clinicians' perceptions and decisions related to mobile teledermoscopy due to the potential consequences of a missed (or delayed) diagnosis. It follows then that perceived medicolegal risk was high among our sample of clinicians and has been similarly reported in other studies [41], even though perceived risk may be higher than actual risk [42]. Our findings suggest that perceived consequences (for patients and clinicians) of a delayed diagnosis, including medicolegal risk, may have impacted the provision of care. This issue needs to be addressed to minimize the potential for medical overuse from patient-conducted teledermoscopy. Possible solutions might include educating clinicians on the lower-than-perceived actual medicolegal risk, the potential for medicolegal action arising from harm from medical overuse, and the need for transparency about the uncertainty of teledermatology assessment when discussing the process with patients.

Potential harms to the patient from medical overuse such as anxiety, risk of complications from medical procedures, changes to physical appearance, and effects of disease labeling [43] should also be considered by the doctor when making a recommendation via teledermatology or deciding to do a biopsy. Clinicians' uncertainty associated with patient-performed teledermoscopy may possibly lessen over time as they gain more experience and confidence using the new technologies. A "transition period" after the introduction of new technology, in which clinical management thresholds change and then return to resemble what they were before its introduction, is well documented [44].

Strengths and Weaknesses

This study is one of the first to explore the experiences of specialized clinicians involved in patient-led surveillance using teledermoscopy. A strength of our study is that our findings are based on unique perspectives from clinicians who had different roles in delivering the patient-led surveillance intervention. Their views reflected their experiences during the MEL-SELF pilot trial, other trials of patient-performed teledermoscopy, and teledermatology in their practice in general. However, accounts of mobile teledermoscopy in a trial context may differ from experiences in clinical practice. In particular, unlike in our trial, the treating clinician may often be the teledermatologist in clinical practice. We also acknowledge that our study sample was small, and our findings are not intended to represent the breadth of experiences and views within each clinician group, namely, skin specialist general practitioners, dermatologists and teledermatologists, and surgical oncologists. A larger sample may have also revealed differences in perspective and opinion between the clinician groups that we did not detect. Additionally, the scope of our inquiry did not allow us to pursue all factors that were previously been found to impact clinicians' views of teledermatology such as reimbursement, patient privacy, and internet security [7,45]. Finally, the findings of our study are influenced by the health system context in which the clinicians work. Although in Australia, community-based health care receives public subsidy through the Medicare Benefits Scheme, there are still significant out-of-pocket costs, on average AU $183 (US$124) over 6 months for patients in the MEL-SELF pilot trial [46]. All clinics involved in the study are privately operated and charge a fee for service. Moreover, competition between private melanoma clinics exists, but this may not be comparable to the provision of melanoma care in other contexts such as the United States where a broader system of universal health care is not present.

Future Research

In response to this study's findings, we made improvements to trial processes for the larger ongoing MEL-SELF trial (ANZCTR12621000176864) [19]. Teledermatologists now have access to an image of the patient's back to give context on the patient's skin in general (eg, signs of sun damage), and each patient selects a target lesion with their treating doctor, making explicit the shared monitoring of the lesion. To facilitate monitoring of a lesion, each patient is allocated to 1 teledermatologist who will review all the patient's images and be able to assess changes over time. Teledermatologists also have the option of seeking a second opinion from another teledermatologist using the DermEngine platform. Each teledermatologist will receive information on subsequent clinical decisions and outcomes as feedback for lesions they have reported on. To encourage perception and use of the intervention as a triage tool, unnecessarily alarming and suggestive terms such as "urgent" or "biopsy" are no longer used in the teledermatologist's feedback to patients. Further decisions regarding clinical intervention (eg, biopsies, excisions) are left to the treating doctor who reviews the lesion in-person, including the decision to override the teledermatologist's recommendation. The ongoing MEL-SELF trial is also collecting information on the quality of images taken by patients and whether teledermatologists can report on them.

Conclusions

This study illuminated the potential benefits and challenges of using patient-performed teledermoscopy from the perspectives of clinicians involved in a pilot RCT of patient-led surveillance. Patient-led surveillance may address inequities in access to melanoma surveillance for patients who live remotely, are less mobile, or require continuity of care during a pandemic [47,48]. It has the potential to deliver high-value care, but safeguards are needed to mitigate against the potential for medical overuse [33,34,36]. The larger MEL-SELF trial, with refinements to the teledermoscopy process in response to the findings from this study, will provide robust evidence on clinical effectiveness to inform the potential wide-scale adoption of patient-led surveillance.

Acknowledgments

The study was funded by an Australian National Health and Medical Research Council (NHMRC) Project grant (APP1163054). RLM is supported by an NHMRC investigator grant (1194703). MJ was supported by an NHMRC TRIP fellowship between 2018 and 2020 (1151021). JH was supported by an NHMRC Early Career fellowship between 2016 and 2021 (1112509). HPS holds NHMRC grants (1062935, 1099021,1137127). AEC and KLJB are supported by NHMRC investigator grants (2008454 and 1174523, respectively). The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Authors' Contributions

KJLB, JH, and DD contributed to the conception and design of the study. DD acquired the data. DD, EH, JH, and KJLB contributed to the analysis and interpretation of the data. DD drafted the manuscript. All authors provided critical revision of the manuscript for important intellectual content and approved its publication.

Conflicts of Interest

HPS is a shareholder of MoleMap NZ Limited and teledermatology consult GmbH and undertakes regular teledermatological reporting for both companies. HPS is a medical consultant for Canfield Scientific Inc, Blaze Bioscience Inc, and a Medical Advisor for First Derm. PG receives a consultancy honorarium from MetaOptima. RPMS has received honoraria for advisory board participation from Merck Sharp & Dohme, Novartis, and Qbiotics and speaking honoraria from Bristol Myers Squibb.

Multimedia Appendix 1
Interview topic guide.
[DOCX File , 24 KB - derma_v5i4e40623_app1.docx]

Multimedia Appendix 2
Illustrative quotations.
[DOCX File , 26 KB - derma_v5i4e40623_app2.docx]

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Abbreviations

AJCC: American Joint Committee on Cancer
GP: general practitioner
RCT: randomized controlled trial
SRQR: Standards for Reporting Qualitative Research
SSE: skin self-examination

Edited by R Dellavalle; submitted 30.06.22; peer-reviewed by C Heckman, J Robinson; comments to author 11.08.22; revised version received 24.10.22; accepted 19.11.22; published 20.12.22.

Please cite as:
Drabarek D, Habgood E, Ackermann D, Hersch J, Janda M, Morton RL, Guitera P, Soyer HP, Collgros H, Cust AE, Saw RPM, Emery J, Mar V, Dieng M, Azzi A, Lilleyman A, Bell KJL
Perspectives and Experiences of Patient-Led Melanoma Surveillance Using Digital Technologies From Clinicians Involved in the MEL-SELF Pilot Randomized Controlled Trial: Qualitative Interview Study
JMIR Dermatol 2022;5(4):e40623
URL: https://derma.jmir.org/2022/4/e40623
doi:10.2196/40623
PMID:37632906

Original Paper

Worldwide Evolution of Vaccinable and Nonvaccinable Viral Skin Infections: Google Trends Analysis

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Abstract

Background: Most common viral skin infections are not reportable conditions. Studying the population dynamics of these viral epidemics using traditional field methods is costly and time-consuming, especially over wide geographical areas.

Objective: This study aimed to explore the evolution, seasonality, and distribution of vaccinable and nonvaccinable viral skin infections through an analysis of Google Trends.

Methods: Worldwide search trends from January 2004 through May 2021 for viral skin infections were extracted from Google Trends, quantified, and analyzed.

Results: Time series decomposition showed that the total search term volume for warts; zoster; roseola; measles; hand, foot, and mouth disease (HFMD); varicella; and rubella increased worldwide over the study period, whereas the interest for *Pityriasis rosea* and herpes simplex decreased. Internet searches for HFMD, varicella, and measles exhibited the highest seasonal patterns. The interest for measles and rubella was more pronounced in African countries, whereas the interest for HFMD and roseola was more pronounced in East Asia.

Conclusions: Harnessing data generated by web searches may increase the efficacy of traditional surveillance systems and strengthens the suspicion that the incidence of some vaccinable viral skin infections such as varicella, measles, and rubella may be globally increasing, whereas the incidence of common nonvaccinable skin infections remains stable.

(JMIR Dermatol 2022;5(4):e35034) doi:10.2196/35034

KEYWORDS

big data; infodemiology; measles; varicella; rubella; hand; foot; mouth disease; skin infection; epidemic; wart; skin; dermatology; trend; Google search; web search; surveillance; vaccinable; incidence; viral epidemics; distribution; measles

Introduction

Viral skin infections are common reasons for consulting health care providers and represent a substantial public health concern throughout the world. Effective vaccines against viral diseases with primary or prominent cutaneous manifestations include those directed against measles and rubella (now commonly used together with a mumps vaccine as the trivalent MMR), human papillomavirus, varicella, and zoster [1]. Although vaccination is an effective method of preventing these diseases [2,3], large-scale epidemiologic data on their evolution and distribution remain scarce. Studying the population dynamics of these viral epidemics using traditional epidemiological methods is costly and time-consuming, especially over wide geographical areas. Moreover, traditional studies may be affected by the underreporting of cases, data quality issues, reporting delays, or even conflicts of interest, resulting in missed opportunities to respond to trends in disease prevalence. Over the last 2 decades, the use of the internet as an initial information source has become almost ubiquitous among the general population. Google Trends is a web-based tracking system by Google that analyzes the popularity of top search queries in the Google search engine across various regions and languages [4,5]. Since 2004, Google Trends has been increasingly used to explore web-based health-seeking behaviors, offering a new, interesting tool to monitor public attention with regard to specific diseases. The association between the predictive power of Google Trends and the data of official surveillance systems has been studied for a wide range of medical topics, with the conclusion that it can provide useful real-time data about epidemiological surveillance, screening, and treatment options [6-13]. Previous studies have examined the utility of Google Trends to monitor various infectious diseases such as influenza, tuberculosis, Lyme disease, COVID-19, dengue, genital warts, lice, or scabies [6-13]. Since the possible resurgence of some viral skin diseases is a growing concern [14], we investigated whether Google Trends could reflect possible changes in the epidemiology of cutaneous viral infections.

Methods

Google Trends Data

The data were obtained from Google Trends, a public web-based database and analytics tool of Google Inc [4,5]. Similar applications of infoveillance in the investigation of health campaign effectiveness have been described previously [15-17].

Google Trends generates data and allows the user to compare the relative search volume (RSV) of 2 or more search terms, offering temporal and geographic models based on the specific terms [16-18]. It shows how often a given search term is entered into the Google search engine relative to the website's total search volume over a given period of time. Google Trends can be used for comparative keyword research and to discover event-triggered spikes in keyword search volume.

The RSV is assigned to the search terms. The RSV values represent the goal of the research based on the highest point of the plot with respect to a region or a specific period. The RSV values do not represent absolute search volume numbers but rather normalized values reflected on a scale from 0 to 100, where 100 is the point of maximum popularity among the search terms or topics over a specified time frame. When no sufficient data are found regarding the search term, the score drops to 0 [5,12,13,19,20]. Relative monthly scores for all search terms and topics are expressed as relative interest scores, which are surrogates for the relative popularity of a particular search term and topic over that time frame.

The keywords were selected from articles on viral skin diseases or infections [21,22], and the usual name of the most common diseases were considered.

A search-term query in Google Trends provides searches for an exact search term, whereas a topic query includes related search terms (in any language, such as German, Portuguese, Chinese, Ukrainian, or Spanish) [23]. Google Trends facilitates the easy comparison of the given terms regardless of the language of Google users. We focused our analysis on the "Related Searches" section, which shows queries (and not keywords) that are related to the entered terms (which are instead true keywords). The data were obtained using the following topic queries, in the "Global" category (all available categories in Google Trends were included): "rougeole" ("measles" in French) as the subject; "herpès" ("herpes" in French) as the disease; "varicelle" ("chickenpox" in French) as the disease; "zona" ("zoster" in French) as the subject; "syndrome pieds-mains-bouche" ("hand, foot, and mouth disease" [HFMD] in French) as the disease; "molluscum contagiosum" as the subject; "verrue" ("warts" in French) as the subject; "pytiriasis rosé de Gibert" ("*Pityriasis rosea*" in French) as the disease; "exanthème subit" ("roseola" in French) as the disease; and "rubéole" ("rubella" in French) as the disease. The data were obtained in the time frame elapsing from January 1, 2004, to May 2021 (n=209 months) worldwide and aggregated by month. To compare the temporal evolution of the searches, the file in CSV format for each search was downloaded separately.

Ethical Considerations

Ethics approval for this type of study was not required as none of the queries in the Google database can be associated with any identity or physical location, as specified in Google's privacy policy [24].

Data and Statistical Analysis

For the entire period (n=209 months), linear adjusted lines of the RSV index representing a normalized value, ranging from 0 (no searches) to 100 (for the peak of the search), were generated separately for several variables of interest. These linear fitted lines visually compared the trends of interest in common viral skin infections over the past 17 years. Seasonality was investigated through decomposition time series multiplicative models [25]. They were used with 12 months as the number of seasons on the RSV index (dependent variable). The quality of the model was evaluated through the pseudo *R*-squared for each variable. Seasonality was investigated for each variable. Their amplitudes, quantified as the difference between their highest and lowest monthly coefficients, were compared. Technical details concerning the statistical model and analysis are described in Multimedia Appendix 1. The statistical software used were SPSS (version 27.0; IBM Corp) and NCSS (version 10; NCSS LLC).

Results

The temporal evolution for the worldwide 17-year Google Trends data (from January 2004 to May 2021) regarding the variables mentioned under the Methods section is presented in Figure 1. They were adjusted through linear straight lines showing that the total search term volume for chickenpox, HFMD, measles, molluscum contagiosum**,** roseola, warts, and zoster increased worldwide over the study period, whereas the interest for *Pityriasis rosea* decreased. We found nearly no change (slopes ≤0.022) in interest for molluscum contagiosum

(Table 1). The quality of the adjustment to the multiplicative model was satisfying.

Seasonality in worldwide internet searches (reflecting mainly the Northern Hemisphere, since 90% of the world's population and most of the internet users lives there [26,27]) was quantified as the difference between the highest and lowest seasonality coefficients, which were in decreasing order as follows: HFMD, chickenpox, measles, molluscum contagiosum, warts, roseola, rubella, *Pityriasis rosea*, zoster, and herpes (Table 1). The peaks of interest were in March for *Pityriasis rosea*; April for measles and chickenpox; May for rubella; June for molluscum contagiosum; July for HFMD, roseola, zoster, and warts; and August for herpes and zoster (Table 1 and Figure 2).

The top 5 regions where the queries for measles and rubella were the most popular were exclusively African countries. The top 5 regions where the queries for HFMD and roseola were the most popular were mostly in East Asia (Table 2).

Figure 1. Data corresponding to searches for chickenpox; herpes; hand, foot, and mouth disease (HFMD); measles; molluscum contagiosum; *Pityriasis rosea*; roseola; rubella; warts; and zoster from Google Trends time data (17 years; 209 months). To compare the temporal evolution of the searches, data for each search were downloaded separately and are presented as a relative search volume (RSV) index. They do not represent absolute search volume numbers but rather a normalized value, ranging from 0 (for no searches) to 100 (for the peak of the search). The linear trends are represented.

Table 1. Seasonality and trends in worldwide internet searches for varicella, herpes, HFMD, measles, molluscum contagiosum, *Pityriasis rosea*, Roseola, rubella, warts, and zoster.

	Varicella	Herpes	HFMD[a]	Measles	MC[b]	*Pityriasis rosea*	Roseola	Rubella	Warts	Zoster
Month, seasonal coefficient (%)										
January	103	100	55	89,8	93	103	85	91	92	97
February	105	103	58	113	93	108	91	100	93	96
March	116	100	67	114	98	107	92	108	95	98
April	118	100	82	123	106	105	105	113	101	100
May	117	99	120	125	112	104	116	115	107	100
June	113	97	122	98	115	104	120	101	111	104
July	95	103	156	84	113	94	124	92	116	105
August	79	105	132	90	108	90	110	96	114	105
September	77	99	115	95	99	93	85	99	102	102
October	84	98	116	90	91	97	91	102	94	101
November	93	99	101	93	90	98	85	98	90	98
December	101	97	75	77	82	97	84	86	84	93
Delta	41	8	101	51	33	18	40	29	32	12
Slope of the adjusted straight lines	–0.091	–0.112	–0.024	0.015	–0.146	–0.121	0.104	–0.016	0.137	0.099

[a]HFMD: hand, foot, and mouth disease.

[b]MC: molluscum contagiosum.

Figure 2. Seasonality coefficients (moving averages) of varicella, HFMD, measles, molluscum contagiosum, and *Pityriasis rosea*. For the clarity of the graph, only the infections with the highest seasonality coefficients are represented. HFMD: hand, foot, and mouth disease; PPGSS: papular-purpuric gloves and socks syndrome.

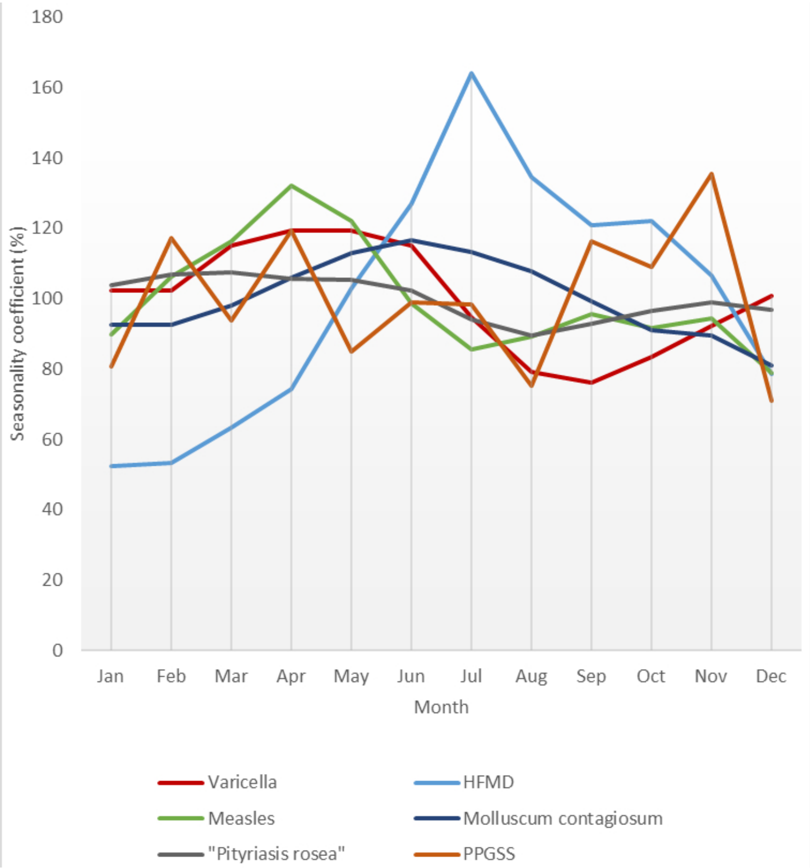

Table 2. Top 5 regions for the queries for HFMD, measles, *Pityriasis rosea*, roseola, and rubella.

Viral skin infection	Region				
	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
HFMD[a]	China	Singapore	Vietnam	Finland	Hong Kong
Measles	Niger	Chad	Congo-Kinshasa	Madagascar	Guinea
Pityriasis rosea	Jamaica	Bulgaria	Belarus	Ukraine	Russia
Roseola	Vietnam	Taiwan	Japan	Czechia	Hong Kong
Rubella	Cameroon	Benin	Algeria	Ivory Coast	Congo-Brazzaville

[a]HFMD: hand, foot, and mouth disease.

Discussion

Although some childhood viral diseases such as measles, rubella, or varicella are notifiable diseases [28], others such as warts, molluscum contagiosum, roseola, HFMD, or *Pityriasis rosea* are not reportable conditions in most countries, so studies on their changing trends and geographic distribution remain scarce.

Google Trends, a web-based tracking system of internet search volumes, has been extensively used in the field of infectious diseases, both for monitoring and surveillance purposes [6-13,29], and has been shown to be truly reliable for the prediction of epidemic outbreaks [9-12].

Previous data indicate a significant correlation between the volume of search keywords for rubella and measles with monthly reported rubella and measles cases from the Centers for Disease Control and Prevention as well as from the European Center of Disease and Prevention. [30]. Our findings indicate increasing interest among the general public regarding measles and, to a lesser extent, rubella, supporting several traditional epidemiological studies assessing a substantial global resurgence of measles cases [31-33]. The overall outbreak risk for rubella is thought to remain low [31]. The decline in vaccination rates, driven by vaccine hesitancy and the lack of confidence in vaccines, has led to recent outbreaks of vaccine-preventable diseases and threatens the public health gains made against these infectious diseases over past decades [34,35]. These outbreaks are possibly further propagated by travel and migration [33]. Infodemiology data suggest that measles may be of particular concern for some African countries (Niger, Chad, Congo-Kinshasa, and Madagascar), supporting Centers for Disease Control and Prevention notices reporting that some parts of Africa are reporting outbreaks of measles [36]. Ongoing political instability, conflict, lack of education, and poverty may also serve as major barriers to the success of vaccination programs.

Varicella still represents the most widespread vaccine-preventable childhood infectious disease in industrialized countries. Due to its relevant burden on health care resources, several countries have introduced varicella vaccination into the recommended routine childhood national immunization schedule. To date, there has been evidence showing a substantial decline in the varicella incidence from some countries that have introduced varicella vaccination [37-41], but most countries have no data about the impact of vaccination. Unexpectedly, some populations (ie, Republic of Korea) that have implemented universal varicella vaccination are facing increases in the incidence of the disease, possibly explained by primary or secondary vaccine failure [42]. Despite the existence of the varicella vaccine, many resource-rich countries have not implemented routine childhood varicella vaccination into their national schedules [42] partly because of concerns about whether herpes zoster will increase due to a lack of exogenous boosting. Our data show a worldwide increased internet interest for varicella. This finding is consistent with epidemiological studies showing that varicella incidence rates, while unreliable in the absence of mandatory reporting, tend to increase, possibly due to greater urbanization and population density [43].

Our data also support the resurgence of HFMD, more specifically in East Asia. Since 1998, HFMD has emerged, becoming a major public health concern across the Asia-Pacific region. Although the disease is responsible for over 2 million hospitalizations in Asia annually, sporadic outbreaks have occurred in Europe and in the United States in recent years [44].

The reason(s) why genital herpes decreased during this period is unclear but is in line with epidemiological studies showing that herpes simplex virus type 1 and 2 seroprevalences have had a strong declining trend for at least 2 decades, in both sexes and in all different ethnicities, possibly reflecting improvements in hygiene and living conditions [45].

We found nearly no change (slopes) in interest for molluscum contagiosum. The interest for *Pityriasis rosea* decreased over the study period. Although *Pityriasis rosea* is not uncommon, information regarding its global epidemiology is limited. Our findings may support some data assessing that the incidence of *Pityriasis rosea* may be decreasing [46].

Seasonality is a long-recognized attribute of many viral infections, but the mechanisms underlying seasonality, particularly for person-to-person communicable diseases, remain poorly understood. Seasonality may reflect oscillatory changes in infectiousness, contact patterns, pathogen survival, or host susceptibility. Google Trends has been shown to be suitable for studying seasonal patterns of various skin problems including infectious diseases or conditions such as hair loss [47-52], but few studies have used eHealth tools to assess the seasonal variations of a cutaneous viral infection.

Clear seasonality could be observed for some infections. HFMD, varicella, measles, molluscum contagiosum, and warts displayed the highest seasonality coefficients. Peaks of interest were noted in July for HFMD, which is in line with traditional epidemiologic studies showing an association between high temperatures and HFMD [53]. The possible seasonality of erythema infectiosum has been poorly investigated. Confirming classic epidemiological studies, the analysis of big data indicate that varicella also has a distinct seasonal pattern [54]. However, although classic epidemiologic studies suggest that the highest incidence of varicella [55] occurs in winter and spring, internet searches show a peak of interest somewhat later, between April and May. Confirming previous infodemiologic data, we found that the worldwide molluscum contagiosum and wart series showed clear seasonality, with a consistent 12-month oscillation period [56]. These results about seasonal patterns should be interpreted with caution, since we analyzed the worldwide interest in cutaneous viral infections including the Southern and Northern Hemispheres. This bias is probably minimized, since 90% of the world's population and most of the internet users live in the Northern Hemisphere [22,23]. Viral skin diseases' seasonality might arise independently of disease incidence, and behavioral trends in skin exposure and self-interest could influence knowledge-seeking for abnormalities such as warts [56].

The main strengths of this study encompass the basic definition of big data, including the "3 V's": volume (data sets with large and ever increasing number of observations), variety (the linkage of many structured and unstructured data into a single data set), and velocity (real-time or frequent data updates that are fully automated) [4,13]. Google Trends supports transparency and credibility because these data are openly available and are not limited by complications related to privacy [57], making the analyses replicable by any other investigators. Further, Google Trends topic queries encompass broad literature search terms, search volume data access has remained continuously available since 2008 [58], and the search is not restricted by language.

There are some limitations associated with this analysis. Google Trends provides only an RSV index, not the absolute search volume, and does not provide a way to calculate the search volume index. Google Trends also only provides data related to the selected search terms. Although we chose search terms as inclusively as possible, people looking for information on Google may have chosen other terms. The motivation of Google users is not known. As a corollary, the data obtained from Google Trends cannot be independently verified. The spike of internet searches may be attributed to various factors. It may be due to changes in case numbers in the community and changes driven by government agencies' announcements, educational purposes, or media coverage (newspapers and newscasts), influencing the web-based research of the population and leading to concerns about the increased risk of obtaining false-positive results [59,60]. Another limitation is that the participant sample was biased toward a certain segment of the population—those with internet access and using Google Search instead of other search engines. However, this bias is mitigated by the fact that as of March 2015, Google accounted for an estimated 65% of all internet search traffic, whereas the next most popular search engine accounted for only 20% of traffic during a given month [61]. Although it is common among the whole population to make web-based health-related searches, younger people tend to use the internet more often. There is also a lack of detailed information on the algorithms Google Trends uses to analyze this search data. For instance, RSV values show a high dependence on the day they are gathered, which can invalidate the reliability of a data set [57]. The collection of worldwide RSVs might minimize these oscillations [57]. It remains also possible that the large amount of data does not necessarily eliminate sources of systematic error and may even amplify them. Finally, Google Trends changed the geographic assignment for internet searches on Jan 1, 2011, and data collection in 2016, which was reflected by Google Trends displaying a respective note in the displayed graphs, but no further information was given [58].

In conclusion, this is the first study using an open web-based infoveillance tool, suggesting that although the incidence of non–vaccine-preventable skin infections is not changing or may be declining, the incidence of vaccinable diseases such as measles, rubella, and varicella is increasing worldwide. The surprising reemergence of measles and other diseases can be attributed to the rise of the anti-vaccination movement, in which groups of people refuse to be vaccinated or have their children vaccinated either out of fear, misinformation, or personal beliefs. The huge potential of the approach of analyzing Google search data could be used in the immediate future to generate timely alerts for clinical epidemiologists on disease outbreaks much earlier than conventional health epidemiology.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Technical details concerning the statistical model and analysis.

[DOC File , 49 KB - derma_v5i4e35034_app1.doc]

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Abbreviations

HFMD: hand, foot, and mouth disease
RSV: relative search volume

Edited by R Dellavalle, T Sivesind; submitted 17.11.21; peer-reviewed by A Rovetta; comments to author 04.07.22; revised version received 24.08.22; accepted 11.09.22; published 04.10.22.

Please cite as:
Simonart T, Lam Hoai XL, de Maertelaer V
Worldwide Evolution of Vaccinable and Nonvaccinable Viral Skin Infections: Google Trends Analysis
JMIR Dermatol 2022;5(4):e35034
URL: https://derma.jmir.org/2022/4/e35034
doi:10.2196/35034
PMID:37632891

Short Paper

An Analysis of Information Sources of YouTube Videos Pertaining to Tattoo Removal: Cross-sectional Study

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Abstract

Background: The American Academy of Dermatology and the Food and Drug Administration recommend consultation with a dermatologist prior to undergoing laser tattoo removal. However, non–health care professionals offer tattoo removal. Understanding the information available on the internet for patients regarding tattoo removal is important given that individuals are increasingly consulting digital sources to make decisions regarding skin care. Prior research has identified that YouTube contains misinformation on dermatologic health.

Objective: Here, we present a cross-sectional study that determined the sources of information in YouTube videos that discuss tattoo removal and described the content presented to viewers.

Methods: Using the query "tattoo removal," we reviewed English-language YouTube videos that explicitly discussed tattoo removal. The following data were recorded: profession of the presenter, tattoo removal method discussed, whether an explicit recommendation to see a dermatologist or physician was present in the video, and number of views.

Results: We analyzed 162 YouTube videos. We found that the majority were presented by non–health care professionals (n=125, 77%), with only 4 (3.7%) records of this subset recommending viewers to seek consultation from a dermatologist to ensure safe and adequate tattoo removal.

Conclusions: Based on our findings, we recommend that dermatologists and other health care professionals provide high-quality, evidence-based information to viewers on tattoo removal and encourage dermatology societies to share via their social media platforms information about the importance of consulting a dermatologist for tattoo removal.

(JMIR Dermatol 2022;5(4):e42759) doi:10.2196/42759

KEYWORDS

tattoo; tattoo removal; laser; internet; YouTube; misinformation; Food and Drug Administration; FDA; professional information; digital; research; skin; skin care; skincare; care; consultation; safe; evidence; dermatologist

Introduction

Laser-based technologies are the preferred methods for tattoo removal, and the American Academy of Dermatology and the Food and Drug Administration recommend consultation with a dermatologist prior to undergoing these procedures [1]. However, tattoo removal performed by non–health care professionals and via do-it-yourself methods (eg, scrubs, at-home lasers) are widely advertised [2]. Inadequate tattoo removal may lead to dermatologic complications, including scarring and suboptimal cosmetic outcomes. The free video platform YouTube is often accessed by individuals seeking information on cosmetic procedures. However, prior research has shown that YouTube contains misinformation regarding skin health [3-6]. This study aimed to determine the sources of information of YouTube videos discussing tattoo removal and to describe the contents that viewers are exposed to. We hypothesized that most YouTube videos pertaining to tattoo removal are presented by non–health care professionals, with many videos failing to recommend viewers to seek consultation with a dermatologist for these procedures.

Methods

A YouTube query for "tattoo removal" was performed on June 22, 2022. To mitigate selection bias, the search was conducted using incognito mode. Eligible videos were presented in English, featured audio (ie, rather than text-only), and explicitly discussed tattoo removal. Videos that met the inclusion criteria were then independently analyzed by 2 researchers, and the following variables were recorded: profession of the presenter, tattoo removal method discussed, whether an explicit recommendation to see a dermatologist or physician was present in the video, and number of views.

Results

A total of 186 videos were initially identified. After excluding videos unrelated to tattoo removal, without audio, or not in English, we included 162 (87%) of these records in our analysis. Of these 162 videos, most videos were presented by non–health care workers (n=125, 77%), with only 37 (23%) featuring health care professionals (ie, either voice-over or on-screen). Among health care professionals, presenters included dermatologists (n=27, 73%), registered nurses (n=5, 14%), plastic surgeons (n=3, 8%), and physician assistants (n=2, 5%). Laser removal was the most common tattoo removal method discussed across all videos (n=143, 88%); 35 videos from health care professionals addressed this approach, and none of them provided a discussion of technical parameters such as laser settings. The remaining 2 videos created by health care professionals discussed excisional surgery and the ineffectiveness of salt and cocoa butter scrubs. All videos presented by health care professionals suggested that viewers seek tattoo removal through physicians, with treatment in a dermatology office (n=33, 89%) being the most frequent recommendation (Table 1).

Table 1. Presenters and methods in YouTube videos discussing tattoo removal included in this study (N=162).

Presenters and methods	Videos, n (%)
Health care professionals	37 (23)
Dermatologists	27 (73)
Plastic surgeon	3 (8)
Registered nurses	5 (14)
Physician assistants	2 (5)
Health care professional methods	
Laser	35 (95)
Excisional surgery	1 (3)
Cocoa butter scrub (comment on lack of effectiveness)	1 (3)
Non–health care workers	125 (77)
Non–health care worker methods	
Laser	108 (86)
Microneedle patch	1 (0.8)
Removal cream	1 (0.8)
Lemon juice scrub	6 (5)
Yogurt scrub	1 (0.8)
Salt scrub	6 (5)
Oral herb therapy	1 (0.8)
Ink and light	1 (0.8)

While 108 videos by non–health care professionals discussed lasers, only 4 (3.7%) explicitly stated that viewers should schedule a consultation with a dermatologist to discuss the removal of their tattoos. The remaining videos focused on the presenters' experiences visiting laser clinics (n=95) or utilizing lasers at home (n=9). Nonlaser methods discussed in the videos presented by non–health care professionals included the use of scrubs composed of lemon juice (n=6), salts (n=6), and yogurt (n=1); microneedle patches (n=1); creams (n=1); oral herb therapy (n=1); and the application of ink followed by light (n=1) (Table 1). However, 119 videos from non–health care professionals addressed adverse reactions to removing tattoos, most often pain, blistering, and pigmentation changes; scarring as an adverse event was not mentioned in any of these videos. Among the top 15 most-viewed videos (range 578,340-15,982,270 views), 6 (40%) were created by dermatologists and 1 (7%) by a plastic surgeon. The remaining most-viewed videos were presented by non–health care professionals, none of which encouraged viewers to see a physician for consultation on their tattoo removal. Table 2 summarizes the content of the top 15 most-viewed YouTube videos pertaining to tattoo removal.

Table 2. Content of top 15 most-viewed videos in this study.

Rank	Views	Presenter	Tattoo removal method	Does the video recommend seeing a health care professional?	Adverse effects discussed
1	15,982,307	Plastic surgeon	Laser	Yes	Procedural pain
2	10,501,863	Dermatologist	Salt and cocoa butter (and its lack of effectiveness)	Yes	None
3	9,153,031	Patient in tattoo clinic	Laser	No	Procedural pain
4	9,018,118	Dermatologist	Laser	Yes	Procedural pain, bruising, scarring
5	7,879,038	Patient in tattoo clinic	Laser	No	None
6	5,301,535	Dermatologist	Laser	Yes	Procedural pain and swelling
7	1,759,919	Patient in tattoo clinic	Laser	No	Procedural pain
8	1,549,586	Dermatologist	Laser	Yes	Procedural pain
9	1,103,570	Dermatologist	Laser	Yes	Procedural pain
10	1,087,641	Patient at home	Salt scrub	No	Crusting
11	1,035,538	Patient in tattoo clinic	Laser	No	Procedural pain, blistering, pigmentation changes
12	820,358	Patient in tattoo clinic	Laser	No	None
13	758,979	Laser tattoo clinic worker	Laser	No	Pigmentation changes
14	653,883	Dermatologist	Laser	Yes	Procedural pain
15	578,340	Patient at home	Lemon juice and baking soda scrub	No	None

Discussion

We report that most YouTube videos regarding tattoo removal are presented by nonmedical professionals. While the majority of videos discuss laser-based methods, only a small fraction of videos recommends viewers to visit a dermatology office for these procedures. Because we only analyzed videos presented in English, we were unable to discuss the full breadth of available content to viewers presented in other languages. However, we suspect that similar misinformation patterns exist across languages.

With patients increasingly seeking health information via the internet [7,8], it is important to ensure the provision of high-quality online patient educational materials pertaining to dermatology. Therefore, we suggest patients view YouTube videos on tattoo removal with caution. Dermatologists have tools to address the misinformation that YouTube contains regarding tattoo removal. Beyond contributing to high-quality patient education through YouTube videos on the topic, the major dermatology societies of the country could consider implementing a robust campaign using their social media platforms that encourages patients contemplating tattoo removal to seek consultation with a board-certified dermatologist. In the clinical setting, proactively taking "social media histories" for patients with tattoos who may be contemplating their removal and assessing patients' understanding of the best way to approach these procedures could be an important opportunity to address areas of misinformation. Ultimately, dermatologists should remain aware of the overall poor quality of information regarding tattoo removal that is publicly accessible on YouTube. Educating patients on how tattoos are safely removed is important to ensure the best cosmetic outcomes while also avoiding potentially serious complications.

Acknowledgments

BGM was supported by National Institutes of Health/National Institute of Allergy and Infectious Diseases (NIH/NIAID) R25AI140490.

Conflicts of Interest

CGW has served as a speaker for Cynosure, Inc, including lectures about laser tattoo removal. Other authors report no conflicts of interest relevant to this work.

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Edited by R Dellavalle; submitted 16.09.22; peer-reviewed by D Zheng, V Palmer; comments to author 04.10.22; revised version received 15.10.22; accepted 16.10.22; published 25.10.22.

Please cite as:
Gallo Marin B, Ezemma O, Frech FS, Flores Servin JC, Rhee BS, Mulligan KM, O' Connell KA, Moseley I, Wambier CG
An Analysis of Information Sources of YouTube Videos Pertaining to Tattoo Removal: Cross-sectional Study
JMIR Dermatol 2022;5(4):e42759
URL: https://derma.jmir.org/2022/4/e42759
doi:10.2196/42759
PMID:36419716

Short Paper

Trends in Tattoo-Related Google Search Data in the United States: Time-Series Analysis

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Abstract

Background: Tattoos are becoming increasingly common in the United States. However, little information is available to help clinicians anticipate where, when, and on what topics patients will seek guidance regarding tattoo care, complications, and removal.

Objective: The aim of this study was to model web searches concerning general interest in tattoo application, tattoo removal, and the geolocation of tattooing services.

Methods: Relative search volumes (RSVs) were elicited from Google Trends, filtered to web searches made in the United States between January 15, 2008, and October 15, 2022. Longitudinal data were analyzed in GraphPad Prism and geospatial data were visualized with Datawrapper for general interest searches (*tattoo* and *tattoo removal*), aggregated geolocating searches (eg, *tattoo shops near me*), and symptomatic searches relating to adverse effects (eg, *itchy tattoo*). Results were compared to previous global literature and national surveys of tattoo prevalence.

Results: In the United States, the search terms *tattoo* and *tattoo removal* have experienced stable RSVs over the past 14 years, with both showing peaks in the summer and troughs in the winter. RSVs for search terms that geolocate tattooing services have experienced a general increase in use since 2008. A compilation of results for all collated geolocating search terms localized these searches mainly to the American South, with lesser involvement in the eastern Midwest and inland West. Increased search interest in the Southeast at the expense of more populous coastal states and Great Plains or western Midwest states reflects the ongoing harmonization of tattoo prevalence across regions, as shown by national surveys. Searches for symptoms related to adverse reactions to tattooing experienced an increase over the period of interest, with the same distribution as previous global findings.

Conclusions: Clinicians should be aware of an increase in search interest regarding tattoos and their removal, especially during the summer months in the Southeast and Midwest. This increase in interest is occurring together with increased tattoo prevalence and increased search interest for adverse reactions in a country lagging behind in tattoo ink regulation.

(JMIR Dermatol 2022;5(4):e40540) doi:10.2196/40540

KEYWORDS

big data; dermatoepidemiology; infodemiology; tattoo; United States; web search; dermatology; tattoo care; skin care; guidance seeking; tattoo removal; tattoo application; information seeking; internet search; web searches; adverse reactions

Introduction

Given that an estimated 2% to 30% of tattoos are complicated by adverse effects [1], institutions in Europe have incrementally enacted recommendations and regulations for maximum allowed concentrations of various injurious compounds and elements in tattoo inks, beginning with a recommendation in 2008 by the Council of Europe, ResAP(2008)1 [2]. With comparatively little research on tattoos being conducted in the United States, and still less regulation, American clinicians are armed with less information with which to counsel and care for this patient population.

Research using Google Trends, a website that calculates relative search volumes (RSVs) of queries in representative samples of searches for specific time ranges and geographic regions [3], has shown steadily rising global search interest in tattoos [4] and their adverse effects [5]. However, such analysis has yet to be adapted specifically to the US, the world's foremost producer of tattoo inks [6].

For this study, data were pulled from Google Trends, a website that calculates relative search volumes (RSVs) for queries in representative samples of searches for specific time ranges and geographic regions [7]. The data are freely available, anonymous, and unidentified. Queries are indexed as "topics" or "search terms"; topics include "a group of terms that share the same concept in any language" and so collate RSVs for multiple search terms [7]. Search interest was aggregated by topic to observe general trends over time, while isolating queries as search terms by subregion (ie, state) enabled observation of user attempts to geolocate tattooing services. Therefore, we sought to depict trends in search interest for tattoos across space and time.

Methods

Search Query Selection

To assess general interest in the application and removal of tattoo ink to and from the skin, respectively, the terms *tattoo*, indexed as a "visual art form," and *tattoo removal*, indexed as a "topic," were selected.

To observe trends in user geolocation of tattooing services, search terms specific to tattooing that localized the practice were collected from autocomplete results in the Google search engine, "top" and "rising" related queries in Google Trends, and other sources. Search strings with an RSV greater than one when compared to *tattoo shops*, the largest by volume, between January 15, 2008, and October 15, 2022, were tabulated (Table 1).

For each search string in Table 1, an average RSV was calculated from January 15, 2008, to October 15, 2015, and from October 15, 2015, to October 15, 2022. The proportions of these average RSVs to the total RSV for each of the 9 search terms were calculated for both the initial and final time periods as decimals.

Lastly, a comparison to prior research was made. Interest in the adverse effects of tattoos was modeled using symptomatic search terms adapted from Kluger [5]: *itchy tattoo*, *raised tattoo*, *swollen tattoo*, *tattoo bumps*, and *tattoo fading*. Trends in search interest were then compared to national surveys of tattoo prevalence conducted within the study's timeframe.

Table 1. Google queries geolocating access to tattooing services and their relative search volumes.

Search string	Relative search volumes, % (percent in decimal)		
	Jan 15, 2008-Oct 15, 2022 (total)	Jan 15, 2008-Oct 15, 2015 (initial)	Oct 15, 2015-Oct 15, 2022 (final)
tattoo shops	31 (0.31)	62 (0.484)	46 (0.271)
tattoo near me	21 (0.21)	6 (0.0469)	42 (0.247)
tattoo shop	16 (0.16)	37 (0.289)	21 (0.124)
tattoo shops near	10 (0.1)	6 (0.0469)	20 (0.118)
tattoo shops near me	10 (0.1)	3 (0.0234)	19 (0.112)
tattoos near me	3 (0.03)	1 (0.00781)	7 (0.0412)
tattoo parlor	3 (0.03)	11 (0.0859)	3 (0.0177)
tattoo shop near	3 (0.03)	1 (0.00781)	6 (0.0353)
tattoo shop near me	3 (0.03)	1 (0.00781)	6 (0.0353)

Search Characteristics

Google Trends was queried on October 23, 2022, with the selected topics and search terms. Results were filtered to web searches made in the United States. Results were not filtered by category, as the appropriate classification of searches as related to "arts & entertainment," "health," "shopping," or other categories could not be independently verified.

Data Retrieval and Analysis

RSVs for *tattoo* and *tattoo removal* were exported as a time series, with values being reported by Google Trends by month from January 15, 2008, to October 15, 2022. The data were imported into Prism 9 (version 9.3.1, GraphPad) to be visualized as a line graph.

RSVs for the geolocating search terms in Table 1 were exported by "subregion," or state, for the periods January 15, 2008, to October 15, 2015, and October 15, 2015, to October 15, 2022. Both the initial and final RSVs for each search term were independently normalized by multiplication with the appropriate percent in decimal (Table 1). The normalized RSVs for the 2 time periods were then aggregated across the 9 search terms by state to give an initial and final relative search interest (RSI) for tattooing services. The pairs of RSIs were imported into the Datawrapper online app (Datawrapper GmBh) by state for visualization as choropleth maps of the US.

RSVs for the 5 selected symptomatic searches for adverse reactions to tattoos were packaged by month over the total time range of interest, from January 15, 2008, to October 15, 2022.

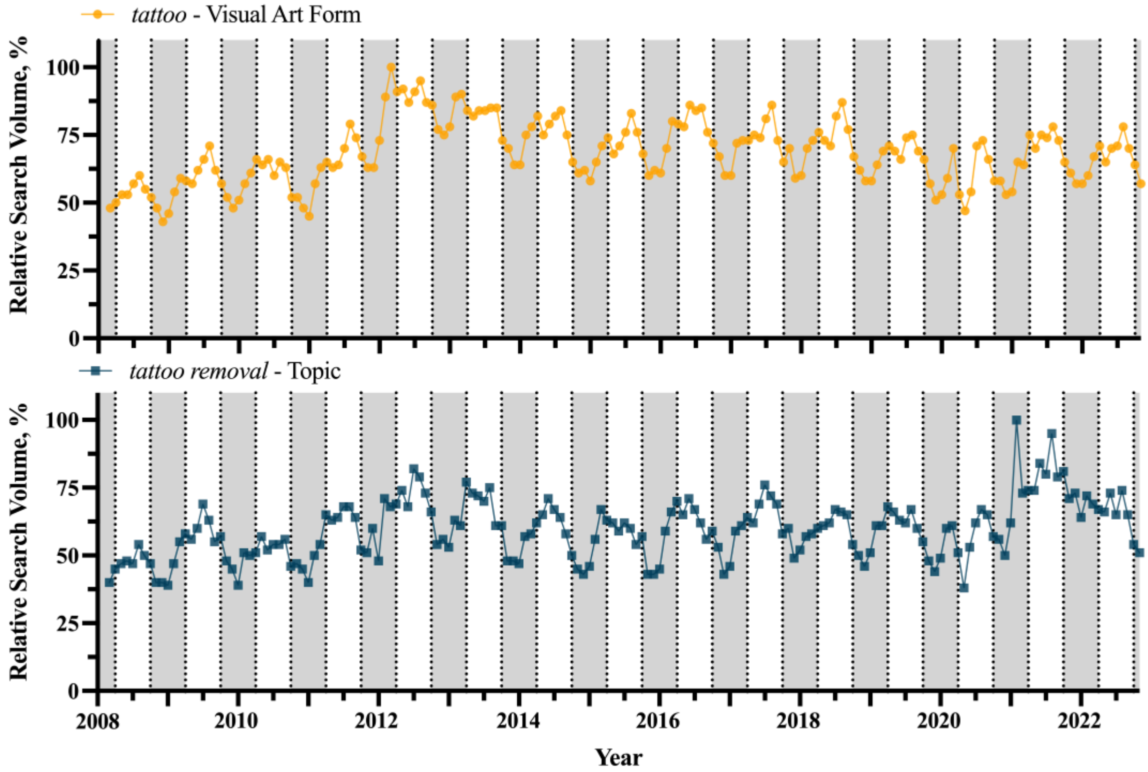
Time-series data for each search term were exported from Google Trends and imported into Prism 9 for visualization. For clarity, the 5 sets of monthly data provided by Google Trends were averaged by year to produce line graphs depicting yearly mean RSVs with error bars representing the standard error of the mean.

Results

General Interest Searches

The RSVs for *tattoo*, when indexed as a "visual art form," and *tattoo removal*, when indexed as a "topic," showed a cyclic wave pattern correlating with the seasons (Figure 1). Volume trends typically peaked in the spring and summer and reached a trough in the fall and winter. For *tattoo*, the month with the highest RSVs was typically July (11/14, 79%). The lowest monthly RSVs were most often reported for November (10/14, 71%). For *tattoo removal*, the month with the highest RSVs was most often June (5/14, 36%). The lowest monthly RSVs were most often reported for December (7/14, 50%).

Figure 1. Relative search volumes for the Google Trends queries *tattoo*, indexed as a "visual art form," and *tattoo removal*, indexed as a "topic." Results were calculated by month from January 15, 2008, to October 15, 2022. Shaded areas denote time points for months from the beginning of September to the end of February.



Searches Locating Access

Geolocating search terms with cumulative RSVs between January 15, 2008, and October 15, 2022, greater than one (Table 1) had their search interest plotted in Figure 2.

Normalized aggregated RSVs, or RSIs, are visualized by state in Figure 3. The initial choropleth map revealed no pattern in RSI density with respect to population or geography, but the final map showed localization to the American South, extending into the Midwest, with lesser involvement in the inland West. This transition was driven by increases in RSI in the mid-South to the Midwest, paired with decreases in highly populated states and in the Great Plains. The largest increases in aggregate RSV over the time period of interest occurred in Alabama (29), Tennessee (28), and North Carolina (21). The largest decreases were seen in South Dakota (–16), Kansas (–15), and Texas (–14).

Figure 2. Relative search volumes for the search terms *tattoo shops*, *tattoo shop*, *tattoo near me*, *tattoo shops near*, *tattoo shops near me*, *tattoos near me*, *tattoo shop near*, *tattoo shop near me*, and *tattoo parlor* calculated by month from January 15, 2008, to October 15, 2022. The dotted line denotes October 2015.

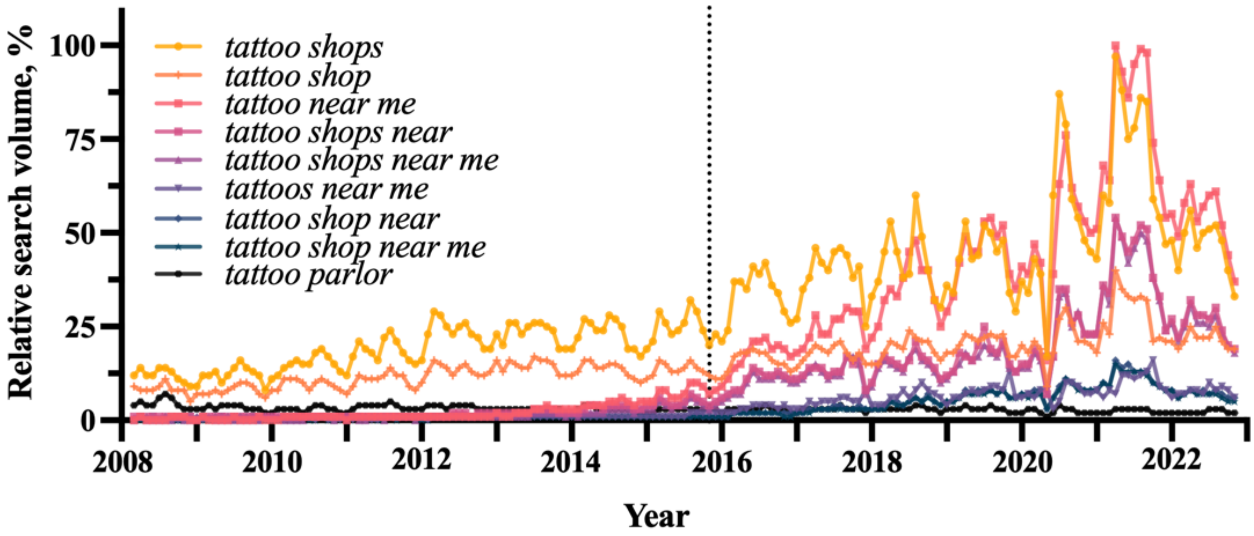
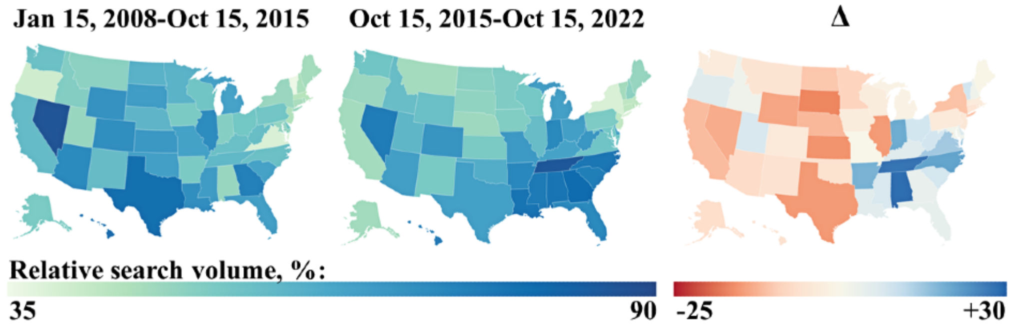


Figure 3. Relative search interest in tattoo service geolocation by state modeled by relative search volume (RSV). RSVs were calculated from January 15, 2008, to October 15, 2015 (left), and from October 15, 2015, to October 15, 2022 (center). The change in RSV by state, indicated by the Δ symbol (right), was calculated by subtracting the results of the initial time period from the results of the final time period.



Searches Based on Previous Work

The 5 search terms modeling Google web searches for symptoms of adverse reactions to tattoos have seen sustained or increased interest since January 15, 2008 (Figure 4). While yearly mean RSVs for *tattoo fading* and *swollen tattoo* were mostly stable between February 2008 and October 2022, *tattoo bumps* saw a sharp increase between 2008 and 2011, and *itchy tattoo* and *raised tattoo* have had sustained growth.

The results of freely available surveys assessing the regional prevalence of tattoos among Americans between 2008 and 2022 are tabulated in Table 2. While the West appears to initially predominate in terms of tattoo prevalence, there is a trend toward harmony among the 4 regions.

Figure 4. Relative search volumes for the search terms *itchy tattoo*, *raised tattoo*, *swollen tattoo*, *tattoo bumps*, and *tattoo fading* from January 15, 2008, to October 15, 2022, presented as yearly means. Errors bars represent the standard error of the mean.

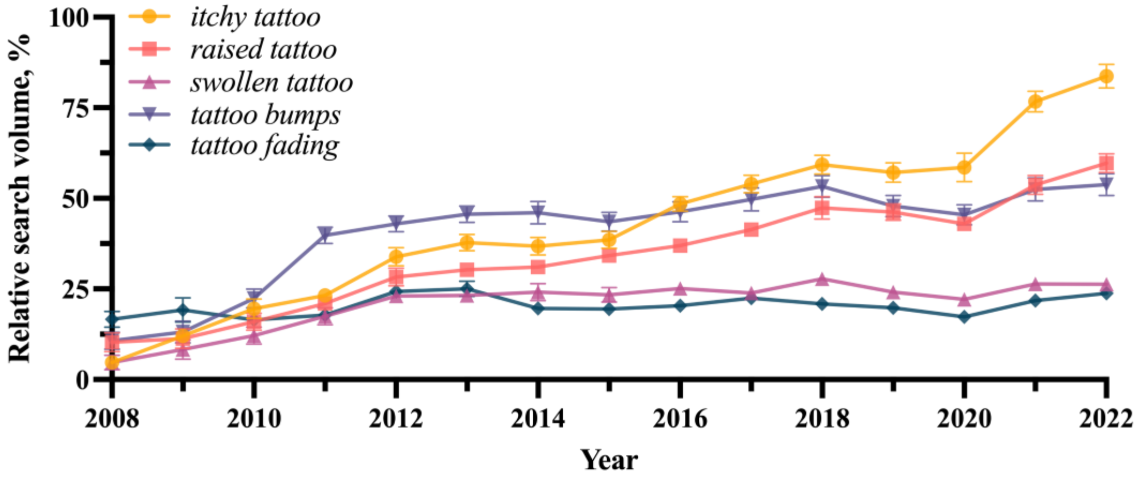


Table 2. Percentage of survey respondents with tattoos by region.

Surveyor (year)	Respondents by region, %			
	Northeast	Midwest	South	West
Harris (2008) [8]	12	10	13	20
Ipsos (2011) [9]	21	17	22	23
Harris (2012) [8]	21	21	18	26
Ipsos (2019) [10]	30	32	29	30

Discussion

Principal Results

Analysis of Google Trends data revealed a seasonal pattern in interest in tattooing and tattoo removal, with interest peaking in the summer and reaching a trough in the winter (Figure 1). Within this context, the use of the Google search engine to geolocate tattooing services has been exponentially increasing since at least 2015 (Figure 2), particularly in the Southeast (Figure 3). The localization of geolocation for tattoo services to the South, eastern Midwest, and inland West, regions considered more conservative, reflects an increase in popularity in perhaps more tattoo-naive areas, with consumers lacking industry knowledge. The decrease in RSI among western Midwest states and the Great Plains, however, defies this trend. Perhaps their distinctly rural character has so far delayed an uptick in tattoo popularity.

Comparison With Prior Work

Increases in searches geolocating tattooing services in the South, as well as the Midwest, reflect the harmonization of tattoo prevalence across US regions, which has been noted by national surveys, although these have been scarce.

The US-derived results of this paper generally reflect findings from global data. Though general search interest for tattoos in the US has been relatively stable when compared to the sustained global increase, which has mainly been driven by Latin American countries [4] (Figure 1), the RSVs of the adapted symptom-related terms have stratified in the US in the same distribution as they have across the Anglosphere [5] (Figure 4).

Limitations

Google Trends samples data generated from people who have internet access and use it, but these data are not necessarily reflective of these people's behavior. Google Trends simply samples from a representative pool of queries within a timeframe and geographic region to generate relative data. Therefore, Google Trends results for a given timeframe and geographic region may slightly change with repeated sampling.

Conclusions

Clinical dermatologists should be aware of the seasonal patterns associated with interest in tattoo application and removal and the effect of these patterns on tattoo care. Further research and surveillance are needed to understand the reasons behind and impact of geolocation of tattooing services, particularly in the American South in comparison to the Great Plains. Lastly, dermatologists should be aware of the interest in signs of localized inflammation when counseling patients on tattoo care and complications.

Conflicts of Interest

None declared.

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Abbreviations

RSI: relative search interest
RSV: relative search volume

Edited by R Dellavalle, T Sivesind; submitted 25.06.22; peer-reviewed by I Brooks, N Kluger; comments to author 08.09.22; revised version received 06.11.22; accepted 17.11.22; published 01.12.22.

Please cite as:
Kiszla BM, Harris MB
Trends in Tattoo-Related Google Search Data in the United States: Time-Series Analysis
JMIR Dermatol 2022;5(4):e40540
URL: https://derma.jmir.org/2022/4/e40540
doi:10.2196/40540
PMID:37632878

Short Paper

Medicare Opt-Out Trends Among Dermatologists May Reflect Systemic Health Policy: Cross-sectional Analysis

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Abstract

Background: Provider opt-out of accepting Medicare insurance is a nationally tracked metric by the Centers for Medicare & Medicaid Services (CMS) for all physicians, including dermatologists. Although this usually only consists of a small number of providers, the magnitude of opting out has varied historically, often tracing changes in systemic health care policy.

Objective: In this paper, we explored dermatologist opt-out data since 2001, as reported by the CMS, to characterize trends and provide evidence that shifts in provider opt-out may represent a potential indicator of the state of health policy and possible needs for reform as it pertains to Medicare.

Methods: The publicly available Opt Out Affidavits data set, available from the CMS, was evaluated for providers in all dermatologic specialties from January 1, 2001, to May 27, 2022.

Results: There were a total of 196 dermatology opt-outs in the overall period, with the largest spike being 33 providers in 2016, followed by generally consistent decreases through 2021. In the most recent 12 months of data, the number of new monthly opt-outs from January 2022 to May 2022 was significantly higher than that of the trailing 7 months of 2021 (*P*=.03).

Conclusions: Despite decreasing numbers of dermatologist opt-outs in the late-2010s, 2022 was marked by a significant increase in opt-outs. The reduced acceptance of Medicare by dermatologists may present risks to care access, so it is important to frequently assess physician opt-out data and changes over time.

(JMIR Dermatol 2022;5(4):e42345) doi:10.2196/42345

KEYWORDS

Medicare; dermatology; opt out; private contracting; ; CMS; health policy; insurance; health coverage; Medicaid

Introduction

Private contracting with Medicare patients is a practice associated with provider "opt-out" from the federal program, where billing and collecting from Medicare is precluded; although the impact of dermatologist opt-out likely varies based on factors such as practice type, provider density, and population composition, fewer physicians accepting Medicare inherently presents greater risks for care access, especially in remote, low-income, or population-sparse areas [1].

Due to the Medicare program's role in providing broad access to care, it is important to explore characteristics associated with provider Medicare opt-out and trends over time to assess potential impacts on aspects of care delivery. Although literature on opting out is limited and the practice is infrequent [2,3], trends among provider opt-out may be revelatory of systemic issues such as complex Medicare reimbursement [1], bureaucratic intricacies, and prolonged accounts receivable periods, which can strain practitioners [4]. Therefore, assessing national metrics such as Medicare opt-out may also provide insights into health policy and systemic changes that shape Medicare provider participation.

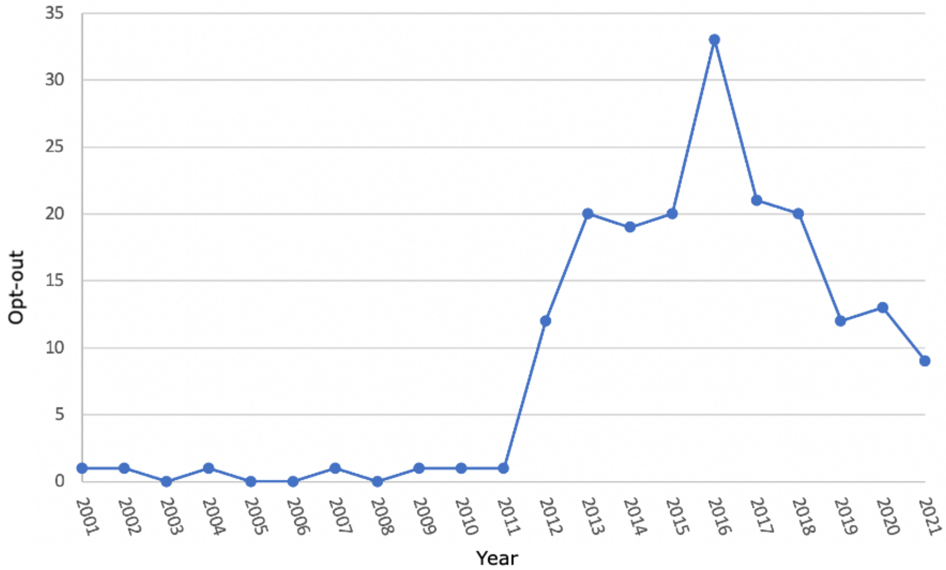
Methods

This cross-sectional analysis evaluates publicly available data from the Opt Out Affidavits data set available from the Centers for Medicare & Medicaid Services, comprehensive of all 50 states and the District of Columbia. We included all entries for physicians indicating dermatologic specialties over the total available period (from January 1, 2001, to May 27, 2022).

Results

There were 196 providers in the overall period who opted out of Medicare. From 2001 to 2011, annual opt-outs were ≤1. In 2012, twelve new providers opted out, followed by annual increases and a peak of 33 in 2016. After 2016, new opt-outs generally decrease by up to 12 providers annually, with a maximum decrease of 40% (8/20) from 2018-2019 (Figure 1). In 2021, there were 9 new opt-outs, and there were 10 in the first 5 months of 2022. Considering the most recent 12 months, the number of new monthly opt-outs for the first 5 months of 2022 (mean 2.0) was significantly higher than that of the trailing 7 months of 2021 (mean 0.57; *P*=.03). In the entire period, 112 (N=196, 57.1%) providers were located in New York, Texas, or California.

Figure 1. Annual number of new dermatologist opt-outs as reported by the Centers for Medicare & Medicaid Services.



Discussion

Overall, 196 (1.8%) dermatologists out of 11,003 total practicing dermatologists in the United States [3] opted out of Medicare. The majority of opt-outs were seen in New York, Texas, and California; although some of these opt-out providers are located in cities with populations lower than 10,000, all are in localities comprising statistical metropolitan areas, suggesting that there is likely still reasonable access to alternate avenues of care for Medicare beneficiaries in these areas. Opt-outs were uncommon until 2012, but the period from 2012 to 2016 represented the largest recorded spike.

Given that provider enrollment for participation in the Medicare program, or "opting in," is a relatively uncomplicated process consisting of a 1-time application, other persistent systemic issues may have relevance to the mid-2010s shift. Rising practice operational expenses [1], complex compliance or regulatory requirements, and uncertainties from delayed payments [3,4], along with resource-constraining policies such as prior authorizations, can make it challenging for providers to effectively deliver patient-centric care [5]. The mid-2010s surge may be explained by heightened consolidation, as 15% of clinic acquisitions among private equity groups from 2014 to 2016 were dermatology clinics [3]. Greater prevalence of large group practices can present difficulty for independent practitioners to negotiate with insurers [3] and remain economically viable if Medicare comprises a large portion of their payer mix given the associated administrative challenges [5]. Another possible contributor to the 2016 spike may be the Medicare Access and CHIP (Children's Health Insurance Program) Reauthorization Act of 2015; although beneficial in promoting patient-centric care, it may be accompanied by a higher risk exposure for providers and additional administrative strain [6]. Further investigation and provider surveying are needed to determine which specific issues are driving the described patterns in provider opt-out, since it is unclear whether the primary catalyst for provider opt-out is economic, logistic, or administrative factors. Although the reduction in dermatology opt-outs during the late-2010s likely represents a positive shift for patients and providers, the latest data show a significant monthly increase in opt-out providers, which should be monitored to ensure optimal care access for communities. Limitations of this analysis include the lack of commercial insurance opt-out data, absent information on nonphysician provider statuses, and unavailable information around reopting into Medicare or those who retired with opt-out status.

In an indirect manner, Medicare opt-out has been previously proposed as a figurative voice for providers to express sentiments about reimbursement policy [1] and may implicitly represent the impacts of other policy challenges on the state of practice. Additionally, the implications of physician opt-out can be broad, where individuals served by Medicare in certain localities may experience inadequate access to care and poorer health outcomes with increasing provider opt-out. As a result, trends in Medicare opt-out should be followed closely to evaluate possible needs to review or refine systemic dermatologic health policy in favor of both patients and providers.

Acknowledgments

The authors report no funding source or sponsor for the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Authors' Contributions

AA and JH had full access to all the data in the study and take responsibility for the integrity of the data. All authors contributed to manuscript preparation.

Conflicts of Interest

None declared.

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Abbreviations

CHIP: Children’s Health Insurance Program
CMS: Centers for Medicare & Medicaid Services

Edited by R Dellavalle, T Sivesind; submitted 31.08.22; peer-reviewed by E Halperin, C Camillo; comments to author 29.09.22; revised version received 11.10.22; accepted 16.10.22; published 08.11.22.

Please cite as:
Agarwal A, Han J, Luu Y, Gulati N
Medicare Opt-Out Trends Among Dermatologists May Reflect Systemic Health Policy: Cross-sectional Analysis
JMIR Dermatol 2022;5(4):e42345
URL: https://derma.jmir.org/2022/4/e42345
doi:10.2196/42345
PMID:37632903

Original Paper

Issues in Melanoma Detection: Semisupervised Deep Learning Algorithm Development via a Combination of Human and Artificial Intelligence

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Abstract

Background: Automatic skin lesion recognition has shown to be effective in increasing access to reliable dermatology evaluation; however, most existing algorithms rely solely on images. Many diagnostic rules, including the 3-point checklist, are not considered by artificial intelligence algorithms, which comprise human knowledge and reflect the diagnosis process of human experts.

Objective: In this paper, we aimed to develop a semisupervised model that can not only integrate the dermoscopic features and scoring rule from the 3-point checklist but also automate the feature-annotation process.

Methods: We first trained the semisupervised model on a small, annotated data set with disease and dermoscopic feature labels and tried to improve the classification accuracy by integrating the 3-point checklist using ranking loss function. We then used a large, unlabeled data set with only disease label to learn from the trained algorithm to automatically classify skin lesions and features.

Results: After adding the 3-point checklist to our model, its performance for melanoma classification improved from a mean of 0.8867 (SD 0.0191) to 0.8943 (SD 0.0115) under 5-fold cross-validation. The trained semisupervised model can automatically detect 3 dermoscopic features from the 3-point checklist, with best performances of 0.80 (area under the curve [AUC] 0.8380), 0.89 (AUC 0.9036), and 0.76 (AUC 0.8444), in some cases outperforming human annotators.

Conclusions: Our proposed semisupervised learning framework can help with the automatic diagnosis of skin disease based on its ability to detect dermoscopic features and automate the label-annotation process. The framework can also help combine semantic knowledge with a computer algorithm to arrive at a more accurate and more interpretable diagnostic result, which can be applied to broader use cases.

(JMIR Dermatol 2022;5(4):e39113) doi:10.2196/39113

KEYWORDS

deep learning; dermoscopic images; semisupervised learning; 3-point checklist; skin lesion; dermatology; algorithm; melanoma classification; melanoma; automatic diagnosis; skin disease

Introduction

Skin cancer is one of the most common cancers worldwide, with steadily increasing incidence rates of melanoma and nonmelanoma cancers [1]. Early detection of skin cancer is an important prognostic factor that can improve patient survival and overall outcomes [2]. Reliable skin cancer screening, however, may not be readily available to all patients. For example, individuals who live in rural areas without local dermatology clinics or who face barriers to attending an in-office evaluation may not have an opportunity to have skin cancer detected at an early stage. To address this concern, the use of teledermatology has become increasingly popular, particularly during the COVID-19 pandemic, which has significantly decreased in-person dermatological evaluation [3,4]. Recently, teledermatology has been shown to increase access to reliable dermatology evaluation and to minimize delays in skin cancer management [3,5]. A useful subset of teledermatology is teledermoscopy, whereby digital images of skin lesions are taken using a dermatoscopy or a smartphone with a dermatoscopy attachment [6]. Studies find that the use of dermoscopic images in teledermatology consultations improves the sensitivity and specificity of the diagnosis [3,7]. In this way, teledermoscopy offers itself as a promising tool to increase patient access to reliable skin cancer screening and, thus, the early detection of skin cancer.

The automated classification of dermoscopic images through convolutional neural networks (CNNs) has emerged as a reliable supplement to visual skin examination by on-site specialists in the detection of skin cancer [8-11]. CNNs have the potential to extend reliable skin cancer recognition to clinicians who lack special dermatology training, including nurse practitioners, physician assistants, and primary care physicians. In addition, the use of CNNs enables the evaluation of skin lesions via telemedicine. Images captured on smartphone cameras and analyzed by similar algorithms have been shown to achieve accuracy in identifying melanomas similar to that of board-certified specialists [12]. Some CNN models even exhibit greater sensitivity and specificity in diagnosing early melanoma compared with those of inexperienced clinicians [13,14].

Artificial intelligence (AI) algorithms, however, have some weaknesses. One weakness is interpretability and transparency regarding how the computer arrived at its output, making it difficult for dermatologists to trust the diagnostic results [15-17]. Another is that the current algorithms, such as the deep CNNs used in triaging and classifying suspicious skin lesions, do not provide the reasoning used to arrive at their given result [18]. This is often due to the complexity of the algorithm and hinders their utility due to a lack of the trust in the diagnosis by the patient and the physician [19].

Another limitation of AI algorithms is that a majority rely solely on images as inputs, whereas in a clinical setting, more information can be obtained through, for instance, palpation of the lesion and clinical data on age and family history [20]. The dermatologist also relies on diagnostic rules to make decisions, such as the ABCD rule, pattern analysis, 7-point checklist, and 3-point checklist, which have been developed to standardize the dermoscopic evaluation of melanoma and play a critical role in skin lesion diagnosis [8,9,21-23].

Recent studies have focused on attempts to combine semantic knowledge with the algorithm to arrive at a more accurate diagnosis [20,24-26]. Several studies have suggested that diagnoses derived using more than one source of input are more accurate than are those conceived by one method alone [27-29]. One study showed that nondermatologist physicians were able to improve their accuracy in classifying pigmented lesions when combining their knowledge of age, sex, and localization of the lesion with deep-learning frameworks [24]. Earlier research added factors such as age, body site, proportion of dysplastic nevi, naevus count, and family history of melanoma to a computer image–analysis program and found that the addition of clinical data significantly improved the ability to distinguish between benign and malignant skin lesions [30]. Another study found an improvement in the detection of basal cell carcinoma after adding factors such as lesion size and elevation, age, gender, and location [31]. Kawahara et al [32] conducted a similar work when proposing a multitask deep CNN trained on multimodal data to classify the 7-point melanoma checklist criteria and perform a skin lesion diagnosis. Even though they intergraded each feature from a 7-point checklist using loss blocks, their studies did not integrate the knowledge with the CNN architecture. One major constraint of these studies is the lack of high-quality data related to diagnosis, for example, the dermoscopic features that dermatologists use to diagnose skin lesions. In this study, we address these limitations by developing a semisupervised deep-learning framework that applies the results learned from a small, annotated data set to a larger unlabeled data set as well as by imitating the human diagnosis process in our CNN structure.

In this experiment, we chose the 3-point checklist for melanoma and melanocytic nevus as an illustration of diagnostic rules and disease class. The 3-point checklist is easy to interpret and is highly sensitive for the diagnosis of melanoma by nonexpert clinicians [33]. Melanoma is well known as the most aggressive cutaneous malignancy, accounting for approximately 75% of all skin cancer deaths [24]. It often shares morphology with melanocytic nevi on naked-eye examination, a technique that yields only 60% accuracy in a melanoma diagnosis by expert dermatologists [34]. In this regard, the International Skin Imaging Collaboration (ISIC) organizes data challenges every year, which focus primarily on diagnostic accuracy when distinguishing melanoma from other malignant and benign lesions [35]. Numerous studies that concern the use of the 3-point checklist to help classify melanomas have been conducted [33,36,37]. In these studies, participants with varying experience were able to score proven nonmelanoma and proven melanoma lesions using just the 3-point checklist criteria. A disadvantage of this method, however, is that the checklist tends to miss thinner melanomas [37]. None of the studies related to 3-point checklist has tried to combine visual inspection with CNN-extracted imaging features to arrive at a diagnosis. This is also the major difference in our state-of-the-art methodology as compared to what was seen in previous ISIC data challenges.

Combining diagnostic rules with the 3-point checklist classification algorithm can yield benefits that improve patient access to care and diagnostic accuracy. The proposed algorithms have several potential application scenarios, including the following: (1) they can automatically classify skin disease images and generate feature labels by listing the criteria used to categorize suspicious lesions to improve trust and acceptance of teledermoscopy; (2) they can assist medical students to learn and identify the features in dermoscopic images; given the detailed evaluation of each criterion in the 3-point checklist by the algorithm, students can use the checklist to learn about the fundamental parameters used to differentiate lesions as a benign nevus or a melanoma; and (3) they can automate the process of feature annotation; thus, fewer human annotators need to be involved, enabling the secondary use of enormous imaging data resources, such as the ISIC archive.

Methods

Data Set

All images from labeled and unlabeled data sets come from the ISIC archive. “Label” here represents the 3-point checklist feature labels, which means both “labeled” and “unlabeled” data sets contain disease type information. For the small, labeled data set, we selected an even distribution of melanoma and melanocytic nevus dermoscopic images from ISIC 2019 to annotate, using the 3-point checklist features. The large unlabeled data set came mainly from ISIC 2020, which contains the 584 melanoma and 5193 melanocytic nevus dermoscopic images. To balance the data set, we added 4062 melanoma images from ISIC 2019, excluding the images in the small, labeled data set. We divided each data set into training and validation sets in an 80/20 ratio and used 5-fold cross-validation, which means the data set was divided equally into 5 subsets and rotating in order to be the training or validation data set. We annotated an additional 400 images as a holdout testing set.

The 3-point checklist is easy to interpret and is highly sensitive for the diagnosis of melanoma versus melanocytic nevus. Our algorithm evaluated dermoscopic images of pigmented lesions based on the 3-point checklist, indicating the presence or absence of (1) asymmetry, (2) atypical pigment network, and (3) blue-white structures. If any one of these features was detected from the skin lesion image, 1 point would be added on top of the scoring for that image. The scoring range per image is 0 to 3. These 3-point automated classification outputs can aid in a provider’s decision to biopsy a lesion or to refer to a specialist for a more thorough evaluation. Table 1 presents the number of images for the skin disease categories of melanoma and melanocytic nevus.

Table 1. Number of images for skin disease categories for labeled and unlabeled data sets.

Disease	Unlabeled data set	Labeled data set
Melanoma	4646	450
Melanocytic nevus	5193	450
Total	9839	900

Annotation of the 3-Point Checklist

There are 3 features of the 3-point checklist, which are atypical network, asymmetry, and blue-white structure. For each feature detected, 1 score will be added for that image. The higher the score is (usually higher than 2), the higher the risk of melanoma will be. If the score is lower than 1, according to the 3-point checklist, the lesion is more likely to be benign. Our experiment was developed based on a gold standard whereby each image was rigorously reviewed by at least 2 annotators. If consensus was reached, the resulting diagnosis was annotated. If not, a third annotator would evaluate the image again. We divided the annotation into 2 steps. First, the 3 annotators had training sessions to develop consensus annotation guidelines. We provided the annotators with a small image set annotated by domain experts to annotate and evaluate. During this phase, the annotators are allowed to discuss their different understandings. After interrater agreement reached at least 70%, we moved to the second step, in which they annotated images independently. We divided the whole image data set into 3 subsets, and each annotator was assigned 2 subsets so that every image had at least 2 annotation results. Our final interrater agreement Kappa-Cohen score for the second step was 0.64, which indicated substantial agreement. If any images had different annotation results, we brought in the third annotator, who was not previously assigned to the image, and took a majority vote. Overall, this is a very time-consuming process.

Image Preprocessing

Crop and Resize

Because the training data set came from 3 data sources, each had a different resolution of the images. There could be 1 lesion that took up the entire image or just 1 corner of the graph. Hence, we developed a rule to crop and resize all the training images, which improved the performance of our model.

Color Constancy

Due to the different imaging sources and illuminations, the color of dermoscopic images varied considerably. Therefore, it was important to calibrate the color of the images in the preprocessing stage to reduce possible bias for the deep neural network. Catarina et al [38] compared 4 color-constancy algorithms (Gray World, max-RGB, Shades of Gray, and General Gray World) to calibrate the color of dermoscopic images for the melanoma classification system. These algorithms improved the system performance by increasing sensitivity and specificity, and Shades of Gray achieved better results than did the other color-constancy algorithms. Thus, for the project, we chose Shades of Gray as the color-constancy algorithm to calibrate the color of the dermoscopic images before the training stages. The calibration procedure involves 2 steps. First, the color of the light source in the RGB color space is estimated. Then, the image is transformed, using the estimated illuminant.

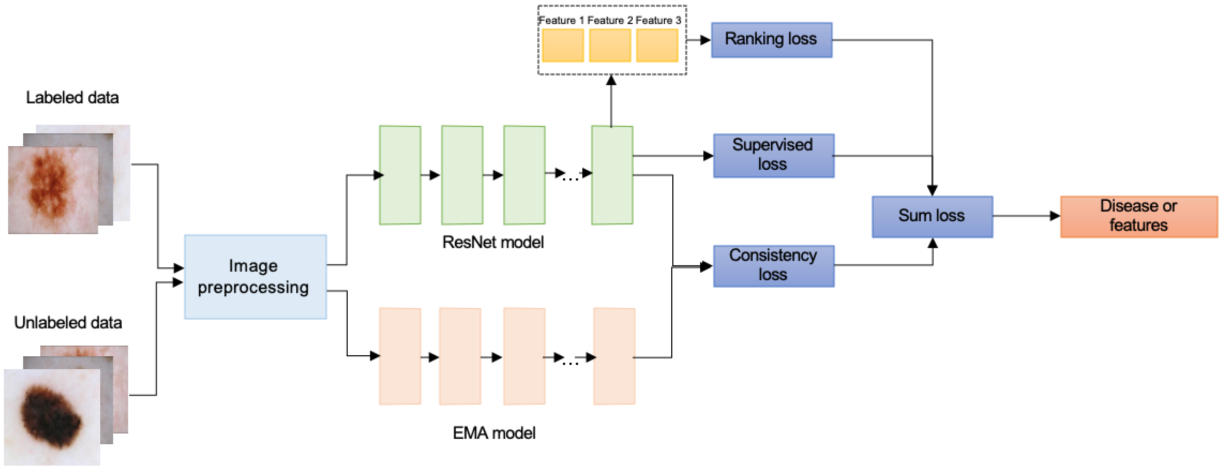
Contrast-Limited Adaptive Histogram Equalization

Contrast-Limited Adaptive Histogram Equalization was used to improve the contrast in images. Unlike histogram equalization, it computes several distinct sections of the image and uses them to redistribute the lightness values of the image. It helps to improve the local contrast and enhance the edges of objects in the image.

Model Architecture

We proposed a semisupervised learning framework for the prediction of skin disease that uses a small set of labeled images and a larger set of unlabeled images. The labeled data set contains 900 images that were labeled with disease tags and the 3-point checklist annotation, while the unlabeled data set contains 9839 images that have only disease tags. The architecture of the proposed classification model is presented in Figure 1 and contains primarily 3 components. The input component involves the preprocessing of both labeled and unlabeled images. The output of the input component is streamed into 2 branches. One branch is the supervised learning component that uses ResNet, inside which the representation of each image is associated with the 3-point labels and the classification tag and with the label-related ranking loss [39] and classification loss, correspondingly. The other is the semisupervised learning component, whereby a consistency loss is optimized using the output from an exponential moving average (EMA) model of the ResNet branch [40]. Finally, the 3 types of losses are combined, and coefficients are used to balance their weights. We provide a detailed description of these 3 components in this section.

Figure 1. Architecture of the proposed semisupervised learning framework. EMA: exponential moving average; ResNet: residual neural network.



Supervised Learning + Ranking Loss

The supervised learning consists of 2 tasks, which are jointly learned during training. One task is the classification of the skin disease, and the other is the classification of each feature in the 3-point checklist. Using the 3-point checklist, each feature is given a binary score of 0 or 1 in the training phase, indicating whether it exists in the image. A total score higher than 2 suggests that the lesion is more likely to be malignant. We incorporated the traditional cross-entropy loss to optimize the skin disease classification part and used ranking loss to represent the 3-point checklist knowledge. The hyperparameters for our training models are as follows: a batch size of 128, stochastic gradient descent optimizer, and ReduceLROnPlateau learning rate decay (mode="min," factor=0.5, threshold=0.01, patience=7, verbose=True).

Semisupervised Learning

Image annotation requires not only extensive time investment but also domain expertise of human annotators. Inspired by the research of Tarvainen and Valpola [40], we developed a semisupervised scheme based on their "mean teacher" framework to automate the feature annotation process of skin lesion images. This model can use the information from small-scaled labeled images and make skin feature and disease predictions on larger unlabeled image data sets. On top of that, we developed and integrated disease- or feature-specific loss functions to combine knowledge from human expertise into the model. The predicted features can be used simultaneously in the training phase to improve the disease classification accuracy. The supervised loss is associated with the disease label of each image and denoted by the cross-entropy function. In the semisupervised learning component, the mean-teacher strategy was adopted to minimize the consistency loss between labeled and unlabeled data sets and to average the model weights from supervised and unsupervised learning.

Theory and Calculation

Supervised Learning + Ranking Loss

Using the ranking loss, we enforce the model to learn a predefined diagnostic rule—the samples with higher scores are more likely to have melanoma. The ranking loss is computed from each pair of samples in a batch. We denote $o_{ij} \equiv f(x_i) - f(x_j)$, where f is the logit corresponding to the disease class, the posterior P_{ij}, and the desired target values :

Then, the cross-entropy loss function can be represented as

We compute P_{ij} from o_{ij} using the sigmoid function as follows; the loss function can be further rewritten as:

Semisupervised Learning

The EMA model behaves as the teacher model on the unlabeled. This method constrains the model to behave similarly to the past models during the update so it can potentially find flatter local minima and avoid singularity points where a small update would result in large behavior change in the model. The mean-teacher strategy proved useful in previous works, and the consistency cost is defined as follows, where is updated based on EMA parameters:

Finally, the ranking loss, disease supervised loss, feature supervised loss (FSL), and consistency loss were added together to train the model.

Results

Our models were built based on the state-of-the-art ResNet model. We tried ResNet-18, ResNet-50, ResNet-152, and Resnext50_32x4d, and there was no significant difference in classification accuracies. To facilitate the training process, we used a relatively light architecture, ResNet-18, as our baseline.

The first task is to test whether the model will increase the classification accuracy after adding human knowledge, which is transformed and represented in the Ranking Loss format. Many state-of-the-art CNN model architectures have been developed for image recognition task, some of which achieved great performance on the skin lesion recognition task on ISIC data sets. In a 2021 paper published by Yiming Zhang et al [41], they reported that DenseNet [42] achieved superior performance over other deep learning approaches on the melanoma classification task using ISIC 2020 data set. MobileNet [43] is another CNN model developed in the recent years, and it has been adapted to ISIC image classification tasks in many cases [44,45]. To choose a CNN architecture as our baseline model and show the improvement of accuracy after combining the human knowledge in the ranking loss format, we compared accuracy results of the state-of-the-art CNN models mentioned above. The comparison outcomes are shown in Table 2. We chose ResNet as our baseline model for its better performance. All the models were trained using a 900 labeled data set (from Table 1). We tested the performance of pretrained baseline model on our larger 9000-image data set using 80/20 data split. The results are shown in Table 2. We used 5-fold cross-validation to calculate the mean and standard deviation of the validation accuracy.

As can be seen from the table, the pretrained baseline model reached the same level of accuracy on the large 9000-image data set. After adding the human knowledge of the 3-point checklist rule, the average accuracy even improved on this basis.

The previous experiment was based on human-annotated, 3-point feature labels. The entire process, from recruiting annotators to finally reaching agreement, took more than 2 months. Hence, we developed the semisupervised model to automate the feature-annotation process. We combined the generated features as human knowledge to test whether such knowledge can help to improve the disease classification accuracy.

To evaluate the performance of the 3-point feature classification for our semisupervised model, we calculated the testing accuracy and area under the receiving operating characteristic curve (AUC) on a separate holdout testing data set that contains 100 images with annotated 3-point features and disease type. We tested the performance for feature and disease classification on the models shown in Table 3, for which “baseline” is the labeled 900-image data set for supervised training, followed by different combinations of loss functions.

As seen in Table 3, the semisupervised model that combined all 3 loss functions achieved the best accuracy for disease classification. Adding FSL improved the performance of disease classification by 2%. The result shows that emphasizing the weight of “Asymmetry” feature improved the testing accuracy of “asymmetry” by 2% and improved the classification of the “atypical network” by 3%. Nevertheless, the accuracy of “Blue-white structure” and disease classification has a significant decrease.

Table 2. Five-fold cross validation results for the disease classification task.

Model	Five-fold accuracy, mean (SD)
MobileNetV3 (Pretrain=True)	0.8733 (0.0113)
DenseNet (Pretrain=True)	0.8856 (0.0114)
Baseline (ResNet-18, Pretrain=True)	0.8867 (0.0191)
Baseline + Human Knowledge (RL[a])	0.8943 (0.0115)

[a]RL: ranking loss.

Table 3. Results for semisupervised model for disease or feature classification tasks with different loss functions—disease supervised loss (DSL), feature supervised loss (FSL), and consistency loss (CL).

Model	Asymmetry, accuracy (AUC[a])	Atypical network, accuracy (AUC)	Blue-white structure, accuracy (AUC)	Disease, accuracy (AUC)
CL	0.51 (0.5760)	0.53 (0.5021)	0.54 (0.5620)	0.54 (0.5648)
DSL	0.51 (0.5480)	0.76 (0.6480)	0.58 (0.5285)	0.76 (0.8690)
FSL	0.80 (0.8380)	0.89 (0.9036)	0.74 (0.8036)	0.51 (0.5339)
FSL+CL	0.68 (0.7816)	0.87 (0.8752)	0.75 (0.8137)	0.53 (0.5402)
DSL+FSL	0.76 (0.7892)	0.86 (0.8602)	0.76 (0.8133)	0.74 (0.8418)
DSL+CL	0.53 (0.5448)	0.79 (0.4340)	0.47 (0.5943)	0.77 (0.8389)
DSL+FSL+CL	0.73 (0.8036)	0.85 (0.8474)	0.76 (0.8444)	0.79 (0.8402)
DSL+FSL[b]+CL	0.75 (0.7932)	0.88 (0.8752)	0.71 (0.7951)	0.69 (0.7971)

[a]AUC: area under the receiving operating characteristic curve.

[b]We emphasized the weight of the "Asymmetry" feature in the loss function.

Discussion

Annotation Process

Annotators in this study were medical students with no expert training in dermatology. They evaluated images based solely on tutorials from web-based resources and textbooks. Without any designated training, using example images, each of the annotators initially had a different idea of what each feature looked like. Preliminary agreement scores may have been improved if annotators had been given reference images from which to learn the dermoscopic features. This finding highlights the potential value of our algorithm as an educational tool. If medical students can evaluate a dermoscopic image and check their 3-point annotation against the algorithm's validated output, it will help them develop their ability to visually identify each dermoscopic feature.

During the image-annotation process, there were some uncertainties for annotators. First, the vague definition of dermoscopic features, especially "atypical network" posed an issue, as each annotator had a different idea of what that looks like. This resulted in initial low agreement scores. We address this concern by proposing an ontology that can integrate the domain knowledge on dermoscopic features and represent the features in a more standardized, computer-readable format.

Another uncertainty in analyzing the images was the use of different screens with various color-display settings. One common error that was encountered was the inability to properly characterize blue structures when night light or blue light filters were activated. As such options can be automatically engaged on a schedule, however, this could lead to annotation errors. The use of different screens led to initial disagreement among the annotators but can be corrected by proper calibration and ensuring that no color filter is on.

One limitation of this study was that most of the images are taken from White skin. This has implications for whether the algorithm can be effective in detecting melanoma in colored skin. Training the algorithm to identify lesions in more than just one group of skin colors would be valuable in helping to screen a larger population of patients at risk of melanoma. Another limitation was that the image quality could have been decreased due to shadows, hairs, reflections, and noise, leading to an inadequate lesion analysis, as discussed in an earlier study [46].

Classification Models

For the first task, after combining the 3-point checklist human knowledge, the loaded model weights from the large data set improved the classification accuracy from an average of 0.8867 to 0.8943. This shows that the ranking loss has a positive impact on classification accuracy. We plan to continue to work on expanding human knowledge to develop more complicated diagnostic rules to test their impacts on computer algorithms.

For the feature- and disease-classification task that used semisupervised architecture, interesting findings were discovered in Table 3. The improvement of the classification accuracy for certain feature labels can be accomplished by assigning a heavier weight on the corresponding feature's loss function, however, at the cost of scarifying the accuracy for disease classification. Among the 3 features, blue-white structure has a relatively low accuracy when classified without feature-supervised loss function, the potential reason being the unbalance of blue-white structure data set where most of them are negative. While adding FSL is helpful for the feature classification task, adding disease-supervised loss function could bring down the performance of feature classification. For the disease classification, adding FSL alone did not improve the accuracy; however, combining consistency loss with FSL is showing a positive effect on disease classification.

We also noticed that, during the human annotation process for the 3-point checklist, the atypical network had the lowest interagreement rate among the 3 annotators. For the computer feature-classification task, however, the atypical network had the highest classification accuracy. This suggests that the algorithm has the advantage of learning certain image features that might be a challenge for human experts. This shows that human intelligence and AI can complement each other.

Because our image data set is from the ISIC archives, we also compared the performance of our algorithm with the winner of the ISIC 2020 leaderboard [47]. The current best performance has an AUC of 0.949. The AUC of the proposed model on the 400 unlabeled-image testing set (from ISIC 2020) is 0.9848 with different settings of disease category. Our 0.9848 AUC, however, cannot be directly compared with the results from the ISIC leaderboard, as our classification task includes only melanoma and melanocytic nevus, whereas the ISIC challenge has some "unknown" images. The remainder of the results in this regard are calculated on the small 100 labeled-image testing set, which has significant improvement over the application of the student-teacher framework, indicating the power of semisupervised learning.

Future Steps

We plan to implement more fine-tuned model architectures trained from scratch so that a more advanced ensemble can be applied by integrating architectures from submodels. Our current experimental setting for the disease classes and rules of the 3-point checklist is only a demonstration of how we can integrate the human thinking process into the structure of CNNs. There are numerous diagnostic rules that are being developed, as dermatology is thriving, and we plan to summarize all the diagnostic rules and dermoscopic features mentioned, as well as their relationship with skin diseases, into ontology and to further accelerate the automation process of clinical decision support by computer algorithms. With our trained algorithm, we can already automate the 3-point checklist annotation process and apply it to a wider range of image databases.

Conclusions

This study is distinctive because it combines the semantic knowledge from the 3-point checklist with a computer algorithm (CNN) to arrive at a more accurate and more interpretable diagnosis. The CNN classification was conducted based on more information than just the imaging pixels. Due to the time and labor consumption of the image-annotation process, there are vast imaging data sets that remain undiscovered. Our proposed semisupervised learning framework can help automate the annotation process, enabling the reuse of many skin-imaging data sets, which is also beneficial to the robustness and domain adaptation of the deep-learning model.

Acknowledgments

XZ conducted the experiments and led the writing of the manuscript. ZX and YX helped with the design of the model and the writing of methodology. IB, MK, and CS conducted the annotation and contributed to the writing of the manuscript from the clinician's perspective. LG and CT supervised the project. All authors participated in the design of this study.

This work was supported by UTHealth Innovation for Cancer Prevention Research Training Program Pre-doctoral Fellowship (Cancer Prevention and Research Institute of Texas Grant No. RP160015 and No. RP210042).

Conflicts of Interest

None declared.

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Abbreviations

AI: artificial intelligence
AUC: area under the receiving operating characteristic curve
CNN: convolutional neural network
EMA: exponential moving average
FSL: feature supervised loss
ISIC: International Skin Imaging Collaboration

Edited by R Dellavalle; submitted 28.04.22; peer-reviewed by V Singh; comments to author 24.05.22; revised version received 01.09.22; accepted 12.10.22; published 12.12.22.

Please cite as:
Zhang X, Xie Z, Xiang Y, Baig I, Kozman M, Stender C, Giancardo L, Tao C
Issues in Melanoma Detection: Semisupervised Deep Learning Algorithm Development via a Combination of Human and Artificial Intelligence
JMIR Dermatol 2022;5(4):e39113
URL: https://derma.jmir.org/2022/4/e39113
doi:10.2196/39113
PMID:37632881

Original Paper

Phenotype Algorithms to Identify Hidradenitis Suppurativa Using Real-World Data: Development and Validation Study

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Abstract

Background: Hidradenitis suppurativa (HS) is a potentially debilitating, chronic, recurring inflammatory disease. Observational databases provide opportunities to study the epidemiology of HS.

Objective: This study's objective was to develop phenotype algorithms for HS suitable for epidemiological studies based on a network of observational databases.

Methods: A data-driven approach was used to develop 4 HS algorithms. A literature search identified prior HS algorithms. Standardized databases from the Observational Medical Outcomes Partnership (n=9) were used to develop 2 incident and 2 prevalent HS phenotype algorithms. Two open-source diagnostic tools, CohortDiagnostics and PheValuator, were used to evaluate and generate phenotype performance metric estimates, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value.

Results: We developed 2 prevalent and 2 incident HS algorithms. Validation showed that PPV estimates were highest (mean 86%) for the prevalent HS algorithm requiring at least two HS diagnosis codes. Sensitivity estimates were highest (mean 58%) for the prevalent HS algorithm requiring at least one HS code.

Conclusions: This study illustrates the evaluation process and provides performance metrics for 2 incident and 2 prevalent HS algorithms across 9 observational databases. The use of a rigorous data-driven approach applied to a large number of databases provides confidence that the HS algorithms can correctly identify HS subjects.

(JMIR Dermatol 2022;5(4):e38783) doi:10.2196/38783

KEYWORDS

dermatology; hidradenitis suppurativa; medical dermatology; observational data; phenotype; inflammation; skin disease; epidemiology; algorithm

Introduction

Hidradenitis suppurativa (HS) is a chronic, recurring inflammatory disease of the skin. Clinically, subjects have nodules, draining skin tunnels (ie, sinus tracts), abscesses, and bands of severe scar formation in the intertriginous skin areas, such as the axillary, groin, perianal, perineal, and inframammary regions [1]. Patients with HS suffer from metabolic, psychiatric, and autoimmune disorders [2].

The use of real-world evidence from observational data is valuable for studying the epidemiology, clinical manifestations, and real-world experience of patients with HS. A critical step in using observational data for the study of HS is the development of accurate phenotype algorithms (PAs). A PA is the translation of the case definition of a health condition or phenotype into an executable algorithm based on clinical data elements in a database [3]. Several studies have investigated HS using health care claims, electronic medical records, patient care, and hospitalization databases and have been conducted using data from the United States, Germany, Finland, Taiwan, Korea, England, Canada, and Denmark [2,4-32]. These studies have focused on a range of topics in patients with HS, including the incidence and prevalence of HS in different populations and the associations between HS and autoimmune disorders. Only 5 studies have provided phenotype validation metrics [9,10,16,29,30]; 2 used hospital data [16,29], 4 used a single phenotype requiring at least one code for HS from the International Classification of Diseases, Ninth Revision (ICD-9) [9,10,29,30], and 1 evaluated several phenotypes [16].

The objectives of this study were to develop HS PAs, evaluate their performance, and characterize the resultant HS phenotypes across a network of 9 US and non-US observational databases. This study used a data-driven framework and developed HS PAs for use in observational databases.

Methods

Overview

A literature search was conducted to identify studies that describe the codes and logic used to identify HS patients in observational databases. This literature search identified 30 articles, which provided a set of diagnosis codes for the identification of HS across vocabularies, including the ICD-9, the International Classification of Diseases, Tenth Revision (ICD-10), and Read codes. Five of the 30 articles included validation metrics. Our study utilized the Systemized Nomenclature of Medicine (SNOMED) vocabulary to develop the codes. The vocabulary and diagnostic codes used in the published studies and the SNOMED terms are presented in Multimedia Appendix 1. The Observational Health Data Sciences and Informatics (OHDSI) open-source Atlas tool [33] was used to create the HS PAs.

The observational databases used in this study were not created specifically to study HS. The observational data were obtained in the delivery of health care or for administrative or billing purposes in electronic format. A network of 9 observational databases (4 administrative claims databases from the United States, 1 from Japan, 1 from France, 1 from Germany, and 1 from Australia; and 1 US electronic health record [EHR] database; Table 1) were used to develop the PAs. The 9 databases were a mix of administrative insurance claims, EHRs, and general practitioner databases. Descriptions and details of each database are shown in Table 2. The databases were transformed to the Observational Medical Outcomes Partnership (OMOP) Common Data Model (version 5.3.1) [34] so the PAs could be consistently applied across databases.

Four HS PAs were developed and evaluated in subjects of all ages [35] (Figure 1). The PA “incident 1x” used the first diagnosis code for HS in a subject’s history and required 365 days of prior continuous enrollment (CE) time to qualify for entry into the HS cohort. The date a subject met both criteria was the subject’s index date. The PA “incident 2x” used the first diagnosis code for HS in a subject’s history and required both a second HS diagnosis code within 31 to 365 days and 365 days of prior CE time. The date a subject met all 3 criteria became the subject’s index date. The prevalent PAs (“prevalent 1x” and “prevalent 2x”) were identical to the corresponding incident versions, except that the first HS diagnosis code was not required to be the first time an HS code occurred in a subject’s history, nor was there a requirement for 365 days prior CE.

The OHDSI CohortDiagnostics tool [36] allowed for evaluation and comparison of PAs at a cohort level, providing overall counts, incidence over time, the diagnosis code that allowed the subject into the cohort, cohort overlap, and temporal characterization.

Use of the PheValuator [37] method provided performance metrics, including the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) associated with each PA. PheValuator is a machine learning–based method of assessing PAs. It constructs a predictive model for the disease and calculates the predictive value of having the disease for each subject using the model. Using PheValuator, performance indices of an algorithm are calculated without reviewing medical charts. While algorithm validation results from chart review are considered the “gold standard,” we have compared the results from PheValuator with prior studies using chart review and found excellent agreement between the 2 methods [38]. Four additional PAs from Kim et al [16] were evaluated for comparison.

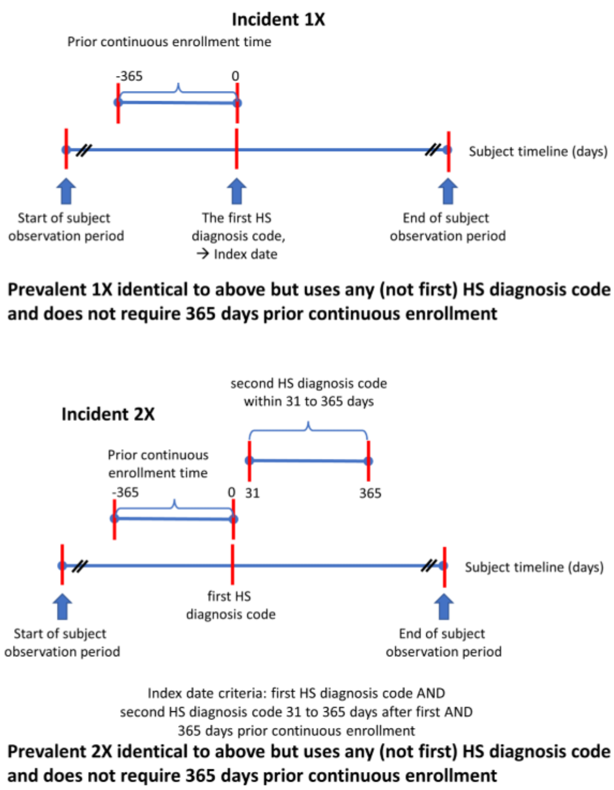
Computer code for PheValuator and CohortDiagnostics and the JSON files for the PAs are available on the authors’ website [39].

Table 1. Description of databases used in the study.

Name	Years	Country	Data type	Clinical visits included	Subjects, n (millions)	Age at first observation, average (years)	Female subjects, %	Length of follow-up, median (years)
IBM MarketScan Commercial Claims and Encounters	2000-2021	United States	Insurance claims	Inpatient/outpatient	157	31	51	1.56
IBM MarketScan Multi-State Medicaid	2006-2020	United States	Insurance claims	Inpatient/outpatient	31	23	56	1.52
IBM MarketScan Medicare Supplemental	2000-2021	United States	Insurance claims	Inpatient/outpatient	10	71	55	2.46
Optum's de-identified Clinformatics Data Mart Database	2007-2021	United States	Insurance claims	Inpatient/outpatient	71	37	51	1.48
Optum Electronic Health Records	2007-2021	United States	Electronic health records	Inpatient/outpatient	99	37	53	2.63
Japan Medical Data Center	2000-2021	Japan	Insurance claims	Inpatient/outpatient	12	31	49	3.29
IQVIA Disease Analyzer–France	2016-2021	France	General practitioner data	Outpatient	4	37	52	0.9
IQVIA Disease Analyzer–Germany	2011-2021	Germany	General practitioner data with supplemental data from participating specialists	Outpatient	31	43	56	0.5
IQVIA Australian Longitudinal Patient Data	1996-2020	Australia	General practitioner data	Outpatient	5	37	22[a]	0.5

[a]59% of subjects did not have a designated sex in this study.

Figure 1. Schematics of phenotype algorithms for Hidradenitis suppurativa (HS).



Ethics Approval

The use of the IBM and Clinformatics databases was reviewed by the New England Institutional Review Board and was determined to be exempt from broad approval, as this project did not involve human subject research. Patient consent for publication was not required. All patients in the databases were deidentified, and the identities of data contributors were removed.

Results

We examined cohort characteristics of the PAs. These characteristics may be viewed interactively online [40]. The number of subjects ranged from 81 in the IQVIA Australian Longitudinal Patient Data (IALPD) database to 170,149 in the IBM MarketScan Commercial Claims and Encounters (CCAE) database for the incident 1x cohort. These numbers were as expected based on the relative sizes of the databases, indicating that all codes used were appropriate for each database. The counts were much higher in the US databases compared to the non-US databases. The reduction in the number of subjects in the incident 1x PA compared to the incident 2x PA ranged from about 90% in the IALPD, IQVIA Disease Analyzer–France (IDAF), and IQVIA Disease Analyzer–Germany (IDAG) databases to about 73% in the IBM MarketScan Multi-State Medicaid (MDCD) database. The incident 1x PA identified a higher proportion of female subjects compared to male subjects: 51% in the Japan Medical Data Center (JMDC) database and 81% in the MDCD database; the incident 2x PA identified a lower proportion of female subjects in the JMDC database (46%) but a higher proportion in all other databases, ranging from 53% for the IDAG database to 82% for the MDCD database. The overlap in subjects between the incident PAs for each database is shown in Figure 2. The incident 2x PA is a subset of the incident 1x PA.

A comparison of standardized differences between the incident 1x and the incident 2x cohorts for 3 data sets across 5 different time frames is shown in Figure 3. Differences in the standardized difference of the mean greater than 0.1 are considered imbalanced [41]. Points closer to the diagonal indicate similar proportions between cohorts; points farther from the diagonal indicate more disparate proportions. The plots compare the diagnosed conditions, prescribed drugs, laboratory measurements, and clinical procedures of the subjects in the incident 1x and incident 2x PA cohorts and illustrate the population differences. The CCAE database showed disparities between the 2 algorithms in the period 31 to 365 days after the index date. Some differences arose from higher proportions of diagnosis codes for HS (50% for incident 2x vs 11% for incident 1x, standard mean difference [SMD] 0.66) and prescriptions for clindamycin (32% for incident 2x vs 14% for incident 1x, SMD 0.3). There were also differences in the MDCD database population, with more subjects of a lower socioeconomic status. The MDCD database also showed differences in diagnosis codes for HS (70% for incident 2x vs 18% for incident 1x, SMD 0.86) and prescriptions for clindamycin (37% for incident 2x vs 13% for incident 1x, SMD 0.31). The Optum's de-identified Clinformatics Data Mart Database (Clinformatics DOD) data set showed differences in proportions between the 2 cohorts for diagnosis codes for HS (62% for incident 2x vs 14% for incident 1x, SMD 0.81) and prescriptions for clindamycin (29% for incident 2x vs 13% for incident 1x, SMD 0.29). The relative proportions between the 2 cohorts for the majority of the characteristics in the CCAE, MDCD, and Clinformatics DOD databases showed similar proportions between the cohorts.

We examined the incident 2x algorithm for subject characteristics across the databases. We identified a higher proportion of female subjects with HS compared to male subjects. The largest disproportionality was in the MDCD database, in which 82% of the subjects were female. The JMDC database had the lowest disproportionality by sex, with 45% female subjects. An outpatient visit was the most common type of clinical visit for the first diagnosis of HS. Less than 5% of first diagnoses were made during an emergency room visit, with the exception of the MDCD database, for which the proportion was 10%. Examination of the index codes or diagnosis codes that allowed subjects into cohorts showed that the most prevalent code was the diagnosis code of "hidradenitis suppurativa" (SNOMED code 4241223; ICD-10 L73.2) in all databases except the CCAE database, in which the most prevalent code was a diagnosis code of "hidradenitis" (SNOMED code 434119; ICD-9 705.83).

Figure 2. Graphical depiction of the overlap in subjects between the 2 incidence cohorts and the 2 prevalence cohorts. CCAE: IBM MarketScan Commercial Claims and Encounters; Clinformatics DOD: Optum's de-identified Clinformatics Data Mart Database; IALPD: IQVIA Australian Longitudinal Patient Data; IDAF: IQVIA Disease Analyzer–France; IDAG: IQVIA Disease Analyzer–Germany; JMDC: Japan Medical Data Center; MDCD: IBM MarketScan Multi-State Medicaid; MDCR: IBM MarketScan Medicare Supplemental; Optum EHR: Optum Electronic Health Records.

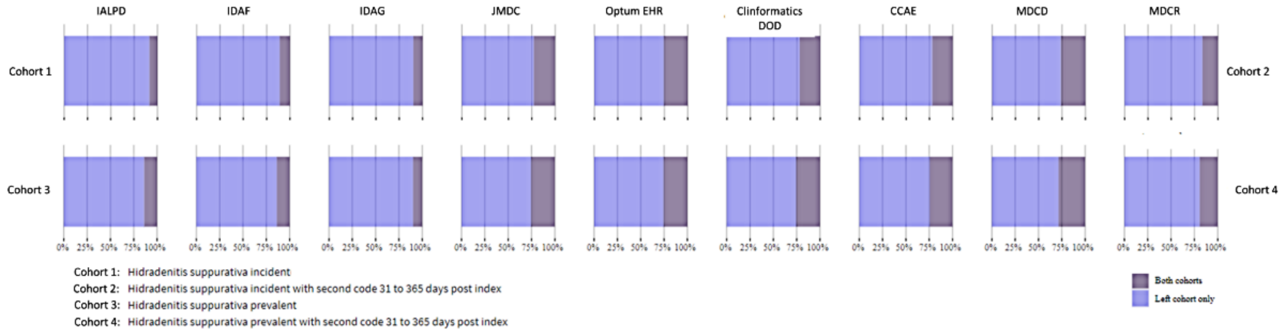
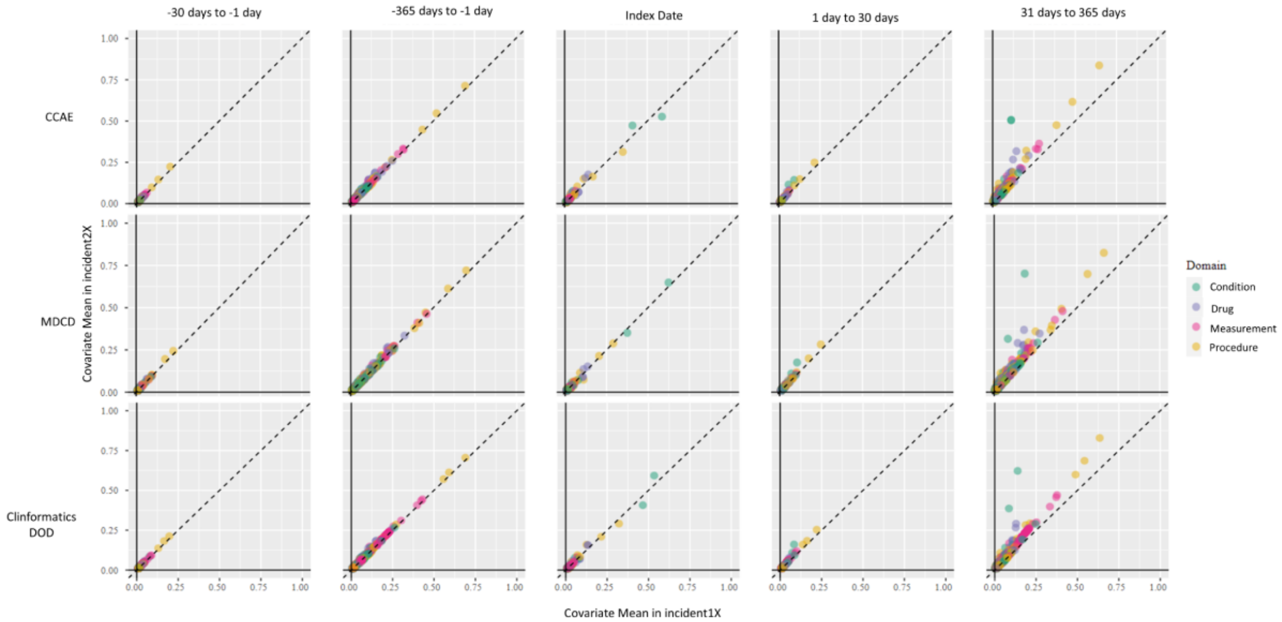


Figure 3. Comparison of the proportion of subjects in the incident 1x cohort and the incident 2x cohort for 3 selected data sets with different demographic characteristics. Points closer to the diagonal indicate similar proportions between the comparators; points farther from the diagonal indicate more disparate proportions. CCAE: IBM MarketScan Commercial Claims and Encounters; Clinformatics DOD: Optum’s de-identified Clinformatics Data Mart Database; MDCD: IBM MarketScan Multi-State Medicaid.



Incidence rates for HS (for the incident 2x algorithm) from 2015 to 2020 differed between databases. The MDCD database had the highest rate at 23 per 100,000 person-years. The rates in the CCAE, Clinformatics DOD, and Optum EHR databases were approximately 12 per 100,000 person-years. Rates in the IDAG and IDAF databases and the JMDC and the IBM MarketScan Medicare Supplemental Database (MDCR) databases were 1 per 100,000 person-years. The rate in the IALPD database was undetectable, likely due to the small sample size. The incidence rates peaked in subjects in the 20- to 29-year-old age group. The incidence rates in the 30- to 39-year-old age group in the MDCD and IDAG databases were higher than in the older age groups but were similar to the 20- to 29-year-old age group. Incidence rates in female subjects were generally higher than in male subjects and were highest in the MDCD database at 24 per 100,000 person-years, followed by 11 per 100,000 person-years in the CCAE, Clinformatics DOD, and Optum EHR databases and 1 per 100,000 person-years in the IDAF database. The rate in female subjects was equal to the rate in male subjects in the MDCR database at 2 per 100,000 person-years.

Performance characteristics for the HS phenotypes assessed using the PheValuator method are presented in Table 2. Due to low subject counts, calculation of performance characteristics for the IDAG, IDAF, IALPD, and JMDC databases was not possible. The mean PPVs were higher in all databases for the PAs requiring a second diagnostic HS code in the 31 to 365 days after the index date. The mean PPVs for the 2 PAs that required a second code was 88% (incident) and 86% (prevalent). This was reduced to 62% (incident) and 59% (prevalent) when only a single diagnosis code for HS was required. The highest sensitivity estimates were in the 2 prevalent cohorts. The sensitivity for the 2 prevalent algorithms was 58% (single code required) and 25% (2 codes required). This decreased to 32% (single code required) and 12% (2 codes required) in the incident cohorts. The estimates for mean PPV for the Kim et al [16] PAs increased with the increase in number of HS diagnosis codes, ranging from 59% (2 codes) to 84% (5 codes). Our results showed a similar trend, but PPV was lower than reported by Kim et al (81% including subjects with 2 HS codes and 97% including subjects with >5 codes).

Table 2. Performance characteristics of the hidradenitis suppurativa phenotypes based on the PheValuator methodology.

Phenotype algorithm/database	Sensitivity (95% CI)	PPV[a] (95% CI)	Specificity (95% CI)	NPV[b] (95% CI)
Hidradenitis suppurativa incidence				
IBM MarketScan Commercial Database	0.380 (0.367-0.393)	0.599 (0.582-0.615)	0.999 (0.999-0.999)	0.998 (0.998-0.998)
Optum's de-identified Clinformatics Data Mart Database	0.369 (0.358-0.380)	0.603 (0.589-0.617)	0.999 (0.999-0.999)	0.998 (0.997-0.998)
IBM MarketScan Multi-State Medicaid Database	0.311 (0.306-0.317)	0.676 (0.668-0.685)	0.998 (0.998-0.998)	0.990 (0.990-0.990)
IBM MarketScan Medicare Supplemental Database	0.298 (0.277-0.319)	0.444 (0.417-0.472)	1.000 (1.000-1.000)	0.999 (0.999-0.999)
Optum's de-identified Electronic Health Record dataset	0.279 (0.269-0.289)	0.777 (0.761-0.793)	1.000 (1.000-1.000)	0.997 (0.997-0.997)
Hidradenitis suppurativa incidence with second diagnosis 31 to 365 days after index date				
IBM MarketScan Commercial Database	0.151 (0.142-0.161)	0.890 (0.868-0.909)	1.000 (1.000-1.000)	0.998 (0.998-0.998)
Optum's de-identified Clinformatics Data Mart Database	0.133 (0.126-0.141)	0.882 (0.862-0.900)	1.000 (1.000-1.000)	0.997 (0.996-0.997)
IBM MarketScan Multi-State Medicaid Database	0.115 (0.112-0.119)	0.874 (0.862-0.885)	1.000 (1.000-1.000)	0.987 (0.987-0.987)
IBM MarketScan Medicare Supplemental Database	0.109 (0.095-0.123)	0.830 (0.778-0.874)	1.000 (1.000-1.000)	0.999 (0.999-0.999)
Optum de-identified Electronic Health Record dataset	0.109 (0.102-0.116)	0.948 (0.931-0.962)	1.000 (1.000-1.000)	0.997 (0.996-0.997)
Hidradenitis suppurativa prevalence				
IBM MarketScan Commercial Database	0.541 (0.531-0.551)	0.649 (0.639-0.660)	0.999 (0.999-0.999)	0.998 (0.998-0.998)
Optum's de-identified Clinformatics Data Mart Database	0.666 (0.655-0.677)	0.602 (0.591-0.613)	0.998 (0.998-0.998)	0.999 (0.999-0.999)
IBM MarketScan Multi-State Medicaid Database	0.664 (0.658-0.670)	0.628 (0.621-0.634)	0.995 (0.995-0.995)	0.996 (0.996-0.996)
IBM MarketScan Medicare Supplemental Database	0.442 (0.422-0.462)	0.355 (0.338-0.373)	0.999 (0.999-0.999)	0.999 (0.999-0.999)
Optum de-identified Electronic Health Record dataset	0.632 (0.618-0.647)	0.754 (0.739-0.768)	1.000 (1.000-1.000)	0.999 (0.999-0.999)
Hidradenitis suppurativa prevalence with second diagnosis 31 to 365 days after index date				
IBM MarketScan Commercial Database	0.296 (0.285-0.307)	0.874 (0.860-0.887)	1.000 (1.000-1.000)	0.997 (0.997-0.998)
Optum's de-identified Clinformatics Data Mart Database	0.233 (0.220-0.246)	0.937 (0.920-0.951)	1.000 (1.000-1.000)	0.998 (0.998-0.998)
IBM MarketScan Multi-State Medicaid Database	0.219 (0.203-0.236)	0.732 (0.699-0.764)	1.000 (1.000-1.000)	0.999 (0.999-0.999)
IBM MarketScan Medicare Supplemental Database	0.288 (0.282-0.294)	0.859 (0.851-0.867)	0.999 (0.999-0.999)	0.992 (0.992-0.992)
Optum de-identified Electronic Health Record dataset	0.231 (0.222-0.239)	0.912 (0.900-0.923)	1.000 (1.000-1.000)	0.996 (0.996-0.996)

[a]PPV: positive predictive value.

[b]NPV: negative predictive value.

Discussion

Principal Findings

This study sought to develop and determine the accuracy of 4 HS PAs. The 4 PAs included 2 for incidence and 2 for prevalence, with one in each group having high sensitivity and specificity. Use of the PheValuator method allowed for estimation of sensitivity, specificity, PPV, and NPV without manual chart review. While both the incident and prevalent PAs were useful for the exploration of HS in observational databases, the PAs with definitions requiring just a single HS diagnosis code had lower specificity and higher sensitivity than the definitions requiring 2 codes, which had higher specificity and lower sensitivity. Thus, the choice of which algorithm to use is dependent on the research question being explored. For example, the use of a more sensitive algorithm would be applicable for safety studies, in which the PA is used to determine HS outcomes and missed identification of possible cases is problematic, whereas the use of a PA with higher specificity would be useful for treatment comparison studies, in which the goal is to ensure that all subjects exposed to a treatment have a high probability of having HS.

A few studies have included validation metrics for HS algorithms for observational databases [9,10,16,29,30]. Kim et al [16] used data available from the Massachusetts General Hospital and reported an increase in PPV with an increasing number of HS diagnosis codes (81% for 2 codes vs 97% for 5 codes). Our study replicated the Kim et al cohorts and found an increase in PPV with the use of 5 or more diagnosis codes compared to the use of at least two HS diagnosis codes (mean 84% for >5 codes vs mean 59% for 2 codes) that was similar to, albeit lower than, the published results. In general, our study found higher PPVs compared to studies that used a single HS diagnosis code [9,10,29,30]. The majority of subjects identified in our study were female, which is similar to findings from other studies [5,6,9,16,31]. A US study that used a cross-sectional design and a large electronic medical records database found an overall prevalence of 24.8% for type 2 diabetes, 71.6% for obesity, and 39.9% for hyperlipidemia among HS subjects [8]. Our study, when restricted to US data and examining covariates 365 days prior to and including the index date, identified type 2 diabetes in 26.5%, obesity in 19.6%, and hyperlipidemia in 26.5% of incident 1x HS subjects. The cross-sectional study was restricted to subjects aged 18 years or older, while our study included all ages, which may help in interpreting the decreased proportion of hyperlipidemia observed in our results. It has been reported that administrative databases underreport obesity as a diagnosis and are not an optimal data source for obesity prevalence [42]. This may support our finding of a lower prevalence of obesity compared to the findings of the cross-sectional study.

Strengths of our study include the use of a rigorous, data-driven approach for generating and evaluating the HS phenotypes across a data network that included 9 databases covering US and non-US countries. Network-based phenotype evaluations greatly strengthen the knowledge base for a given algorithm, because they allow the assessment of the consistency of findings across data types, geographic locations, and time periods. When concordant trends emerge, it increases confidence that the observations are the effect of the PA itself rather than an artifact of a particular data source. The PAs were analyzed using multiple approaches, providing ancillary verification of decisions made in determining the cohort logic. Our study includes several study artifacts, including JSON files for the PAs, computer code, and results for all the analyzed PAs, providing transparency in our interpretation of the results.

There were also several limitations to our study. We used administrative data sets primarily maintained for insurance billing, which are well-known to have significant deficits, including coding inaccuracies [43]. In addition, the estimation of performance characteristics using the PheValuator methodology was dependent on the quality of the data in the data set, which can vary substantially [37]. The algorithm validation was performed using a method involving predictive modeling of HS rather than case reviews. Results from PheValuator have been compared to results from previously published validation studies and have demonstrated excellent agreement [38]. This method does have the advantage of using multiple databases to provide a full set of performance metrics, including sensitivity and specificity, which are rarely provided in validation studies using case reviews [37]. The generalizability of our findings to uninsured populations is uncertain, given the insured population that was observed in this study. In the incident PA that defined HS with only a single diagnosis code, it was not possible to determine if any of these were "rule-out" diagnoses. The algorithms presented in this study use codes specific to HS; therefore, jurisdictions and practices that do not use these specific codes and instead use codes for "abscess" or "cyst" would be unable to operationalize these PAs. The study period used for evaluation of the HS algorithms includes the year (2015) when the drug Humira was introduced to treat HS [44]. Education on HS increased, and physicians became more likely to use diagnosis codes specifically indicating HS in observational data. Therefore, to avoid temporal bias, researchers should avoid use of these algorithms in data from prior to 2015.

Conclusions

This study developed and evaluated 4 HS PAs using a rigorous, data-driven approach and generated phenotype performance metrics including sensitivity, specificity, PPV, and NPV. Based on the analyses, we recommend that PAs requiring a single HS diagnosis code be used in studies requiring high sensitivity, while studies requiring high specificity should use PAs requiring 2 HS diagnosis codes. These algorithms will enable researchers to use large observational databases to research HS, which has a high burden of disease. There is a need for better evidence, as currently there are clinical knowledge gaps for HS that observational data is well suited to address.

Acknowledgments

Manuscript review was provided by Anna Sheahan, PhD. All authors contributed to all aspects of the study (study design and execution, data analysis and interpretation, and writing of the manuscript). This research was funded by Janssen Research and Development, LLC. The data source for this study was a retrospective claims database and thus there are no patient or public contributors.

Data Availability

The data used for this study are proprietary and only available through a licensing data-use agreement process. This process ensures that confidentiality of the data contributors is maintained and that the data are used appropriately. The MarketScan Research Database can be licensed by researchers.

Conflicts of Interest

All authors are employees of Janssen Research and Development, LLC, and may own stock or stock options. The work performed for this study was part of their employment.

Multimedia Appendix 1
Diagnostic codes.
[DOCX File , 15 KB - derma_v5i4e38783_app1.docx]

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Abbreviations

CCAE: IBM MarketScan Commercial Claims and Encounters
CE: continuous enrollment
Clinformatics DOD: Optum's de-identified Clinformatics Data Mart Database
EHR: electronic health record
HS: hidradenitis suppurativa
IALPD: IQVIA Australian Longitudinal Patient Data
ICD-9: International Classification of Diseases, Ninth Revision
ICD-10: International Classification of Diseases, Tenth Revision
IDAF: IQVIA Disease Analyzer–France
IDAG: IQVIA Disease Analyzer–Germany
JMDC: Japan Medical Data Center
MDCD: IBM MarketScan Multi-State Medicaid
MDCR: IBM MarketScan Medicare Supplemental
NPV: negative predictive value
OHDSI: Observational Health Data Sciences and Informatics
OMOP: Observational Medical Outcomes Partnership
PA: phenotype algorithm
PPV: positive predictive value
SMD: standard mean difference
SNOMED: Systemized Nomenclature of Medicine

Edited by R Dellavalle, T Sivesind; submitted 15.04.22; peer-reviewed by S Gulliver, S Feldman, S Steingrimsson; comments to author 29.06.22; revised version received 09.11.22; accepted 10.11.22; published 30.11.22.

Please cite as:
Hardin J, Murray G, Swerdel J
Phenotype Algorithms to Identify Hidradenitis Suppurativa Using Real-World Data: Development and Validation Study
JMIR Dermatol 2022;5(4):e38783
URL: https://derma.jmir.org/2022/4/e38783
doi:10.2196/38783
PMID:37632892

Research Letter

The Evolution of Live Patient Viewing in the Era of COVID-19: Survey Study

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(JMIR Dermatol 2022;5(4):e39952) doi:10.2196/39952

KEYWORDS

COVID-19 pandemic; live patient viewing; dermatology education; dermatology; COVID-19; residency program; residency; dermatology residency; medical education; virtual education; didactic

Over two years into the COVID-19 pandemic, the effects of this unprecedented crisis continue to unfold. Despite increasing vaccination rates and relaxation of "social distancing," avoiding extraneous person-to-person contact remains the gold standard, particularly in health care settings. In dermatology, where close examination of the skin is paramount, this policy has far-reaching consequences. Dermatology resident education has been particularly disrupted because live patient viewing sessions (LPVSs)—a longstanding pillar of dermatology training—have been infeasible when "distancing" is required. While much of dermatology education will likely return to baseline post pandemic, the fate of LPVSs remains unclear. We thus aimed to assess the baseline integration of LPVSs, identify pandemic modifications, and ascertain permanent pedagogical changes.

In September 2020, an institutional review board–approved web-based survey was sent to 123 US dermatology residency programs (Multimedia Appendix 1). The survey queried demographics and curricular integration of LPVSs before, during, and after the pandemic. Of 123 contacted, 44 (35.8%) surveys were completed. Most programs hosted LPVSs prepandemic (n=39, 89%), and the majority supplemented these live sessions with virtual cases (n=35, 80%; Table 1). All programs canceled LPVSs at the onset of the pandemic, with most substituting virtual cases (n=40, 91%). Regarding LPVS resumption post pandemic, 13 (30%) reported they would restart, 25 (57%) were ambivalent at the time, and 6 (14%) reported LPVSs would not recommence. Fisher exact test revealed no significant relationship between geography and LPVS resumption (P=.21). Of the programs reporting that LPVSs would *not* resume, the majority believed virtual cases were sufficient to replace live sessions. All programs committed to restarting LPVSs will continue incorporating virtual cases.

The 19th-century physician Osler [1] revolutionized medical education with his emphasis on bedside training. His tradition of live patient viewing has been maintained by academic dermatology departments nationwide, as reflected by our results: prior to the COVID-19 pandemic, 39 (89%) dermatology programs hosted LPVSs, with the majority (n=40, 90%) during grand rounds, and over half (51%) hosting LPVSs several times a month. LPVSs are consistently ranked highly among residents, and our results suggest similar sentiments among program leadership, with 34 (77%) viewing LPVSs as integral to resident education and 36 (82%) believing LPVSs facilitate collaboration (Table 2) [2-5].

Yet despite the value of LPVSs to trainees and faculty alike, our results demonstrate a surfeit of uncertainty in reintroducing in-person sessions, with 25 (57%) respondents unsure about preserving LPVSs. At least 6 surveyed programs discontinued LPVSs altogether. Whether additional programs ultimately decide against readopting LPVSs remains uncertain. Our results suggest an overwhelming trend toward incorporating virtual patient conferences into didactic curricula. As vaccination rates increase and the COVID-19 pandemic wanes, the proportional fates of live and virtual patient viewing sessions within dermatology will doubtlessly declare themselves. As Osler [1] wrote, "to study...the disease without books is to sail an uncharted sea, while to study books without patients is not to go to sea at all."

Table 1. Demographic and curricular integration results (N=44).

Participant responses	Participants, n (%)
Demographic characteristics	
Geographic location	
Northeast	10 (23)
Southeast	9 (20)
Midwest	13 (30)
Northwest	4 (9)
Southwest	8 (18)
Program size (residents)	
≤8	8 (18)
9-18	27 (61)
≥19	9 (20)
Curricular integration	
Live PVS[a]	
Pre–COVID-19[b]	39 (89)
During COVID-19[c]	0 (0)
Anticipated return post COVID-19[d]	13 (30)
Virtual PVS	
Pre–COVID-19[b]	35 (80)
During COVID-19[c]	40 (91)
Anticipated return post COVID-19[d]	17 (39)

[a]PVS: patient viewing session.

[b]Pre–COVID-19 corresponds to prior to March 2020.

[c]Defined as March 2020 to time of the survey distribution (September 2020).

[d]A total of 25 participants were unsure at the time whether they would return to PVSs.

Table 2. Live PVS needs assessment survey results (N=44).

	Strongly agree, n (%)	Agree, n (%)	Neutral, n (%)	Disagree, n (%)
Integral part of resident education	21 (47)[a]	13 (30)[a]	4 (9)	1 (2)
Teach trainees morphology, differential diagnoses, and disease management	24 (55)	13 (30)	2 (5)	0 (0)
Provide opportunities for clinicopathological correlation	23 (52)	14 (32)	2 (5)	0 (0)
Useful for providing high-quality patient care	20 (45)	14 (32)	5 (11)	0 (0)
Useful for seeking other dermatologists' opinions about diagnosis or management of difficult cases	26 (59)[b]	10 (23)[b]	3 (7)	0 (0)
Conducted in a humanistic manner	21 (48)	14 (32)	2 (5)	2 (5)
Has a set of rules/conduct guidelines that are consistently followed	17 (39)	16 (36)	3 (7)	3 (7)
Patients generally feel comfortable with being seen by a group of physicians	11 (25)	19 (43)	7 (16)	2 (5)
Patients view their participation in PVSs[c] as worthwhile	15 (34)	19 (43)	4 (9)	1 (2)
Strengthen the physician-patient relationship	8 (18)	16 (36)	13 (30)	2 (5)

[a]A total of 77% (n=34) of respondents agree or strongly agree that live patient viewing sessions are an integral part of resident education.
[b]A total of 82% (n=36) of respondents agree or strongly agree that live patient viewing sessions help foster collaboration between physicians.
[c]PVS: patient viewing session.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Institutional review board–approved web-based survey via RedCap.
[DOCX File , 653 KB - derma_v5i4e39952_app1.docx]

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Abbreviations

LPVS: live patient viewing session

Edited by R Dellavalle, T Sivesind; submitted 29.05.22; peer-reviewed by L Samuel, S Hertling; comments to author 28.09.22; revised version received 05.10.22; accepted 06.10.22; published 18.10.22.

Please cite as:
Sally R, Shaw K, Ho R
The Evolution of Live Patient Viewing in the Era of COVID-19: Survey Study
JMIR Dermatol 2022;5(4):e39952
URL: https://derma.jmir.org/2022/4/e39952
doi:10.2196/39952
PMID:36937784

Research Letter

Top Pediatric Dermatology Twitter Post Characteristics and Trends From 2020 to 2021: Content Analysis

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(JMIR Dermatol 2022;5(4):e37029) doi:10.2196/37029

KEYWORDS

pediatric dermatology; pediatrics; dermatology; Twitter; social media; social media engagement; content analysis

Social media platforms, including Twitter, provide dermatologists with opportunities for collaboration [1], promotion of peer-reviewed content [2], and enhancement of disease prevention efforts [3]. However, Twitter posts (Tweets) remain largely unregulated for misinformation [1]. In previous studies, 44.7% of dermatology Twitter content was rated imprecise and 20% confusing [4]. Despite the growth of recent dermatology Twitter research, there remains a paucity of literature on pediatric dermatology Tweet content, hindering optimized information delivery. We, therefore, sought to characterize top pediatric dermatology Tweet characteristics and engagement trends in 2020 and 2021.

A search of the Twitter web application was performed periodically from August 2021 to March 2022 using the combination of hashtags #pediatrics and #dermatology, and the Twitter-designated top 3 posts for each month in 2020 and 2021 were recorded. Post content was categorized by two independent reviewers as Educational for medical information, Advertising for advertisement of a product, Promotional for promotion of an event, and Personal for all other posts, with a consensus meeting to resolve discrepancies. Posts were evaluated for Likes, Retweets, and COVID-19 content. The average Likes and Retweets for each Tweet category were tabulated and analyzed.

In total, 72 top Tweets from 2020 and 2021 were identified. Of the 72 Tweets, 43.1% (n=31) were Promotional, 36.1% (n=26) Educational, 19.4% (n=14) Advertising, and 1.4% (n=1) Personal. Two (2.7%) of the top posts were related to the COVID-19 pandemic. Promotional posts were commonly announcements for dermatology conferences, webinars, or society memberships, whereas Educational posts highlighted case reports, presentations, or publications. Overall, top posts garnered a total of 405 Likes and 101 Retweets. Compared to 2020 data, the Promotional and Educational post categories showed increased total Likes in 2021, whereas Advertising, Personal, and COVID-19 total Likes decreased (Table 1). The average number of Likes per post increased from 2020 to 2021 (5.4 to 5.9 Likes/post), with Promotional posts demonstrating the greatest increase (2.8 to 7.7 Likes/post; Table 2). Although only 1 Personal category Tweet was included, it was the most Liked (77) and Retweeted (12) post overall; it focused on the challenges faced during residency. Notably, almost half of the top Tweets were created by nonphysicians (n=35, 49%), with 31% (n=22) by physician group accounts and 21% (n=15) by single physicians.

Our results demonstrate that most pediatric dermatology top Tweets from 2020 and 2021 were Promotional and posted by roughly equal numbers of physicians and nonphysicians, with average Tweet engagement (number of Likes per post) increasing over the study interval. Additionally, we observed that Personal posts, albeit scarce, can draw significant engagement, perhaps by inspiring connection through storytelling and vulnerability [5]. Future recommendations for pediatric dermatology Twitter research include increasing the scope of hashtags chosen, analyzing other social media platforms, and examining a broader range of posts. This could expand our work and contribute to more effective patient communication and information distribution as social media engagement continues to grow.

Table 1. Total Likes by top pediatric dermatology Twitter post category in 2020 and 2021.

	Posts, n (%)		Likes, n (%)	
	2020 (n=36)	2021 (n=36)	2020 (n=193)	2021 (n=212)
Promotional	16 (44)	15 (42)	45 (23)	116 (55)
Educational	8 (22)	18 (50)	43 (22)	94 (44)
Advertising	11 (31)	3 (8)	28 (15)	2 (1)
Personal	1 (3)	0 (0)	77 (40)	0 (0)
COVID-19	2 (6)	0 (0)	4 (2)	0 (0)

Table 2. Average Likes by top pediatric dermatology Twitter post category in 2020 and 2021.

	Average Likes per post in 2020	Average Likes per post in 2021
Promotional	2.81	7.73
Educational	5.38	5.22
Advertising	2.55	0.67
Personal	77.00	0.00
COVID-19	2.00	0.00
Overall	5.36	5.89

Conflicts of Interest

RPD is a joint coordinating editor for *Cochrane Skin*, a dermatology section editor for *UpToDate*, a social media editor for the *Journal of the American Academy of Dermatology*, a podcast editor for the *Journal of Investigative Dermatology*, editor in chief of the *JMIR Dermatology*, coordinating editor representative on Cochrane Council, Cochrane Council cochair and director of the University of Colorado Anschutz Medical Campus US Cochrane Affiliate. He receives editorial stipends (JMIR Dermatology, *Journal of Investigative Dermatology*), royalties (*UpToDat*e), and expense reimbursement from *Cochrane Skin*. MDS is a member of the Cochrane Collaboration.

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Edited by R Alhusayen; submitted 12.04.22; peer-reviewed by C Sibbald, F Lamy; comments to author 05.09.22; revised version received 12.09.22; accepted 06.10.22; published 26.10.22.

Please cite as:
Kokoska RE, Kim LS, Szeto MD, Aukerman EL, Dellavalle RP
Top Pediatric Dermatology Twitter Post Characteristics and Trends From 2020 to 2021: Content Analysis
JMIR Dermatol 2022;5(4):e37029
URL: https://derma.jmir.org/2022/4/e37029
doi:10.2196/37029
PMID:37632885

Case Report

Melanoma Identification and Management in an Unsheltered Male Using Teledermatology: Street Medicine Perspective

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Abstract

Skin cancers are concerning for unsheltered people experiencing homelessness because of their high levels of sun exposure. Currently, there is little data on the prevalence of skin cancers in people experiencing homelessness. Skin diseases are often untreated in people experiencing homelessness due to a lack of access to specialized care. Miami Street Medicine (MSM) is an organization that provides people experiencing homelessness in the Miami Health District with medical care in a nonclinical street setting, near overpasses, sidewalks, and encampments. We present a case of an unsheltered 59-year-old male with a pigmented, 2 cm × 2 cm facial lesion that developed over several years. Through a teledermatology consultation, his lesion was highly suspicious of melanoma and further evaluation was recommended. Due to a lack of insurance, he could not be treated at any dermatology clinic. Coincidentally, 2 weeks later, he developed cellulitis of his lower extremity and was admitted to the local safety-net hospital through the emergency department. By coordinating with his primary inpatient team, MSM was able to include a biopsy of the lesion as part of his hospital stay. The results demonstrated melanoma in situ. The vital course of action was to ensure treatment before metastasis. After registration for insurance and follow-up with a surgical oncology team, he is weeks away from excision and reconstruction surgery. His unsheltered status made follow-up difficult, but MSM bridged the gap from the street to the clinical setting by incorporating teledermatology into patient evaluations and leveraging connections with community shareholders such as charitable clinics and volunteer physicians. This case also represents the barriers to care for cancer-based dermatologic outreach among people experiencing homelessness.

(JMIR Dermatol 2022;5(4):e42113) doi:10.2196/42113

KEYWORDS

skin cancer; REDCap; homelessness; melanoma; teledermatology; street medicine; dermatology; homeless; case report; case study; skin lesion; biopsy; dermatologist; insurance; low income; health coverage; skin; cancer

Introduction

People experiencing homelessness are a high-risk patient population with suboptimal health outcomes. People experiencing homelessness can be sheltered, meaning they are living in a temporary housing facility like a homeless shelter, or unsheltered, meaning they do not have any temporary housing and are living outside. By some estimates, the average life expectancy of people experiencing homelessness is 55 years, more than 20 years below the United States national average [1]. People experiencing homelessness are more likely to have decreased access to longitudinal care while also having a high burden of HIV, respiratory illnesses, chronic liver diseases, and severe skin diseases [2,3]. In 2019, there were an estimated 580,000 sheltered and unsheltered people experiencing homelessness in the United States, which has likely increased due to the SARS-CoV-2 pandemic [4,5]. The resulting fallout from the loss of employment and evictions has only served to worsen the homelessness crisis. There are fewer social services offered to people experiencing homelessness due to concerns over close contact, and programs geared specifically toward medical outreach in people experiencing homelessness communities continue to suffer from scarce funding [5,6]. As a result, people experiencing homelessness lack access to basic primary care and specialized dermatologic care.

Unsheltered people experiencing homelessness in regions like the Southern United States have high levels of sun exposure, which increases their risk of developing skin cancer. However, there is still insufficient data on skin health and cancer parameters in this vulnerable population.

People experiencing homelessness with lesions suspicious of skin cancers are often unable to receive timely evaluation due to a lack of insurance, transportation, or funds. Commonly comorbid health conditions such as substance use disorders, soft tissue infections, lung diseases, and mental health issues may also lead to primary physicians prioritizing those over skin cancer screening [7].

Street medicine is a model of direct care where providers see people experiencing homelessness at encampments, sidewalks, and overpasses. This is different from the common free clinic model because street medicine brings providers directly to the patients rather than vice versa [7]. These patients live in abject poverty, lacking food, shelter, and medication, as well as the means to coordinate formal health care visits. It has often been called “house calls for the homeless” and represents a shift in the delivery of health care to the most socially and medically vulnerable patients.

This case describes encountering a 59-year-old unsheltered male with a suspicious pigmented lesion that was later found to be melanoma and the notable barriers to care that prevented timely evaluation. This also highlights how the street outreach model used by Miami Street Medicine (MSM), in conjunction with teledermatologist consultation, connected this patient to specialized care for the comprehensive evaluation of his melanoma.

Case Report

During regular street outreach, a 59-year-old Spanish-speaking man with a history of hypertension, poorly managed type 2 diabetes mellitus, and venous stasis was encountered. He was wheelchair-bound as a result of being hit by a car a year prior and displayed limited reading literacy in English or Spanish. After taking a guided history focused on preventable health problems, he was noted to have a dark brown, irregular, 2 cm × 2 cm patch on his left upper cheek (Figure 1).

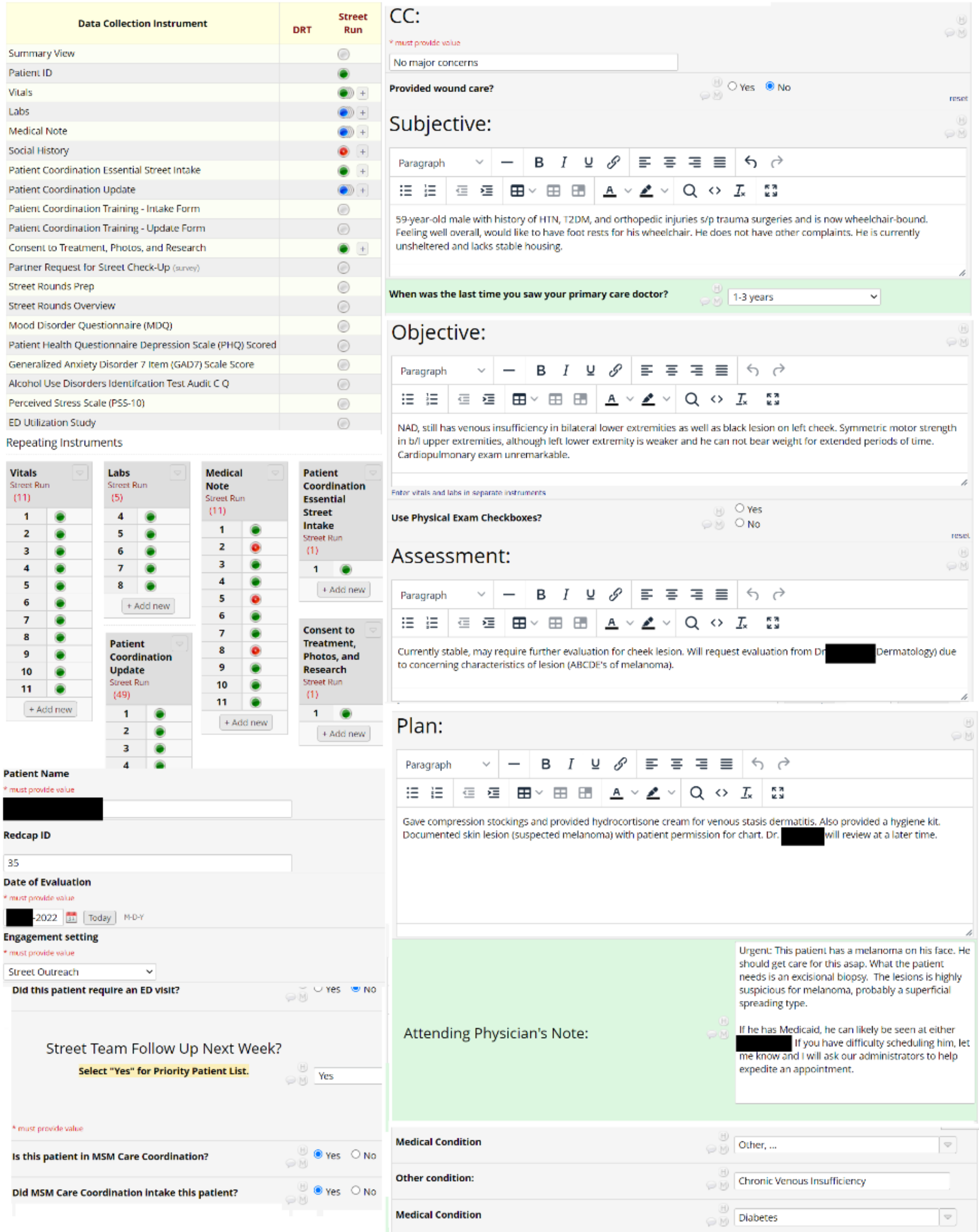
He was unsure of when this lesion started growing and did not endorse any itching or bleeding. Three years prior, he had been previously seen by a charity-based primary provider without any appropriate workup. The suspicious character of the lesion warranted documentation and a tele-consult with a dermatologist. The tele-consult was done using a modified secure medical data collecting application called REDCap. Through this software, physicians could assess photos of the lesion and consider the need for a biopsy.

A custom electronic medical record for street medicine use was developed in REDCap. This stored patient data in a confidential manner for team members to review patient charts and coordinate with other providers (Figure 2). Special emphasis is given to social history as it can provide a more complete picture of the patient’s housing status and comorbidities like alcohol use disorder. After inputting the data into our custom REDCap, an attending dermatologist was requested to view the chart containing the medical history and images of the patient’s lesion.

The team was informed that this lesion had a high probability of being melanoma and to seek further evaluation promptly. However, his lack of insurance made an outpatient dermatology clinic visit impossible. The street medicine team continued to maintain a close level of follow-up while also working toward some form of Medicaid enrollment. Our patient had reliable access to a phone and communicated with the team regularly about where to meet next and any questions after the first visit.

Figure 1. Pigmented 2 cm × 2 cm lesion noted, later biopsied and confirmed to be melanoma in situ.

Figure 2. The layout of the REDCap-based medical record for this patient's initial evaluation. There are multiple documented instances of vitals, labs, photographs, and medical notes from providers, reflecting a continued relationship with the patient. The Plan section included a dermatology evaluation, which was then completed according to the Attending Physician's Note. HTN: hypertension; MSM: Miami Street Medicine; T2DM: type 2 diabetes mellitus.



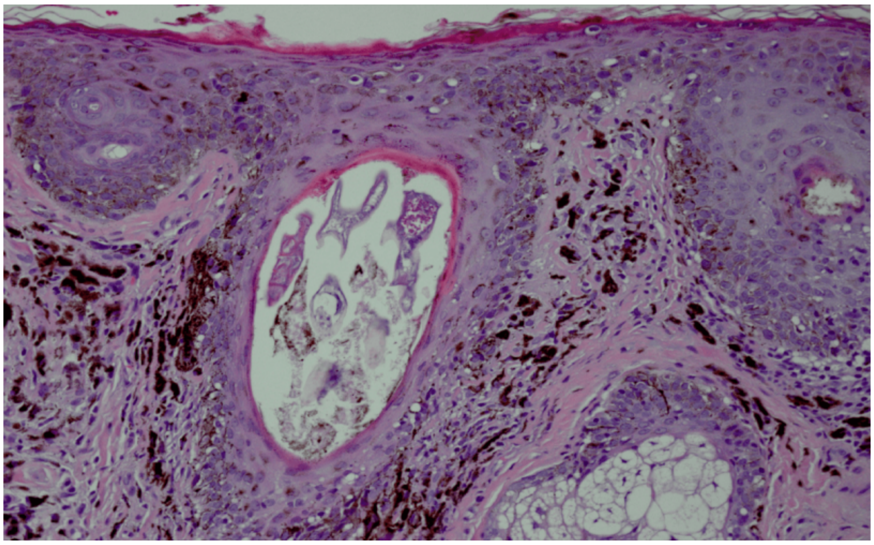
Unfortunately, 2 weeks after the initial evaluation, the patient presented to the emergency department with a soft tissue infection of the lower extremity. The severity of his condition necessitated hospitalization and intravenous antibiotic administration.

MSM providers established contact with the patient and later his primary inpatient team to arrange for a formal dermatological consult and skin biopsy. Two punch biopsies were obtained from the lesion, confirming a diagnosis of melanoma in situ (Figure 3).

Additionally, the MSM team expedited his Medicaid enrollment to cover his much-needed treatment. Given the size and sensitive location of the lesion, our team also coordinated with surgical oncology and plastic surgery providers on his behalf for management at a later date. After discharge, our patient was at risk of being lost to follow-up due to his unstable housing situation, lack of funds, and limited health literacy. Transportation was arranged so that he could make his appointments, and street medicine providers followed up regularly in a street setting and via telephone calls to assess his overall status. He attended his first set of appointments, which involved circumferential biopsy for staging through the staged marginal and central excision method [8]. He is currently being cleared for surgery, which will involve excision and reconstruction.

He also continues to be followed by the street medicine team to ensure that he can follow up appropriately, as well as for the management of his other health issues.

Figure 3. Pathology slide of pigmented lesion. Numerous dermal macrophages with an increased number of melanocytes along the dermal-epidermal junction and extending down hair follicles. Melanoma in situ extending to peripheral edges.



Discussion

MSM participated in the care of the patient before, during, and after hospitalization. Timely intervention by MSM led to the diagnosis and ongoing management of melanoma-in-situ in a patient experiencing homelessness. Many people experiencing homelessness do not have access to consistent medical care, which can delay the diagnosis of their illnesses [9]. Care is often unaffordable and navigating the health care system while being homeless without reliable access to technology (eg, phones and the internet) is extremely difficult. In this case, he was evaluated by dermatology providers due to being admitted for an unrelated condition. The patient had access to a phone, which greatly streamlined care coordination for treatment. Unfortunately, many people experiencing homelessness do not have reliable access to phones or other technology, which makes further coordination challenging. Our only source of communication with phoneless patients is through weekly street encounters.

Our patient's story also highlights a common scenario for people experiencing homelessness: inpatient hospitalization often being the only way to access specialty care.

However, teledermatology evaluation through REDCap provided a valuable consultation that guided further treatment. Our custom REDCap database provides a secure yet accessible medical record for patient care. The evaluation completed through teledermatology in this setting allowed a systematic relay of information from the consultant dermatologist to the rest of the care team. This can be a valuable adjunct to standard street medicine projects as it provides a customizable framework depending on patient needs, especially for resource-limited settings [10].

The unfortunate reality of our patient's story is that it may be one of many underdocumented instances of vulnerable patients being lost to follow-up in the current system. In our patient's case, issues with insurance, funding, transportation, and even understanding of discharge instructions meant that, had the MSM team not followed him longitudinally, his cancer would have remained untreated. The imperfect system of health care and human rehabilitation leaves notable barriers that may not be resolved until there is a fundamental inclusion of the health of society's most vulnerable [11]. Until then, organizations like Miami Street Medicine have no choice but to step in and try to bridge glaring defects in care for the homeless.

Conclusions

This 59-year-old unsheltered patient with multiple comorbidities was successfully screened and evaluated for his melanoma before it metastasized. Instead of the traditional free clinic model where patients come to the provider, initiatives like street medicine can directly provide screening and care for unsheltered patients who are unable to attend such clinics. Even so, the street medicine team had to leverage connections with the medical community to coordinate care. The technology used by MSM, such as REDCap, provided another way to connect people experiencing homelessness to care via tele-consults. In the current health care model where people experiencing homelessness face difficulties in longitudinal care, street-based outreach can be a valuable tool for establishing a sustained connection, thereby improving follow-up.

Acknowledgments

We would like to acknowledge the generous volunteers at the Miami Street Medicine organization who provide care to those at the periphery of society, with no expectation of reward or recognition. We would also like to acknowledge Dr Brian Morrison for his exceptional work in taking care of this patient.

Consent was received from the patient for publication, and their information was deidentified to maintain anonymity.

Conflicts of Interest

None declared.

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Abbreviations

MSM: Miami Street Medicine

Edited by R Dellavalle, T Sivesind; submitted 22.08.22; peer-reviewed by C Heckman, H Mahler; comments to author 29.09.22; revised version received 02.10.22; accepted 03.10.22; published 04.11.22.

Please cite as:
Eachus E, Rasul T, Henderson A
Melanoma Identification and Management in an Unsheltered Male Using Teledermatology: Street Medicine Perspective
JMIR Dermatol 2022;5(4):e42113
URL: https://derma.jmir.org/2022/4/e42113
doi:10.2196/42113
PMID:37632907

Case Report

Multiple Keratoacanthomas Following Moderna Messenger RNA-1273 COVID-19 Vaccination Resolved With 5-Fluorouracil Treatment: Case Report

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Abstract

Cutaneous reactions have been commonly associated with the Moderna messenger RNA (mRNA) COVID-19 vaccine. Among the reported cutaneous side effects, there have not been any associations reported yet regarding keratoacanthoma development after COVID-19 mRNA vaccination. We report a novel case of an 86-year-old man who experienced an eruption of multiple keratoacanthomas 2 weeks after inoculation with the Moderna mRNA-1273 vaccine that resolved following treatment with intralesional 5-fluorouracil.

(JMIR Dermatol 2022;5(4):e41739) doi:10.2196/41739

KEYWORDS

keratoacanthoma; COVID-19 vaccine; COVID-19; vaccine; treatment; Moderna; messenger RNA; side effects; vaccination; case report; oncology; tumor

Introduction

The Moderna messenger RNA (mRNA) COVID-19 vaccine was granted emergency use authorization within the United States in December 2020. As vaccination administration expands, a growing body of evidence becomes available, allowing for a greater understanding of a novel vaccine's adverse effects. A recent registry-based study by McMahon et al [1] documented 414 unique cases of cutaneous reactions after COVID-19 vaccination, with 343 (83%) occurring in patients who received the Moderna mRNA vaccine. In our study, we report a novel case of an eruption of multiple keratoacanthomas 2 weeks after inoculation with the Moderna mRNA-1273 vaccine that resolved following treatment with intralesional 5-fluorouracil.

Case Report

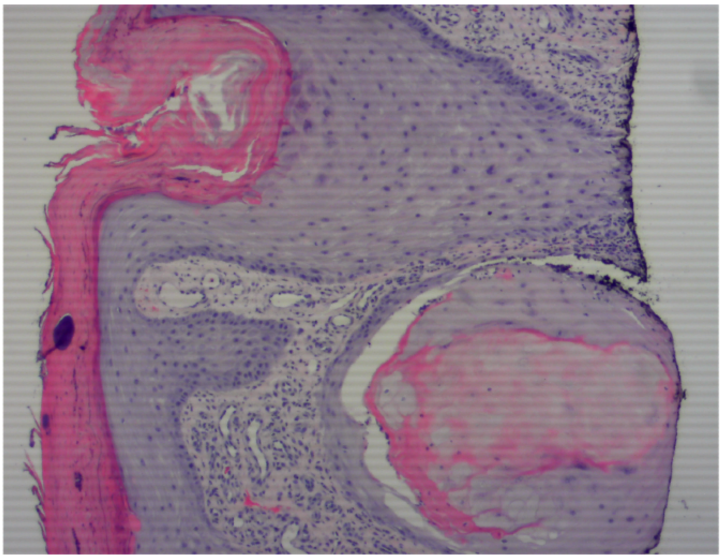
An 86-year-old man with no past medical history who had not recently initiated any medications received the second dose of the Moderna COVID-19 vaccine on March 2, 2021. On March 16, 2021, he began to experience severe pruritus of the lower pretibial area, and within 2 days, he noticed red nodules on the bilateral legs (7 on the right and 4 on the left; Figure 1). Prior to this date, the patient did not experience any previous cutaneous signs or symptoms that were concerning for keratoacanthomas on the bilateral legs. A shave biopsy of the left calf 1 week later demonstrated a well-differentiated keratoacanthoma-type squamous cell carcinoma (SCC). There were 11 other similar lesions at the time of initial presentation; however, none were biopsied. Of note, there were no lesions at the vaccination site. The lesion was cleared via Mohs surgery in 2 stages; however, the area was complicated by infection and required almost 2 months to heal. The remainder of the eruption was diagnosed as *prurigo nodularis*, and the patient was prescribed a clobetasol ointment, with minimal improvement. The patient then presented to our clinic in August 2021, at which point 2 scallop biopsies were taken from the right pretibial area (Figure 2 and Figure 3). The pathology results were consistent with SCC, keratoacanthoma type (Figure 4). Given the numerous lesions, the patient was treated with intralesional 5-fluorouracil with resolution over a 6-week period, that is, the patient was treated with 1.5 mL of 50-mg/mL 5-fluorouracil, which was injected intralesionally into each growth once per week for 6 weeks. Initially, the right leg was treated, requiring 3 weeks of treatment. Afterward, the left leg was treated, also requiring 3 weeks of treatment.

Figure 1. Clinical image taken on the day of the initial visit (March 2021).

Figure 2. Clinical image taken at follow-up (August 2021). Arrow indicates biopsy site.

Figure 3. Clinical image taken at follow-up (August 2021).

Figure 4. Histopathology of squamous cell carcinoma, keratoacanthoma type. This skin biopsy demonstrates atypical keratinocytes replacing the full thickness of normal epithelium. Cells with large hyperchromatic and atypical nuclei are seen at all levels. Atypical keratinocytes extend into the dermis as small islands. Scattered mitotic figures are also observed. A hematoxylin and eosin stain is used.



Discussion

Keratoacanthomas represent tumors with atypical, highly differentiated squamous epithelia that typically arise on the head, neck, and extremities as volcano-like lesions that form quickly and have been shown to regress spontaneously. Keratoacanthomas share many histopathologic features with SCC, resulting in their recent reclassification as “squamous cell carcinoma, keratoacanthoma type.” Eruptive keratoacanthomas are a variant of keratoacanthomas that involve the appearance of multiple nodules in a short period. Although the etiology and pathophysiology of keratoacanthomas are widely considered to be multifactorial, immune status has been reported as a contributing risk factor. Similarly, our patient’s rapid keratoacanthoma development may have been influenced by this vaccine (ie, vaccination resulting in the development of a proinflammatory response). In one study, the tumor microenvironment and subsequent keratoacanthoma progression were shown to be influenced by the ratio of T helper 17 cells to regulatory T cells and proinflammatory and anti-inflammatory responses, respectively [2]. Multiple eruptive keratoacanthomas are also seen in some syndrome associations, including Muir-Torre syndrome, Ferguson-Smith disease, Grzybowski syndrome, *incontinentia pigmenti*, and xeroderma pigmentosum associations, and are also associated with human papillomavirus infection.

The Moderna COVID-19 vaccine is a relatively novel mRNA- and proinflammatory response–based technology. Although very rare, keratoacanthomas have been reported after pneumococcal and smallpox vaccine inoculation. Notably however, these vaccines do not use mRNA delivery technology [3,4]. Additionally, multiple cases of eruptive keratoacanthomas in short time frames following treatment with various immune modulators, such as leflunomide, pembrolizumab, and vemurafenib, have been reported in the literature [5-7]. Although the role of immunosuppression in the pathogenesis of SCC is well documented in the literature, the role of the immune system in the context of vaccine-induced keratoacanthomas or drug-induced keratoacanthomas is less well understood. In all stages of a keratoacanthoma (proliferative, maturation, and involution), the infiltration of lymphocytes has been demonstrated. These infiltrates could be responsible for the rapid tumor growth and tissue necrosis seen with keratoacanthomas [2]. Thus, an immune-mediated mechanism may be responsible for the dermatological adverse events resulting from vaccination with the mRNA-1273 COVID-19 vaccine.

Eruptive keratoacanthomas that do not show signs of regression can be a challenge to treat due to the number of lesions and the risks associated with surgical management in certain clinical settings (ie, patient age, comorbidities, and lesion severity). The efficacy of intralesional 5-fluorouracil—a chemotherapeutic agent—has not been studied extensively, although promising results have been reported in limited data sets. Kraus et al [8] reported that 96% (22/23) of the evaluable cutaneous SCCs in their study were completely cleared, as confirmed by histopathology. Adding to this evidence, Maxfield et al [9] recently demonstrated the resolution of 92% (158/172) of the cutaneous SCCs in their study with intralesional 5-fluorouracil, which is comparable in efficacy to Mohs surgery; 5-fluorouracil was injected at a concentration of 50 mg/mL, with volumes ranging from 0.2 to 2 mL per lesion, and in some cases, repeat injections were required at follow-up.

COVID-19 has shown a deadly predilection for individuals in the older population who become infected with SARS-CoV-2, with some studies showing case fatality rates and hospitalization rates as high as 14.8% and 18.4%, respectively [10]. The development of mRNA technology and the rapid production of the vaccines from Pfizer-BioNtech and Moderna have resulted in the reduction of mortality rates in the older population. Given these high mortality figures, all patients over the age of 65 years should be strongly encouraged to receive the vaccines; however, given their novelty, cutaneous eruptions, side effects, and associated treatments will need to be well recognized by dermatology providers. In the case of multiple eruptive keratoacanthomas in an older population with many comorbidities, 5-fluorouracil can be beneficial as a first-line, nonsurgical treatment option, especially for patients who are poor surgical candidates or areas that are difficult to heal or have a high risk for infection.

As our patient did not have any new or known risk factors for the development of eruptive keratoacanthomas on the bilateral legs, clinicians should be aware of Moderna COVID-19 vaccine–induced keratoacanthomas—a novel finding—as a potential occurrence following vaccination with the mRNA vaccine. As with any individual case report, we acknowledge the limitation of our report in determining the causation of eruptive keratoacanthomas following COVID-19 vaccination. However, our case will contribute to the limited clinical data on cutaneous, adverse COVID-19 vaccine side effects. Further reports and studies of any additional cases will be important for investigating the incidence and pathophysiology of this potential adverse reaction. Our patient's 11 keratoacanthomas resolved after treatment with intralesional 5-fluorouracil, which can be considered as a first-line therapy for multiple keratoacanthomas in similar clinical contexts.

Conflicts of Interest

None declared.

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Abbreviations

mRNA: messenger RNA
SCC: squamous cell carcinoma

Edited by R Dellavalle; submitted 09.09.22; peer-reviewed by M Kapsetaki; comments to author 10.11.22; revised version received 14.11.22; accepted 21.11.22; published 01.12.22.

Please cite as:
Ahmed F, Memon N, Haque A
Multiple Keratoacanthomas Following Moderna Messenger RNA-1273 COVID-19 Vaccination Resolved With 5-Fluorouracil Treatment: Case Report
JMIR Dermatol 2022;5(4):e41739
URL: https://derma.jmir.org/2022/4/e41739
doi:10.2196/41739
PMID:36504544

Short Paper

Cochrane Skin Group's Global Social Media Reach: Content Analysis of Facebook, Instagram, and Twitter Posts

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Abstract

Background: Researchers in all medical specialties increasingly use social media to educate the public, share new publications with peers, and diversify their audiences.

Objective: Given Cochrane Skin Group's expanded use of social media in the past years, we aimed to characterize Cochrane Skin Group's international social media audience and identify themes that result in increased content engagement.

Methods: Cochrane Skin Group's Facebook, Instagram, and Twitter analytics data were extracted for follower demographics and the most viewed posts within a 3-year span (June 2019 to June 2022).

Results: Overall, Cochrane Skin Group had the highest number of followers on Facebook (n=1037). The number of Instagram and Twitter followers reached 214 and 352, respectively. The greatest numbers of Facebook followers were from Brazil, Egypt, and India, with 271, 299, and 463 followers, respectively. Facebook's most viewed post about Cochrane Skin Group's annual meeting received 1041 views. The top post on Instagram, which introduced Cochrane Skin Group's social media editors, received 2522 views.

Conclusions: Each of the social media platforms used by Cochrane Skin Group reached varying audiences all over the world. Across social media platforms, posts regarding Cochrane Skin Group meetings, members, and professional opportunities received the most views. Overall, Cochrane Skin Group's multiplatform social media approach will continue to grow an international audience, connecting people interested in skin disease.

(JMIR Dermatol 2022;5(4):e40905) doi:10.2196/40905

KEYWORDS

social media; Cochrane Skin; dermatology; content engagement; Facebook; Cochrane; Twitter; social media analysis; content analysis; skin disease; dermatologist

Introduction

The goal of Cochrane Skin Group (CSG) is to publish systematic reviews regarding all aspects of skin disease, including prevention, management, and treatment [1]. CSG has been an international leader in dermatoepidemiology and evidence-based dermatology since its creation 25 years ago [2]. To encourage the dissemination of review information, CSG has used social media to reach a broad global audience. As previously described, social media provides an accessible and popular avenue for the sharing of health care information, networking, and outreach in medicine [3]. In this study, we aimed to characterize CSG's international social media audience and identify themes that result in increased content engagement.

Methods

Facebook, Instagram, and Twitter analytics data were extracted for followers' country of origin and sex as of June 28, 2022. The top 3 countries of origin for followers of each platform were recorded. Each social media platform uses varying terminology to refer to the number of people who have seen a post; Facebook uses "reach," and Instagram and Twitter use "impressions." For clarity, we refer to the number of people who have seen a post as "views." Posts with the highest number of views within a 3-year span (June 2019 to June 2022) were extracted.

Results

CSG had 1037, 214, and 352 Facebook, Instagram, and Twitter followers, respectively. Among CSG's Facebook followers, 43.4% (450/1037) were female, and 56.6% (587/1037) were male; 44.6% (463/1037) were from India, 26.2% (271/1037) were from Brazil, and 22.1% (299/1037) were from Egypt (Table 1). Among CSG's Instagram followers, 52.3% (112/214) were female, and 47.7% (102/214) were male; 25.7% (55/214) were from Brazil, 13.6% (29/214) were from the United States, and 5.1% (11/214) were from Iran (Table 1). Among CSG's Twitter followers, 35.8% (126/352) were female, and 64.2% (226/352) were male; 28.1% (99/352) were from the United Kingdom, 13.6% (48/352) were from the United States, and 5.4% (19/352) were from Spain (Table 1).

The CSG's posts with the greatest number of views were all posted within the last year. Facebook's top post about CSG's annual meeting at the American Academy of Dermatology Conference received 1041 views (Table 2). The top post on Instagram, which introduced CSG's social media editors, received 2522 views (Table 2). The top post on Twitter, which highlighted a dermatoepidemiology research fellowship opportunity, received 4422 views.

Table 1. Demographics of Cochrane Skin Group Facebook, Instagram, and Twitter followers.

Variable	Facebook	Instagram	Twitter
Followers, n	1037	214	352
Sex, n (%)			
Female	450 (43.4)	112 (52.3)	126 (35.8)
Male	587 (56.6)	102 (47.7)	226 (64.2)
Country[a], n (%)			
Brazil	271 (26.2)	55 (25.7)	—[b]
Egypt	299 (22.1)	—	—
India	463 (44.6)	—	—
Iran	—	11 (5.1)	—
Spain	—	—	19 (5.4)
Taiwan	40 (3.9)	—	19 (5.4)
United Kingdom	—	—	99 (28.1)
United States	—	29 (13.6)	48 (13.6)

[a]The countries listed each have greater than 3% of the social media platform followers.

[b]Not available.

Table 2. The highest viewed posts on the social media platforms used by Cochrane Skin Group.

Title of post	Type of post	Date posted	Views, n	Platform
"We hope everyone had a great time at the AAD annual meeting…" [4]	CSG[a] meeting	August 9, 2021	1041	Facebook
"We would like to introduce ourselves as the new Cochrane Skin's social media editors…" [5]	CSG editors	July 28, 2021	2522	Instagram
"Dermatoepidemiology Fellowship Opportunity…" [6]	Fellowship opportunity	May 22, 2022	4422	Twitter

[a]CSG: Cochrane Skin Group.

Discussion

Overall, the countries of origin for followers of CSG social media accounts vary by platform. CSG Facebook followers are predominantly from South Asia and Africa, while Instagram followers are primarily from North America and South America. Furthermore, Twitter followers are primarily from the United States and United Kingdom—the same countries of origin as those of CSG's coordinating editors. These differences in audience background between each social media platform suggest that CSG's multiplatform social media approach allows information to be spread to a broader international audience.

Generally, the most viewed social media posts involved content regarding CSG meetings, members, and professional opportunities. Therefore, posting content that references CSG's mission, events, and team can be prioritized alongside review dissemination to engage established and new followers. Although CSG's Facebook page had the most followers, CSG's Twitter posts consistently had a greater number of views, with Twitter's top post having 3 times the number of views when compared to Facebook's top post. As described in previous studies, Twitter is the most popular social media platform for health care communication [7], which may explain CSG's high levels of Twitter engagement.

Some recommendations to help further enhance CSG's social media presence may include, but are not limited to, (1) creating polls to ask users for their opinion on the most valuable content and (2) embedding social media content into newsletters and blog posts. Although our study is specific to CSG's social media analytics data from the last 3 years, our highest performing social media posts can act as a guide for other journals interested in expanding their digital reach. Concise posts that are specific to editorial board members and research opportunities tend to accrue the most engagement. As CSG's social media presence continues to grow, it will provide new ways to connect with an international audience interested in dermatology.

Conflicts of Interest

RD is the joint coordinating editor of *Cochrane Skin Group* and also the Editor-in-Chief of *JMIR Dermatology*, but had no role in the evaluation of this manuscript for publiction.

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Abbreviations

CSG: Cochrane Skin Group

Edited by R Boyle; submitted 08.07.22; peer-reviewed by A Drucker, M Umoquit; comments to author 27.08.22; revised version received 23.10.22; accepted 15.11.22; published 30.11.22.

Please cite as:
Ahmad A, Alhanshali L, Jefferson IS, Dellavalle R
Cochrane Skin Group's Global Social Media Reach: Content Analysis of Facebook, Instagram, and Twitter Posts
JMIR Dermatol 2022;5(4):e40905
URL: https://derma.jmir.org/2022/4/e40905
doi:10.2196/40905
PMID:37632904

Original Paper

The Burden of Disease in Alopecia Areata: Canadian Online Survey of Patients and Caregivers

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Abstract

Background: Alopecia areata (AA) is associated with negative impacts on the quality of life (QoL). Data on this impact are lacking for Canadian patients and their caregivers.

Objective: This study aims to investigate the burden of AA on Canadian patients and their caregivers.

Methods: We created 4 online surveys for patients 5-11 years old, 12-17 years old, and ≥18 years old and for caregivers of children (<18 years old) with AA. These were disseminated through the Canadian Alopecia Areata Foundation (CANAAF) website and to dermatologists across Canada.

Results: In total, 115 adult patients (n=100, 87%, female), 14 pediatric patients (n=13, 92.9%, female), and 15 caregivers completed the surveys online. The majority (n=123, 95%) of patients felt uncomfortable or self-conscious about their appearance. Camouflaging hair loss with hats, scarves, and hairpieces was a common practice for 11 (78.6%) pediatric and 84 (73%) adult patients. Avoidance of social situations was reported by 8 (57.1%) pediatric and 75 (65.2%) adult patients. Constant worry about losing the achieved hair growth was a concern for 8 (57.1%) pediatric and 75 (65.2%) adult patients. On a scale of 1-5, the mean score of caregivers' own feelings of sadness or depression about their child's AA was 4.0 (SD 0.9) and of their feelings of guilt or helplessness was 4.2 (SD 1.2). The impact on the QoL was moderate for both children and adults. Based on the Adjustment Disorder New Module-20 (ADNM-20), 71 (61.7%) of 115 patients were at high risk of an adjustment disorder. Abnormal anxiety scores were recorded in 40 (34.8%) patients compared to abnormal depression scores in 20 (17.4%) patients.

Conclusions: This study confirmed a significant burden of AA on Canadian patients' and caregivers' QoL.

(JMIR Dermatol 2022;5(4):e39167) doi:10.2196/39167

KEYWORDS

alopecia areata; quality of life; burden of disease; alopecia; QoL; burden; dermatology

Introduction

Background on Alopecia Areata

Alopecia areata (AA) is an autoimmune disease affecting the hair follicles that presents with nonscarring hair loss [1]. The hair loss manifests as patches localized to the scalp or affecting eyebrows and eyelashes (alopecia totalis [AT]) or all hair-bearing areas of the body (alopecia universalis [AU]) [2]. AA affects approximately 2% of the general population at some point in their lifetime [1]. It is associated with multiple comorbidities, including atopic dermatitis (AD), hypothyroidism, psoriasis, vitamin D deficiency, and anemia [3,4]. Additionally, it can be psychologically burdensome to the patient as it is known to cause significant emotional stress and low self-esteem [5,6]. In some cases, this burden results in clinical manifestations of anxiety or depression [2].

A large factor in the development of emotional and psychological distress in patients with AA is societal stigmatization [7]. Stigmatization is the state of being isolated, marginalized, and ignored by the general population because of a disease or the presence of a degrading sign [7]. Patients with AA are subjected to stigmatization as their physical appearance is significantly altered by the hair loss [7]. Patients with more extensive forms of AA, such as AT and AU, may experience a greater burden [5]. This noticeable change in physical appearance causes people to view them differently, and potentially treat them differently. As a means of preventing stigmatization, patients with AA may try to conceal their hair loss. However, those with extensive hair loss may not be able to conceal it to their liking, which can cause incredible anxiety when they are faced with the task of being in public spaces or around other people. The full impact of the disease can be underestimated in clinical practice [8]. This may be due to the patients' hesitancy to discuss their feelings with their clinicians or the clinicians' inability to properly address the issue. This exacerbates the burden of disease as patients may feel as though their feelings are not validated by their health care providers. The emotional distress caused by stigmatization and other factors contribute to the overall burden of AA on the patients' quality of life (QoL). Studies on the impact of AA on patients' QoL have demonstrated that the burden often continues into adulthood [9,10]. The concept of QoL is quite subjective and multifaceted, and thus, many definitions exist [11]. For the purposes of this study, the QoL is defined as physical, emotional, and psychological well-being.

Rationale and Objectives

There is a lack of Canadian data on the impact of AA on patients' QoL in both adult and pediatric populations as well as the caregivers of pediatric patients. We developed a Canada-wide online survey to gather more data from patients and caregivers to help describe the disease burden. The results of this study will equip clinicians with the knowledge to actively address the burden of AA on patients and their caregivers, with the hope of improving their QoL.

Methods

Online Survey Development

We created 4 surveys for the following sample groups: patients 5-11 years of age (40 questions), patients 12-17 years of age (43 questions), patients 18 years of age and older (74 questions), and caregivers of children (<18 years of age) with AA (18 questions). Eligibility criteria were defined as individuals living in Canada aged 5 years or older who were clinically diagnosed with AA or the caregivers of a child clinically diagnosed with AA living in Canada. Caregivers were defined as any parent (biological or other) of a child (<18 years of age) with AA. The surveys contained questions created by the authors, as well as established clinical questionnaires. The format of the questionnaires included multiple-choice questions, yes/no questions, Likert scales, and open-ended questions. Questions created by the authors aimed to collect information about participant demographics (age and sex), history of AA (age at diagnosis, subtype, and treatments used), and the psychosocial and economic burden of the disease. The clinical questionnaires included were the Children's Dermatology Life Quality Index (CDLQI), the Dermatology Life Quality Index (DLQI), the Hospital Anxiety and Depression Scale (HADS), and the Adjustment Disorder New Module-20 (ADNM-20).

Validated Assessment Tools

The CDLQI questionnaire has 10 questions and is used to measure the impact of any skin disease on the lives of children aged 4-16 years [12]. The scoring of each question ranges from 3 (very much) to 0 (no impact) [12]. The total score falls into 5 categories: no effect on the child's life (0-1), small effect on the child's life (2-6), moderate effect on the child's life (7-12), very large effect (13-18), and extremely large effect (19-30) [13]. In adult patients (18 years and older), the DLQI questionnaire is used [14]. The DLQI categorizes their final scores in the same way as the CDLQI but has slightly different cut-off values [15]. The HADS questionnaire is a self-assessment scale used for detecting states of depression and anxiety in a hospital medical outpatient clinic setting [16]. The HADS comprises two 7-question subscales, one targeting anxiety (HADS-A) and the other targeting depression (HADS-D) [16]. Scores for each question range from 0 (no effect) to 3 (large effect) [16]. The total score falls into 3 categories: normal (0-7), borderline abnormal (8-10), and abnormal (11-12) [16]. The ADNM-20 questionnaire has 20 questions and is used to assess the risk of an adjustment disorder diagnosis in adults [17]. The scoring of each question ranges from 1 (never) to 4 (often) [17]. The total score indicates the respondents' risk of an adjustment disorder diagnosis, with a score of 48 or greater indicating high risk [17].

Ethical Considerations

Ethical approval was granted through the University of Toronto (REB #00040364). Participants were required to provide written informed consent prior to completion of the surveys.

Online Survey Dissemination

The surveys were uploaded to the SurveyMonkey platform, and the associated links were disseminated through the Canadian Alopecia Areata Foundation (CANAAF) website and to dermatologists across Canada. The surveys were completed anonymously by respondents over a period of 2 months (April-May 2021). Respondents younger than 12 years of age were required to complete the survey under the supervision of their caregivers. Respondents did not receive a monetary reward for completing the surveys.

Data Analysis

After 2 months of data collection, the study was closed and the collected data were analyzed. Numerical data were analyzed quantitatively using Microsoft Excel version 2109. Qualitative data, namely free-text responses, were analyzed descriptively, and the most common responses were reported.

Results

Demographic Results

A total of 129 patients and 15 caregivers completed the surveys. The survey completion rates were 91.3% (n=105) for adult respondents, 92.9% (n=13) for pediatric respondents, and 80% (n=12) for caregiver respondents. In total, 115 (89.1%) of these 129 patients were 18 years of age and older, and 14 (10.9%) of these patients were pediatric (less than 18 years old). The mean age of pediatric patients was 13.2 (SD 3.6) years, with 13 (92.9%) being female and 1 (7.1%) being male (Table 1). The mean age of adult patients was 44.2 (SD 15.6) years, with 100 (87%) being female and 5 (13%) being male (Table 1). The mean age at diagnosis was 27.6 (SD 19.0) years for adult patients and 7.5 (SD 4.7) years for pediatric patients. The mean disease duration was 16.5 (SD 13.8) years for adult patients and 5.7 (SD 4.4) years for pediatric patients. AA affecting the scalp only and AU were the most prevalent subtypes of AA in both pediatric and adult patients (Table 1).

Topical corticosteroids and intralesional corticosteroid injections were the most common treatments used in adult patients (Figure 1). In pediatric patients, topical corticosteroids and topical minoxidil were the most common treatments used (Figure 1). Vitamin D, biotin, and probiotics were the most used over-the-counter supplements by patients.

Table 1. Demographic characteristics of study participants.

Characteristics	Participants <18 years of age (n=14)	Participants ≥18 years of age (n=115)
Sex, n (%)		
Male	1 (7.1)	15 (13.0)
Female	13 (92.9)	100 (87.0)
Age (years)		
Mean, (SD)	13.1 (3.6)	44.2 (15.6)
Median (range)	14.5 (6-17)	43 (18-94)
Age grouping (years), n (%)		
5-11	4 (28.6)	N/A[a]
12-17	10 (71.4)	N/A
18-30	N/A	25 (22)
31-40	N/A	25 (22)
41-50	N/A	20 (17)
51-60	N/A	25 (22)
61+	N/A	20 (17)
AA subtype, n (%)		
AA[b] (scalp only)	7 (50)	43 (37.4)
AT[c]	2 (14.3)	17 (14.8)
AU[d]	5 (35.7)	60 (52.2)

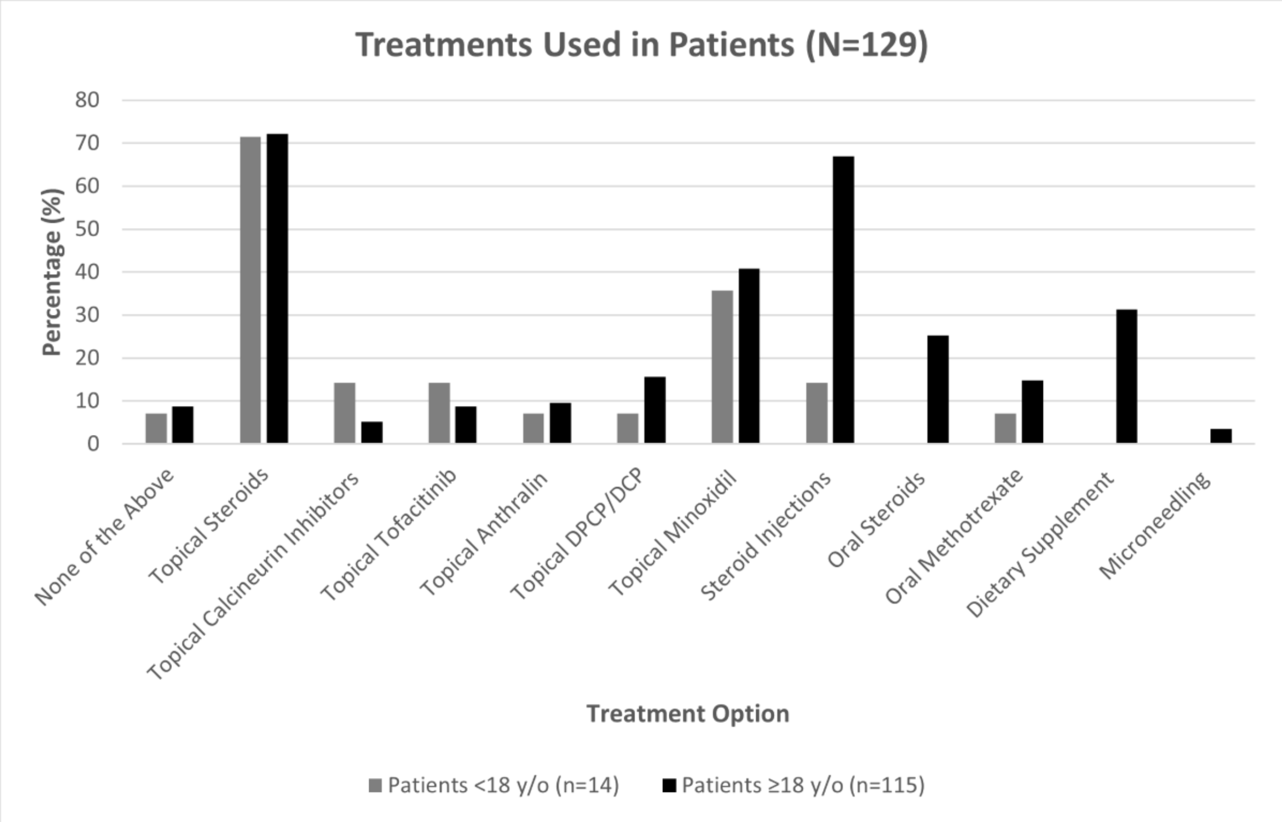
[a]N/A: not applicable.

[b]AA: alopecia areata. Five respondents selected AA (scalp only) plus AT or AU. Respondents were members of the Canadian Alopecia Areata Foundation (CANAAF) or referred to the survey by a dermatologist.

[c]AT: alopecia totalis, defined by loss of hair on scalp as well as eyebrows and eyelashes.

[d]AU: alopecia universalis, defined by loss of hair on areas of the body other than the head.

Figure 1. Treatments reported by respondents. The respondents were members of CANAAF or referred to the survey by a dermatologist. CANAAF: Canadian Alopecia Areata Foundation; DCP: diphencyprone; DPCP: diphenylcyclopropenone; y/o: years old.



Psychosocial Impact of Alopecia Areata

There was a clear impact of AA on patients' and caregivers' daily lives. Of the 129 patients, 123 (95%) felt uncomfortable or self-conscious about their appearance. Camouflaging hair loss with hats, scarves, and hairpieces was a common practice for 11 (78.6%) pediatric patients and 84 (73%) adult patients. Avoidance of social situations was the second highest impact of AA on daily life and was seen in 8 (57.1%) pediatric and 75 (65.2%) adult patients. Of the 15 caregivers, 6 (40%) reported this behavior in their children. Constant worry about losing the achieved hair growth was a concern for 8 (57.1%) pediatric and 75 (65.2%) adult patients. Of the 15 caregivers, 9 (60%) reported the same alopecia-related anxiety in their children. On a scale of 1-5, the mean score of caregivers' own feelings of sadness or depression about their child's AA was 4.0 (SD 0.9) and of their feelings of guilt or helplessness was 4.2 (SD 1.2). Caregivers' mean satisfaction rating with the currently available AA treatment options was 1.8 (SD 0.9).

Validated Assessment Tool Scores

In the pediatric population, 11 (78.6%) respondents completed the CDLQI and had a mean score of 9.7 (SD 6.8), which fell within the moderate-effect range (Figure 2). In their adult counterparts, 106 (92.2%) respondents completed the DLQI section of the survey and had a mean score of 6.7 (SD 5.7), which also fell within the moderate-effect range (Figure 2).

Of the 115 adult respondents, 106 (92.2%) completed the ADNM-20 portion of the survey. The mean score for the ADNM-20 was 49.4 (SD 13.7), which indicated a high risk of an adjustment disorder diagnosis. In addition, 106 (92.2%) adult respondents completed the HADS-A and HADS-D portions of the survey. The mean HADS scores were 9.0 (SD 5.0) for anxiety and 5.5 (SD 4.3) for depression. The mean HADS-A score fell within the borderline abnormal range, compared to the mean HADS-D score, which fell within the normal range (Figure 3).

Figure 2. DLQI scores for all respondents. The respondents were members of CANAAF or referred to the survey by a dermatologist. The total score for both questionnaires out of 30 was categorized for impact of the dermatosis on the QoL as follows: 0-1 (no effect), 2-6 (small effect), 7-12 (moderate effect), 13-18 (very large effect), and 19-30 (extremely large effect). CANAAF: Canadian Alopecia Areata Foundation; CDLQI: Children's Dermatology Life Quality Index; DLQI: Dermatology Life Quality Index; QoL: quality of life.

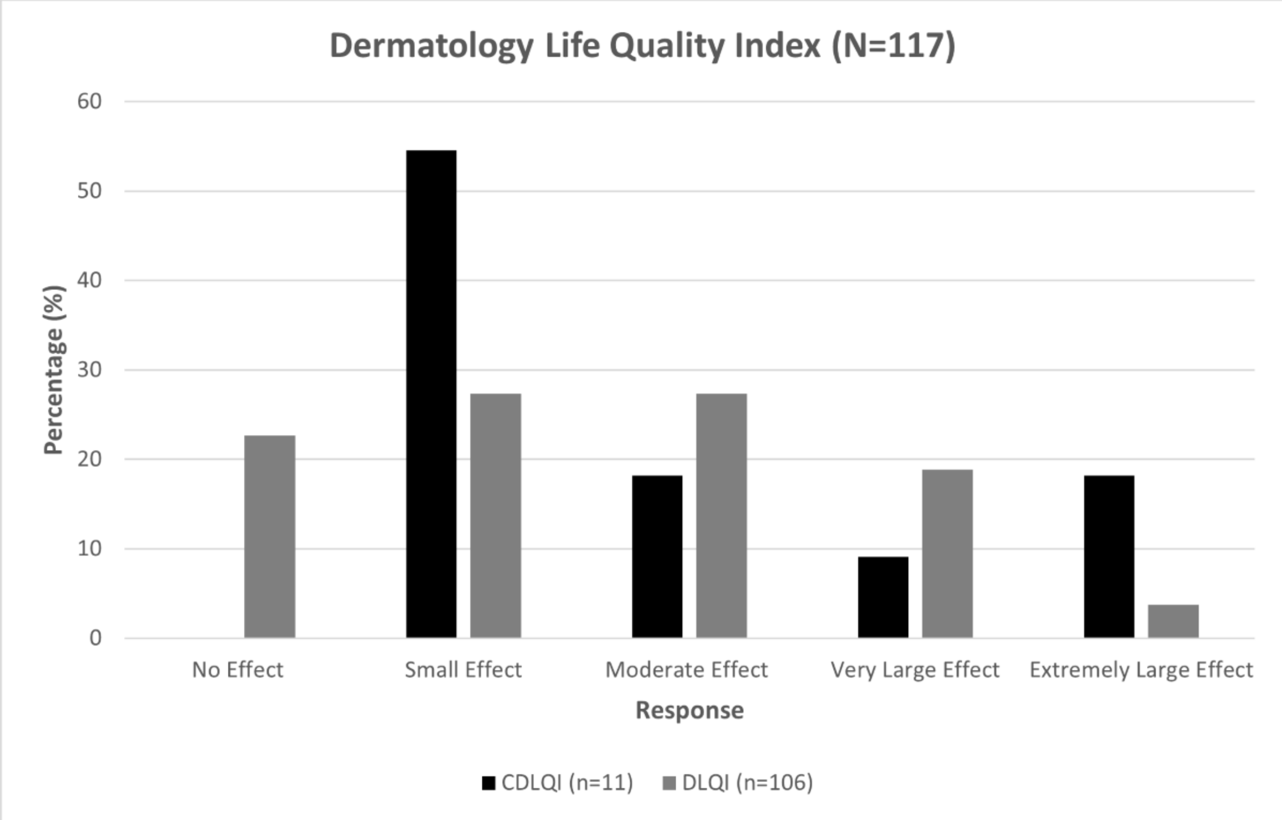
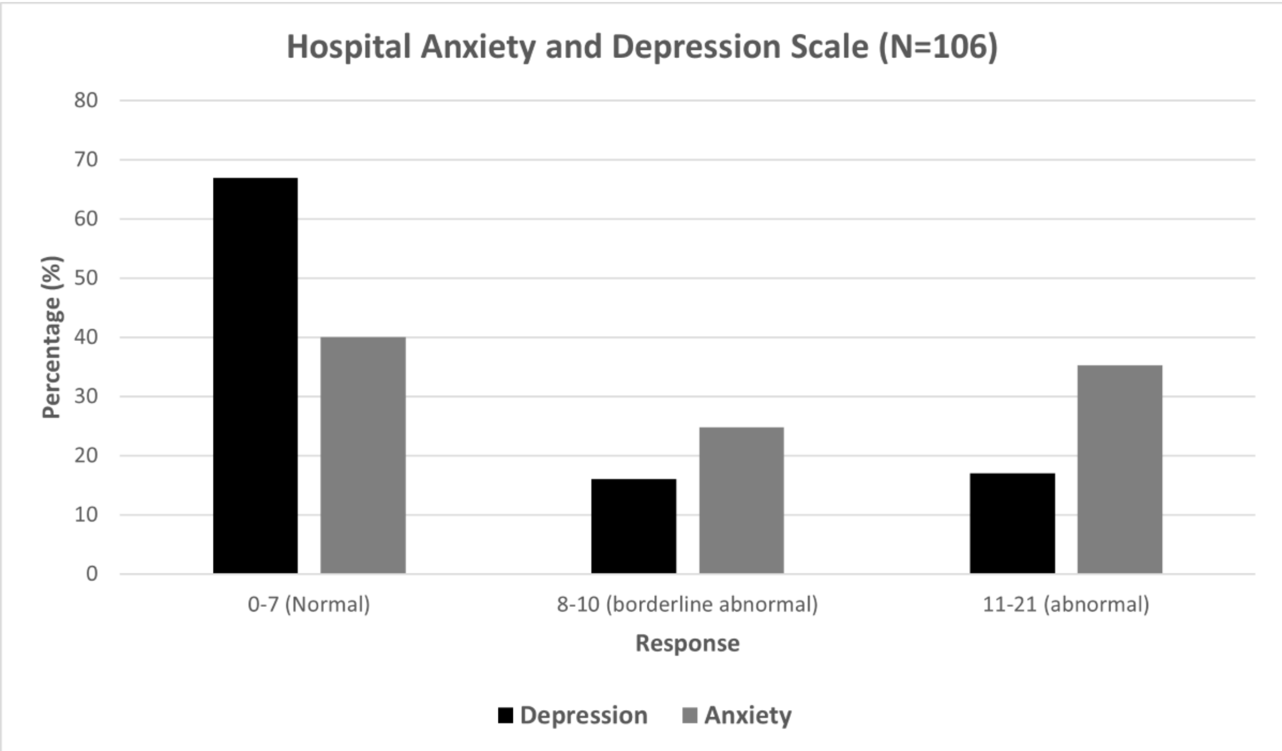


Figure 3. HADS scores for all respondents. The respondents were members of CANAAF or referred to the survey by a dermatologist. Both HADS-A and HADS-D scales had a total possible score of 21 from 7 questions. Results were categorized based on the total score as follows: normal (0-7), borderline abnormal (8-10), and abnormal (11-21). CANAAF: Canadian Alopecia Areata Foundation; HADS: Hospital Anxiety and Depression Scale; HADS-A: Hospital Anxiety and Depression Scale-Anxiety; HADS-D: Hospital Anxiety and Depression Scale-Depression.



Financial Impact of Alopecia Areata

Adolescent (12-17 years of age) and adult patients were asked to describe how much money they spent on eyebrow microblading and their satisfaction with the results (n=67, 51.9%). The cost of an initial microblading session ranged from CA $200-$2500 (US $146-$1825) and CA $150-$500 (US $109.5-$365) for subsequent sessions. Of the 67 patients, 54 (80.6%) were satisfied with their results. Patients described needing at least 1 or 2 microblading sessions per year to maintain cosmetically favorable results. The cost of microblading sessions and the need for continuous touch-ups were a source of frustration and financial burden.

Adult and adolescent patients were then asked to describe how much money they spent on hairpieces and whether they found them helpful (n=103, 79.8%). The cost of hairpieces ranged from CA $150-$7000 (US $109.5-$5110). Of the 103 patients, 71 (68.9%) found their hairpieces helpful, while 11 (10.7%) patients reported the hairpieces to be uncomfortable on their scalp and thus not a helpful way to conceal their hair loss. Patients reported that their hairpieces lasted 1-3 years before needing to be replaced.

Use of Support Groups and Open-Ended Responses

Adult patients described support groups as safe spaces to express themselves and seek comfort while coping with their AA. On a Likert scale of 1-5, the mean rating of the helpfulness of both in-person and online support groups was 3.7 (SD 1.2) for adult patients. On the same scale, the mean rating for pediatric patients was 4.0 (SD 1.5) for in-person support groups and 2.8 (SD 1.5) for online support groups. Pediatric patients described support groups as fun, and they enjoyed participating in interactive activities with other youth diagnosed with AA. Both adult and pediatric patients appreciated being able to talk openly about their AA with other patients.

Patients and caregivers were asked to share any additional input they felt was valuable for us to know, and 93 (72.1%) of 129 patients and 11 (72.1%) of 15 caregivers provided free-text responses to this open-ended question. A common theme was the desire for their clinicians to provide them with more information about AA at the time of diagnosis, specifically regarding prognosis and alternative treatment options. Patients felt they were left to seek this information on their own, which was both time-consuming and emotionally taxing for them. The desire to connect sooner with support groups, such as CANAAF, was also echoed by many patients and caregivers who had wished their physicians provided them with these resources.

Discussion

Principal Findings

This online study confirms the burden of AA on Canadian patients' and caregivers' QoL. To date, this is the first Canada-wide online study of its kind. Our results demonstrated a negative financial, emotional, and psychosocial burden of AA on respondents' daily lives. From a financial perspective, respondents reported spending several hundred to thousands of dollars yearly on cosmetic cover-ups, such as hairpieces and eyebrow microblading. From an emotional and psychosocial standpoint, respondents reported pervasive feelings of anxiety and depression that affected their ability to function as they did prior to their diagnosis of AA. Difficulty coping with AA was common among respondents, and the results of the ADNM-20 questionnaire reported a high risk of an adjustment disorder diagnosis in approximately 62% of adult patients. This is the first study to use the ADNM-20 questionnaire to assess for the risk of adjustment disorder in adult patients with AA. Adjustment disorder is a psychological reaction to a traumatic psychosocial stressor, resulting in the development of clinically significant emotional distress [18]. It has been attributed as an aggravating factor for the development of self-inflicted hair loss disorders, such as trichotillomania [19], and was reported to be the most common psychiatric comorbidity of AA by Ruiz-Doblado et al [20]. Our work has set the foundation for further Canadian studies on the association of adjustment disorder and AA, as well as other appearance-altering dermatological disorders, such as vitiligo. The online nature of the study allowed us to reach a more diverse group of patients who otherwise would have been missed using alternative formats, such as a clinic-based study. Most importantly, the results of our study have the potential to influence evidence-based care both in Canada and worldwide. For example, many patients and caregivers reported the need for more education on AA during their medical appointments, specifically as it relates to alternative treatment options and prognosis. With this information, providers may choose to allocate more time to patient education during their consultations. The emotional and psychosocial burden of disease reported by patients may also signal the need to include referral to mental health care services in the clinical management of AA.

Comparison With Prior Studies on Alopecia Areata

The burden of AA on patients' QoL has been previously described in studies outside of Canada [10,21,22]. A study conducted by Shi et al [23] revealed that close to 50% of patients with AA experience poor health-related QoL. Patients with more advanced forms of AA, such AT and AU, tend to have a worse QoL [24]. The mean DLQI score of our respondents was 6.7, which reflects a moderate effect of AA on patients' QoL. This was slightly higher than the mean score of 6.3 reported by Rencz et al [25] and lower than the mean score of 7.7 reported by Liu et al [26], both of which also fall within the moderate-effect range. In our pediatric respondents, the mean CDLQI score was 9.7, which also reflects a moderate effect of AA on the QoL. This is higher than the mean score of 4.4 reported by Putterman et al [27] and drastically higher than the mean score of 2.25 reported by Vélez-Muñiz et al [28]. The large variation in mean CDLQI scores is likely due to our small pediatric population compared to the population sizes in the referenced studies. The prevalence of anxiety and depression in adults with AA can be assessed using the HADS questionnaire. The mean HADS-A score of our respondents was 9.0, which is considered borderline abnormal, and the mean HADS-D score was 5.5, which is considered normal. These values were similar to the mean scores reported by Titeca et al [29], which were 7.9 for HADS-A and 5.4 for HADS-D. A pattern can be observed in the HADS scores of our respondents and the scores found in the literature, where the HADS-A score is typically borderline abnormal or abnormal, whereas the HADS-D scores are generally normal. The high HADS-A scores can be explained by the high levels of anxiety that patients with AA experience, particularly early in their diagnosis. Much of the anxiety is social, and patients fear unpleasant social encounters with people, such as being stared at, asked intrusive questions, or being harassed. Despite the lower HADS-D scores, it is known that patients with AA experience depression at higher rates than the general public [30], which may be explained by the feelings of hopelessness and social isolation. The ADNM-20 has not been used in any other AA QoL studies to date, so no comparisons to other AA QoL studies could be made.

Comparison With Prior Studies on Other Dermatoses

Compared to other dermatological diseases, AA appears to be less burdensome to the patient, likely due to the absence of physical symptoms, such as itch or pain. The disease most similar to AA with respect to pathogenesis and psychosocial burden is vitiligo, which manifests with disfiguring loss of skin pigmentation. A study of 100 vitiligo patients by Mishra et al [31] reported a mean DLQI score of 6.86, which is minutely higher than our mean score of 6.7. With respect to anxiety and depression, a study of vitiligo patients conducted by Ajose et al [32] reported mean HADS scores of 7.73 for anxiety and 6.18 for depression. As with the HADS scores for patients with AA, we see that the HADS scores for anxiety are higher than those of depression in vitiligo patients. Unlike AA and vitiligo, AD, an inflammatory skin disease, is notably much more burdensome for patients. Patients with AD experience chronic itching and inflammation of the skin and report much higher DLQI/CDLQI scores as a result. A systematic review by Basra et al [33] found that AD patients reported a mean DLQI score of 11.2, which is significantly higher than our mean score of 6.3. The same trend was seen in the pediatric AD population in a study conducted by Weidinger et al [34], which reported a mean CDLQI score of 14.5. The ADNM-20 questionnaire has not been used to assess for the risk of an adjustment disorder diagnosis in other dermatological disease QoL studies, and thus a comparison with our results could not be made.

Limitations

A limitation of this study was that we relied on anonymous respondents' self-reported AA and were not able to formally confirm their diagnoses. Most members of CANAAF are referred to the organization by their physicians, and only dermatologists were provided with information about the survey to give their patients. Thus, we felt that respondents were unlikely to have another diagnosis. Moreover, most members of CANAAF are female, which is reflected in our low number of male respondents. This is a potential source of bias and may impact the generalizability of our results. Another limitation of this study is that the surveys did not contain an AA-specific instrument, such as the Alopecia Areata Symptom Impact Scale (AASIS). However, the CDLQI/DLQI, HADS, and ADNM-20 are all validated and used routinely in clinical practice. Respondents 17 years of age completed the CDLQI despite it not being validated for their age. However, a study by van Geel et al. [35] found that DLQI and CDLQI scores were closely related in 16- and 17-year-olds; thus, we believe the resultant data are still much valuable. Due to the long duration of the surveys, respondent fatigue and resultant bias must also be considered, given the moderate length of the surveys. To mitigate this, surveys were not timed, and respondents got an opportunity to take breaks, if desired. We also had lower numbers of young children and caregivers respond, which may be due to their apprehension to answer sensitive questions in an online format. Finally, we did not analyze the impact of disease severity or patient characteristics on the disease burden because of the sample size and lack of detailed disease data.

Conclusion

Despite limitations, the results of this first-of-its-kind Canadian survey have set the stage for further investigations on the epidemiology of AA and its impact on patients' QoL in Canada.

Acknowledgments

The authors would like to sincerely thank the Canadian Alopecia Areata Foundation (CANAAF) for providing input on the survey questions, funding the SurveyMonkey account, and disseminating the surveys through its network. The authors would also like to thank the many practitioners who helped disseminate information about the survey to their patients. The authors received financial support from CANAAF to complete this research.

Conflicts of Interest

AJG is on the board of directors at the Canadian Alopecia Areata Foundation (CANAAF) but was not involved in decisions surrounding financial support for this research. CS has received honoraria from Pfizer, Abbvie, Leo, Novartis, UCB, and Sanofi/Regeneron for work unrelated to this research. EP and NH have no conflicts to disclose.

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Abbreviations

AA: alopecia areata
AD: atopic dermatitis
ADNM-20: Adjustment Disorder New Module-20
AT: alopecia totalis
AU: alopecia universalis
CANAAF: Canadian Alopecia Areata Foundation
CDLQI: Children’s Dermatology Life Quality Index
DLQI: Dermatology Life Quality Index
HADS: Hospital Anxiety and Depression Scale
HADS-A: Hospital Anxiety and Depression Scale-Anxiety
HADS-D: Hospital Anxiety and Depression Scale-Depression
QoL: quality of life

Edited by R Dellavalle, T Sivesind; submitted 01.05.22; peer-reviewed by C Shah, V Long, A Oganesyan, M Szeto; comments to author 23.06.22; revised version received 29.08.22; accepted 22.09.22; published 06.10.22.

Please cite as:
Gilding AJ, Ho N, Pope E, Sibbald C
The Burden of Disease in Alopecia Areata: Canadian Online Survey of Patients and Caregivers
JMIR Dermatol 2022;5(4):e39167
URL: https://derma.jmir.org/2022/4/e39167
doi:10.2196/39167
PMID:37632886

Publisher:
JMIR Publications
130 Queens Quay East.
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Phone: (+1) 416-583-2040
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