Experiences of Health Care Providers Using a Mobile Medical Photography Application

Kirk D. Wyatt[1] Brian N. Willaert[2] Christine M. Lohse[3] Peter J. Pallagi[4] James A. Yiannias[5,6] Thomas R. Hellmich[7,8]

[1] Division of Pediatric Hematology/Oncology, Mayo Clinic, Rochester, Minnesota, United States
[2] Information Technology, Mayo Clinic, Rochester, Minnesota, United States
[3] Division of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, Minnesota, United States
[4] Media Support Services, Mayo Clinic, Scottsdale, Arizona, United States
[5] Center for Connected Care, Mayo Clinic, Rochester, Minnesota, United States
[6] Department of Dermatology, Mayo Clinic, Scottsdale, Arizona, United States
[7] Department of Emergency Medicine, Mayo Clinic, Rochester, Minnesota, United States
[8] Department of Pediatric and Adolescent Medicine, Mayo Clinic, Rochester, Minnesota, United States

Address for correspondence Thomas R. Hellmich, MD, Department of Emergency Medicine, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, United States (e-mail: Hellmich.Thomas@mayo.edu).

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Abstract

Objective To understand the ways in which providers use a mobile photography application integrated with the electronic health record (EHR) to facilitate clinical care, and the process outcomes that result from the application's use.

Methods An e-mail survey was sent on November 13, 2017, to 1,463 health care providers at Mayo Clinic who had used an internally developed, EHR-integrated medical photography application.

Results The survey was completed by 712 (49%) providers. Providers reported using the application on approximately 1 in 7 days spent in clinical practice. Median provider satisfaction with the use of the application (0–100 scale; higher numbers indicate favorable response) was 94 (interquartile range [IQR]: 74–100). Although the use for store-and-forward telemedicine was reported (22% often or frequently used the application to send photographs to a specialist for advice), the most common use was for clinical documentation (65% often or frequently used the application to supplement text-based notes with photographs, and 71% often or frequently used the application to take photographs for reference by a colleague who may see the patient in the future). Of the health care providers, 36% indicated that the application's use often or frequently expedited treatment.

Discussion Health care providers reported using a mobile point-of-care medical photography application regularly in clinical practice and were generally satisfied with the application.

Conclusion Point-of-care medical photography using a secure mobile, EHR-integrated application has potential to become a new standard of care for clinical documentation and may facilitate continuity across the continuum of care with multiple providers who see a patient.

Keywords
- medical photography
- photography
- mobile application

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Background and Significance

Mobile applications play an increasingly central role in patient care. Although many forms of health information technology have become a source of frustration for health care providers,[1–5] others may be seen as facilitators of patient care.[6–8] For example, disease-specific self-care applications for diabetes mellitus have demonstrated a beneficial effect of application use on outcomes such as glycated hemoglobin levels.[9,10] However, many applications used for other purposes have been poorly studied, and there is little evidence to support claims that they improve outcomes.[11,12] One barrier to a formal study of mobile applications is that outcomes of interest may be heterogeneous or difficult to measure.

The practice of medical photography dates back to the 1840s,[13] and it has been employed in most medical specialties.[14–20] Since its inception, the practice has evolved to include the use of smartphone cameras to capture patient photographs.[16,20–25] In many cases, photography is conducted using native smartphone applications,[16,24] which may not be compliant with legal and regulatory requirements and may not facilitate incorporation of the photographs into the patient's medical record for review by other providers. To address compliance and facilitate use in clinical care, mobile applications that integrate medical photographs taken using a smartphone into the electronic health record (EHR) have been developed.[19,22,23,26,27] Although these applications can facilitate telemedicine and documentation, their impact on clinical care remains largely unclear.

In 2015, Mayo Clinic released an internal iOS-based secure mobile application (PhotoExam) for medical photography. The application was integrated with the EHR and allowed for the capture and storage of clinical images. For the first time, the application allowed any clinical staff member within the Mayo Clinic enterprise to conduct medical photography using his/her smartphone in a manner that was compliant with health care record-keeping and privacy regulations and maintained data security. Photographs taken using the application were viewable in the EHR within minutes of upload.

Objectives

The application's release was a result of an institutional directive to facilitate image privacy, security, and appropriate care team sharing—rather than a formal research study—and the impact on clinical care following the application's release was unclear. For example, for what purposes do health care providers use the application and is its use perceived to favorably affect clinical care processes? How can successful use cases be leveraged to further expand the application's use and integration within clinical practice? On the other hand, what are barriers to providers' use of the application to improve care processes? Anecdotal evidence seemed to justify ongoing maintenance and continuous improvement of the application; however, confirmatory evidence on the impact of the application's use to facilitate care processes was lacking. We therefore aimed to use a provider survey to assess the clinical utility of the PhotoExam application at Mayo Clinic.

Methods

PhotoExam Application

The functionality of the PhotoExam application is described in detail elsewhere.[22] The application can be downloaded on employees' personal mobile devices, which are secured using third-party mobile device management software. Alternatively, the application can be used on institutionally owned mobile devices, which are shared within a department. Upon launching the application, the user opens the patient record and is prompted to select the anatomical site(s) that will be photographed. Users are able to take up to six photographs of each anatomical site and are able to enter a brief free-text description to accompany the photographs. Users then indicate when they have finished taking photographs, and this triggers the upload of photographs to the EHR. Upon successful upload or closure of the application, the photographs are deleted. No personally identifiable health information remains on the device at the completion of the photography session.

Anecdotal evidence suggested several existing workflows that integrated the application into clinical practice. For example, the application has been used for store-and-forward telemedicine, whereby a specialist is consulted remotely while the patient is in a primary care office or the emergency department. Another use case is to augment documentation of the physical examination. Finally, the application is used to facilitate continuity of care across multiple providers and care settings by documenting the appearance of clinical findings over time to facilitate a shared mental model.

Participants

Any staff member who used the PhotoExam application to take five or more photographs was eligible to complete the survey. We chose this threshold, which captured the top 70th percentile of users, so that respondents had sufficient clinical experience using the application to provide formative feedback. Additionally, this threshold was chosen to exclude staff who had used the application only for testing purposes (i.e., downloaded the application and captured photographs using a "test patient" record but had not photographed a real patient). The number of photographs taken by each respondent was extracted from the PhotoExam database, and human resource records were cross-referenced to determine each respondent's primary work role and department.

Surveys

The survey (Supplementary Material A, available in the online version) was designed by a multidisciplinary team including physicians practicing in multiple specialties, a medical photographer, and the application's development team. The team underwent an iterative process to refine survey questions prior to sending it to invited participants. Because we could not identify other surveys in the literature that addressed the aspects of mobile point-of-care medical photography in which we were interested, questions were generated de novo rather than being based on similar surveys from the literature. Resources allocated to the project did not permit validation of survey questions by an expert in survey design. Similarly, the

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survey was not pretested or piloted prior to being sent to invited participants. Survey questions were written to capture the frequency of known and potential use cases of the application and to identify meaningful ways the application has been integrated into clinical care. We also sought to identify potential barriers to use.

Survey invitations were sent to each user's institutional e-mail address using REDCap.[28] Initial survey invitations were sent on November 13, 2017. Users who did not initially respond to the survey were sent two reminders, each one week apart. All survey questions were optional, and some respondents chose not to answer all survey questions.

Statistical Analysis

Continuous variables were summarized with medians and IQRs, and categorical variables were summarized with frequency counts and percentages. In cases in which not all respondents answered a question, percentages were calculated using the number of respondents to the individual question as the denominator. The number of photographs taken was compared between responders and nonresponders using Wilcoxon's rank-sum test. Associations of provider department with reported uses of the application were evaluated using the Kruskal–Wallis tests. Statistical analyses were performed using SAS, version 9.4 (SAS Institute, Cary, North Carolina, United States). All tests were two-sided, and p-values < 0.05 were considered statistically significant.

Results

Survey Participants

Query of the PhotoExam database revealed 2,418 unique health care staff who had used the PhotoExam application. Contact information was unavailable for 319 users who were no longer employed or training at Mayo Clinic at the time the surveys were sent, leaving 2,099 users who were still affiliated with Mayo Clinic. After restricting to only users who had taken five or more photographs using the application (i.e., the top 70th percentile of users), there were 1,463 health care staff to whom the survey was e-mailed. Staff to whom the survey was sent had taken a median of 21 photographs (IQR: 9–59; range: 5–4,898). Surveys were completed by 49% ($n = 712$) of staff and trainees. Respondents had used the application to take significantly more photographs when compared with nonrespondents (median 27 photographs [IQR: 10–66] versus 18 photographs [IQR: 8–48]; $p < 0.001$).

The most common work roles of respondents were attending physicians (29%; $n = 207$), nurses (26%; $n = 186$), resident/fellow (19%; $n = 133$), and advanced practice providers (i.e., nurse practitioner or physician assistant; 16%; $n = 114$). When considered generally, 32% ($n = 227$) of respondents were from primary care departments, 23% ($n = 163$) were from surgical departments, and 45% ($n = 322$) were from other specialty departments. At a more granular level, the five specialties most represented were internal medicine (11%; $n = 78$), family medicine (11%; $n = 76$), dermatology (10%; $n = 69$), emergency medicine (9%; $n = 64$), and wound and ostomy care (7%; $n = 52$). All other specialties accounted for 50 or fewer respondents.

Use of PhotoExam in Clinical Practice

Respondents indicated that they used the PhotoExam application on a median of 15% of days that they spent in clinical practice (i.e., approximately one in seven days; IQR 8–33%; 664 responses). Of the 702 total responses, 143 (20%) reported that they recommended the application to other colleagues on multiple occasions in a given week. Respondents reported that a median of 50% (IQR: 22–83; 605 total responses) of their colleagues also used the application. Use of PhotoExam to capture photographs rather than video recordings predominated, with most respondents reporting use exclusively to capture photographs (median 100% of uses to take photographs; IQR: 97–100%; 680 responses).

Use Cases

Users were prompted with a variety of use cases and asked to rate how frequently they used the application for each use case. Responses for each use case are summarized in ►Fig. 1. The

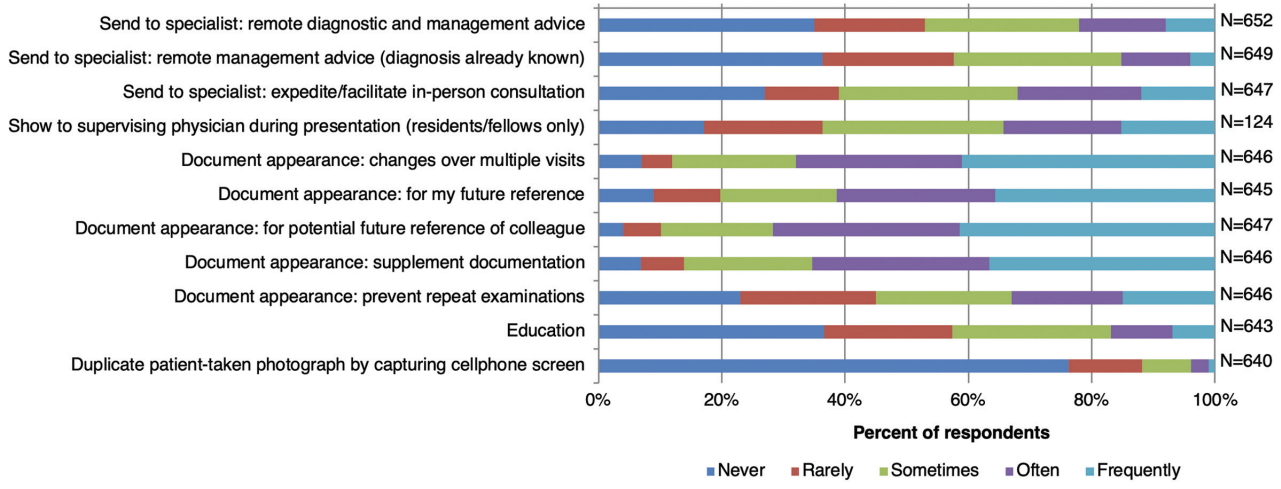

Fig. 1 Frequency of use cases for medical photography using PhotoExam.

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most common use case was to document the appearance of a clinical finding—often to capture temporal trends or with the intent that the photograph would be referenced at a later clinical visit. In contrast, use for teleconsultation appeared to be less frequent.

The 343 users who used the application for educational purposes indicated that they used the application to educate not only trainees involved with the patient's care (83%; $n = 284$) but also patients who were photographed and/or their families (66%; $n = 227$).

When analyzed according to each user's specialty (i.e., primary care, surgical, or other), primary care providers were more likely to use the application to seek specialist advice or consultation, whereas surgeons and other specialists were more likely to use the application to document findings over time ($p < 0.001$; Supplementary Material B, available in the online version). For example, 59% of surgeons and 42% of other specialists indicated that they frequently used the application to document findings over time compared with 27% of primary care providers.

Consent

Institutional policies required express consent from patients for photography using the application but did not specify whether consent needed to be written or verbal. When asked how they typically obtain consent, 23% ($n = 126$) of the 555 respondents always obtained consent in written form and 41% ($n = 229$) always obtained consent verbally; the remaining 36% ($n = 200$) respondents used a mix of the two methods.

Device Used

Most users used the application on a personal iPhone or iPod touch (59%; $n = 372$; 632 respondents). Personal iPads were used by 15% ($n = 93$), shared departmental iPhone or iPod touch devices were used by 12% ($n = 76$), and shared departmental iPads were used by 27% ($n = 169$). Among 71 users who had used multiple devices, the primary device used was their personal iPhone or iPod touch (58%; $n = 41$).

Reliability

More than one-third of users reported that they had experienced an image upload failure while using the application (34%; $n = 218$; 642 responses). Among those who experienced an upload failure, 39% ($n = 84$; 215 responses) did not retake the photographs that failed to upload, and 21% ($n = 45$) reported that they now use the application less often as a consequence of unreliability.

Users were asked to rate the sufficiency of image quality for clinical purposes. On a scale of 0 to 100, with higher numbers indicating more favorable responses, the median response was 86 (IQR: 73–99; 574 responses), suggesting acceptable quality.

Satisfaction

Users were asked to rate their satisfaction on a 0- to 100-point scale, with higher numbers representing more favorable responses. When asked about the experience installing the application for the first time through the internal "application store," the median satisfaction score was 86 (IQR: 68–100; 326 responses). The median overall satisfaction score for use of the application to capture photographs following installation was 94 (IQR: 74–100; 535 responses).

At the time of the survey, the patient-facing medical record application did not allow patients to upload self-taken photographs to the EHR, and 63% ($n = 405$; 640 responses) indicated that they thought such functionality would be useful.

Use of Professional Medical Photographers

Nearly half (48%; $n = 310$; 641 responses) of respondents reported that they had access to a professional medical photographer at their clinical practice site, 36% ($n = 231$) did not have access to a professional medical photographer, and the remainder were unsure if a professional medical photographer was available at their site.

Users indicated that they preferentially used the PhotoExam application rather than a professional medical photographer for photography. Users who had access to a medical photographer at their clinical practice site were asked how often they used the PhotoExam application compared with professional medical photographers using a scale of 0 to 100, where higher numbers indicate more frequent use of professional medical photographers rather than the PhotoExam application. The median response was 18 (IQR: 6–37; 274 responses), indicating a preference to use the PhotoExam application. The majority of respondents with access to a professional medical photographer said that they call medical photographers less often since they became users of the PhotoExam application (61%; $n = 187$; 309 respondents), 2% ($n = 5$) said they now call for medical photographers more frequently, and 38% ($n = 117$) said their use of medical photographers has been unaffected by their use of the PhotoExam application.

Outcomes of PhotoExam Use

Users were asked to indicate how frequently various care process outcomes resulted from the use of the PhotoExam application. Responses are summarized in ►Fig. 2. Respondents felt that violations of patient privacy as a result of use of the PhotoExam application were rare, and patient satisfaction was generally perceived to be increased. Although the application's use did not typically eliminate the need for in-person subspecialist consultations, in some cases, providers perceived that it expedited diagnosis, treatment, or referral to a specialist.

Discussion

Principal Findings

We report on the use of a mobile application that allows medical photographs to be taken securely on a health care provider's personal mobile device and integrated into the EHR. The predominant use case was documentation of clinical findings for various purposes. Although the use for teleconsultation was less frequent, around two-thirds of users had used the application at least once for teleconsultation.

Comparison with the Existing Literature

This study adds to a small—albeit growing—base of literature regarding point-of-care medical photography. We previously

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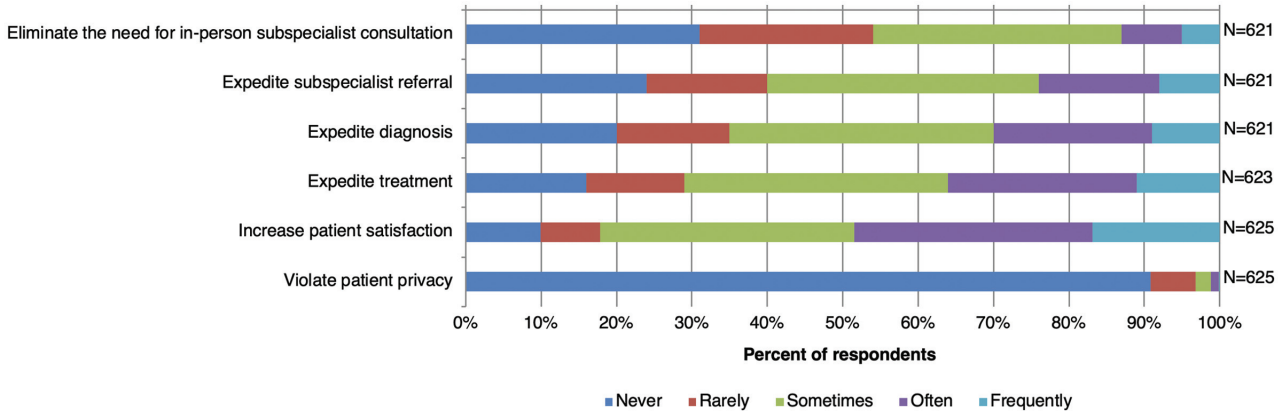

Fig. 2 Frequency of process outcomes of medical photography using PhotoExam.

reported that primary care providers at our institution sought dermatologist input in one-third of cases where a patient was photographed using the PhotoExam application.[23]

A majority of users who had access to a professional medical photographer at their site reported that they request the services of professional medical photographers less often since they started using the PhotoExam application. This appears to contradict our previous observation that requests for medical photography services did not appear to change in the year following the application's release.[22]

Earlier patient surveys on medical photography conducted elsewhere identified that patients were far less comfortable with photography conducted using a health care provider's mobile phone rather than a hospital- or clinic-owned camera.[21,29] However, attitudes appear to be influenced by assurances that the images will be stored securely. One study compared attitudes of 400 dermatology patients who had or had not received an information sheet that explained the security features of a smartphone-based photography application prior to completing a survey.[20] Patients who received the information sheet prior to completing the survey were more accepting of medical photography using a mobile device compared with patients who were provided the information sheet afterward.[20]

The distinction between use of a phone's native camera application and a secure, EHR-integrated mobile application to capture photographs of patients is an important one. Not only are photographs stored in the native camera application not kept as medical records within the EHR, but they may also be stored and transferred using relatively insecure methods. Furthermore, these images may be inadvertently uploaded to a third-party cloud-based storage service (e.g., iCloud, DropBox) by way of automatic image backup processes. In the event that the device is lost or stolen, the images may become accessible to third parties if the device has not been properly secured. Finally, images may be inadvertently shown to third parties if patient photographs are intermixed with personal photographs.

Despite these limitations and disadvantages of using native camera applications to capture patient photographs, the practice is common. A survey of Canadian plastic surgeons and plastic surgery residents identified that 89% of respondents used their smartphones to capture patient photographs and 57% stored photographs on their phones, with many of these stored alongside personal photographs. A quarter of respondents had inadvertently shown a patient photograph stored on their phone to a friend or family member.[16] A similar survey of Canadian neurosurgery residents observed that smartphone use to capture patient photographs was common and that 68% of respondents reported storing patient photographs alongside personal images—only 8% stored photographs within a password-protected application.[24] Approximately one-third (32%) of respondents said that they deleted patient photographs immediately after use, but one-quarter (23%) indicated they usually do not delete the photographs.

These significant data security and patient privacy issues highlight the need to use secure applications that allow for clinical photographs to be integrated into the EHR and maintain data security. There is evidence that such applications may have an impact on clinical care processes. For example, the NHS (National Health Service) Trust in the United Kingdom recently reported on the use of a mobile application similar to PhotoExam that was integrated with the EHR.[25] Use of the application improved compliance with clinical practice guidelines that recommended the use of photography to track open fractures over time with the aim of augmenting clinical documentation and preventing the need for multiple examinations.[25] Whether other care processes are affected remains an area of needed study.

Implications for Clinical Care and Ongoing Use of the Application

Favorable provider attitudes reported in this study supported the ongoing use and maintenance of the PhotoExam application at Mayo Clinic. However, we identified upload failures as a barrier to use. Previous versions of the application did not confirm network connectivity prior to attempting to upload and deleted photographs if upload failure occurred. To mitigate upload failure, several updates were made to the application. First, the application now verifies connection with the network prior to attempting to upload. While the previous version of the application only tried once to upload photographs, the newest version automatically retries in the event of an image upload failure. Furthermore, users can now cancel a stalled

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upload attempt and manually retry uploading the images. The original photograph is deleted upon successful image upload or closure of the application, whichever comes first.

A previous study observed that patients who were provided with an information sheet on the use of mobile point-of-care medical photography viewed the process more favorably.[20] Patient surveys are likely to inform whether a similar approach would be necessary or beneficial at our institution.

Strengths

Strengths of this survey include that we captured the experience of more than 700 health care providers who voluntarily completed the survey, with a response rate of 49%. This response rate is higher than other internet-based surveys of health care professionals published in the literature.[30–32] We captured the experience of users with various work roles who were from many different departments. In addition to capturing attitudes and experiences of health care providers at the three large Mayo Clinic academic sites in Minnesota, Florida, and Arizona, we also captured attitudes and experiences of providers in the regional Mayo Clinic Health System. We additionally assessed a variety of domains of experience (use cases, observed outcomes, etc.).

Limitations

One weakness of this study is that we were only able to assess providers' self-reported uses and perceived outcomes. We were unable to verify the effect of the PhotoExam application's use on care process measures, such as time to diagnosis or in-person referral, with more objective measures.

Infrequent users of the application were less likely to respond to the survey. Therefore, high users of the application are overrepresented in survey responses; experiences of these users may be different from those of the larger user base as a whole. Moreover, we did not assess the experiences of clinical staff who did not use the application or who used the application only once, and their attitudes may have been different from the established users who were surveyed. We also did not assess downstream providers who may not have directly used the application but reviewed the photographs taken using the application.

Our previous assessment of the application's use demonstrated that the specialties of the largest user base were surgical specialties (36% of users), dermatology (14% of users), and internal medicine (13% of users). In terms of work role, residents accounted for 31% of users, attending physicians accounted for 29% of users, advanced practice providers accounted for 16% of users, and nurses accounted for 14% of users. Therefore, while survey representation appears to be proportionate when considered according to work role, surgical specialties appear underrepresented in survey responses, as we observed that only 23% of respondents were from surgical departments.

Although we report on the experience using the application at multiple sites nationwide, experiences may differ at other institutions (e.g., private practice or governmental hospital) or with other applications by different developers. It is unclear to what extent the attitudes and experiences assessed reflect the process of capturing and uploading photographs to the EHR in general compared with the functionality and user experience with this specific application.

Demonstration of the clinical utility of mobile applications like PhotoExam presents several challenges. For one, the most relevant outcomes may vary from specialty to specialty or user to user based on the use case being assessed. Furthermore, the application's current use and integration within clinical practice makes the conduct of a randomized controlled study at our institution challenging. We chose a pragmatic approach, asking providers to describe their experiences and attitudes, realizing that these may not always accurately reflect reality. Future studies may assess the utility of such applications through a randomized study design prior to widespread implementation within clinical practice. Alternatively, use may be studied within a narrow use case in which appropriate outcomes may be better defined.

Finally, as a provider-facing tool, PhotoExam is designed for use within a clinical setting. Our survey identified that providers perceived the ability of patients to contribute self-taken photographs to the medical record as valuable. The integration of patient-provided photographs has been well-described,[33] and patient-facing applications by EHR vendors allow patients to share self-taken photographs. Further research will be necessary to understand how patient-provided photographs affect care processes.

Conclusion

Point-of-care medical photography has promise to become a new standard of care for clinical documentation. Practice-level adoption of secure mobile applications that facilitate medical photography can ensure that photographs are stored in a manner that respects patient privacy and facilitates clinical care.

Clinical Relevance Statement

Point-of-care medical photography applications facilitate capture and integration of patient photographs into the medical record in a manner that maintains data security. The predominant use case is to augment clinical documentation. The impact on clinical outcomes remains unclear.

Multiple Choice Questions

1. Which of the following is the predominant use case self-reported by providers for a point-of-care medical photography application?
   a. Supplement documentation.
   b. Store and forward teleconsultation for diagnostic assistance. c. Store and forward teleconsultation for management assistance.
   c. Prevent the need for repeat examinations.

   Correct Answer: The correct answer is option a. Although all of the above are potential use cases for a point-of-care

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medical photography application, a survey that included 712 health care professionals observed that the most common use case (i.e., occurring "frequently" or "often") was to document the appearance of clinical findings. Reasons to document the appearance of findings include to supplement documentation or for the future reference of the photographing provider or a colleague.

2. Which of the following is the most common self-reported use of a camera-enabled rich media capture application integrated with the EHR?
   a. Capture of patient audiorecordings.
   b. Capture of patient videorecordings with audio.
   c. Capture of patient videorecordings without audio.
   d. Capture of patient photographs.

   Correct Answer: The correct answer is option d. A total of 680 providers who self-reported their use of a mobile point-of-care medical photography/videography application reported that a median 100% of their uses of the application were to take photographs (IQR: 97–100%) compared with video- or audiorecordings. Therefore, the vast majority of uses of the application were for photography as opposed to capture of other forms of rich media.

Protection of Human and Animal Subjects

The survey was reviewed by the Mayo Clinic Institutional Review Board, but it was deemed "not research," as it was a quality improvement initiative that aimed to gather data on local processes, with the goal of assessing and improving the application's use and clinical impact within our practice.

Funding

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Conflict of Interest

The PhotoExam application is the institutional intellectual property of Mayo Clinic. All coauthors are employees or trainees at Mayo Clinic. Mayo Clinic is currently only using the PhotoExam application internally for clinical care and has not licensed the application for sale.

References

1 Sittig DF, Wright A, Ash J, Singh H. New unintended adverse consequences of electronic health records. Yearb Med Inform 2016;(01):7–12
2 Guo U, Chen L, Mehta PH. Electronic health record innovations: helping physicians - one less click at a time. Health Inf Manag 2017;46(03):140–144
3 Khairat S, Burke G, Archambault H, Schwartz T, Larson J, Ratwani RM. Perceived burden of EHRs on physicians at different stages of their career. Appl Clin Inform 2018;9(02):336–347
4 Harris DA, Haskell J, Cooper E, Crouse N, Gardner R. Estimating the association between burnout and electronic health record-related stress among advanced practice registered nurses. Appl Nurs Res 2018;43:36–41
5 Tutty MA, Carlasare LE, Lloyd S, Sinsky CA. The complex case of EHRs: examining the factors impacting the EHR user experience. J Am Med Inform Assoc 2019;26(07):673–677
6 Mounessa JS, Chapman S, Braunberger T, et al. A systematic review of satisfaction with teledermatology. J Telemed Telecare 2018;24(04):263–270
7 Cronin RM, Conway D, Condon D, Jerome RN, Byrne DW, Harris PA. Patient and healthcare provider views on a patient-reported outcomes portal. J Am Med Inform Assoc 2018;25(11):1470–1480
8 Andrews AL, Nitchie HL, Harvey JB. Parent preferences for methods and content of mobile technology-based asthma medication adherence intervention. Hosp Pediatr 2019;9(03):209–215
9 Hou C, Carter B, Hewitt J, Francisa T, Mayor S. Do mobile phone applications improve glycemic control (HbA1c) in the self-management of diabetes? A systematic review, meta-analysis, and GRADE of 14 randomized trials. Diabetes Care 2016;39(11):2089–2095
10 Cui M, Wu X, Mao J, Wang X, Nie M. T2DM self-management via smartphone applications: a systematic review and meta-analysis. PLoS One 2016;11(11):e0166718
11 Wisniewski H, Liu G, Henson P, et al. Understanding the quality, effectiveness and attributes of top-rated smartphone health apps. Evid Based Ment Health 2019;22(01):4–9
12 Byambasuren O, Sanders S, Beller E, Glasziou P. Prescribable mHealth apps identified from an overview of systematic reviews. NPJ Digit Med 2018;1:12
13 Wilson GM. Early photography, goitre, and James Inglis. BMJ 1973;2(5858):104–105
14 Cheung A, Al-Ausi M, Hathorn I, Hyam J, Jaye P. Patients' attitudes toward medical photography in the emergency department. Emerg Med J 2005;22(08):609
15 Kunde L, McMeniman E, Parker M. Clinical photography in dermatology: ethical and medico-legal considerations in the age of digital and smartphone technology. Australas J Dermatol 2013;54(03):192–197
16 Chan N, Charette J, Dumestre DO, Fraulin FO. Should 'smart phones' be used for patient photography? Plast Surg (Oakv) 2016;24(01):32–34
17 Sandler J, Gutierrez RJ, Murray A. Clinical photographs: the gold standard, an update. Prog Orthod 2012;13(03):296–303
18 Morse GA, Haque MS, Sharland MR, Burke FJ. The use of clinical photography by UK general dental practitioners. Br Dent J 2010;208(01):E1
19 Aveta A, Filoni A, Persichetti P. Digital photography in plastic surgery: the importance of standardization in the era of medico-legal issues. Plast Reconstr Surg 2012;130(03):490e–491e
20 Accetta JL, Schoenfeld J, Bitar C, Murina A. Smartphones in dermatology: acceptance of smartphone photography by the informed patient. Dermatol Surg 2019. Doi: 10.1097/DSS.0000000000001976
21 Hsieh C, Yun D, Bhatia AC, Hsu JT, Ruiz de Luzuriaga AM. Patient perception on the usage of smartphones for medical photography and for reference in dermatology. Dermatol Surg 2015;41(01):149–154
22 Wyatt KD, Willaert BN, Pallagi PJ, Uribe RA, Yiannias JA, Hellmich TR. PhotoExam: adoption of an iOS-based clinical image capture application at Mayo Clinic. Int J Dermatol 2017;56(12):1359–1365
23 Pecina JL, Wyatt KD, Comfere NI, Bernard ME, North F. Uses of mobile device digital photography of dermatologic conditions in primary care. JMIR Mhealth Uhealth 2017;5(11):e165
24 Kameda-Smith MM, Iorio-Morin C, Winkler-Schwartz A, et al; Canadian Neurosurgery Research Collaborative (CNRC). Smartphone usage patterns by Canadian neurosurgery residents: a national cross-sectional survey. World Neurosurg 2018;111:e465–e470
25 Li MK, Howard DP, King R. "A picture tells a thousand words" smartphone-based secure clinical image transfer improves compliance in open fracture management. Injury 2019;50(07):1284–1287

This document was downloaded for personal use only. Unauthorized distribution is strictly prohibited.

26 Ai AC, Maloney FL, Hickman TT, Wilcox AR, Ramelson H, Wright A; The Use of Clinical Images in Electronic Medical Records. A picture is worth 1,000 words. Appl Clin Inform 2017;8(03):710–718
27 Landman A, Emani S, Carlile N, et al. A mobile app for securely capturing and transferring clinical images to the electronic health record: description and preliminary usability study. JMIR Mhealth Uhealth 2015;3(01):e1
28 Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42(02):377–381
29 Leger MC, Wu T, Haimovic A, et al. Patient perspectives on medical photography in dermatology. Dermatol Surg 2014;40(09): 1028–1037
30 Cunningham CT, Quan H, Hemmelgarn B, et al. Exploring physician specialist response rates to web-based surveys. BMC Med Res Methodol 2015;15:32
31 Hardigan PC, Popovici I, Carvajal MJ. Response rate, response time, and economic costs of survey research: a randomized trial of practicing pharmacists. Res Social Adm Pharm 2016;12(01): 141–148
32 Cook DA, Wittich CM, Daniels WL, West CP, Harris AM, Beebe TJ. Incentive and reminder strategies to improve response rate for internet-based physician surveys: a randomized experiment. J Med Internet Res 2016;18(09):e244
33 Miller MW, Ross RK, Voight C, et al. Patient-generated digital images after pediatric ambulatory surgery. Appl Clin Inform 2016;7(03):646–652

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