The Open Dermatology Journal

Content list available at: https://opendermatologyjournal.com

REVIEW ARTICLE

Artificial Intelligence in Dermatology: Current Uses, Shortfalls, and Potential Opportunities for Further Implementation in Diagnostics and Care

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Abstract: Artificial Intelligence (AI) has the potential to transform medical delivery by improving patient care and provider experience. Implementing AI into health care is limited in scale, but the projected demand for health care, combined with the shortfall in practitioners, will necessitate the inclusion of AI-based technology in clinical medicine to maintain quality care. AI applications may range from enhancing clinical diagnosis to managing population health through big data. In today's world, AI scaling in health care is at phase one: AI is either utilized for administrative tasks or imaging. Although the implementation of AI will be difficult, the need for the adoption of AI in the coming years will lead the technology to be a vital aspect of diagnosis and care in and out of the hospital. Dermatology is one medical specialty in which AI applications are in use and in which medical care will evolve. Dermatology has progressed over the years in correspondence with advancements in AI-based technologies such as imaging and medical speech recognition. To better equip future dermatologists, exposure to AI through medical education is necessary for dermatologists to utilize AI effectively. There are hurdles to overcome, but AI is necessary, and it will change health care through effective time management and clinical decision-making. This review, created in collaboration with Precision Pundits, was developed to achieve an understanding of AI in the present-day medical landscape; this project explored the impact AI technology has on dermatology and medical care.

Keywords: Dermatology, BMI, AI, Disease, Healthcare services, Diagnostics.

Article History	Received: December 29, 2022	Revised: March 03, 2023	Accepted: March 31, 2023

1. INTRODUCTION

The expansion of digitization has reached every facet of human life, and eventually, it will remodel the delivery of future healthcare services. Medically relevant technologies such as robotic processes, automation, and artificial intelligence (AI) have matured to a level where AI's adoption into healthcare services is a genuine possibility. Our mission at Precision Pundits is to devise a comprehensive healthcare network by bridging physicians' process orientation and technology to encourage and implement preventative healthcare practices. To accomplish this objective, Precision Pundits have been working diligently to build a collaborative environment for physicians and data scientists to harness the power of data and machine learning to improve healthcare diagnosis and care. Essentially, we aim to design a hospital-centered application that can be utilized concurrently by both physicians and data scientists to utilize patient data for disease forecasting. In their roles, physicians would not have to change their treatment or diagnostic process, but they would be responsible for entering accurate patient data into the application, which would then be processed through machine learning algorithms by computer scientists. Based upon previous research, it is known that disease forecasting is not 100 percent accurate; however, it can utilize current data profiles to forecast morbidity based on key performance indicators that include body mass index (BMI), co-morbidity, social behavior, and family history [1, 2]. To build towards this application, Precision Pundits is currently focused on supporting their Research and Development (R&D) division by focusing on Big Data analytics. Big Data is an exponentially large, complex data set requiring high-level processing to determine patterns [1 - 3]. Precision Pundits built the DataXzen platform to process Big Data, which utilizes AI and automation to profile, cleanse, and enrich data to accurately predict trends buried within healthcare data. Usage of DataXzen requires a data lake, a data platform aggregating cross-siloed data in a single location, such as MongoDB [1, 3]. MongoDB is often utilized in Big Data projects and is readily available online because it can hold terabytes of information without

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interference. Medically relevant information in the data lake includes real-time monitoring, molecular profiles, medical history, environmental conditions, and other variables fundamental to building a predictive model [3]. DataXzen is one part of the entire application we hope to create in the future for widespread hospital usage; DataXzen can filter and identify relevant health markers in data which will be essential for forecasting morbidity in individual patients. In recent years, Precision Pundits have focused on various research projects ranging from AI educational reviews to the implementation of DataXzen for the analysis of population health trends [1].

Due to the limitations of technology, population-based clinical research is key to the expansion of AI in clinical care. Fortunately, the World Health Organization (WHO) provides high-volume data sets on various public health issues for public usage. Therefore, Precision Pundits have focused on non-personalized medical AI projects such as analysis of the disease Tuberculosis (TB). In this project, DataXzen was implemented to organize, refine, and implement WHO's TB data set to examine patterns in population health dynamics to gather more understanding of TB-vulnerable countries such as India, China, and Indonesia [1]. Specifically, the data was processed by key performance indicators (KPIs) that included gender, HIV, country, and age to perform an accurate regression analysis to illustrate previous data and predict the incidence rate of TB from the years 2022 to 2030 [1]. Most importantly, the prediction model aimed to assess the necessity to update or replace the current public health model to better focus on eradicating TB in highly vulnerable populations. Precision Pundits' initial research was published, but the project is still being continued for further study. Education of AI in medicine is a branch of research that Precision Pundits focus on; medical professionals and the health care system require information on emerging technologies. The only viable way to competently utilize technology in their medical practice is through medical education or experience. This review focuses on providing information about the need for AI in medicine and the usage of AI-based technologies in dermatology.

The height of the COVID-19 pandemic was two years ago, and it is now clear that the healthcare system is centered upon shifts in patient lifestyles, emerging technologies, and population aging. Importantly, there has been a dramatic shift in lifestyle choices during the COVID-19 pandemic due to the sudden lockdown period initiated worldwide. Physical and mental health was significantly impacted as normal daily activities ceased, and people were forced to stay indoors in isolation [4, 5]. The inability to continue normal life activities leads to unhealthy lifestyle choices involving diet, exercise, and human interaction, which has only exacerbated illness in populations across the world [4, 6]. Not only is patient lifestyle rapidly changing, but population aging is a key factor in the future of medical care; 25% of all people in North America and Europe will be over the age of 65 by 2050 [2, 7]. Unfortunately, the present healthcare system could not effectively care for that large volume of people with multi-morbidity. Therefore, the entire clinical structure would need to shift from an episodic care-based philosophy to a more focused one on long-term patient health [2, 7, 8]. Other than funda-mental healthcare changes, the World Health Organization has calculated a projected deficit of 9.9 million physicians, nurses, and midwives globally during the next two decades [2]. As the population ages and increases, physicians must use their time effectively to diagnose and care for their patients. It would really take a vast coordinated effort to prepare the medical system to address the challenges we face in the healthcare system. Most importantly, this problem can be alleviated by implementing Artificial Intelligence (AI) and advanced medical technology [4, 9]. Many scientists shared this sentiment during the early stages of the COVID-19 pandemic; moreover, scientists in China developed a highly accurate altered stacked auto-encoder to forecast the transmission dynamics of COVID-19. Their article stated that the applied data was WHO's data from January 2020 to February 2020; clustering algorithms were applied to group Chinese provinces and cities to individually study the transmission dynamics. They concluded that AI methodologies were accurate, and the COVID-19 epidemic was significantly less severe in the middle of April; most importantly, the data provided by the AI technology allowed the government and public health organizations to plan accordingly to combat the pandemic [10].

2. AI IN HEALTHCARE

Over the past few years, AI has quickly evolved from an idea into realistic applications utilized in healthcare systems around the world due to its variability of use by physicians. AI is not seen as a potential substitute for physicians; in fact, it is being utilized to complement physicians and enhance the delivery of care for patients [11]. As stated, emerging technologies are now more needed than ever to fulfill the growing demands of healthcare establishments. Although there have been several definitions of AI, the European Parliament stated that "AI is the capability of a computer program to perform tasks or reasoning processes that we usually associate with intelligence in a human being" [12]. In broad terms, AI can improve the overall healthcare system in two facets: patient care and the healthcare team [7, 9, 12]. First, improving diagnosis, decision-making, and treatment will directly impact the patients. Furthermore, the efficiency and effective time management that AI enables will allow medical specialists to spend more time with each patient, increasing the patient-physician relationship and raising staff assurance [11, 12]. In terms of computer science, AI can analyze large volumes of data by utilizing algorithms such as Linear Regression and Support Vector machines [13]. By analyzing these sets, AI can learn the distinct aspects of the data and determine trends, which is especially useful for characterizing population health and predicting health outcomes; AI can also reduce the frequency of diagnostic errors due to human error [12, 13]. AI opens the door for automation in health care to combat the eventual lack of medical professionals needed. It is important to mention that the degree to which automation impacts medicine is vastly different compared to other jobs – only 35% of healthcare "tasks" will be automated, which is the lowest out of any occupation [2]. Healthcare automation is viewed in terms of hours; therefore, AI can be viewed as a complement that will help specialists effectively time manage their work even with shortages in staff. According to industry experts, AI

will continue to evolve and rapidly transform due to the abundance of technology and innovation we are experiencing. Additionally, we are in an early period of AI incorporation, as normal AI usage in a clinical environment is limited to repetitive, time-consuming tasks or diagnostic imaging [8]. The scaling of AI has been separated into three phases based on the normal clinical environment. The first phase includes AI solutions that target routine, non-clinical tasks that take up the time of healthcare professionals, which lowers the number of patients they see on each working day. An additional aspect of phase one is AI image applications in the fields of pathology and radiology that provide more efficient and accurate diagnostic capabilities. The second phase of AI scaling involves the patients, focusing on home-based care such as virtual assistants and remote monitoring. The phase introduces AI in clinical processes in which healthcare professionals use AI technology daily based on their specific patients. It is important to note that this phase is difficult to implement because technology rapidly evolves; therefore, the clinical work process will be interrupted consistently to include new technology. The third phase involves AI solutions as a permanent and integral part of healthcare; AI will be implemented to improve care decisions, forecasting, and population health [2]. The industry is transitioning from phase one to two; phase two will explore the use of AI in more specialties, such as cardiology and oncology [2, 14]. AI is limited to studying population health, but phase three has the potential for AI to be an integral factor in personalized clinical treatment [8]. This paper focuses on the current uses and implementation of AI in dermatology.

3. AI IN DERMATOLOGY

A dermatologist is a doctor that treats conditions that involve the skin, hair, and nails [15]. AI has the power to restructure dermatology by improving accuracy, efficiency, and patient outcomes. In dermatology, the most useful aspect of AI is to utilize imaging to analyze skin cancer, ulcers, and psoriasis; image analysis is an AI-powered tool that can be utilized to recognize and distinguish lesions [16, 17]. The process includes analysis of each pixel in the image and validation and cross-checking with a certified dermatologist [13, 18]. In general, Deep Learning (CNN) is utilized to analyze the data through a neural network that mimics the human brain [13]. In terms of Mohs micrographic surgery, AI studies tumor size and patient age, so the dermatologist can better determine which patients should be prioritized. For ulcer treatment, AI can determine ulcer impacts by measuring wound boundaries [17, 18]. Potential early detection of certain skin diseases can aid in improving patient outcomes and health. Apart from image analysis, AI can complement a physician in choosing the best intervention depending on patient data (age, sex, ethnicity), creating less room for medical error and again contributing to improved patient outcomes [18, 19]. Lastly, AI can help improve the efficiency of a Dermatology practice by helping automate appointments, case files, and referral letters [20, 21]. A major AI component in dermatology is teledermatology, in which skin disorders can be analyzed through imaging [20]. Companies such as DermDetect have played a major role in bringing dermatological AI to use by a wide range of customers that require skincare but do not have the means to meet a dermatologist in person [21]. Besides the medical aspects, AI is also utilized to effectively manage patients in the hospital. Programs such as Hello Rache have been actively used to analyze a patient-physician interaction during an appointment and automatically convert it into writing [21]. These types of technologies will ensure healthcare professionals do not spend their time on repetitive tasks, which can increase their workload. Fortunately, these AI technologies are available to purchase through the internet. It has become more popular in private clinics because it allows physicians to reduce the workload and increase the number of patients seen daily [20, 21]. The AI applications open as of now are already changing the status quo of dermatological care around the world. However, necessary innovation is still required for progression into phase three of AI's usage in the clinical setting [2, 7].

Skin cancer is among the most common malignancies globally and ranks number one in fair-skinned people [22]. As with any type of cancer, the prognosis and treatment for melanoma could be improved with early diagnosis and preventative social behavior. Even with the abundant dermatology training and usage of medical devices such as dermatoscopy, the clinical test sensitivities for melanoma are below 80% [19]. However, a 2018 study concluded that AI models produced a sensitivity of 95% which was significantly higher than dermatologists [23]. In addition to having high sensitivity in identifying true positive cases of melanoma, the AI algorithm in the study also has a higher specificity than dermatologists. Specificity is correctly identifying true negative cases (no melanoma present). The AI algorithm had a specificity of 82.5%, while the dermatologists had a specificity of 65.2%. This suggests that the AI algorithm was better able to correctly rule out cases that were not melanoma, which could help reduce the number of unnecessary biopsies and treatments, further streamlining treatment and expenses for patients [23]. This was just one example of AI's capabilities in dermatological care, but other studies showed AI's vast ability to improve care for other common dermatological conditions.

According to the National Eczema Association, 1 in 10 individuals will develop eczema during their lifetime, with the highest prevalence in early childhood. Eczema, a part of inflammatory dermatoses, has been shown to cause intense emotions such as stress, anxiety, and depression [24]. Therefore, properly detecting and treating eczema can benefit patient outcomes. Eczema is difficult to diagnose because it has a unique presentation based on the patient and has different subtypes. Computer-aided diagnosis, or CAD, has aided in streamlining the diagnosis process for inflammatory dermatoses commonly diagnosed in routine practice. Moreover, a multi-model, multi-level artificial neural network (ANN) architecture has been designed specifically for eczema detection, incorporating a multi-step processing technique. The probability of eczema is calculated through various models that match input features, and their outputs are combined through a multi-level decision layer. This is a promising tool for diagnosing eczema and is attributed to higher confidence in the diagnosis of eczema [24]. Furthermore, scientists also developed and trained a deep neural network algorithm capable

of distinguishing eczema from other infectious skin diseases, including classifying rare skin lesions with direct clinical implications. The diagnostic capabilities of this study further extended treatment recommendations accordingly, such as topical steroids versus antiseptics [24]. This demonstrates the potential of AI in personalized treatment planning for patients with eczema.

AI could help address the shortage of dermatologists, the uneven distribution of medical resources, and the need for more diverse and accessible treatment options. With the increasing incidence of skin disease and shortage of dermatologists, AI can create a metamorphic change in turnaround time and accessibility of dermatological care. AI-based care also allows for fewer slip-ups in a medical setting providing personalized care for patients as it can evaluate vast databases and cross reference those to tailor care for patients avoiding any negative reactions to care [25]. Furthermore, AI could also be used to create more effective care by focusing research efforts on fruitful approaches by using AI to simulate testing, which can both reduce the cost burden of research and add efficiency. AI integration into interactive educational access points can improve public health by improvement of knowledge [25]. For example, a mobile application called "Sunface" can assess a user's skin according to facial features and skin type and provide a tailored recommendation for sunscreen and skin care products. Sunface not only helps users choose the right products but also reminds users daily to apply sunscreen to help prevent the incidence of sun damage-associated skin disease [26]. With the integration of AI-aided systems into routine dermatology, faster and more accurate diagnoses could become the norm.

4. HURDLES TO IMPLEMENTATION

The process of AI implementation in dermatological offices has been slow due to numerous hurdles due to technology, fundamentals of medical practice, and accessibility [27]. Although the integration of AI into healthcare fields presents healthcare practitioners with many advantages, certain challenges must be overcome and addressed. One of these challenges is the ethical and legal issues relating to acquiring and creating AI learning models. Due to healthcare patient confidentiality laws such as the Health Insurance Portability and Accountability Act of 1996 (HIPPA), healthcare practitioners must follow strict guidelines, including not sharing patient data with outside companies. This has proven to be a hurdle for AI developers to access a wide range of healthcare data [27]. Furthermore, this limitation may affect the diversity of images and datasets fed into these AI systems, which could negatively affect healthcare inequities and further introduce healthcare disparities. If models based on non-inclusive global datasets are applied in ethnically diverse communities, incorrect patient diagnoses may occur [27]. Additionally, there is great diversity in the presentation of the same conditions in various populations. This is especially important in preventing misdiagnosis of individuals within Black, Indigenous, and People of Color (BIPOC) communities [28]. For example, psoriasis in black individuals typically may present with violet with an ash-gray scale, while in a white individual, it may typically present as a red or pink color with a silvery scale [28]. This phenomenon may be similar in conditions including eczema, melanoma, cellulitis, and vitiligo. Solutions to this challenge include emphasizing an extensive and inclusive library of images that includes all skin tones [27, 28]. Additionally, obtaining data from ethnically and racially diverse communities may also help. VisualDx is one such clinical system support software that aims to help healthcare practitioners in their differential diagnosis. It utilizes both desktop and mobile apps that aid in the identification of skin-symptom patterns of patients [28]. Another solution to this issue is testing AI software more frequently and the natural evolution of technology. Next, to accurately provide a complete diagnosis, a dermatologist requires biographical and medical information that needs to be compiled with the skin images [27]. Essentially, a dermatologist cannot build a treatment plan if they have one part of the patient's data; the technology needs to be improved to integrate clinical data with skin images. Dermatology is going to evolve dramatically due to AI implementation; most importantly, the understanding and ability to detect melanoma at an early stage will be the key to bringing AI to the forefront of cancer treatment for all specialties.

AI will change medical care and the overall workforce since it will be directly responsible for creating new jobs in the health industry and expanding medical education. Just as no one will handle AI technology, only computer-science experts such as data architects will have the necessary education to properly store, generate, and expand the data utilized by AI algorithms [7, 29, 30]. The healthcare team will also have to become more exposed to clinical data; further medical education in AI technology will be required for physicians, nurses, and physician assistants as AI becomes a more concrete and important aspect of clinical decision-making [29]. In European countries, there has been a recent push for dual degrees in which science and technology combine so incoming physicians or data scientists are more intertwined with the healthcare industry and its technological needs [2]. Overall, the necessity for advancements in technology to mediate the challenges of patient volume, aging, and efficient care is driving prompt change in the healthcare workforce [2, 30].

CONCLUSION

AI's ability to combine clinical care and technology will be at the forefront of medicine in the future; it will not only augment clinical decisions but also improve the lives of healthcare professionals. AI analysis mimics a human brain to make diagnostic decisions; AI also minimizes the healthcare team's workload. Currently, AI implementation is between phases one and two of AI integration, but the medical industry will rapidly incorporate AI algorithms in numerous medical specialties for early and accurate diagnosis and treatment. AI is already flourishing in dermatology as AI-based imaging has become an important component of a skin cancer diagnosis. However, there are still numerous hurdles to cross for AI to be a part of the healthcare team. Medical research companies, such as Precision Pundits, will continuously improve and evolve the technology to capture relevant patient data, manage data, and improve patient outcomes through machine learning and AI processes; as of now, Precision Pundits have focused on improving R&D, research on population health trends, and AI education based on the technology available now. Most importantly, the progression of technology will allow for more personalized medical treatment; diagnosis and delivery of care will become more predicated upon Preventative health in fields

such as dermatology. The future of AI and technology in medicine is bright; it can revolutionize the healthcare system for the better of all patients.

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

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