The Role and Impact of Artificial Intelligence in Addressing Sexually Transmitted Infections, Nonvenereal Genital Diseases, Sexual Health, and Wellness

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Abstract

The potential of artificial intelligence (AI) in diagnosing and managing sexually transmitted infections (STIs), nonvenereal genital diseases, and overall sexual health is immense. AI shows promise in STI screening and diagnosis through image recognition and patient data analysis, potentially increasing diagnostic accuracy while ensuring inclusivity. AI can fuel the transformation of e-health and direct-to-consumer services, enhancing targeted screening and personalized interventions while improving the user-friendliness of services. There is a significant role for AI in sexual education, particularly its use in interactive, empathetic chatbots. AI's integration into health care as a decision support tool for primary health-care providers can boost real-time diagnostic accuracy. Furthermore, AI's use in big data can enhance real-time epidemiology, predictive analysis, and directed interventions at population levels. However, challenges such as real-world diagnostic accuracy, liability, privacy concerns, and ethical dilemmas persist. Future directions include an emphasis on inclusivity, language accommodation, and swift research-to-practice transitions. Collaboration among policymakers, researchers, and health-care providers is needed to leverage AI's transformative potential in sexual health.

Keywords: *Artificial intelligence, digital diagnosis, nonvenereal genital diseases, sexual education, sexual health, sexually transmitted infections*

Introduction

There has been much hype around artificial intelligence (AI) in health care, with an exponential rise in publications, opinion pieces, and discussion about it. The areas of genital dermatoses and sexual health form excellent use cases for AI in health care. This paper specifically explores the use, distinct advantages, and challenges of AI in sexually transmitted infections (STIs), nonvenereal genital dermatoses, sexual health, and wellness.

Present Status of STIs and Nonvenereal Genital Dermatoses

STIs are escalating worldwide. Roughly 500 million individuals live with genital herpes, 300 million with human papillomavirus and chronic hepatitis B each, and 37.7 million with human immunodeficiency virus (HIV). Annually, an estimated 374 million new infections occur from the four curable STIs (syphilis, gonorrhea, chlamydia, and trichomoniasis), and over 1 million curable STIs are contracted daily.[1,2] India's nationwide prevalence study from 2002 to 2003 estimated that 6% of adults had one or more STIs annually, translating to 30–35 million episodes.[3] Despite reduced HIV infections in India since 2000, 2.4 million people were living with HIV in 2021.[4] From 1990 to 2019, global STIs excluding HIV rose by 58.15%, surpassing the population increase of 46.31%.[5] A resurgence occurred in syphilis, genital herpes, trichomoniasis, and chlamydia from 2010 to 2019, and gonorrhea from 2017.[6] Surprisingly, while the underdeveloped African and western Pacific regions bear a heavier burden of HIV, hepatitis B, gonorrhea, and trichomoniasis, the Americas have the highest and fastest growing incidence of the curable diseases of chlamydia and syphilis and fastest growing incidence of gonorrhea.[6,7] STIs have been a great leveler, sparing none.

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Data are limited for non-STI genital diseases, but they're presumed to be prevalent. Indian reports suggest a prevalence rate between 14.1 and 31.5 per 10,000 dermatology outpatients.[8] These diseases often lead to anxiety and patient fears of STIs, impacting sexual health. In patients with psoriasis, dermatitis, and vitiligo, sexual health and quality of life are poorer in patients with genital involvement than those without it.[8] Half of females with chronic vulvovaginal symptoms experience sexual dysfunction, potentially higher in cases of genital lichen sclerosus.[9] Nonvenereal genital dermatoses have a moderate-to-large impact on the quality of life in most patients.[8]

Current Challenges

What factors have spurred the recent global surge in STIs? Increased reporting due to increased health-care access, testing, and reporting mechanisms is likely, yet the numbers are expected to be underreported. Paradoxically, sexual activity is declining in the USA, yet riskier behaviors like reduced condom use, increased oral and anal sex, opioid and other drug use, and other unsafe practices, especially among antiretroviral prophylaxis users and Men Who Have Sex With Men (MSMs), are on the rise.[10–14] Perception of Acquired Immunodeficiency Syndrome (AIDS) as not being a fatal disease but a chronic manageable condition has contributed to it.[15] The digital age has significantly reshaped societal and behavioral norms through social media, online chat rooms, and dating apps.[16–18] The COVID-19 pandemic and monkeypox pandemic lead to a decrease and delay in testing, severe diversion of resources from already severely underfunded programs of various countries, and lockdowns which were associated with rebound increases.[19,20]

In resource-constrained settings, traditional issues such as limited awareness and prevention measures, stigma, delayed diagnosis, limited health-care access, reduced funding to STI programs, and lack of innovation persist.[14,21–23] Adolescents and young adults, who face unique concerns like confidentiality issues, are at heightened risk. Sexually active adolescents in the USA covered by their parents' insurance plan forgo sexual health services as they are concerned that their parents will find out. When alone with a health-care provider, adolescents are twice as likely to receive STI screening and greater delivery of sexual health services.[24] Not just adolescents, but people of any age group are likely to prefer a discrete, nonjudgmental, and empathetic platform that is not dismissive of their concerns.

Due to limited STI specialists and a lack of a dedicated workforce, primary health-care providers (PHPs) are often tasked with preventing, screening, diagnosing, treating, and counseling patients. However, this approach often falls short due to a lack of funding, focus, and priority for the STI programs, and among PHPs, a lack of awareness and a reluctance to discuss STIs, in addition to the heavy caseload and limited training of PHPs.[14]

Despite the information age, there is still a lack of accurate and widespread knowledge about sexual health. Social media often disseminates misinformation, and mainstream platforms lack reliability. Stigma, shame, privacy concerns, overburdened PHPs, and the specific needs of neglected but at-risk groups like homosexuals and transgenders further complicate the situation.[21] Although there is some advantage of anonymity and discretion afforded by some websites and mobile apps, they are neither mainstream nor reliable. The big social media giants indiscriminately prevent the posting of genital images even for case discussion among venereologists, and some censor words referring to genitals and sex. There are many deterrents to imparting the right information about sexual health and wellness to adolescents and young adults.

Herein lies the role of AI in dermatology. Dermatology, being a visual branch, is particularly suited for diagnosis through image analysis. STIs and genital diseases comprise the priority use cases of AI in dermatology, particularly because these are the conditions for which patients are most embarrassed and stigmatized and least willing to reveal them to other people. They desire an anonymous consultation and a reliable and convenient source of education and advice.

Artificial Intelligence and Machine Learning

It is important to delineate AI from other technologies already widely prevalent in health care. Internet-based health services/e-health and non-AI algorithms/programs that are automated instructions do not constitute AI, although they can be significantly enhanced through AI. Most non-AI algorithms constitute a set of instructions that respond to a particular input to yield a particular output through combinations of "if this, then that" functions. In contrast, AI algorithms can mimic human intelligence. A subtype of AI is machine learning (ML), which entails automatically changing and adapting by learning from new data. A common algorithm is usually created by a programmer to perform a task in a certain manner, while AI learns how to perform a task through the data fed to it and creates its own algorithm that may not be known to humans (termed "black-box" AI) and can change itself in response to new data. Deep learning is a specific type of ML that is based on artificial neural networks (ANNs). ANNs are inspired by neural networks between human neurons. Deep learning involves the use of multiple layers to extract features of progressively increasing complexity. When used in image diagnosis, humans do not need to manually select defining features in the training images, in contrast to other ML techniques, and unknown patterns can be detected. It requires a reasonably large dataset and computational power.

Several products branded as AI-based actually rely on non-AI algorithms. The domain ".ai" is actually a country code domain for Anguilla, a small British territory in the Eastern Caribbean, but is open to purchase for anyone, not just its residents.[25] AI-based computer vision algorithms capable of pattern recognition in pictures enabling image diagnosis and natural language processing (NLP) algorithms enabling AI to talk as humans are common AI functions used in health care that cannot be rendered through non-AI algorithms. NLP-based technology used in AI chatbots, including voice assistants like Alexa and Siri, is significantly more complex compared to the "rule-based" non-AI chatbots trying to replace common customer care services.

The "training through data" principle of ML entails that an AI is as good as the data through which it has been trained. If it is trained with low-quality data, it will yield suboptimal results, termed the "garbage-in, garbage-out" principle. It also reflects the inherent bias of the data on which it has been trained. For example, diseases like psoriasis, lichen planus, and lichen sclerosus have a different morphology when located over the genitals. The training datasets for common computer vision-based AI-image diagnosis mobile applications lack genital images, likely due to consent issues. They will not be able to diagnose these dermatoses if they are located on the genitals. Similarly, they lack images from skin-of-color patients, yielding less accuracy in this subset of patients.[26] They might have been trained with unverified images with a gold standard of the clinician's diagnosis without a supplementary investigation. For example, training with images labeled with the clinician's visual diagnosis as the gold standard may limit the accuracy of the AI model, as clinicians who see genital diseases can commonly miss or misdiagnose some cases without histopathology, and histopathology is useful to resolve clinically ambiguous cases.[9,27] If trained through images with verified investigational diagnosis, AI-based image diagnosis platforms are more likely to alleviate the need for those investigations in ambiguous cases. There's less availability of AI for women's STIs, and ailments like vaginal discharge and pelvic inflammatory disease aren't image-diagnosable. Similar to many advances in health care, women's sexual health is underrepresented in the AI revolution.

Uses of AI in STIs, Nonvenereal Genital Diseases, Sexual Health, and Wellness

AI in STI screening and diagnosis

In the image diagnosis of various dermatological diseases, trained AI models outperform PHPs and match dermatologists. In cases of skin cancer, they sometimes even outperform dermatologists.[28] Only a few have separate data for STIs and nonvenereal genital diseases, showing trained artificial algorithm models outperforming PHPs. HeHealth, a computer vision-based digital diagnostic tool trained using 5,000 images of penile STIs, diagnosed syphilis, genital herpes, and genital warts with accuracies of 86%, 93%, and 96%, respectively.[29] DermaAId, an app trained for 40 dermatoses, including STIs and genital dermatoses in both males and females, outperformed PHPs, showing a top 1 sensitivity of 68.9% in correctly diagnosing genital diseases, including 80%, 75%, 45%, and 78.6% for anogenital warts, genital lichen sclerosus, anogenital herpes, and genital molluscum contagiosum, respectively.[30] Both of these platforms are trained with datasets having a significant proportion of skin-of-color patients. AI-based platforms can potentially be trained to recognize oral and anal lesions, genital lesions in transgenders, and female genital diseases, promoting diversity, equity, and inclusion.

Image analysis is a very small part of AI in genital dermatoses. Algorithms utilizing data about the sexual behavior of patients and combining findings from history or patient-reported data (e.g. symptoms, sexual history) with images can improve the yield of diagnosis and enable risk assessment and targeted screening recommendations.

Linkage to E-health, social media, and direct-to-consumer services

E-health and direct-to-consumer (D2C) models are slowly revolutionizing STI and sexual health services,[21] and AI is just the fuel to accelerate this revolution. For example, policymakers may mandate or organizations can choose programming to display ads for discreet delivery services for condoms, STI kits, and links for sexual education websites at "critical times" like having a successful match on dating platforms. Linkages of sexual health information and STI testing, including self-testing kits for HIV, with dating apps for homosexuals have been found to be feasible and acceptable.[31,32] However, in the current E-health model, such a rollout of services will require smart manpower, be slow, need several iterations of tweaking the algorithm, and have delayed analytics of the impact. The addition of an AI-based platform to identify other such critical points based on match frequency, usage, geolocation, and so on will allow it to potentially self-learn, improve, and yield personalized interventions. A lot of current barriers to E-health services, including improper search results, overly technical language, a lack of user-friendliness, information overload, unverified information, and so on, can be overcome by AI. AI can potentially better understand what people actually want to ask through a given set of search strings, sift through the word clouds, and render results in an easy-to-understand language within seconds.[33] So it can further reduce administrative and manpower costs and hours, improve efficiency and flexibility, and lead to faster and more widespread adoption of e-health services, although it may require significant initial investment in training and computational infrastructure.

D2C screening and testing have multiple advantages; it will reduce barriers to access to STI services, including confidentiality, embarrassment, stigmatization, and inconvenience.[34] It can decrease the burden on overloaded public health-care services and contribute to the broader vision to decentralize health. Self-testing kits at home have reasonable sensitivity, good patient perception, and detect STIs in patients, especially adolescents, who otherwise do not go to a traditional setting despite their concerns.[35] However, such D2C services can lead to significant unnecessary concern among consumers due to the high false positivity rate. AI-based platforms are the easiest to incorporate in the D2C model of STI services, as they can identify eligible people and the products and services they need and can further refine the eligibility criteria and services through self-learning. The Apple Watch's arrhythmia monitoring and potential ECG analysis features are examples of D2C AI-based systems.

AI-based platforms can be linked to social media and digital social marketing campaigns to encourage prevention or testing.[22]

Sexual education and counseling, chatbots

In an era where algorithms, AI-based platforms, and chatbots offer general health, personalized nutrition, exercise, and wellness services, sexual health and wellness services should be included with the same rigor. Fortunately, adolescents, who are most prone to STIs and have significant barriers to accessing public STI services, are usually the earliest adopters of new technology. Various health chatbots should incorporate sexual health and education. Such chatbots have performed well for education related to HIV and have been integrated into social media.[36,37] AI-based chatbots have an advantage over simple E-health educational resources by being more interactive and conversational with natural language flow and sometimes have been rated to be better and more empathetic than physicians' responses![38]

Integration of AI into the health-care system

STIs require rapid diagnosis and treatment. The waiting times for dermatologists and venereologists are significantly long in many countries; hence, such patients are primarily seen by PHPs. Many countries have syndromic approach-based programs in their public health-care delivery systems. Various nonvenereal genital diseases are also first seen by PHPs before being referred further, as they are frequently confused with STIs. They are not included in the syndromic approach, despite having a significant burden and being seen in an integrated health-care setup. AI-based platforms can be a rapid decision support tool for PHPs and can be integrated with the syndromic approach, increasing their accuracy in real time. They may suggest treatment to the PHPs, although the final treatment or referral call is to be made by the PHPs themselves. They complement rather than replace the dermatologists.

Big data collection, epidemiology, and statistical analysis

AI-based mobile applications can easily have options to report data, both when integrated with public health platforms or with private practitioners; hence, integrated with the digital monitoring services, can analyze nationwide trends in real time, and can indicate outbreaks earlier than the current reporting systems. It can also be used to direct targeted interventions and sentinel surveillance. ML-based statistical models have been used to predict the actual incidence of STIs during the COVID-19 pandemic, when STI reporting services took a hit.

Data from chatbots and social media can be analyzed to yield frequently asked questions by youth and responses that satisfy them. Such data can be used to direct information, education, and counseling activities.

Algorithms can scour data from social media and predict trends of increasing risky behavior, and they have been shown to predict trends in HIV and syphilis.[39] ML has been shown to be able to predict which patients are at greater risk of acquiring HIV infection and are suitable for pre-exposure prophylaxis through electronic medical records.[40] Interestingly, data need not be organized into structural fields for AI to work. NLP has enabled prediction of the risk of acquiring HIV through the free text of clinical notes too.[41] AI-based platforms can yield close to real-time analysis and prediction of trends by scouring combined data from public hospitals, electronic medical records, surveillance sites, and dating and social media platforms.

Limitations and Drawbacks of AI

AI-based computer vision systems lack widespread field testing, and results in real-life settings may not match the experimental accuracy obtained from test data. Existing models train for limited diseases, and accuracy plateaus beyond a certain point. Similar concerns are possible for image diagnosis of genital lesions, where real-life patient-clicked images can be of much poorer quality, especially the genital lesions, which are likely to be partially covered and underlit. If AI misdiagnoses, who's liable—the machine, the clinician, or the system owner?

Despite privacy claims, large tech companies often sell personal data, and AI-based platform owners, mostly originating from the same technology ecosystems, are likely to go down the same path. This concern significantly risks the integration of AI with E-health. Anonymous and unlinked data collection complicates maintaining electronic medical records and follow-up visits. The use of AI in STIs has certain unique concerns compared to other diseases. A compromise in discretion has more severe concerns for patients with STIs and genital diseases compared to others. In some nations, STIs are reportable diseases, and AI platforms may be mandated to report users. Contract tracing and partner treatment complexities also arise. Ethical dilemmas compound with the use of AI in STIs.

Future Directions and Potential Applications

Although most of the current researchers are not in favor of AI-directed STI treatment, with the most important limitations in this regard being legal and legislative issues, automated treatment pathways for STIs similar to syndromic management protocols are not that far away. Such an innovative policy expanding D2C services to treatment will significantly increase access to STI services. Robust field testing is required to compare them with the syndromic approach to show if they can replace AI in some settings or only add to it.

Under-representation of women and LGBTQ (lesbian, gay, bisexual, transgender, and queer) people in AI for STIs requires attention, including image inclusion. Improving treatment of vaginal discharge or pelvic inflammatory disease requires better analysis of subjective symptoms and predictors of response to treatment through big data and AI. Health and wellness information for females, often lacking or misinformed, needs addressing.

A significant contributor to E-health disparity pertains to language.[42] Most resources are English-based, yet in countries like India, only 10.6% of the population speaks English. Misinformation campaigns often use vernacular languages. Chatbots need to cater to these needs, requiring robust NLP for vernacular conversation.

Although there is a huge hype around AI in health care and a plethora of studies around it, they rarely translate to active routine clinical use.[43] Ways to ensure the swift translation from research to practical use include standardization of regulatory frameworks and guidelines enabling to assess them as per established parameters and better regulatory approaches than classifying these models as medical devices (software as a Medical Device Framework), which approves only the locked nonevolving version at a point in time.[44] Translation to real-life clinical scenarios entails that human behavior and how humans respond to the results of AI are also kept in mind during studies, rather than just focusing on the accuracy or sensitivity of AI-based algorithms in experimental settings.[44]

Conclusion

Addressing STIs, nonvenereal genital dermatoses, and sexual health is a pressing need where AI can be transformative. Resistance to AI in health care is partly due to the protectionist attitudes of providers and policymakers and the inherent medical conservatism. The latter can be a good thing, as it necessitates robust quality evidence and field trials of AI systems prior to widespread adoption. AI should consistently demonstrate significantly superior results over PHPs in real-world scenarios for broad implementation. Overcoming this resistance requires forward-thinking, openness, increased research and funding in AI, rigorous trials, swift policy adaptation, and the inclusion of all stakeholders in decision-making.

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Conflicts of interest

Dr Nikhil Mehta and Dr Somesh Gupta are authors of a study involving the diagnosis of STIs using DermaAId, an AI-based platform. They have not and did not receive any renumeration, financial or otherwise, from the platform. Dr. Yudara Kularathne is the CEO of HeHealth, a for-profit company that uses AI to diagnose male genital dermatoses.

References

1. Sexually transmitted infections (STIs). Available from: https://www.who.int/news-room/fact-sheets/detail/sexually-transmitted-infections-(stis). [Last accessed on 2023 Apr 24].
2. Incidence, Prevalence, and Cost of Sexually Transmitted Infections in the United States | Fact Sheets | Newsroom | NCHHSTP | CDC; March 17, 2022. Available from: https://www.cdc.gov/nchhstp/newsroom/fact-sheets/std/STI-Incidence-Prevalence-Cost-Factsheet.html. [Last accessed on 2023 Apr 24].
3. National RTI STI technical guidelines Sep 2014. Available from: https://naco.gov.in/sites/default/files/National%20RTI%20STI%20technical%20guidelines%20Sep2014_0.pdf.Vol. 0.pdf. [Last accessed on 2023 Apr 24].
4. India HIV Estimates.pdf. Available from: https://naco.gov.in/sites/default/files/India%20HIV%20Estimates.pdf. [Last accessed on 2023 Apr 24].
5. Fu L, Sun Y, Han M, Wang B, Xiao F, Zhou Y, *et al*. Incidence trends of five common sexually transmitted infections excluding HIV from 1990 to 2019 at the global, regional, and National levels: Results from the global burden of disease Study 2019. Front Med (Lausanne) 2022;9:851635.
6. Du M, Yan W, Jing W, Qin C, Liu Q, Liu M, *et al*. Increasing incidence rates of sexually transmitted infections from 2010 to 2019: An analysis of temporal trends by geographical regions and age groups from the 2019 Global Burden of Disease Study. BMC Infect Dis 2022;22:574.
7. WHO Global progress report on HIV, viral hepatitis and sexually transmitted infections, 2021. Available from: http://apps.who.int/iris/bitstream/handle/10665/342808/9789240030985-eng.pdf. [Last accessed on 2023 Apr 24].
8. Vinay N, Ranugha PSS, Betkerur JB, Shastry V, Ashwini PK. Non-venereal genital dermatoses and their impact on quality of life-A cross-sectional study. Indian J Dermatol Venereol Leprol 2022;88:354-9.
9. Kellogg Spadt S, Kusturiss E. Vulvar dermatoses: A primer for the sexual medicine clinician. Sex Med Rev 2015;3:126-36.
10. Fetters A. Why are STDs on the rise if Americans are having less sex? The Atlantic; August 29, 2018. Available from: https://www.theatlantic.com/family/archive/2018/08/why-are-stds-on-the-rise-if-people-are-having-less-sex/568909/. [Last accessed on 2023 May 24].
11. Zhang Kudon H, Mulatu MS, Song W, Heitgerd J, Rao S. Trends in condomless sex among MSM who participated in CDC-funded HIV risk-reduction interventions in the United States, 2012-2017. J Public Health Manag Pract 2022;28:170-3.

12. Katz DA, Copen CE, Haderxhanaj LT, Hogben M, Goodreau SM, Spicknall IH, *et al*. Changes in sexual behaviors with opposite-sex partners and sexually transmitted infection outcomes among females and males ages 15-44 years in the USA: National survey of family growth, 2008-2019. Arch Sex Behav 2023;52:809-21.
13. Rusley JC, Tao J, Koinis-Mitchell D, Rosenthal AE, Montgomery MC, Nunez H, *et al*. Trends in risk behaviors and sexually transmitted infections among youth presenting to a sexually transmitted infection clinic in the United States, 2013-2017. Int J STD AIDS 2022;33:634-40.
14. Scott-Sheldon LAJ, Chan PA. Increasing sexually transmitted infections in the U.S.: A call for action for research, clinical, and public health practice. Arch Sex Behav 2020;49:13-7.
15. Carpenter KM, Stoner SA, Mikko AN, Dhanak LP, Parsons JT. Efficacy of a web-based intervention to reduce sexual risk in men who have sex with men. AIDS Behav 2010;14:549-57.
16. Garga S, Thomas MT, Bhatia A, Sullivan A, John-Leader F, Pit SW. Motivations, dating app relationships, unintended consequences and change in sexual behaviour in dating app users at an Australian music festival. Harm Reduc J 2021;18:49.
17. DeVost MA, Beymer MR, Weiss RE, Shover CL, Bolan RK. App-based sexual partner seeking and sexually transmitted infection outcomes: A cross-sectional study of HIV-Negative MSM Attending an STI Clinic in Los Angeles, California. Sex Transm Dis 2018;45:394-9.
18. Watchirs Smith L, Guy R, Degenhardt L, Yeung A, Rissel C, Richters J, *et al*. Meeting sexual partners through internet sites and smartphone apps in Australia: National representative Study. J Med Internet Res 2018;20:e10683.
19. Impact of COVID-19 on STDs; April 11, 2023. Available from: https://www.cdc.gov/std/statistics/2021/impact.htm. [Last accessed on 2023 May 29].
20. Charles H, Ratna N, Thorn L, Sonubi T, Sun S, Mohammed H, *et al*. COVID-19 impact on bacterial sexually transmitted infections in England between 1 January 2019 and 31 December 2020. Sex Transm Infect 2022;98:537-8.
21. Minichiello V, Rahman S, Dune T, Scott J, Dowsett G. E-health: Potential benefits and challenges in providing and accessing sexual health services. BMC Public Health 2013;13:790.
22. Friedman AL, Kachur RE, Noar SM, McFarlane M. Health communication and social marketing campaigns for sexually transmitted disease prevention and control: What is the evidence of their effectiveness? Sex Transm Dis 2016;43(Suppl 1):S83-101.
23. CDC. Newsroom; January 1, 2016. CDC. Available from: https://www.cdc.gov/media/releases/2022/p0412-STD-Increase.html. [Last accessed on 2023 May 24].
24. Leichliter JS, Copen C, Dittus PJ. Confidentiality issues and use of sexually transmitted disease services among sexually experienced persons aged 15-25 years — United States, 2013-2015. MMWR Morb Mortal Wkly Rep 2017;66:237-41.
25. Get a domain name that is perfect for you –.ai-GoDaddy IN. GoDaddy. Available from: https://www.godaddy.com/en-in/tlds/ai-domain. [Last accessed on 2023 May 24].
26. Chan S, Reddy V, Myers B, Thibodeaux Q, Brownstone N, Liao W. Machine learning in dermatology: Current applications, opportunities, and limitations. Dermatol Ther (Heidelb) 2020;10:365-86.
27. Samuel M, Brady M, Tenant-Flowers M, Taylor C. Role of penile biopsy in the diagnosis of penile dermatoses. Int J STD AIDS 2010;21:371-2.
28. Li Z, Koban KC, Schenck TL, Giunta RE, Li Q, Sun Y. Artificial intelligence in dermatology image analysis: Current developments and future trends. J Clin Med 2022;11:6826.
29. Tan RKJ, Perera D, Arasaratnam S, Kularathne Y. Adapting an artificial intelligence sexually transmitted diseases screening tool for monkeypox detection: The HeHealth experience. Manuscript accepted for publication in BMJ innovations (In press).
30. Mehta N, Khan E, Choudhary R, *et al*. Performance of an artificial intelligence-based mobile application in image diagnosis of genital dermatoses: A prospective cross-sectional study. Manuscript submitted.
31. Rosengren AL, Huang E, Daniels J, Young SD, Marlin RW, Klausner JD. Feasibility of using GrindrTM to distribute HIV self-test kits to men who have sex with men in los Angeles, California. Sex Health 2016. doi: 10.1071/SH15236.
32. Sun CJ, Stowers J, Miller C, Bachmann LH, Rhodes SD. Acceptability and feasibility of using established geosocial and sexual networking mobile applications to promote HIV and STD testing among men who have sex with men. AIDS Behav 2015;19:543-52.
33. Cline RJ, Haynes KM. Consumer health information seeking on the Internet: The state of the art. Health Educ Res 2001;16:671-92.
34. Exten C, Pinto CN, Gaynor AM, Meyerson B, Griner SB, Van Der Pol B, *et al*. Direct-to-consumer sexually transmitted infection testing services: A position statement from the American Sexually Transmitted Diseases Association. Sex Transm Dis 2021;48:e155-9.
35. Wiesenfeld HC, Lowry DL, Heine RP, Krohn MA, Bittner H, Kellinger K, *et al*. Self-collection of vaginal swabs for the detection of Chlamydia, gonorrhea, and trichomoniasis: Opportunity to encourage sexually transmitted disease testing among adolescents. Sex Transm Dis 2001;28:321-5.
36. Brixey J, Hoegen R, Lan W, Rusow J, Singla K, Yin X, *et al*. SHIHbot: A Facebook chatbot for Sexual Health Information on HIV/AIDS. In: Proceedings of the 18th annual SIGdial meeting on discourse and dialogue. Association for Computational Linguistics; 2017. p. 370-3.
37. 3 lessons learned. HIV.gov. Available from: HIV.gov's Chatbot Pilot. Available from: https://www.hiv.gov/blog/3-lessons-learned-hivgov-s-chatbot-pilot. [Last accessed on 2023 May 08].
38. Ayers JW, Poliak A, Dredze M, Leas EC, Zhu Z, Kelley JB, *et al*. Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social Media Forum. JAMA Intern Med 2023:e231838.
39. Young SD, Mercer N, Weiss RE, Torrone EA, Aral SO. Using social media as a tool to predict syphilis. Prev Med 2018;109:58-61.
40. Marcus JL, Sewell WC, Balzer LB, Krakower DS. Artificial intelligence and machine learning for HIV prevention: Emerging approaches to ending the epidemic. Curr HIV AIDS Rep 2020;17:171-9.
41. Feller DJ, Zucker J, Yin MT, Gordon P, Elhadad N. Using clinical notes and natural language processing for automated HIV risk assessment. J Acquir Immune Defic Syndr 2018;77:160-6.
42. Viswanath K, Kreuter MW. Health disparities, communication inequalities, and ehealth. Am J Prev Med 2007;32(Suppl):S131-3.
43. Sendak MP, D'Arcy J, Kashyap S, Gao M, Nichols M, Corey K, *et al*. A path for translation of machine learning products into healthcare delivery. EMJ Innov 2020.
44. Meskó B, Görög M. A short guide for medical professionals in the era of artificial intelligence. npj Digit Med 2020;3:126.