INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Dermatological Manifestations of Infectious Diseases: A Global Public Health Concern

Narrative Review

Ahmad Ibne Yousaf[1]*, Qaswara Affaf[2], Azzah Khadim Hussain[3], Maya Bint Yousaf[4], Syed Younus Ali[4], Kashif Khattak[5], Summer Rashid[6], Ayesha Bint Yousaf[7]
[1]School of Human Nutrition & Dietetics / Assistant Registrar, Minhaj University Lahore, Pakistan
[2]MS Scholar, Department of Public Health, University of Otago, Wellington, New Zealand.
[3]MPhil. Scholar, School of Human Nutrition & Dietetics, Minhaj University Lahore, Pakistan
[4]Lecturer, School of Software Engineering, Minhaj University Lahore, Pakistan
[5]District Nutrition Coordinator BNP UN-WFP, DoH KP.
[6]Associate Professor, School of Food Science & Technology, Minhaj University Lahore, Pakistan
[7]Post Graduate Resident, Neurosurgery, DHQ Hospital, Gujranwala, Punjab, Pakistan.
Corresponding Author: Ahmad Ibne Yousaf, ahmadyousaf.reg@mul.edu.pk, School of Human Nutrition & Dietetics / Assistant Registrar, Minhaj University Lahore, Pakistan

Conflict of Interest: None
Grant Support & Financial Support: None

ABSTRACT

Background: Infectious diseases pose a persistent global public health challenge, with dermatological symptoms often serving as pivotal indicators of underlying infections. Recognizing and understanding these manifestations are essential for timely diagnosis, management, and prevention.

Objective: This narrative review explores the intricate interplay between dermatological manifestations and infectious diseases, shedding light on their pathogenesis, clinical presentations, and epidemiological significance.

Methods: A comprehensive review of the literature was conducted to assess the roles of bacterial, viral, fungal, and parasitic infections in dermatological presentations. The analysis also included the influence of socioeconomic factors, emerging infectious diseases, and antibiotic resistance on the burden of skin-related conditions.

Results: Skin changes, including rashes, ulcers, and lesions, frequently act as early markers of systemic infections, providing crucial clues for rapid intervention. Conditions such as erythema migrans in Lyme disease, maculopapular rashes in measles and dengue, and vesicular eruptions in herpes simplex highlight the diagnostic significance of dermatological symptoms. Emerging infections like COVID-19 and monkeypox further emphasize the evolving landscape of infectious dermatology. The socioeconomic impact of these conditions, compounded by stigma and healthcare disparities, underscores the urgent need for integrated approaches in their management.

Conclusion: The review underscores the importance of heightened awareness among healthcare providers and the integration of dermatological assessments into global disease surveillance systems. Strengthening these efforts will enhance patient outcomes and support the development of more effective public health strategies.

Keywords: Antibiotic resistance, Bacterial infections, Dermatology, Fungal infections, Infectious diseases, Public health, Viral infections

INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

INTRODUCTION

A significant proportion of dermatological illnesses worldwide arise from skin infections, which vary extensively in terms of etiology, prevalence, and clinical presentation. The skin and subcutaneous tissue serve as critical interfaces between systemic and environmental factors, often manifesting the effects of local and systemic processes. Understanding these manifestations is essential for clinicians, as many cases are treatable if recognized early (1).

Dermatological manifestations of infectious diseases represent a vital yet frequently overlooked aspect of global public health, contributing significantly to both morbidity and disability. Conditions such as cutaneous ulcers, rashes, and lesions often serve as diagnostic markers for underlying systemic infections, including life-threatening conditions such as HIV and malaria (2). Despite their clinical importance, dermatological conditions receive limited attention and funding in global health initiatives, which hampers advancements in patient care, research, and education. Addressing these challenges, especially in resource-limited settings, is essential. Innovations like telemedicine and advanced diagnostic tools have shown promise in bridging healthcare disparities and improving outcomes in these regions (3).

Pathophysiology of Dermatological Manifestations in Infectious Diseases

The skin, as the body's primary barrier against infections, frequently displays early signs of systemic diseases. Dermatological symptoms are shaped by complex interactions between pathogens and the host immune response, with variations depending on the pathogen type—bacterial, viral, fungal, or parasitic.

Mechanisms Linking Infections to Skin Manifestations: Pathogens can affect the skin through direct invasion or as a result of systemic immune responses. Direct invasion occurs when infectious agents proliferate in the epidermis or dermis, producing localized symptoms. For example, herpes simplex virus (HSV) and varicella-zoster virus (VZV) directly infect epithelial cells, causing vesicular lesions through viral replication within these cells (4). In other cases, toxins released by pathogens, such as exfoliative toxins in toxic shock syndrome caused by Staphylococcus aureus, lead to widespread skin rashes (5). The immune system also plays a pivotal role in mediating dermatological responses. Inflammatory reactions triggered by cytokines often result in skin symptoms such as erythema, edema, and vesicle formation. For instance, cytokine storms during severe viral infections like COVID-19 can cause widespread erythematous rashes and urticaria (7). These immune-mediated responses illustrate how infections influence skin manifestations both directly and indirectly.

Role of Pathogen Type in Cutaneous Presentations

The type of pathogen significantly determines the nature and severity of dermatological manifestations:

Viral Infections: Viruses commonly cause skin manifestations through direct infection or immune-mediated reactions. Vesicular eruptions in chickenpox and herpes or maculopapular rashes in measles are typical examples. Such rashes are often the result of the immune system's attempt to eliminate infected cells (8).

Bacterial Infections: Bacterial infections can cause skin symptoms either by toxin production or through direct invasion. For example, Streptococcus pyogenes can lead to necrotizing fasciitis, cellulitis, and erysipelas, while Staphylococcus aureus may cause impetigo or cutaneous abscesses. These bacterial infections often escalate during post-disaster periods, highlighting the role of environmental and systemic factors (10).

Fungal Infections: Fungal pathogens, particularly dermatophytes, colonize the skin's outer layer and metabolize keratin, leading to conditions like dermatophytosis, which manifests as erythema and scaling. Severe fungal infections may penetrate deeper layers in immunocompromised patients, resulting in extensive skin damage (11).

Parasitic Infections: Parasitic infections, such as those caused by Leishmania species and Sarcoptes scabiei, elicit diverse cutaneous responses, from nodules to pruritus. In cutaneous leishmaniasis, Leishmania parasites infiltrate macrophages in the skin, causing localized nodules and ulcers (12).

Pathophysiological Mechanisms of Skin Manifestations

Direct Pathogen Invasion of Skin Cells: Certain pathogens invade skin cells directly, leading to specific dermatological manifestations. For instance, HSV infection of keratinocytes results in cellular damage and vesicle formation. Similarly, the spread of Borrelia burgdorferi in Lyme disease produces the characteristic "bull's-eye" erythema migrans rash (14). Dermatophytosis exemplifies fungal pathogens that metabolize keratin in the stratum corneum, causing erythema and scaling (15).

Immune-Mediated Responses: In many cases, dermatological symptoms arise not from the pathogen itself but from the host's immune response. Cytokine release, immune complex deposition, and hypersensitivity reactions are central mechanisms. For example, dengue fever and measles trigger cytokine-mediated maculopapular rashes (16). Autoimmune processes may also play a role, as seen in post-streptococcal erythema nodosum, where immune complexes deposited in skin tissues lead to inflammation and subcutaneous nodules (17).

Hypersensitivity Reactions and Vasculitis: Immune complex deposition in the blood vessel walls leads to vasculitis, contributing to dermatological symptoms in conditions like meningococcemia and disseminated gonococcal infections. Secondary syphilis, caused by Treponema pallidum, illustrates the diversity of cutaneous reactions resulting from immune responses (18).

Cytokine Release and Systemic Inflammation: Cytokine overproduction during systemic infections can result in tissue damage, including in the skin. Conditions such as toxic shock syndrome, caused by exotoxins from Staphylococcus aureus or Streptococcus pyogenes, illustrate how excessive cytokine release leads to diffuse erythema and tissue necrosis (20).

Clinical Dermatological Presentations and Patterns: The clinical presentation of dermatological manifestations often provides critical diagnostic clues. Specific patterns, such as petechiae, vesicular eruptions, and maculopapular rashes, enable clinicians to narrow down differential diagnoses. Table 1 outlines common skin manifestations associated with various infectious diseases.

Sr.	Infectious Disease	Dermatological Manifestation	Description	Example Case(s)
1	Measles	Maculopapular rash	Red, flat spots often accompanied by fever	Outbreaks in unvaccinated areas
2	Chickenpox	Vesicular eruptions	Small, itchy, fluid-filled blisters	Common in children
3	Dengue	Petechial rash	Small red or purple spots due to bleeding	Endemic regions in Asia
4	Lyme Disease	"Bull's-eye" erythema migrans	Red, expanding rash with central clearing	Tick-borne in the United States
5	COVID-19	Chilblain-like lesions	Red or purple lesions on extremities	Observed during the pandemic
6	Lupus (differential)	Malar "butterfly" rash	Rash across cheeks and nose	Autoimmune, systemic lupus erythematosus

Common Presentation Patterns of Dermatological Manifestations in Infectious Diseases

Maculopapular Rashes: Maculopapular rashes, characterized by a combination of flat and raised red areas, are a hallmark of several viral infections, including measles, dengue, and COVID-19. In dengue, these rashes typically develop on the face, trunk, and extremities, driven by immune activation and increased vascular permeability (21). Similarly, COVID-19-associated maculopapular eruptions have been attributed to cytokine activity and vascular impairment, reflecting the systemic nature of the disease (22). These rashes are often crucial diagnostic features, enabling clinicians to recognize underlying viral etiologies.

Vesicular Eruptions: Vesicular eruptions are fluid-filled blisters that are prominently seen in herpes simplex virus (HSV) and varicella-zoster virus (VZV) infections. In chickenpox, lesions evolve from macules to vesicles and subsequently crust, often presenting at varying stages simultaneously. Vesicular lesions in HSV reactivation are typically localized, recurring due to viral latency in nerve ganglia (24). Interestingly, vesicular rashes have also been documented in COVID-19, likely resulting from immune-mediated damage or direct viral effects on the skin (23). These lesions provide critical insights into disease pathophysiology and progression.

Petechiae: Petechiae, small non-blanching red spots caused by capillary injury, are commonly associated with infections involving vascular damage or thrombocytopenia, such as dengue and meningococcemia. Severe dengue is often marked by vascular leakage and immune-driven platelet damage, leading to petechial rashes (25). In meningococcal septicemia, endotoxin-mediated capillary damage results in petechiae and purpura, forming part of the characteristic clinical presentation (26). These findings are vital for identifying and managing systemic infections with significant vascular involvement.

Disease-Specific Dermatological Findings

"Bull's-Eye" Rash in Lyme Disease: The erythema migrans rash, commonly referred to as the "bull's-eye" rash, is a defining feature of Lyme disease caused by Borrelia burgdorferi. This lesion reflects bacterial dissemination in the dermis, presenting as an expanding red ring with central clearing at the site of a tick bite (27). Notably, this rash occurs in approximately 70–80% of patients, making it an essential early diagnostic marker for Lyme disease (28).

"Butterfly Rash" in Systemic Lupus Erythematosus (SLE): The butterfly-shaped malar rash, spanning the cheeks and nasal bridge, is a characteristic dermatological manifestation of systemic lupus erythematosus (SLE). While SLE is an autoimmune condition, infections can exacerbate the disease, leading to rash flare-ups. Immune complex deposition in the skin underlies the inflammation observed in this pattern, which can complicate differential diagnoses (29).

Koplik Spots in Measles: Koplik spots, small white lesions with a red halo on the buccal mucosa, are a pathognomonic early sign of measles. These precede the widespread maculopapular rash and reflect viral replication and mucosal inflammation. Their presence is a critical diagnostic indicator, especially during measles outbreaks (30).

Purpura Fulminans in Meningococcal Septicemia: Purpura fulminans is a severe manifestation of meningococcal infections, resulting from endothelial damage and disseminated intravascular coagulation (DIC). Large, necrotic purpuric lesions develop due to vascular occlusion and thrombotic events caused by Neisseria meningitidis endotoxins (31). Prompt recognition and intervention are essential in such life-threatening presentations.

Diagnostic Challenges and Approaches: The diversity of dermatological manifestations in infectious diseases poses significant diagnostic challenges. Accurate identification relies on integrating clinical examination, laboratory testing, and imaging techniques. Table 2 outlines key diagnostic tools and their applications.

Table 2: Diagnostic Tools and Their Applications in Dermatological Infections

Sr.	Diagnostic Tool	Application	Purpose	Example Diseases
1	Clinical Examination	Visual inspection, dermoscopy	Initial assessment of lesion characteristics	Measles, chickenpox
2	Serological Tests	Detect antibodies or antigens	Confirm exposure to specific pathogens	HIV, Lyme disease
3	PCR (Polymerase Chain Reaction)	Detect viral or bacterial DNA	Highly specific pathogen detection	COVID-19, herpes simplex
4	Skin Biopsy	Histopathological examination	Differentiate infectious from non-infectious etiologies	Leprosy, Kaposi's sarcoma
5	Imaging (Ultrasound, MRI)	Assess deeper skin and soft tissue	Detect spread to internal structures	Cellulitis, deep fungal infections

Clinical Examination Techniques

Clinical Inspection: Visual inspection of lesion morphology, distribution, and patterns is the cornerstone of dermatological diagnosis. For example, maculopapular rashes in viral infections or vesicular eruptions in herpes can be differentiated based on appearance and distribution (32).

Dermoscopy: Dermoscopy enhances the visualization of pigmentation, vascular patterns, and other microscopic features, aiding in distinguishing infectious conditions from inflammatory or malignant diseases (33).

Laboratory and Imaging Support

Serological Tests: Serological assays, such as ELISA, are essential for detecting antibodies or antigens specific to infections like dengue, measles, and HIV (35). Two-tiered serology, including Western blot confirmation, is particularly useful for Lyme disease diagnosis (36).

Polymerase Chain Reaction (PCR) : PCR provides rapid and highly specific detection of pathogen DNA or RNA, making it invaluable for conditions such as COVID-19 and herpes simplex virus infections (37). It is also crucial for identifying uncommon infections in atypical dermatological presentations (38).

Health Implications

Public Health Implications: The dermatological manifestations of infectious diseases carry profound public health significance, encompassing epidemiological, social, and economic dimensions.

Epidemiological Significance: Dermatological signs often serve as early indicators of infectious disease outbreaks. Conditions like measles and dengue are highly transmissible and frequently linked to global travel and urbanization (42). Emerging diseases, such as monkeypox and COVID-19, underscore the importance of rapid identification and containment of infections with dermatological features (43).

Social and Economic Burdens: Visible skin lesions often lead to stigma, discrimination, and psychological distress, as seen in conditions like leprosy and HIV-associated Kaposi's sarcoma (44). These factors, coupled with healthcare costs and lost productivity, impose significant social and economic burdens (46).

Impacts on Healthcare Systems: Outbreaks of infectious diseases strain healthcare resources. Managing highly contagious conditions like measles necessitates vaccination drives, quarantine measures, and public education campaigns, underscoring the need for robust healthcare infrastructure (47).

Prevention and Management Strategies: Effective prevention involves vaccination, vector control, and improved hygiene practices. Vaccines for measles, chickenpox, and rubella remain central to controlling these diseases (48). Vector control measures, including larval source reduction and insecticide use, are critical in dengue prevention (49). Treatment strategies include antivirals, antibiotics, and disease-specific therapies. For instance, acyclovir is widely used for herpes simplex infections, while multidrug regimens are essential for managing leprosy (51, 52). The COVID-19 pandemic highlighted the importance of public health interventions such as contact tracing and vaccination in mitigating outbreaks (53).

Global Health Initiatives and Future Directions

Global organizations like the World Health Organization (WHO) and Médecins Sans Frontières (MSF) play pivotal roles in addressing infectious diseases with dermatological manifestations. Their efforts include vaccination programs and community-based interventions, which have significantly reduced disease incidence in vulnerable regions (54, 56). Future research should focus on understanding immune variability, pathogen resistance, and climate change's impact on disease patterns. Advancements in diagnostic tools and treatments will be crucial for addressing emerging challenges in infectious dermatology (41).

CONCLUSION

Dermatological manifestations are critical for the early recognition and management of infectious diseases. A collaborative global approach, involving healthcare providers, researchers, and public health organizations, is essential to mitigate the burden of these conditions. Sustained investment in prevention, research, and treatment is necessary to reduce the global impact and improve patient outcomes.

REFERENCES

1. Miró EM, Sánchez NPJAodiim. Cutaneous manifestations of infectious diseases. 2012:77-119.

2. Hay RJ, Johns NE, Williams HC, Bolliger IW, Dellavalle RP, Margolis DJ, et al. The global burden of skin disease in 2010: an analysis of the prevalence and impact of skin conditions. 2014;134(6):1527-34.

3. Williams VL, Kovarik CLJDC. The Growing Importance of Dermatology on the Global Stage. 2021;39(1):xiii-xiv.

4. Zhu S, Viejo-Borbolla AJV. Pathogenesis and virulence of herpes simplex virus. 2021;12(1):2670-702.

5. Piewngam P, Otto MJTLM. Staphylococcus aureus colonisation and strategies for decolonisation. 2024.

6. Karki R, Kanneganti T-DJTii. The 'cytokine storm': molecular mechanisms and therapeutic prospects. 2021;42(8):681-705.

7. Singh H, Kaur H, Singh K, Sen CKJAiwc. Cutaneous manifestations of COVID-19: a systematic review. 2021;10(2):51-80.

8. Fernández-Lázaro D, Garrosa MJV. Identification, mechanism, and treatment of skin lesions in COVID-19: a review. 2021;13(10):1916.

9. Swaney MH, Kalan LRJI, immunity. Living in your skin: microbes, molecules, and mechanisms. 2021;89(4):10.1128/iai. 00695-20.

10. Parker ER, Mo J, Goodman RSJTJoCC, Health. The dermatological manifestations of extreme weather events: a comprehensive review of skin disease and vulnerability. 2022;8:100162.

11. Martinez-Rossi NM, Peres NT, Bitencourt TA, Martins MP, Rossi AJJoF. State-of-the-art dermatophyte infections: epidemiology aspects, pathophysiology, and resistance mechanisms. 2021;7(8):629.

12. Maia C, Conceição C, Pereira A, Rocha R, Ortuño M, Muñoz C, et al. The estimated distribution of autochthonous leishmaniasis by Leishmania infantum in Europe in 2005–2020. 2023;17(7):e0011497.

13. Steiner I, Benninger FJCn. Herpes simplex viruses. 2020:45-58.

14. Steere A, Strle F, Wormser G, Hu L, Branda J, Hovius J. Lyme borreliosis. Nature reviews Disease primers. 2016; 2: 16090.

15. Havlickova B, Czaika VA, Friedrich MJM. Epidemiological trends in skin mycoses worldwide. 2008;51:2-15.

16. Ooi EE, Kalimuddin SJStm. Insights into dengue immunity from vaccine trials. 2023;15(704):eadh3067.

17. Conforti C, Dianzani C, Agozzino M, Giuffrida R, Marangi GF, di Meo N, et al. Cutaneous manifestations in confirmed COVID-19 patients: a systematic review. 2020;9(12):449.

18. Pintea I, Petricau C, Dumitrascu D, Muntean A, Branisteanu DC, Branisteanu DE, et al. Hypersensitivity reactions to monoclonal antibodies: Classification and treatment approach. 2021;22(3):1-8.

19. Scott J, Hartnett J, Mockler D, Little MAJAR. Environmental risk factors associated with ANCA associated vasculitis: a systematic mapping review. 2020;19(11):102660.

20. Atchade E, De Tymowski C, Grall N, Tanaka S, Montravers PJA. Toxic shock syndrome: a literature review. 2024;13(1):96.

21. Côrtes N, Lira A, Prates-Syed W, Dinis Silva J, Vuitika L, Cabral-Miranda W, et al. Integrated control strategies for dengue, Zika, and Chikungunya virus infections. 2023;14:1281667.

22. Genovese G, Moltrasio C, Berti E, Marzano AVJD. Skin manifestations associated with COVID-19: current knowledge and future perspectives. 2021;237(1):1-12.

23. Marzano AV, Cassano N, Genovese G, Moltrasio C, Vena GJBJoD. Cutaneous manifestations in patients with COVID-19: a preliminary review of an emerging issue. 2020;183(3):431-42.

24. Fathy R, McMahon D, Lee C, Chamberlin G, Rosenbach M, Lipoff J, et al. Varicella-zoster and herpes simplex virus reactivation post-COVID-19 vaccination: a review of 40 cases in an International Dermatology Registry. 2022;36(1):e6.

25. Bhatt P, Sabeena SP, Varma M, Arunkumar GJCm. Current understanding of the pathogenesis of dengue virus infection. 2021;78(1):17-32.

26. Deghmane A-E, Taha S, Taha M-KJID. Global epidemiology and changing clinical presentations of invasive meningococcal disease: a narrative review. 2022;54(1):1-7.

27. Mahajan VKJIdoj. Lyme disease: An overview. 2023;14(5):594-604.

28. Baarsma M, Hovius JWJTJoID. Persistent Symptoms After Lyme Disease: Clinical Characteristics, Predictors, and Classification. 2024;230(Supplement_1):S62-S9.

29. Fanouriakis A, Tziolos N, Bertsias G, Boumpas DTJAotrd. Update on the diagnosis and management of systemic lupus erythematosus. 2021;80(1):14-25.

30. Almansour IJFim. Mumps vaccines: current challenges and future prospects. 2020;11:1999.

31. Mittal A, Elias ML, Schwartz RA, Kapila RJDt. Recognition and treatment of devastating vasculopathic systemic disorders: Coronavirus disease 2019 and rickettsioses. 2021;34(4):e14984.

32. Maldar NP, Khubchandani R, Khan AJIJoP. Genetic disorders in pediatric rheumatology clinic: when to suspect, and why? 2024;91(9):934-40.

33. Glines KR, Haidari W, Ramani L, Akkurt ZM, Feldman SRJDoj. Digital future of dermatology. 2020;26(10).

34. Murthy SI, Sabhapandit S, Balamurugan S, Subramaniam P, Sainz-De-La-Maza M, Agarwal M, et al. Scleritis: Differentiating infectious from non-infectious entities. 2020;68(9):1818-28.

35. Namazi F, Khodakaram Tafti AJVM, Science. Lumpy skin disease, an emerging transboundary viral disease: A review. 2021;7(3):888-96.

36. Miraglia CMJJoCM. An Update to a Review of Guidelines for the Clinical Laboratory Diagnosis of Lyme Disease. 2020;19(3):201.

37. Rai P, Kumar BK, Deekshit VK, Karunasagar I, Karunasagar IJAm, biotechnology. Detection technologies and recent developments in the diagnosis of COVID-19 infection. 2021;105:441-55.

38. Merino I, de la Fuente A, Domínguez-Gil M, Eiros JM, Tedim AP, Bermejo-Martín JFJCC. Digital PCR applications for the diagnosis and management of infection in critical care medicine. 2022;26(1):63.

39. Vickery SB, Roach JK, Parsons C, Vickery PBJTNP. Possible levetiracetam-induced aseptic meningitis versus viral meningitis: Case report and literature review. 2022;47(7):32-7.

40. Khandpur S, Ahuja RJD. Drug-induced vs. Viral maculopapular exanthem—resolving the dilemma. 2022;9(2):164-71.

41. Baker RE, Mahmud AS, Miller IF, Rajeev M, Rasambainarivo F, Rice BL, et al. Infectious disease in an era of global change. 2022;20(4):193-205.

42. Gwee XWS, Chua PEY, Pang JJBID. Global dengue importation: a systematic review. 2021;21:1-10.

43. Tan SW, Tam YC, Oh CCJJi. Skin manifestations of COVID-19: a worldwide review. 2021;2:119-33.

44. Kelly KA, Balogh EA, Kaplan SG, Feldman SRJC. Skin disease in children: effects on quality of life, stigmatization, bullying, and suicide risk in pediatric acne, atopic dermatitis, and psoriasis patients. 2021;8(11):1057.

45. Cortés H, Rojas-Márquez M, Del Prado-Audelo ML, Reyes-Hernández OD, González-Del Carmen M, Leyva-Gómez GJIjod. Alterations in mental health and quality of life in patients with skin disorders: a narrative review. 2022;61(7):783-91.

46. Carrion C, Robles N, Sola-Morales O, Aymerich M, Postigo JARJJm, uHealth. Mobile health strategies to tackle skin neglected tropical diseases with recommendations from innovative experiences: systematic review. 2020;8(12):e22478.

47. de Soarez PC, Rozman LM, Fonseca TS, Borsari PR, Percio J, Barrera LSG, et al. The methodological quality of economic evaluations of measles outbreaks: A systematic review of cost-of-illness studies. 2023;41(7):1319-32.

48. Hasso-Agopsowicz M, Crowcroft N, Biellik R, Gregory CJ, Menozzi-Arnaud M, Amorij J-P, et al. Accelerating the development of measles and rubella microarray patches to eliminate measles and rubella: recent progress, remaining challenges. 2022;10:809675.

49. Oliver J, Larsen S, Stinear TP, Hoffmann A, Crouch S, Gibney KBJPNTD. Reducing mosquito-borne disease transmission to humans: A systematic review of cluster randomised controlled studies that assess interventions other than non-targeted insecticide. 2021;15(7):e0009601.

50. Donde OO, Atoni E, Muia AW, Yillia PTJWR. COVID-19 pandemic: Water, sanitation and hygiene (WASH) as a critical control measure remains a major challenge in low-income countries. 2021;191:116793.

51. Niaki OZ, Anadkat MJ, Chen ST, Fox LP, Harp J, Micheletti RG, et al. Navigating immunosuppression in a pandemic: A guide for the dermatologist from the COVID Task Force of the Medical Dermatology Society and Society of Dermatology Hospitalists. 2020;83(4):1150-9.

52. Lazo-Porras M, Prutsky GJ, Barrionuevo P, Tapia JC, Ugarte-Gil C, Ponce OJ, et al. World Health Organization (WHO) antibiotic regimen against other regimens for the treatment of leprosy: a systematic review and meta-analysis. 2020;20:1-14.

53. Girum T, Lentiro K, Geremew M, Migora B, Shewamare SJTm, health. Global strategies and effectiveness for COVID-19 prevention through contact tracing, screening, quarantine, and isolation: a systematic review. 2020;48:1-15.

54. Bozzola E, Spina G, Tozzi AE, Villani AJRm, policy h. Global measles epidemic risk: current perspectives on the growing need for implementing digital communication strategies. 2020:2819-26.

55. Keng BM, Gan WH, Tam YC, Oh CCJJi. Personal protective equipment-related occupational dermatoses during COVID-19 among health care workers: A worldwide systematic review. 2021;5:85-95.

56. Wong JM, Adams LE, Durbin AP, Muñoz-Jordán JL, Poehling KA, Sánchez-González LM, et al. Dengue: a growing problem with new interventions. 2022;149(6).