Co-Infection with Chikungunya and Malaria: A Case Report

Emmanuel Siddig[1], Alaa Habeeb Abdallah[2], Yousif Ali[3], Claude Muvunyi[4], Nouh Mohamed[1], and Ayman Ahmed[1]

[1]University of Khartoum
[2]Rufaa Teaching Hospital, Sudan
[3]Republic of Sudan Federal Ministry of Health
[4]Rwanda Biomedical Center

November 19, 2024

Co-Infection with Chikungunya and Malaria: A Case Report

Emmanuel Edwar Siddig [1], Alaa Tajeldeen Habeeb Abdallah[2], Yousif Ali[3], Claude Mambo Muvunyi [4], Nouh Mohamed [5], Ayman Ahmed [4,5,6]

1 Faculty of Medical Laboratory Sciences, University of Khartoum, Khartoum, Sudan.

2 Rufa'a Teaching Hospital

3 Sudan Field Epidemiology Training Program, Health Emergencies and Epidemics Control General Directorate, Sudan Federal Ministry of Health, Khartoum 11111, Sudan

4 Rwanda Biomedical Center (RBC), Kigali P.O. Box 7162, Rwanda

5 Pan-Africa One Health Institute (PAOHI), Kigali 11KG ST203, Rwanda

6 Institute of Endemic Diseases, University of Khartoum, Khartoum 11111, Sudan.

Correspondence: Ayman Ahmed; Institute of Endemic Diseases, University of Khartoum, Khartoum, Sudan.

Tel: +249123997091

Email: ayman.ame.ahmed@gmail.com

ORCID: 0000-0002-9516-9508.

Consent for Publication

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

Acknowledgments

None.

Funding:

None

Disclosure

The author reports no conflicts of interest in this work.

Key clinical message:

Healthcare providers in regions endemic with similar clinical manifestations' diseases must consider investigating co-infections. However, this should be implemented without increasing the socioeconomic burden on patients through subsiding laboratory test and integrating robust and cost-effective diagnostic tools. This should be supplemented by strengthening the differential diagnosis capabilities by improving the knowledge about the clinical presentation of endemic diseases.

Abstract:

Chikungunya and malaria are mosquito-borne diseases that impose considerable health burdens, particularly in endemic regions of Sub-Saharan Africa such as Sudan. This report details a case of co-infection in a 35-year-old male patient presenting with an 8-day history of fever, chills, rigors, vomiting, and musculoskeletal pain. Laboratory investigations confirmed infections with *Plasmodium falciparum* and Chikungunya virus. The overlap in clinical presentations of these diseases complicates diagnosis and treatment, highlighting the necessity for heightened clinical awareness and robust laboratory capabilities. Effective management of co-infections requires enhanced diagnostic infrastructure, improved awareness among healthcare providers, and integrated vector control strategies. This case underscores the importance of accurate diagnosis and tailored treatment protocols in regions where multiple vector-borne diseases coexist.

Keywords

Chikungunya; malaria; co-infection; Sub-Saharan Africa; diagnostic challenges; public health.

1 Introduction

Malaria and arboviral diseases including Chikungunya are major mosquito-borne diseases that challenge health system and pose substantial threats to human health, and socioeconomic stability and development, particularly in under-resourced endemic countries mainly in Africa [1 - 8]. The co-circulation and dual burden of both diseases is increasingly prevalent in Africa including Sudan, where the interplay of these infections exhausted the fragile health system, complicated diseases prevention and control as well as health outcomes of the local population [5, 9 - 18].

Malaria in human is mainly caused by one or more of five species of*Plasmodium* parasites, primarily transmitted by various species of Anopheles mosquitoes including *Anopheles arabiensis, An. funestus, An. pharoensis,* and *An. stephensi* [14, 19, 20].*Plasmodium falciparum* and *Plasmodium vivax* are the predominant species affecting the majority of humans at risk of malaria [21 - 23]. Conversely, Chikungunya fever result from infection with Chikungunya virus belong to alphavirus belong to the *Togaviridae* family, primarily spread by Aedes mosquitoes [24 - 26].

In tropical regions, the geographic distribution and transmission areas for these diseases frequently overlap, leading to a heightened risk of co-infections [1- 5, 27 - 30]. Several factors, including conflicts, climate change, globalization, urbanization, deforestation, and the establishment of agricultural settlements in peri-urban areas enhance the spread of invasive disease vectors and emergence of infectious diseases [31 - 38]. These factors increase the environmental suitability, population vulnerability, and health systems susceptibility to the emergence and development of diseases outbreaks [39 - 42].

Sudan, characterized by its diverse ecological zones, limited resources, and fragile health system, this increased the country vulnerability to wide range of endemic diseases [43 - 54]. Among these, malaria continues to be a leading cause of morbidity and mortality, and it's co-circulating with viral infections such as Hepatitis viruses and several arboviruses like dengue, Rift valley fever [30, 55 - 57]. The clinical presentations of these diseases frequently overlap, which eventually challenges the limited local diagnostic capacity [1,5,10,11, 30, 55].

In this communication, we present a case of Chikungunya and malaria co-infection in Sudan. Documenting challenges and best practices in investigating co-infection in high burden and limited resources country; Sudan. Through this case report, we aim to enhance awareness among healthcare providers and foster improved differential diagnosis and diagnostic protocols to coop up the rapidly growing prevalence and burden of infectious diseases.

2 Case History

A 35-year-old male from Kassala State presented in September 2024 with 8-day history of fever, chills, rigors, vomiting, and severe musculoskeletal pain. Upon examination, his temperature was 39.4°C, with a heart rate of 117 beats per minute (bpm), and hypotension evidenced by a blood pressure reading of 94/55 mmHg. The tourniquet test yielded a positive result, indicating a potential bleeding disorder.

3 Methods

A blood sample was collected for laboratory investigations to ascertain the cause of his symptoms. A peripheral blood smear identified both trophozoite and schizont stages of *Plasmodium falciparum* , confirming the involvement of malaria infection. Additionally, appreciating the epidemiological risk due to the endemicity and recent outbreaks of arboviruses in the area, a blood sample was collected and the patient was screened for arboviral diseases including dengue, Chikungunya, Yellow fever and Rift valley fever using RT-PCR. The result confirmed a concurrent infection with Chikungunya virus. While testing negative for other arboviral diseases. Additionally, the laboratory assessment showed thrombocytopenia, anemia, and lymphocytosis. Detailed laboratory results are presented in Table 1.

4 Conclusion and Results

To stabilize the patient's condition, he was hospitalized and administered a bolus of normal saline, which significantly improved his hemodynamic status. Continued hydration was maintained, and both clinical indicators and laboratory parameters began to show marked improvement. The treatment protocol included the initiation of artesunate injections at a dosage of 2.4 mg/kg/dose. The first injection was administered upon admission, followed by subsequent doses at 12 hours and 24 hours post-admission. This was followed by once-daily injections for three additional days, after which the patient transitioned to an oral regimen of an artemisinin-based combination therapy.

Two weeks post-discharge, the patient reported no residual symptoms, and follow-up laboratory tests indicated that all parameters had returned to normal ranges, confirming full recovery. This case underscores the complexity and importance of thorough diagnostic investigation in patients presenting with febrile illnesses, particularly in regions where multiple vector-borne diseases coexist.

5 Discussion:

We present a case of patient presented with 8 days history of fever accompanied by chills, rigors, vomiting, muscle and joint pain. Laboratory investigations confirmed coinfection with Chikungunya and malaria, specifically *Plasmodium falciparum* . Such malaria and Chikungunya co-infections are increasingly reported globally [5].

The co-infection of Chikungunya and malaria presents significant diagnostic and therapeutic challenges, particularly in endemic regions like Sudan, where both diseases are prevalent [2 - 5]. Clinically, the symptoms of these infections often overlap, leading to potential misdiagnosis and delayed treatment [5, 16, 29]. For instance, the presentation of fever, chills, and musculoskeletal pain can be indicative of both malaria and Chikungunya, complicating the clinical picture. This overlap necessitates heightened awareness among healthcare providers to distinguish between these conditions effectively [10,29,30,55]. Particularly that, modeling and evidence from the field have revealed the risk of arboviral diseases overgrown the burden of malaria in the area [58].

In addition to malaria and Chikungunya, other febrile illnesses, such as dengue fever, leptospirosis, and viral hemorrhagic fevers and typhoid fever, must also be considered in differential diagnoses [5,10,29,30,55].

This broad spectrum of potential conditions emphasizes the need for comprehensive clinical evaluations and robust diagnostic capabilities. Accurate diagnosis is critical, as misattributing the symptoms to one disease could lead to inadequate treatment, worsening the patient's condition and increasing mortality risks.

This case report highlights the importance of laboratory capacity in managing co-infections. Enhanced laboratory infrastructure with access to advanced diagnostic tools, such as RT-PCR, can significantly improve the accuracy and speed of diagnosis [2]. Investing in laboratory facilities and training personnel to conduct rapid and precise diagnostic tests is vital in mitigating morbidity and mortality associated with these infections. Such capacity building should focus on the identification of not only malaria and Chikungunya but also other endemic diseases that present similar clinical features.

For effective prevention and control of these mosquito-borne diseases, integrated vector management strategies are essential [39, 59, 61]. This approach should encompass environmental management to reduce mosquito breeding sites, public awareness campaigns about the symptoms and transmission vectors, and community engagement in control efforts [61,62]. Engaging the community through a One Health approach in improving the living environment, water sanitation and hygiene, and waste management is more sustainable and cost-effective strategy to prevent and control several risk factors and infections in limited resources settings [39,42, 57,63,64].

Additionally, collaboration between health authorities, research institutions, and non-governmental organizations is crucial in formulating evidence-based strategies to enhance surveillance and response capabilities to emerging health threats. Research efforts should also focus on vaccine development for Chikungunya and improved therapeutics for malaria to augment existing control measures.

In conclusion, addressing the dual burden of Chikungunya and malaria requires a multi-faceted approach that encompasses improved clinical awareness, enhanced diagnostic capabilities, and robust preventive measures. By fostering collaboration and investing in public health infrastructure, we can better manage these infections and ultimately reduce their impact on health systems in endemic regions like Sudan.

Consent for Publication

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

Authors' contributions

EES, ATH, YA, CMM, NM and AA contributed in the Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Supervision; Validation; Visualization; Writing – original draft and Writing – review & editing of final version.

Acknowledgments

None.

Funding:

None

Disclosure

The author reports no conflicts of interest in this work.

References:

1. **Raut CG, Rao NM, Sinha DP, Hanumaiah H, Manjunatha MJ. Chikungunya, dengue, and malaria co-infection after travel to Nigeria, India. Emerg Infect Dis. 2015 May;21(5):908-9.**

2. **Ahmed A, Dietrich I, LaBeaud AD, Lindsay SW, Musa A, Weaver SC. Risks and Challenges of Arboviral Diseases in Sudan: The Urgent Need for Actions. Viruses. 2020 Jan 9;12(1):81.**
3. **Ahmed A, Ali Y, Mohamed NS. Arboviral diseases: the emergence of a major yet ignored public health threat in Africa. Lancet Planet Health. 2020 Dec;4(12):e555.**
4. Ahmed A. Urgent call for a global enforcement of the public sharing of health emergencies data: lesson learned from serious arboviral disease epidemics in Sudan. Int Health. 2020 Jul 1;12(4):238-240.
5. Mala W, Wilairatana P, Kotepui KU, Kotepui M. Prevalence of Malaria and Chikungunya Co-Infection in Febrile Patients: A Systematic Review and Meta-Analysis. Trop Med Infect Dis. 2021 Jun 30;6(3):119.
6. Moizéis RNC, Fernandes TAAM, Guedes PMDM, Pereira HWB, Lanza DCF, Azevedo JWV, Galvão JMA, Fernandes JV. Chikungunya fever: a threat to global public health. Pathog Glob Health. 2018 Jun;112(4):182-194.
7. Mourad O, Makhani L, Chen LH. Chikungunya: An Emerging Public Health Concern. Curr Infect Dis Rep. 2022;24(12):217-228.
8. Claude Mambo Muvunyi, Jean Claude Semuto Ngabonziza, Noella Bigirimana, et al. Risk assessment, Preparedness, Prevention, and Response (PPR) framework for Yellow fever in Rwanda. Authorea. November 15, 2024. DOI: 10.22541/au.173167058.80703493/v1
9. Siddig EE, Ahmed A. When parasites stray from the path: a curious case of ectopic cutaneous Schistosoma haematobium. QJM. 2023 Oct 6;116(9):794-795. doi: 10.1093/qjmed/hcad112. PMID: 37255318.
10. Siddig EE, Mohamed NS, Ahmed A. Severe coinfection of dengue and malaria: A case report. Clin Case Rep. 2024 Jun 11;12(6):e9079.
11. Ahmed A, EL-SADIG SM, Eltigani H, Siddig E. Guillain-Barre syndrome associated with COVID-19 and malaria coinfection: a case report. Authorea Preprints. 2023 Mar 1. DOI: 10.22541/au.167767321.12356900/v1
12. Siddig EE, Misbah El-Sadig S, Eltigani HF, Musa AM, Mohamed NS, Ahmed A. Delayed cerebellar ataxia induced by Plasmodium falciparum malaria: A rare complication. Clin Case Rep. 2023 Oct 20;11(10):e8053.
13. Elagali A, Ahmed A, Makki N, Ismail H, Ajak M, Alene KA, Weiss DJ, Mohammed AA, Abubakr M, Cameron E, Gething P, Elagali A. Spatiotemporal mapping of malaria incidence in Sudan using routine surveillance data. Sci Rep. 2022 Aug 18;12(1):14114.
14. Altahir O, AbdElbagi H, Abubakr M, Siddig EE, Ahmed A, Mohamed NS. Blood meal profile and positivity rate with malaria parasites among different malaria vectors in Sudan. Malar J. 2022 Apr 15;21(1):124.
15. Rubuga FK, Moraga P, Ahmed A, Siddig E, Remera E, Moirano G, Cissé G, Utzinger J. Spatiotemporal dynamics of malaria in Rwanda between 2012 and 2022: a demography-specific analysis. Infect Dis Poverty. 2024 Sep 16;13(1):67.
16. Rubuga FK, Ahmed A, Siddig E, Sera F, Moirano G, Aimable M, Albert T, Gallican NR, Nebié EI, Kitema GF, Vounatsou P, Utzinger J, Cissé G. Potential impact of climatic factors on malaria in Rwanda between 2012 and 2021: a time-series analysis. Malar J. 2024 Sep 10;23(1):274.
17. Ali Mude AS, Nageye YA, Bello KE. Current Epidemiological Status of Chikungunya Virus Infection in East Africa: A Systematic Review and Meta-Analysis. J Trop Med. 2024 Oct 25;2024:7357911.
18. Bangoura ST, Sidibé S, Kaba L, Mbaye A, Hounmenou CG, Diallo A, Camara SC, Diaby M, Kadio KJO, D'Ortenzio E, Camara A, Vanhems P, Delamou A, Delaporte E, Keita AK, Ottmann M, Touré A, Khanafer N. Seroprevalence of seven arboviruses of public health importance in sub-Saharan Africa: a systematic review and meta-analysis. BMJ Glob Health. 2024 Oct 31;9(10):e016589.
19. Abubakr M, Sami H, Mahdi I, Altahir O, Abdelbagi H, Mohamed NS, Ahmed A. The Phylodynamic and Spread of the Invasive Asian Malaria Vectors, Anopheles stephensi, in Sudan. Biology (Basel). 2022 Mar 7;11(3):409. doi: 10.3390/biology11030409. PMID: 35336783; PMCID: PMC8945054.
20. Abdelwhab OF, Elaagip A, Albsheer MM, Ahmed A, Paganotti GM, Abdel Hamid MM. Molecular and morphological identification of suspected Plasmodium vivax vectors in Central and Eastern

Sudan. Malar J. 2021 Mar 4;20(1):132. doi: 10.1186/s12936-021-03671-9. PMID: 33663534; PMCID: PMC7934255.
21. Garcia LS. Malaria. Clin Lab Med. 2010 Mar;30(1):93-129. doi: 10.1016/j.cll.2009.10.001. PMID: 20513543.
22. Milner DA Jr. Malaria Pathogenesis. Cold Spring Harb Perspect Med. 2018 Jan 2;8(1):a025569.
23. Savi MK. An Overview of Malaria Transmission Mechanisms, Control, and Modeling. Med Sci (Basel). 2022 Dec 23;11(1):3.
24. Alguridi HI, Zaki EA, Hapuarachchi HC, Almalki SA, Alzahrani AA, Alsalem WS, Alzahrani FA, Altayb HN. Genetic characterization and phylogenetic analysis of Chikungunya Virus: A case from Jeddah during the COVID-19 Pandemic. IDCases. 2024 Oct 11;38:e02087.
25. Deregibus MI, Botana Rodríguez CB, Berberian G, Pérez G, Borgnia D, Rovetta M, Lavaze R, Bagnara EI, Martínez MB, Zlotogora A, Carrafancq J, Vázquez M, Melgarejo M, Jaciuk P, Amoedo DI. Clinical and epidemiological characteristics of children with mosquito-borne diseases in a tertiary hospital, Buenos Aires, Argentina, 2023. Arch Argent Pediatr. 2024 Oct 31:e202410415.
26. Gonzalez-Perez AL, Vazquez A, de Ory F, Negredo A, Plante KS, Plante JA, Palermo PM, Watts D, Sanchez-Seco MP, Weaver SC, Estrada-Franco JG. Outbreak of Chikungunya Fever in the Central Valley of Chiapas, Mexico. medRxiv [Preprint]. 2024 Oct 11:2024.10.09.24314897. doi: 10.1101/2024.10.09.24314897..
27. Ahmed A, Eldigail M, Elduma A, Breima T, Dietrich I, Ali Y, Weaver SC. First report of epidemic dengue fever and malaria co-infections among internally displaced persons in humanitarian camps of North Darfur, Sudan. Int J Infect Dis. 2021 Jul;108:513-516. doi: 10.1016/j.ijid.2021.05.052.
28. Rugarabamu S, Rumisha SF, Mwanyika GO, Sindato C, Lim HY, Misinzo G, Mboera LEG. Viral haemorrhagic fevers and malaria co-infections among febrile patients seeking health care in Tanzania. Infect Dis Poverty. 2022 Apr 25;11(1):33. doi: 10.1186/s40249-022-00959-z. PMID: 35462550; PMCID: PMC9036688.
29. Rugarabamu S, Mwanyika G, Rumisha SF, Sindato C, Lim H-Y, Misinzo G, et al. Seroprevalence of selected zoonotic viral haemorrhagic fevers and associated risk factors in Tanzania. Int J Infect Dis. 2021;109:174–181.
30. Ali Y, Siddig EE, Mohamed N, Ahmed A. Rift Valley fever and malaria co-infection: A case report. Clin Case Rep. 2023 Sep 18;11(9):e7926.
31. Ali Y, Siddig EE, Ahmed A. Resurgence of cholera amidst ongoing war in Sudan. Lancet. 2024 Nov 2;404(10464):1724-1725. doi: 10.1016/S0140-6736(24)02290-6. Epub 2024 Oct 17. PMID: 39427665.
32. Siddig EE, Eltigani HF, Ahmed A. Healing the unseen wounds: Sudan's humanitarian crisis traumatizing a nation. Asian J Psychiatr. 2023 Nov;89:103764. doi: 10.1016/j.ajp.2023.103764. Epub 2023 Sep 16. PMID: 37757540.
33. Alfadul ESA, Alrawa SS, Eltigani HF, Ahmed A, Siddig EE. The unraveling of Sudan's health system: catastrophic consequences of ongoing conflict. Med Confl Surviv. 2023 Dec;39(4):364-368.
34. Siddig EE, Eltigani HF, Ali ET, Bongomin F, Ahmed A. Sustaining hope amid struggle: The plight of cancer patients in Sudan's ongoing war. J Cancer Policy. 2023 Dec;38:100444.
35. Siddig EE, Eltigani HF, Ahmed A. Urgent call to protect children and their health in Sudan. BMJ. 2023 Aug 9;382:1799.
36. El-Sadig SM, El-Amin SO, El-Amin RO, Siddig EE, Ahmed A. Humanitarian crisis in Sudan: the collapsed health system threats the public and global health. QJM. 2023 Oct 6;116(9):810.
37. Ahmed A, Mohamed NS, Siddig EE, Algaily T, Sulaiman S, Ali Y. The impacts of climate change on displaced populations: a call for action. The Journal of Climate Change and Health. 2021 Aug 1;3:100057.
38. Ortiz DI, Piche-Ovares M, Romero-Vega LM, Wagman J, Troyo A. The Impact of Deforestation, Urbanization, and Changing Land Use Patterns on the Ecology of Mosquito and Tick-Borne Diseases in Central America. Insects. 2021 Dec 23;13(1):20.
39. Remera E, Rwagasore E, Muvunyi CM, Ahmed A. Emergence of the first molecularly confirmed outbreak of Rift Valley fever among humans in Rwanda, calls for institutionalizing the One Health strategy.

IJID One Health. 2024 Sep 1;4:100035.
40. Remera E, Rwagasore E, Nsekuye O, Semakula M, Gashegu M, Rutayisire R, Ishema L, Musanabaganwa C, Butera Y, Nsanzimana S, Muvunyi CM, Ahmed A. Rift Valley Fever Epizootic, Rwanda, 2022. Emerg Infect Dis. 2024 Oct;30(10):2191-2193. doi: 10.3201/eid3010.240264. PMID: 39320366; PMCID: PMC11431898.
41. Gashema P, Musafiri T, Ndahimana F, Iradukunda H, Saramba E, Nyakatswau ST, Gahamanyi N, Iradukunda PG, Ahmed A, Dzinamarira T, Muvunyi CM. Mpox in East Africa: Learning from COVID-19 and Ebola to Strengthen Public Health Responses. Viruses. 2024 Oct 8;16(10):1578. doi: 10.3390/v16101578. PMID: 39459912; PMCID: PMC11512314.
42. Muvunyi, C.M.; Ngabonziza, J.C.S.; Bigirimana, N.; Ndembi, N.; Siddig, E.E.; Kaseya, J.; Ahmed, A. Evidence-based guidance for One Health preparedness, prevention, and response strategy to Marburg virus disease outbreaks. Diseases 2024.
43. Ahmed A, El-Sadig SM, Siddig EE. Guillain-Barre syndrome associated with hepatitis E virus infection: A case report. Clin Case Rep. 2023 Aug 29;11(9):e7863. doi: 10.1002/ccr3.7863. PMID: 37655129; PMCID: PMC10465721.
44. Ahmed A, Ali Y, Mohamed NS, Zinsstag J, Siddig EE, Khairy A. Hepatitis E Virus Outbreak among Tigray War Refugees from Ethiopia, Sudan. Emerg Infect Dis. 2023 Feb;29(2):460-461.
45. Ahmed A, Ali Y, Salim B, Dietrich I, Zinsstag J. Epidemics of Crimean-Congo Hemorrhagic Fever (CCHF) in Sudan between 2010 and 2020. Microorganisms. 2022 Apr 28;10(5):928. doi: 10.3390/microorganisms10050928.
46. Mohamed NS, Osman HA, Muneer MS, Samy AM, Ahmed A, Mohammed AO, Siddig EE, Abdel Hamid MM, Ali MS, Omer RA, Elaagip AH. Identifying asymptomatic Leishmania infections in non-endemic villages in Gedaref state, Sudan. BMC Res Notes. 2019 Sep 11;12(1):566. doi: 10.1186/s13104-019-4608-2.
47. Ahmed A, El-Sadig SM, Eltigani HF, Bongomin F, Siddig EE. The first Helicobacter pylori-induced Guillain-Barré syndrome in Sudan. Clin Case Rep. 2023 Nov 14;11(11):e8204. doi: 10.1002/ccr3.8204.
48. Ortiz DI, Piche-Ovares M, Romero-Vega LM, Wagman J, Troyo A. The Impact of Deforestation, Urbanization, and Changing Land Use Patterns on the Ecology of Mosquito and Tick-Borne Diseases in Central America. Insects. 2021 Dec 23;13(1):20.
49. Tjaden NB, Suk JE, Fischer D, Thomas SM, Beierkuhnlein C, Semenza JC. Modelling the effects of global climate change on Chikungunya transmission in the 21st century. Sci Rep. 2017 Jun 19;7(1):3813.
50. Servadio JL, Rosenthal SR, Carlson L, Bauer C. Climate patterns and mosquito-borne disease outbreaks in South and Southeast Asia. J Infect Public Health. 2018 Jul-Aug;11(4):566-571.
51. Siddig EE, Aradaib IE, Ahmed A. A study of case management challenge for black grain eumycetoma during the ongoing war in Sudan. Clin Case Rep. 2024 Sep 16;12(9):e9438.
52. Mohamed NS, Ali Y, Siddig EE, Ahmed A. Assessment of the COVID-19 Surveillance System in Sudan: Performance, Limitations, and Recommendations. Am J Trop Med Hyg. 2024 Aug 13;111(5):1093-1096.
53. GBD 2021 Tuberculosis Collaborators. Global, regional, and national age-specific progress towards the 2020 milestones of the WHO End TB Strategy: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Infect Dis. 2024 Jul;24(7):698-725.
54. Abdallah ATH, Abdelkhalig RE, Hamid E, Ahmed A, Siddig EE. Recurrent abdominal wall mass in a hepatitis B-positive male: An unusual case of lumbar mycetoma. Clin Case Rep. 2023 Nov 30;11(12):e8275.
55. Elduma AH, LaBeaud AD, A Plante J, Plante KS, Ahmed A. High Seroprevalence of Dengue Virus Infection in Sudan: Systematic Review and Meta-Analysis. Trop Med Infect Dis. 2020 Jul 18;5(3):120. doi: 10.3390/tropicalmed5030120.
56. Elaagip A, Alsedig K, Altahir O, Ageep T, Ahmed A, Siam HA, Samy AM, Mohamed W, Khalid F, Gumaa S, Mboera L, Sindato C, Elton L, Zumla A, Haider N, Kock R, Abdel Hamid MM. Seroprevalence and associated risk factors of Dengue fever in Kassala state, eastern Sudan. PLoS Negl Trop Dis. 2020 Dec 9;14(12):e0008918. doi: 10.1371/journal.pntd.0008918.
57. Ahmed, A.; Ali, Y.; Ibrahim, N. A.; Mohamed, S. I.; Zinsstag, J.; Siddig, E. E.; Mohamed, N. S.;

Muvunyi, C. M. One Health Response for Rift Valley Fever Outbreak in Sudan. Preprints 2024, 2024081358. https://doi.org/10.20944/preprints202408.1358.v1

58. Mordecai EA, Ryan SJ, Caldwell JM, Shah MM, LaBeaud AD. Climate change could shift disease burden from malaria to arboviruses in Africa. Lancet Planet Health. 2020 Sep;4(9):e416-e423. doi: 10.1016/S2542-5196(20)30178-9.
59. Hemming-Schroeder E, Ahmed A. Anopheles stephensi in Africa: vector control opportunities for cobreeding An. stephensi and Aedes arbovirus vectors. Trends Parasitol. 2023 Feb;39(2):86-90. doi: 10.1016/j.pt.2022.11.011.
60. Ahmed A, Abubakr M, Ali Y, Siddig EE, Mohamed NS. Vector control strategy for Anopheles stephensi in Africa. Lancet Microbe. 2022 Jun;3(6):e403. doi: 10.1016/S2666-5247(22)00039-8.
61. Sande S, Zimba M, Nyasvisvo D, Mukuzunga M, Kooma EH, Mberikunashe J, Dube B. Getting ready for integrated vector management for improved disease prevention in Zimbabwe: a focus on key policy issues to consider. Malar J. 2019 Sep 23;18(1):322.
62. Dusfour I, Chaney SC. Mosquito control: Success, failure and expectations in the context of arbovirus expansion and emergence. In: Hall M, Tamïr D, editors. Mosquitopia: The Place of Pests in a Healthy World [Internet]. New York: Routledge; 2022. Chapter 14. Available from: https://www.ncbi.nlm.nih.gov/books/NBK585173/ doi: 10.4324/9781003056034-19
63. Siddig EE, Ahmed A. The urgent need for developing and implementing a multisectoral One Health strategy for the surveillance, prevention, and control of Eumycetoma. IJID One Health. 2024 Oct 22:100048.
64. Ahmed A, Mahmoud I, Eldigail M, Elhassan RM, Weaver SC. The Emergence of Rift Valley Fever in Gedaref State Urges the Need for a Cross-Border One Health Strategy and Enforcement of the International Health Regulations. Pathogens. 2021 Jul 13;10(7):885. doi: 10.3390/pathogens10070885.

Table legend:

Table 1. Demonstrated the laboratory investigations results done for the patient

Hosted file

`Table 1.docx` available at https://authorea.com/users/618000/articles/1242548-co-infection-with-chikungunya-and-malaria-a-case-report