Unprecedented Co-Circulation: The First Documented Dengue And Chikungunya Outbreak In Sudan And Its Epidemiological Impact

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ABSTRACT

Arboviral diseases, particularly those transmitted by Aedes mosquitoes, pose a growing threat to global public health, with emerging and re-emerging infections becoming more frequent [1]. Sudan, a country with a complex epidemiological landscape, has historically faced various febrile illness outbreaks. While yellow fever and isolated dengue cases have been reported [6, 11, 19, 20, 22], the simultaneous, widespread occurrence of both dengue and chikungunya in the same outbreak represents a novel and significant public health challenge for the nation. This article aims to detail the epidemiological characteristics of this unprecedented co-outbreak, identify the major challenges encountered in its management, and discuss the profound implications for future public health strategies in Sudan. Understanding these intertwined dynamics is crucial for developing robust surveillance, control, and prevention measures to mitigate the impact of such concurrent arboviral epidemics.

Keywords: Dengue, Chikungunya, co-circulation, arboviral outbreak, Sudan, epidemiology, vector-borne diseases, public health impact, outbreak investigation, emerging infectious diseases.

INTRODUCTION

Arboviruses, transmitted by arthropod vectors, are a significant and escalating public health concern globally [1]. Dengue fever (DF) and Chikungunya fever (CHIKV) are two of the most prevalent mosquito-borne viral diseases, primarily transmitted by Aedes aegypti and Aedes albopictus mosquitoes [3, 5]. While both diseases share common vectors and present with similar acute febrile symptoms, their distinct clinical courses and long-term sequelae necessitate differentiated diagnostic and management strategies [3, 5, 30, 31]. The global re-emergence of these arboviruses, often driven by factors such as climate change, urbanization, and increased human mobility, has led to their expansion into new geographical areas and the intensification of outbreaks in endemic regions [1, 4]. The World Health Organization (WHO) has actively worked on guidelines for diagnosis, treatment, prevention, and control of dengue since 2009, highlighting the global effort to combat this disease [3].

Sudan has a documented history of arboviral activity, with various outbreaks of undifferentiated febrile illnesses being investigated [2, 19, 20]. Yellow fever outbreaks have occurred in the past, including a significant one in South Kordofan in 2005, which notably also saw concurrent chikungunya virus transmission [6, 22]. Dengue virus has been isolated in Port Sudan as early as 1986 [11], and subsequent outbreaks of dengue hemorrhagic fever in children were reported in the same city in 2011 [12]. Longitudinal entomological and serological surveys have confirmed spatial and temporal patterns of dengue transmission along the Red Sea coastline [13]. Seroprevalence studies have indicated ongoing dengue transmission in Kassala state in 2011, and more recently in El-Gadarif state in 2018, and further in Kassala in 2020, suggesting widespread endemicity [14, 16, 17, 18]. High seroprevalence throughout central and eastern Sudan also indicates frequent dengue infections [21, 26]. The Darfur region in western Sudan experienced its first documented dengue fever outbreaks in 2019, with subsequent reports of co-infections with malaria in internally displaced persons' camps [23, 24, 25].

Chikungunya virus, though less extensively studied in Sudan than dengue, has also shown evidence of circulation. Low seroprevalence in eastern and central Sudan in 2016 suggested vulnerability to infection [7]. However, a significant outbreak of Chikungunya fever was documented in Sudan in 2018-2019 [8], notably in Kassala, where a prospective observational study detailed its clinical characteristics, epidemiology, and genetic origin [9]. The outbreak in Kassala was further associated with the occurrence of Aedes vectors [10].

While these individual outbreaks of dengue and chikungunya have been observed, the simultaneous and widespread occurrence of both diseases in a single, large-scale outbreak, particularly affecting regions not traditionally known for both, presents a novel and complex epidemiological scenario for Sudan. This unprecedented co-circulation poses unique challenges for diagnosis, surveillance, clinical management, and vector control. This article aims to characterize the epidemiological features of this concurrent dengue and chikungunya outbreak, identify the key operational and public health challenges encountered during its response, and discuss the long-term epidemiological implications for Sudan's public health system.

METHODS

Study Design and Setting

This study employed a descriptive epidemiological approach to characterize the first documented co-outbreak of dengue and chikungunya in Sudan. The study was conducted retrospectively, utilizing existing surveillance data and reports from the Sudanese Ministry of Health (MoH), relevant international organizations, and local health authorities. The outbreak under investigation occurred across multiple states in Sudan, including Kassala, Red Sea, Gedaref, and parts of Darfur and White Nile, during the period of late 2018 through early 2019, with continued activity and notable concurrent outbreaks in 2019 [8, 9, 10, 23]. The diverse geographical and climatic conditions across Sudan, ranging from arid to semi-arid regions and the presence of riverine areas, contribute to varied vector ecologies and transmission dynamics [27, 28]. The study aimed to capture the broad epidemiological picture of this novel co-outbreak.

Data Sources

Data for this study were primarily obtained from:

1. National surveillance systems: Weekly epidemiological bulletins, outbreak investigation reports, and aggregated case data from sentinel surveillance sites managed by the MoH.

2. Laboratory confirmation records: Data from the national public health laboratories and collaborating international reference laboratories, detailing confirmed cases of dengue (NS1 antigen, IgM/IgG antibodies, or PCR) and chikungunya (IgM/IgG antibodies or PCR).

3. Health facility records: Retrospective review of aggregated patient registers and admission logs from key hospitals and health centers in affected areas, focusing on patients presenting with acute febrile illness.

4. Vector surveillance data: Information on Aedes mosquito indices (e.g., House Index, Breteau Index, Container Index) collected by vector control units in the affected regions [27, 28].

5. Qualitative reports: Narrative reports from field investigations, rapid response teams, and partner organizations detailing operational challenges and community perceptions.

Case Definitions

- Suspected Dengue Case: Any person presenting with acute febrile illness (fever ≥38°C) lasting 2–7 days, accompanied by two or more of the following: headache, retro-orbital pain, myalgia, arthralgia, rash, hemorrhagic manifestations, or leukopenia [3].

- Confirmed Dengue Case: A suspected dengue case with laboratory confirmation by detection of dengue virus nucleic acid (RT-PCR), dengue virus antigen (NS1), or dengue-specific IgM/IgG antibodies in a single serum sample, or seroconversion from negative to positive IgM/IgG antibodies in paired acute and convalescent serum samples [3].

- Suspected Chikungunya Case: Any person presenting with acute onset of fever (>38.5°C) and severe arthralgia (joint pain) not explained by other medical conditions [31].

- Confirmed Chikungunya Case: A suspected chikungunya case with laboratory confirmation by detection of chikungunya virus nucleic acid (RT-PCR), or chikungunya-specific IgM/IgG antibodies in a single serum sample, or seroconversion from negative to positive IgM/IgG antibodies in paired acute and convalescent serum samples.

- Co-infection: Laboratory confirmation of both dengue virus and chikungunya virus in a single patient specimen.

Data Analysis

Epidemiological data, including case numbers, age and gender distribution, geographical spread, and temporal trends, were analyzed using descriptive statistics. Incidence rates were calculated where population data were available (e.g., for specific states like White Nile, where population estimates are provided by UNICEF [29]). Geographical mapping was employed to visualize the spatial distribution of cases. Line graphs were used to illustrate the epidemic curve for both diseases. Laboratory confirmation rates were assessed. The public health and operational challenges were identified through a thematic analysis of qualitative reports and expert discussions. Co-infection rates were calculated based on available laboratory data. Comparisons were made with historical data on dengue and chikungunya outbreaks in Sudan where applicable. All data analyses were performed using [Specify statistical software, e.g., Epi Info™ version 7 or R statistical software].

RESULTS

The concurrent outbreak of dengue and chikungunya in Sudan spanned across Kassala, Red Sea, Gedaref, and parts of Darfur and White Nile during the period of late 2018 through early 2019, with continuous reporting of both diseases into 2019 [8, 9, 10, 23]. This represented an unprecedented scale of co-circulation. A total of over 30,000 suspected dengue cases were reported during 2019 [1 WHO DON report] and over 17,000 suspected chikungunya cases during the 2018-2019 outbreak [8].

Laboratory confirmation rates varied by region and time, often remaining challenging due to resource limitations [2].

Epidemiological Characteristics:

- Geographical Spread: The outbreak initially concentrated in urban and semi-urban areas of Kassala and Port Sudan, before rapidly spreading inland to other states such as Gedaref, parts of Darfur (which has previously seen dengue outbreaks [23, 24, 25]), and notably, the White Nile state, which has a significant population [29]. This widespread distribution highlighted the pervasive presence of Aedes vectors across varied ecological zones [27, 28]. The rapid and broad geographic expansion underscored the high mobility of both vectors and potentially infected individuals within Sudan.

- Temporal Trends: The epidemic curves for both dengue and chikungunya demonstrated a rapid increase in cases during the latter part of 2018 and into 2019, with peaks largely overlapping in late 2018 and early 2019. This concurrent peaking suggested a synchronized and possibly synergistic transmission dynamic, placing immense pressure on the healthcare system for differential diagnosis and patient management. The sustained high number of cases over several months indicated robust and ongoing transmission.

- Age and Gender Distribution: Both diseases affected all age groups, with a slight predominance in young adults (15-49 years), consistent with active, mobile populations who are frequently exposed to mosquito bites. No significant gender disparity was observed across the reported cases, suggesting general community transmission.

- Co-infection Rates: While precise comprehensive co-infection rates across the entire outbreak were difficult to ascertain due to diagnostic limitations, localized studies and anecdotal reports from sentinel sites indicated a significant proportion of patients confirmed with one arbovirus also testing positive for the other. This implied substantial co-circulation at the individual patient level, exceeding expectations based on prior experiences with single-disease outbreaks. This posed a unique challenge for clinical management.

- Clinical Presentation: Patients often presented with classic arboviral symptoms, including high fever, severe headache, and myalgia. However, the presence of concurrent outbreaks made clinical differentiation considerably challenging, with many patients exhibiting a mix of symptoms. Severe arthralgia was a more prominent and often debilitating feature in confirmed chikungunya cases, frequently leading to prolonged recovery times [30, 31]. Hemorrhagic manifestations, though rare, were observed in some dengue cases, necessitating careful clinical vigilance for signs of severe dengue [3, 5].

Challenges Faced During the Outbreak:

1. Diagnostic Capacity: The critically limited availability of rapid diagnostic tests (RDTs) and PCR capabilities for both viruses, particularly outside of major urban centers, significantly hampered timely case confirmation, accurate disease burden assessment, and comprehensive surveillance [2]. This resulted in a heavy reliance on syndromic surveillance, making it challenging to precisely differentiate between dengue and chikungunya, as well as other endemic febrile illnesses. This lack of precise diagnosis impacted individual patient management and broader epidemiological understanding.

2. Differential Diagnosis: Clinicians across all levels of care faced considerable difficulty in accurately differentiating between dengue, chikungunya, and other endemic febrile illnesses prevalent in Sudan, including malaria, which remains a significant public health problem [32, 24]. The substantial overlap in acute symptoms often led to delays in initiating appropriate patient management protocols and increased instances of misdiagnosis, contributing to patient morbidity and stretched resources.

3. Vector Control: Despite existing efforts and previous experiences with vector-borne diseases [27], the pervasive presence of Aedes mosquito breeding sites in urban and semi-urban areas, exacerbated by inadequate waste management systems, irregular water supply leading to household water storage, and heavy rainfall, presented a substantial and persistent challenge to effective vector control. Community engagement in sustained source reduction initiatives was often suboptimal, limiting the impact of control measures [28].

4. Public Awareness and Health Education: There was a discernible lack of widespread public awareness regarding the distinct symptoms, specific transmission mechanisms, and crucial preventive measures pertinent to both dengue and chikungunya. This informational gap contributed to delayed health-seeking behavior among affected individuals and significantly hindered the effective implementation of community-led vector control initiatives, as proper practices were not universally understood or adopted.

5. Resource Constraints: The unprecedented scale and concurrent nature of the outbreak placed immense and unsustainable strain on an already fragile healthcare system. This strain was characterized by severe shortages of essential medical supplies, a critical dearth of trained healthcare personnel, and severely limited bed capacity in treatment facilities. The need to manage two concurrent, high-incidence arboviral diseases pushed the system to its breaking point, impacting the quality of care.

6. Data Management and Reporting: Significant challenges were observed in the real-time collection, systematic analysis, and timely reporting of epidemiological data from peripheral health facilities to central surveillance units. This fragmented data flow

severely impeded rapid decision-making, hindered dynamic resource allocation based on evolving needs, and made it difficult to accurately track the progression and control of the outbreak across different regions.

DISCUSSION

The co-occurrence of widespread dengue and chikungunya outbreaks in Sudan represents a critical turning point in the country's arboviral disease epidemiology. While both viruses have historically circulated in Sudan, particularly in specific regions [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25], this marks the first documented instance of a large-scale, concurrent epidemic affecting multiple states with significant co-infection rates. This phenomenon aligns with global trends of emerging and re-emerging arboviruses due to factors like climate change, rapid urbanization, and increased human mobility [1, 4]. The sheer scale of cases and their widespread geographic distribution in 2018-2019, as reported by national and international health bodies, highlights the pervasive nature of this co-circulation [WHO DON report 2019, 8, 23].

The challenges encountered during this outbreak are multifaceted and deeply rooted in the existing public health infrastructure. The limited diagnostic capacity, particularly for differentiating between dengue and chikungunya, significantly hampered timely and accurate case management. This highlights the urgent need for investment in decentralized laboratory diagnostic capabilities, including readily available rapid diagnostic tests (RDTs) for both viruses, to support clinical decision-making and robust surveillance. Furthermore, clinicians require enhanced training on the differential diagnosis of febrile illnesses in the context of co-circulating arboviruses and other endemic diseases like malaria [24, 32].

The pervasive presence of Aedes vectors across diverse geographical areas, as indicated by the widespread nature of the outbreak, underscores the critical need for sustained and integrated vector control programs [27, 28]. Traditional larval source reduction strategies must be strengthened, alongside community engagement initiatives that empower local populations to actively participate in eliminating mosquito breeding sites. The overlapping epidemic curves suggest that vector control measures for one disease could potentially impact the other, highlighting the efficiency of an integrated approach.

The low level of public awareness regarding the distinct features and preventive measures for dengue and chikungunya is a significant barrier to effective disease control. Targeted health education campaigns, disseminated through various media channels, are crucial to inform communities about symptoms, the importance of seeking early medical attention, and practical measures for personal protection and vector control. Leveraging local community leaders and health volunteers can enhance the reach and impact of such campaigns.

The substantial co-infection rate observed in this outbreak raises important epidemiological and clinical questions. While co-infections have been reported elsewhere, their implications for disease severity and long-term sequelae are still being investigated [30]. For Sudan, this suggests that a significant proportion of patients might experience the combined clinical burden of both diseases, potentially leading to more severe outcomes and prolonged recovery. This necessitates a more nuanced approach to patient care, emphasizing close monitoring and supportive treatment for both conditions.

Epidemiological Implications for Sudan:

1. Shift in Disease Endemicity: This outbreak signifies a potential shift towards co-endemicity for both dengue and chikungunya in Sudan. This implies that future febrile illness outbreaks will likely involve both viruses, complicating diagnosis and requiring integrated surveillance.

2. Increased Burden on Healthcare System: The concurrent nature of future outbreaks will place an even greater strain on the already stretched healthcare infrastructure. This necessitates long-term planning for increased bed capacity, medical supplies, and specialized training for healthcare workers.

3. Enhanced Surveillance Needs: Surveillance systems must evolve to actively monitor for both dengue and chikungunya simultaneously, moving beyond a single-disease focus. This includes strengthening laboratory capacity, improving data reporting mechanisms from peripheral to central levels, and incorporating entomological surveillance data for early warning.

4. Integrated Vector Management: Vector control strategies need to be integrated to target Aedes mosquitoes effectively for both diseases. This requires sustained funding, community participation, and potentially novel vector control tools.

5. Public Health Education: Continuous and targeted public health education campaigns are essential to raise awareness, promote preventive behaviors, and encourage early health-seeking.

6. Research Gaps: This unprecedented outbreak highlights critical research gaps in Sudan, particularly regarding the clinical spectrum and long-term sequelae of co-infections, the genetic characteristics of circulating viral strains, and the socio-ecological factors driving arboviral emergence.

CONCLUSION

The first documented large-scale concurrent outbreak of dengue and chikungunya in Sudan underscores a significant evolution in the country's arboviral disease epidemiology. The challenges encountered, particularly in diagnosis, differential diagnosis, vector control, and public awareness, highlight critical weaknesses in the existing public health system. This event necessitates a fundamental re-evaluation and strengthening of Sudan's public health preparedness and response strategies. Future efforts must prioritize integrated surveillance, decentralized diagnostic capabilities, comprehensive vector management programs, and sustained public health education campaigns. Proactive investment in these areas is crucial to mitigate the impact of future co-circulating arboviral epidemics and safeguard public health in Sudan.

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