POLICY BRIEF

Integrating Climate Information into Meningitis Preparedness in West Africa: Insights from Saharan Dust and Large-Scale Atmospheric Drivers

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Main Highlights

- Saharan dust and BM incidence are strongly correlated. Peaks in PM10 concentrations, low humidity, and high temperature precede meningitis outbreaks by 2 to 4 weeks, especially in the Sahelian zone.
- ENSO influence West African dust variability through modulation of synoptic systems. During El Niño, weakened Azores High and reduced pressure gradients lead to lower dust activity. During La Niña or positive NAO phases, the Azores High strengthens, intensifying dust transport. In addition, due to the Siberian High enhancing the north-south pressure gradient during winter, Harmattan wind strength increases and promotes dry, dusty airflow over the region.
- Predictive models using climate and environmental variables provide early warning with 2–3 weeks lead time. Machine learning models like Machine learning models like XGBoost in Nigeria, CatBoost in Burkina Faso) highlight vaccination, RH, and meridional wind as the most influential predictors across countries.

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1. Background

Meningitis is an inflammation of the meninges (brain and spinal cord coverings), caused mainly by *Neisseria meningitidis (Nm)*, *Streptococcus pneumoniae*, *Haemophilus influenzae* type B *(WHO, 2024).*

Bacterial Meningitis (BM) is one of the deadliest infectious diseases in Africa. It can cause death in less than 24 hours.

BM has a rapid onset that leads to death in roughly 1 in 6 cases. Those that survive often suffer from mental retardation, deafness, epilepsy, paralysis, or cognitive impairment, as well as limb amputation and skin scarring.

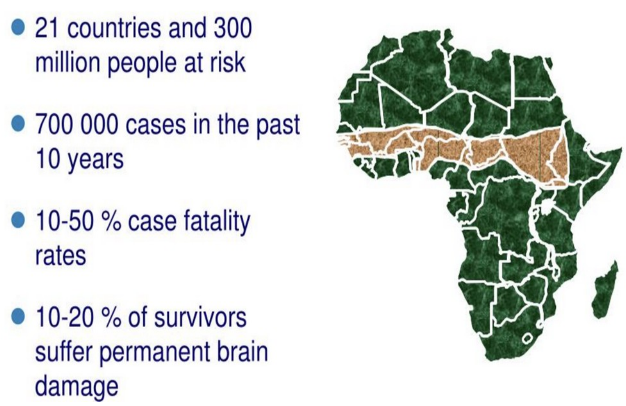

Fig. 1: African meningitis belt. Source: **WHO**

BM is a major public health concern
- 4th leading cause of neurological disorder burden globally

2nd leading cause of neurological disorders in sub-Saharan Africa.

Inequity and Vulnerability

Disproportionately affects vulnerable populations, which amplifies existing health disparities in low-resource settings.

Future Outlook Without Action
- By 2030, BM is projected to:
- Cause ~360,000 deaths
- Disable ~400,000 people globally*(WHO,2024).*

BM is also an airborne and seasonal disease highly influenced by environmental factors especially dust, RH and temperature during the dry season. These factors can dry out the mucous membranes of the nose and throat, making it easier for bacteria to invade the bloodstream. Within Climate change has the potential to exacerbate these risks. Rising temperatures, increased frequency and duration of dry spells, dust storms, and extreme weather events are expected to further influence disease dynamics in West Africa. Fine particles suspended in the air can irritate the respiratory tract and compromise the immune system, while increasing ambient ozone concentrations may aggravate respiratory health conditions. In 2016, WHO estimated that ambient air pollution caused approximately 456,000 deaths in West Africa alone. Globally, nearly 9 million deaths were linked to air pollution in 2020 accounting for 12% of all recorded deaths.

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Northern Africa is recognized as the largest global source of mineral dust, contributing about 60% of the world's annual aerosol load. During the dry season, dust plumes transported by the Harmattan reach the Gulf of Guinea and surrounding regions, resulting in persistently dusty and dry environmental conditions (Senghor et al., 2016; Diop et al., 2022). These conditions align closely with the peak meningitis season across the West African Meningitis Belt.

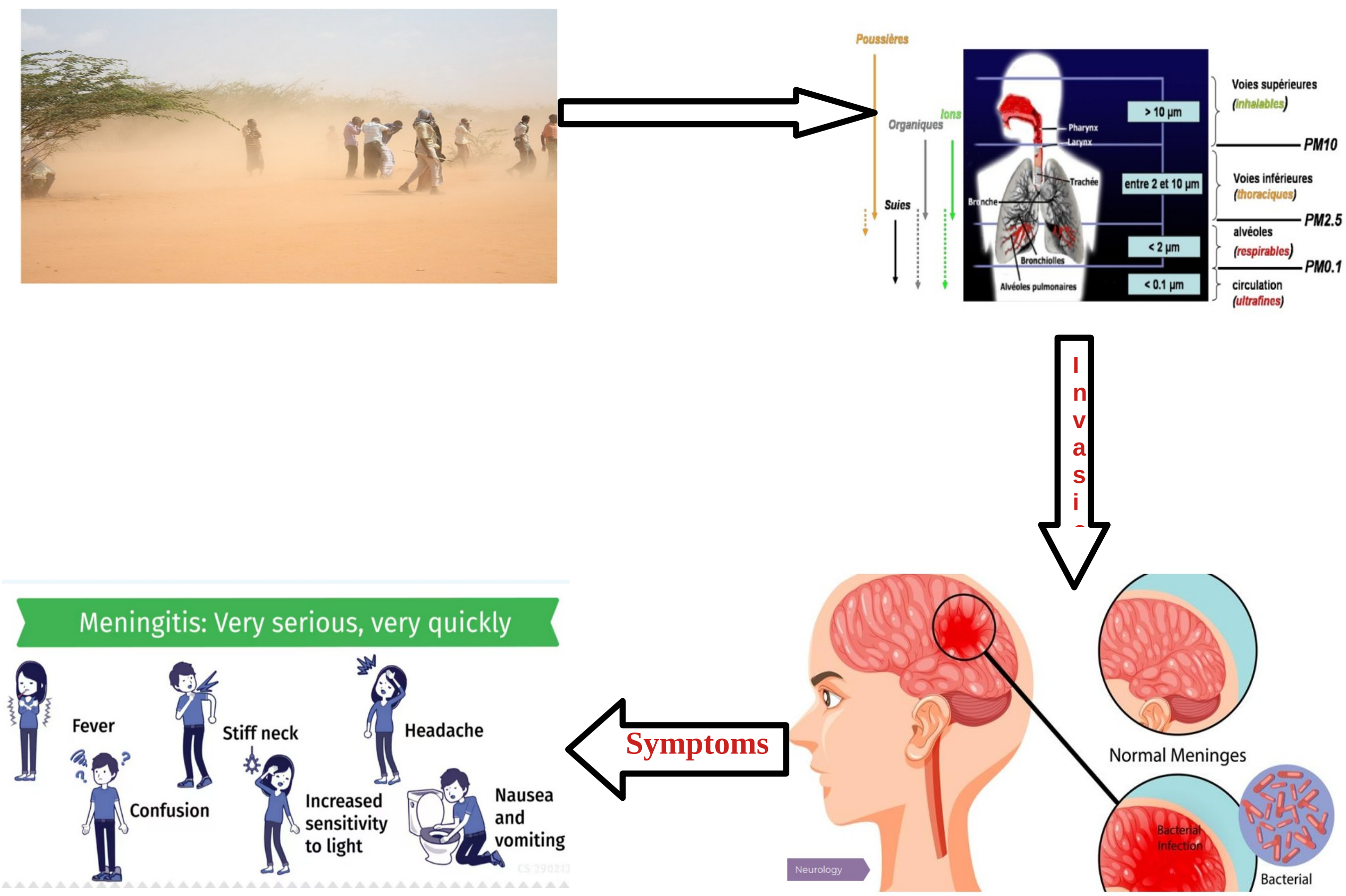

Fig. 2: Mechanism of dust influencing BM
Source: **google**

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2. **Operational Recommendations**

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- ✓ **Operationalize climate-informed early warning systems:** Ministries of Health should incorporate dust and climate forecasts into meningitis preparedness strategies, especially between January and April.
- ✓ **Strengthen cross-sector collaboration:** Promote partnerships between meteorological agencies (e.g., ACMAD, national met services) and public health institutions to enable routine data sharing and joint decision-making.
- ✓ **Use ENSO monitoring to guide risk anticipation:** Incorporate these indices into seasonal outlooks to assess regional vulnerability to meningitis outbreaks.
- ✓ **Build capacity for regional disease-climate modeling:** Invest in training programs and regional modeling centers that apply machine learning and statistical models to forecast meningitis risk.
- ✓ **Support open-access platforms for climate-health analytics:** Establish a shared regional platform where climate and health data can be visualized, accessed, and used collaboratively by stakeholders.

3. Community and Stakeholder Sensitization

To ensure effective implementation of climate-informed meningitis preparedness, active sensitization and engagement are essential:

3.1 Community Level:

- **How:** Conduct awareness campaigns using local media, health workers, and community leaders to explain how seasonal climate conditions (e.g., dust, dry air) relate to meningitis risk.
- **Impact:** Improves early health-seeking behavior, encourages timely vaccination, and fosters local ownership of prevention efforts.

3.2 Health System:

- **How:** Organize training workshops and provide operational guidance for health personnel on integrating climate indicators (e.g., RH, dust forecasts) into outbreak preparedness.
- **Impact:** Builds capacity for anticipatory action and improves response effectiveness.

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3.3 Stakeholders and Decision-Makers:

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- **How:** Share tailored policy briefs, organize stakeholder roundtables, and create decision-support tools linking climate data to public health outcomes.
- **Impact:** Informs evidence-based planning, strengthens multi-sectoral coordination, and ensures policy alignment across climate and health domains.

Stakeholders and Decision-Makers:

4. Conclusion

Climate variability, especially as expressed through large-scale systems such as ENSO and NAO, plays a significant role in shaping the environmental conditions that drive meningitis outbreaks in West Africa. The predictive power of dust, wind, temperature, and humidity variables when combined with teleconnection indicators offers a critical window of opportunity for anticipatory action. By integrating climate intelligence into early warning systems, West African countries can shift from reactive outbreak response to proactive epidemic prevention, ultimately reducing disease burden and saving lives.

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ACKNOWLEDGEMENT

Source: This policy brief is produced as part of the Doctoral Research Program on Climate Change and Climate Systems, WASCAL hosted by the Department of Meteorology and Climate Science of the Federal University of Technology, Akure, Nigeria. This thematic is aligned with the Sustainable Development Gold (SDG3: Good Health and well being and the SDG13: Climate Action). This thesis research has been realised with the financial assistance from the Federal Ministry of Education and Research (BMBF), Germany through WASCAL PhD programme and the Universidad Complutense de Madrid through ERASMUS+.

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