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Climate change, migration, and infectious disease vulnerability at Europe's southern border: Lampedusa as a sentinel interface

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ABSTRACT

Background: The Mediterranean basin is warming faster than the global average, reshaping ecological niches for vector-borne, water-borne, and environmentally linked pathogens. Concurrent climate shocks across the Sahel, West Africa, and the Horn of Africa—combined with conflict, food and water insecurity, and fragile health systems—drive sustained mobility toward North Africa and Europe. Frontline entry points along the Central Mediterranean route often capture early clinical signals of these pressures.

Methods: We conducted a narrative, expert-informed evidence synthesis integrating peer-reviewed literature and institutional reports from WHO, ECDC, UNHCR, IOM, MSF, IPCC, and MedECC published between 2000 and 2025. We reviewed climate-sensitive pathogen dynamics in the Euro-Mediterranean region, infectious disease burdens in major regions of origin, transit-related exposures, and clinical patterns observed at first medical contact. Evidence was synthesised into a Climate–Migration–Infection sentinel framework.

Findings: Mediterranean warming increases ecological suitability for *Aedes* mosquitoes, intensifies West Nile virus activity, and promotes *Vibrio* proliferation. Climate shocks in regions of origin are associated with higher burdens of malaria, cholera, meningococcal disease, respiratory and dermatological infections, and antimicrobial resistance. Transit through North African hubs amplifies vulnerability through overcrowding, unsafe water, malnutrition, trauma, and disrupted access to care. Clinical presentations at first European entry points reflect cumulative deprivation and pose a generally low public-health risk to Europe under typical post-arrival conditions.

Interpretation: Central Mediterranean entry points such as Lampedusa function as sentinel interfaces for climate-driven infectious vulnerability. Strengthening syndromic surveillance and climate-informed preparedness at these sites could enhance early-warning capacity at Europe's southern border.

1. Summary box

- Climate change in the Mediterranean increases the ecological suitability for vector-borne, water-borne and environmentally linked infectious diseases.
- Migrants arriving at frontline Central Mediterranean entry points reflect cumulative vulnerability from climate shocks, fragile health systems and hazardous transit conditions rather than the importation of novel pathogens.
- The most frequent clinical presentations at first medical contact include skin infections, scabies, respiratory illness, gastroenteritis and dehydration, with negligible public-health risk to Europe.
- Frontline islands such as Lampedusa function as sentinel interfaces where climate-driven health instability becomes clinically visible earlier than in mainland Europe.
- Strengthening syndromic surveillance and diagnostic capacity at frontline islands could enhance Europe's climate-informed early-warning systems.

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2. Introduction

Climate change is accelerating across the Euro-Mediterranean region, reshaping ecological niches for vector-borne, water-borne and environmentally linked pathogens at rates exceeding global averages [1–3]. Rising sea-surface temperatures, marine heatwaves and altered precipitation patterns are increasing ecological suitability for *Aedes* mosquitoes, intensifying West Nile virus circulation and promoting *Vibrio* proliferation in coastal waters [4–6]. These trends are consistent with European regional assessments documenting increasing climate vulnerability across southern Europe [3].

Concurrently, populations across the Sahel, West Africa and the Horn of Africa face intersecting pressures—including drought, extreme heat, food insecurity, conflict and fragile health systems—that drive sustained mobility toward North Africa and Europe [7–11,12]. Migration along the Central Mediterranean route frequently occurs under conditions of disrupted healthcare, malnutrition, overcrowding, unsafe water and trauma, shaping health vulnerability long before arrival and influencing clinical presentations more than any risk of importing novel pathogens [10] [13,14].

Frontline entry points along the Central Mediterranean represent interfaces where climate instability, mobility dynamics and health-system fragility converge. Lampedusa, geographically closer to Tunisia than mainland Italy, exemplifies this convergence. Despite high arrival volumes, such settings often have limited diagnostic capacity and minimal structured infectious-disease surveillance; beyond targeted scabies screening, systematic assessment for tuberculosis, febrile or respiratory syndromes is uncommon [15,16,17]. Chronic overcrowding and rapid turnover further hinder early detection [18,19].

Although climate-sensitive risks and migration-related vulnerabilities are widely recognised, few frameworks integrate climate shocks, upstream epidemiology and transit exposures to explain clinical patterns observed at first medical contact.

This Analysis aims to develop a conceptual and operational framework integrating climate-driven ecological changes, migration-related exposures, and clinical syndromes observed at first medical contact, in order to interpret frontline health signals at Europe's southern border. Specifically, we propose the concept of a “sentinel interface” as a clinically grounded model linking upstream environmental pressures with downstream healthcare presentations, providing a basis for future operationalisation and empirical evaluation.

3. Methods

3.1. Study design

This study is a narrative, expert-informed Analysis aimed at integrating climate, epidemiological, and migration-health data into a conceptual Climate–Migration–Infection Sentinel Model. This approach was selected because the heterogeneous nature of climate-sensitive infectious diseases, migration flows, and transit conditions precludes the feasibility of a formal systematic review or meta-analysis and is consistent with the objectives of an Analysis article, which aims to integrate heterogeneous evidence and generate clinically relevant frameworks rather than to provide exhaustive or quantitative synthesis.

3.2. Search strategy and data sources

We conducted a structured literature search of peer-reviewed publications between January 1, 2000, and March 1, 2026 across PubMed, Embase, Scopus, and Web of Science. The detailed search strategy, including full search strings and keyword combinations, is provided in Supplementary Material 1.

To complement academic literature and capture epidemiological and operational data not consistently represented in peer-reviewed sources, institutional reports from WHO, ECDC, UNHCR, IOM, MSF, IPCC, and MedECC were incorporated. Reference lists of key publications were manually screened to identify additional relevant sources.

3.3. Eligibility criteria and study selection

Eligible sources included epidemiological studies, modelling analyses, environmental assessments, migration-health surveys, and clinical or public-health reports describing climate-sensitive infectious risks, epidemiological patterns in regions of origin, transit-related exposures, or health conditions at arrival in Mediterranean entry points.

Peer-reviewed studies were prioritised when available. Grey literature was included when providing unique contextual, epidemiological, or operational insights not captured in academic publications, particularly in migration and humanitarian settings.

Conference abstracts, non–peer-reviewed commentary, and unpublished reports were excluded unless offering essential contextual or epidemiological information.

3.4. Data synthesis and analytical approach

Data were synthesised qualitatively to map converging climate-related, epidemiological, and mobility determinants and to interpret their clinical expression at Europe's southern border. Rather than extracting predefined quantitative outcomes, evidence was synthesised across disciplines to construct an analytical framework linking upstream determinants with clinical presentations at first medical contact.

The expert-informed component was based on the multidisciplinary clinical and operational experience of the authors, including intensivists, emergency physicians, and specialists involved in frontline and migrant health care. Evidence interpretation and synthesis were conducted through iterative discussion and consensus.

When findings from different sources were inconsistent, priority was given to higher-quality peer-reviewed studies and large institutional datasets, with discrepancies resolved through group discussion.

3.5. Risk of bias and limitations of the approach

A formal risk-of-bias assessment was not conducted, as the aim of this Analysis was to integrate heterogeneous evidence into a conceptual and clinically interpretable framework rather than to estimate pooled quantitative effects. To minimise selection bias, we prioritised high-quality sources and triangulated findings across multiple data streams.

3.6. Role of lampedusa in the analysis

Lampedusa is used as an illustrative sentinel setting rather than an empirical case study, due to the absence of systematic and publicly available epidemiological or clinical datasets. Its role in this Analysis is to provide a clinically relevant interface where upstream climate and migration-related determinants become observable at first medical contact.

3.7. Patient and public involvement

Patients and members of the public were not involved in the design, conduct, reporting or dissemination plans of this research. This study is based on secondary analysis of published literature and institutional reports, with no primary data collection involving patients or the public.

4. Climate-sensitive infectious risks in the euro–Mediterranean region

The Mediterranean basin is one of the world's fastest-warming climate hotspots, with temperatures rising 20% faster than the global mean [1–4]. Rapid warming, recurrent marine heatwaves and sea-surface temperature anomalies are reshaping ecological niches for

vector-borne, water-borne and environmentally linked pathogens [3–6] [20]. These dynamics form the ecological backdrop for interpreting clinical presentations in high-turnover settings such as Lampedusa.

4.1. Vector-borne diseases in a warming mediterranean

Rising temperatures, prolonged warm seasons and altered precipitation patterns have expanded the range and activity of *Aedes albopictus* and *Aedes aegypti*, enabling autochthonous dengue, chikungunya and Zika transmission in previously low-risk areas [5,6] [21,22].

4.1.1. Aedes expansion and arboviruses

Aedes albopictus is now established across Italy, including Sicily and the Pelagie Islands, supported by warmer winters [5] [21,22]. Autochthonous dengue outbreaks in France, Italy and Spain indicate increasing climate-mediated receptivity [6] [20]. Further expansion of *Aedes* suitability, and possible introduction of *A. aegypti*, is projected [21].

4.1.2. West Nile virus

WNV transmission has intensified across southern and eastern Europe; higher temperatures accelerate viral replication in *Culex* vectors and shorten the extrinsic incubation period, amplifying transmission during heatwaves [21,23]. The severe 2018 Italian season highlights climate-driven shifts in WNV epidemiology [23].

4.1.3. Other arboviruses

Chikungunya outbreaks in Italy show *A. albopictus* can sustain transmission under favourable conditions [20]. Zika has not circulated sustainably in Europe, but warming increases theoretical receptivity [6] [21].

4.2. Environmental and water-borne bacteria under rapid warming

Rapid shifts in sea-surface temperature, salinity and hydrological stability affect environmentally linked bacteria, particularly relevant for coastal islands such as Lampedusa [1–3].

4.2.1. Vibrio species

Vibrio spp. proliferate in warm, stratified waters. Exceptional marine heatwaves have been associated with increased detection and sporadic cases along Italian coasts [24,25]. Elevated temperatures near Lampedusa raise theoretical concern for wound infections in individuals with skin lesions.

4.2.2. Enteric pathogens

Heatwaves accelerate replication of Salmonella and Campylobacter and contribute to seasonal peaks [26,27]. Seasonal amplification of infectious diseases under warming conditions has been widely described, particularly for enteric and vector-borne pathogens [27]. Heavy rainfall and flooding increase water contamination, elevating outbreak risk [26], intersecting with migration conditions where hygiene is limited.

4.2.3. Legionella

Warmer temperatures and humidity fluctuations favour *Legionella* proliferation; seasonal increases in Legionnaires' disease correlate with warming across the Mediterranean[27].

4.3. Climate–AMR interactions

Climate change may accelerate antimicrobial resistance through increased bacterial replication, altered water systems and extreme weather-driven dissemination [28–32]. Southern European studies link warmer seasons to higher detection of resistant *Salmonella*, *Campylobacter* and *E. coli* [3] [32,33]. Flooding and wastewater overflows disperse resistant organisms, whereas drought concentrates contaminants [26] [31,32].

Migration itself does not drive AMR; however, interrupted treatments, irregular antibiotic access, overcrowding and poor sanitation along the Central Mediterranean route may facilitate colonisation with resistant Enterobacterales, including ESBL-producing strains [10] [13] [29] [31].

In this context, these pathways are better supported at the level of colonisation and exposure risk, whereas broader climate–AMR interactions remain more difficult to demonstrate at first medical contact in Mediterranean entry points.

4.4. Implications for southern Italy and lampedusa

Southern Italian islands such as Sicily, Pantelleria and Lampedusa are micro-environments where climatic trends, high turnover and limited infrastructure converge. Warmer winters, elevated humidity and abundant container habitats support *Aedes* proliferation, while high sea temperatures and modest wastewater infrastructure may increase exposure to environmental bacterial hazards.

These climatic pressures converge along migration routes, shaping vulnerability before arrival (Fig. 2). Although no autochthonous arboviral transmission has been detected in Lampedusa, its climatic suitability, limited surveillance and rapid turnover position it as an early-warning hotspot for climate-sensitive infectious risks.

5. Determinants before arrival

5.1. Overview of migrant demographics and flows toward lampedusa

The Central Mediterranean route is one of the world's most active migration corridors, linking the Sahel, West Africa and the Horn of Africa to North Africa and southern Europe [7] [12] [9]. In 2023, Italy recorded 157,652 sea arrivals, with roughly two-thirds disembarking in Lampedusa; although arrivals declined to about 50,000 in 2024, the island remained the primary landing site due to its proximity to Tunisia and Libya [UNHCR Operational Data Portal] [8]. Lampedusa therefore operates beyond its infrastructural capacity as the first European entry point for departures from North Africa [9,10].

5.1.1. Trajectory and scale of arrivals

Between 2015 and 2025, arrival numbers fluctuated with conflict dynamics in Libya, changing transit-country policies and climate-related agricultural losses in the Sahel [9] [34]. Despite this variability, movement toward Europe has persisted, with episodic surges regularly overwhelming reception and triage systems.

5.1.2. Demographic profile

Most arrivals are young adult men, though increasing numbers of women, unaccompanied minors and individuals with chronic conditions have been documented [10] [13,14]. Many reach Lampedusa with dehydration, malnutrition, untreated illness or stress-related symptoms acquired during prolonged transit, reflecting structural vulnerability rather than heightened infectious risk.

5.1.3. Climate as a driver of mobility

Recurrent droughts, heatwaves, crop failures and desertification in the Sahel and Horn of Africa increasingly contribute to displacement and onward movement toward North Africa [9] [13] [34], amplifying socioeconomic and political pressures underlying migration.

5.1.4. Transit conditions and health vulnerability

Overcrowding, inadequate sanitation, limited water access and fragmented medical care in Libya or Tunisia shape the respiratory, dermatologic, enteric and wound-related infections observed at arrival [10] [13,14].

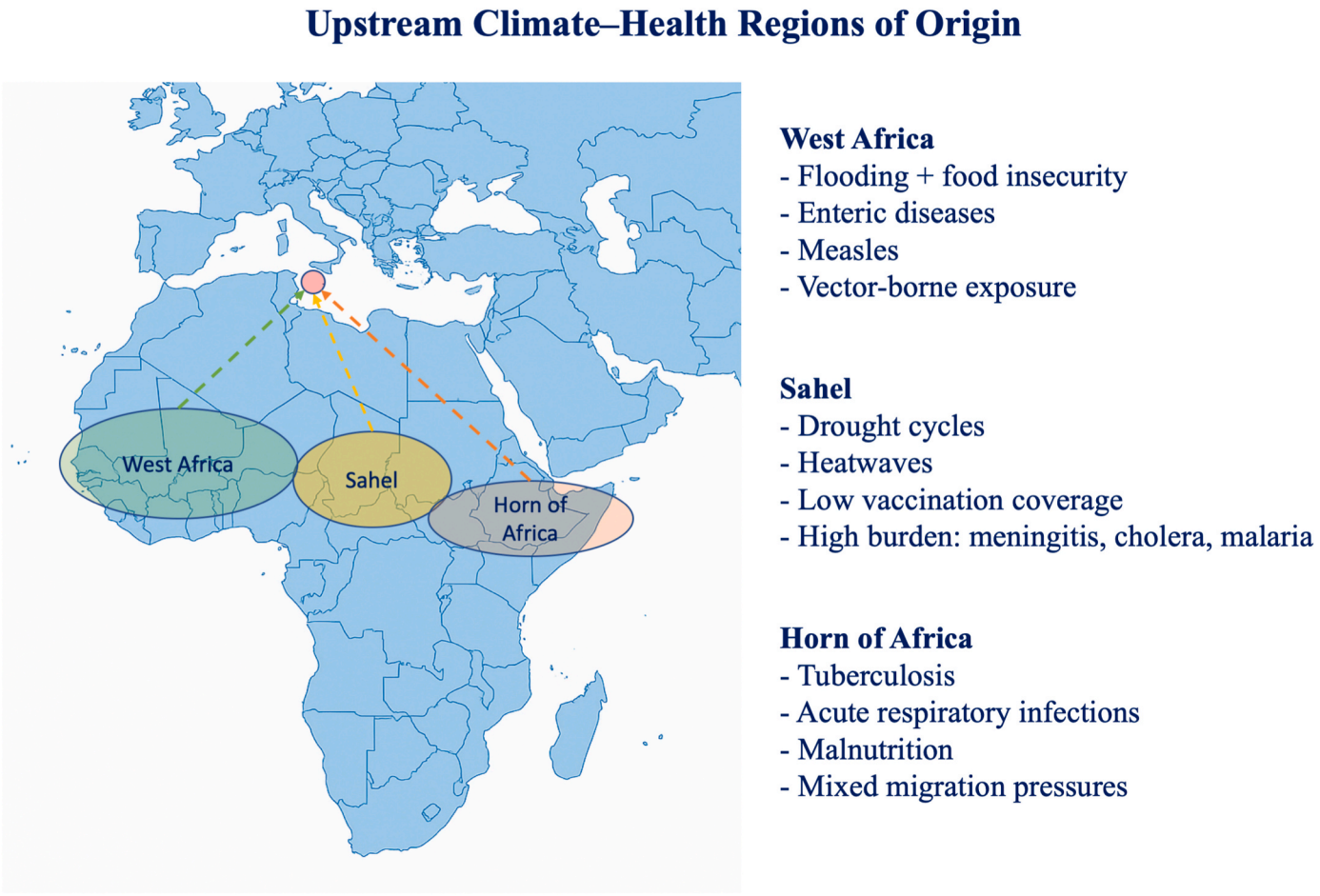

Fig. 1. Upstream climate–health regions of origin for migrants arriving in Lampedusa.
The figure highlights three climate-sensitive regions—Sahel, West Africa, and the Horn of Africa—where recurrent drought, extreme heat, flooding, and changing vector ecology interact with fragile health systems to shape baseline vulnerability before migration. These upstream conditions contribute substantially to the clinical profiles observed on arrival in Lampedusa, reflecting cumulative environmental and structural stressors rather than the introduction of novel infectious threats.

5.1.5. Implications for screening and surveillance

The scale and complexity of arrivals challenge structured health screening. Current triage prioritises dermatologic conditions such as scabies, with limited capacity to detect respiratory, gastrointestinal or febrile illnesses [12,35]. Strengthened early-detection and syndromic-surveillance systems are essential for interpreting health signals at Europe's southern frontier.

5.2. Geographical origin and epidemiological patterns

Migrants arriving in Lampedusa predominantly originate from the Sahel, West Africa, the Horn of Africa and North African transit countries—regions marked by climate instability, conflict, fragile health systems and limited vaccination coverage [7,8] [13] [34]. These epidemiological patterns differ substantially across regions and are shaped by local climate conditions, conflict dynamics, and health-system capacity. These upstream determinants are essential for interpreting clinical presentations at arrival (Fig. 1).

A] Sahel and West Africa

Countries such as Mali, Burkina Faso, Niger and Guinea experience recurrent extreme heat, drought, food insecurity, vector proliferation and weak surveillance systems, sustaining high burdens of meningococcal disease, cholera, measles, *Plasmodium falciparum* malaria and arboviral infections [9,10] [34]. Conflict, displacement and disrupted primary care further erode immunisation coverage, creating fragile immunological baselines amplified during migration.

B] Horn of Africa

Migrants from Eritrea, Ethiopia and Somalia often come from settings characterised by protracted drought, food insecurity, high tuberculosis prevalence, malaria endemicity, acute respiratory infections and malnutrition-driven susceptibility [9,10] [13]. Endemic disease and delayed access to care shape vulnerability at departure.

C] North African transit hubs [Libya and Tunisia]

North African countries serve as prolonged transit zones where migrants may remain for months or years. Overcrowded, poorly ventilated accommodation with unsafe water, inadequate sanitation and limited healthcare facilitates transmission of scabies, bacterial skin infections, respiratory clusters, diarrhoeal disease and wound infections [10] [13,14]. Physical trauma, psychological stress, restricted mobility and sexual violence contribute to a syndemic burden extending beyond infectious morbidity.

5.3. Conditions of the journey and their impact on infectious diseases

The Central Mediterranean route is among the longest and most hazardous migration pathways globally, and transit conditions

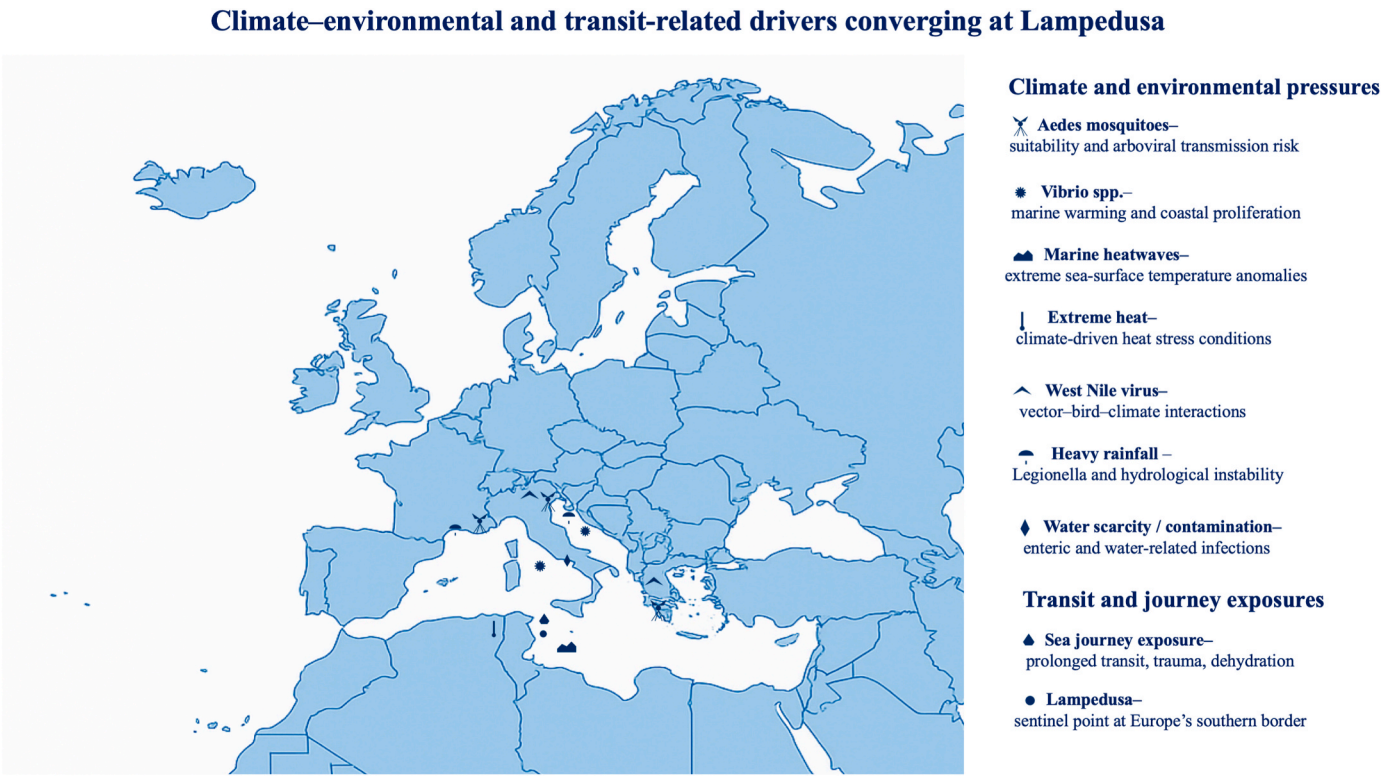

Fig. 2. Climate–environmental and transit-related drivers converging at Lampedusa.
This figure summarises upstream climate and environmental pressures—including vector suitability, marine warming, water instability, and extreme heat—together with transit-related exposures such as dehydration, trauma, and prolonged sea journeys. These combined stressors shape the health conditions observed on arrival and explain why the clinical burden at first contact reflects cumulative vulnerability rather than unusual or highly transmissible infectious threats.

substantially modify infectious-disease risk.

5.3.1. *Overcrowding and poor ventilation*

Migrants often travel for days in confined, poorly ventilated vessels or concealed compartments, enabling spread of respiratory infections—including tuberculosis, influenza-like illness and COVID-19—especially when compounded by dehydration, cold exposure and physical stress [9] [14].

5.3.2. *Poor sanitation and water scarcity*

Limited access to safe water and hygiene contributes to skin infections, scabies, diarrhoeal disease, conjunctivitis and urinary tract infections. Sanitation breakdown increases exposure to enteric pathogens and impedes wound care [14].

5.3.3. *Physical trauma and chronic stress*

Fuel burns, musculoskeletal injuries and prolonged immobilisation are common. Chronic stress, sleep deprivation and nutritional deficits weaken immune responses, increasing susceptibility to bacterial and viral infections and worsening pre-existing conditions.

Across origin and transit regions, climatic instability, conflict-driven displacement, fragile health systems and disrupted preventive services generate high baseline prevalence of vaccine-preventable diseases, tuberculosis, malaria, respiratory and gastrointestinal infections. Transit conditions then act as epidemiological amplifiers, intensifying transmission and exacerbating untreated illness. These cumulative vulnerabilities shape the infectious-disease profile long before arrival and underpin the clinical patterns seen at first medical contact [36].

6. Lampedusa as a sentinel hotspot at Europe's southern border

Lampedusa represents a frontline interface where upstream climate pressures, fragile health systems and hazardous migration conditions become clinically visible within days (Fig. 3). This positioning gives the island unique value as an epidemiological early-warning point for Europe.

6.1. *Structural and operational vulnerability of the reception system*

Located along the Central Mediterranean corridor and receiving flows from climate-unstable regions, Lampedusa functions as a natural sentinel where health, mobility and environmental pressures converge [7] [8]. However, the reception system was not designed for sustained epidemiological monitoring and often operates under extreme strain.

The hotspot frequently hosts several thousand people in a facility intended for a few hundred. Turnover is rapid, clinical resources are limited and medical evaluation focuses on emergencies, trauma, scabies, dehydration and respiratory distress. Systematic screening for tuberculosis, febrile syndromes or gastrointestinal infections is uncommon [15] [37]. Minimal laboratory capacity further limits early detection [18,19].

6.1.1. *Why Lampedusa functions as a sentinel site*

Convergence of high-risk flows: Arrivals originate from regions affected by climate shocks, food insecurity, conflict and disrupted vaccination services [8,12] [10] [14].

Amplification during transit: Overcrowding, dehydration, malnutrition, cold exposure and poor sanitation transform latent or subclinical conditions into acute presentations [10] [13,14].

Temporal proximity to climate disruptions: Clinical patterns often mirror climate-related events in origin regions occurring weeks to months earlier [12] [13].

6.1.2. *A sentinel with limited surveillance capacity*

Syndromic surveillance is limited, diagnostics are scarce and

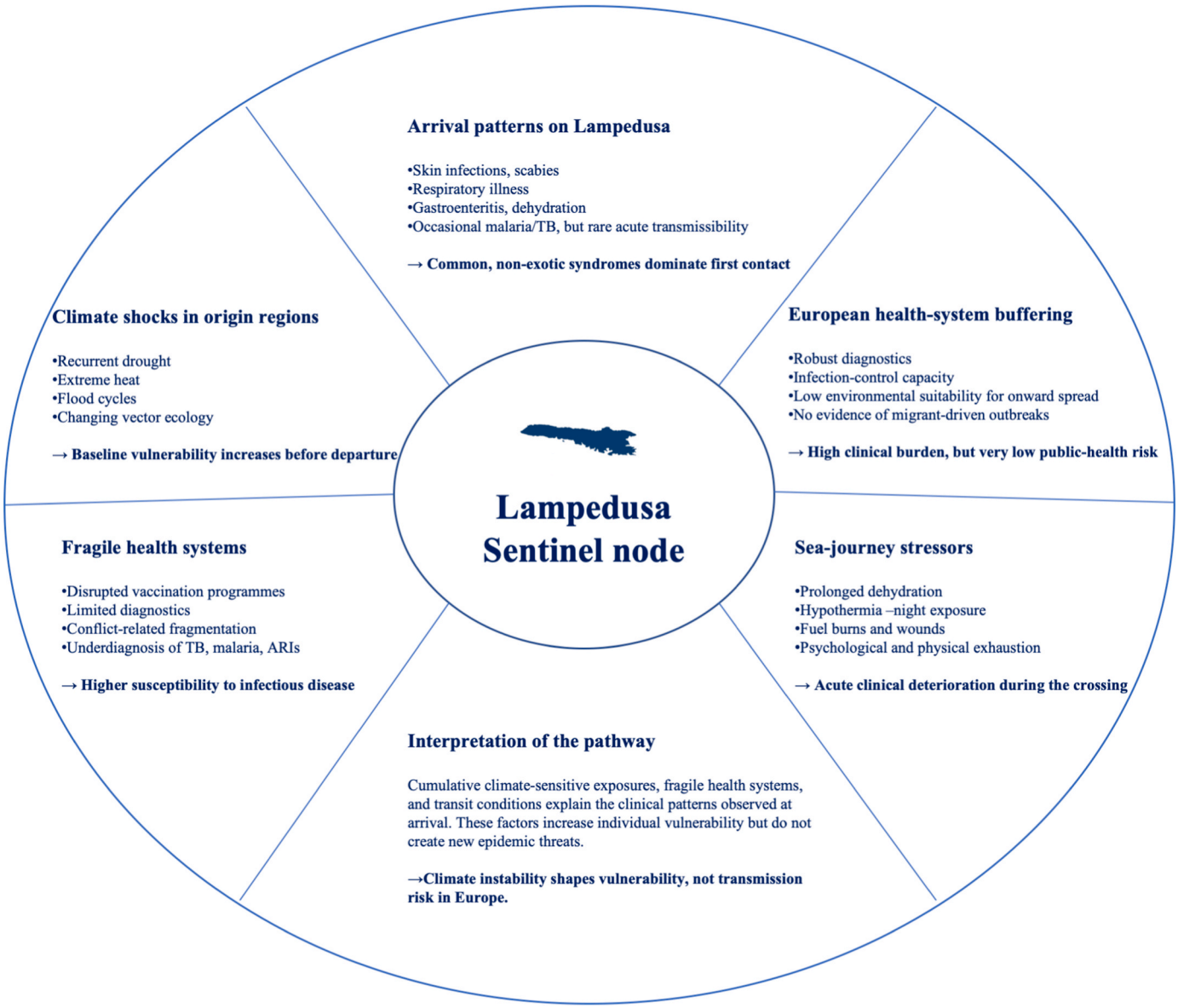

Fig. 3. Conceptual pathway linking climate shocks, migration conditions, and clinical presentations at Lampedusa.
The figure illustrates how upstream climate pressures, fragile health systems, and hazardous sea-journey conditions interact to shape the health status of migrants upon arrival. Clinical patterns observed at first contact largely reflect accumulated vulnerability rather than the importation of high-risk pathogens. In Europe, robust diagnostic capacity and limited environmental suitability for pathogen transmission mitigate onward public-health risk despite a high clinical burden.

reporting is largely reactive [15,17] [18], creating a significant gap in Europe's climate-health preparedness.

6.2. *Clinical patterns observed at first medical contact*

Clinical presentations reflect pre-existing vulnerabilities, prolonged transit exposures and acute environmental stress rather than rare or novel pathogens. Patterns remain consistent with epidemiology along migration routes under climatic and humanitarian strain [9,10] [38,34] [17].

6.2.1. *Skin and soft-tissue infections*

Overcrowding, saltwater and fuel exposure, friction injuries and poor hygiene favour bacterial superinfection. Scabies is highly prevalent due to crowding in pre-departure camps and transit facilities [10] [16] [12].

6.2.2. *Respiratory infections*

Upper respiratory infections and bronchitis arise from enclosed, poorly ventilated transit conditions. Pneumonia may reflect dehydration or cold exposure. Active, highly contagious tuberculosis at first contact is uncommon and typically represents longstanding disease [14] [16] [39,40].

6.2.3. *Gastrointestinal and dehydration-related conditions*

Diarrhoeal illness reflects unsafe water, food scarcity and contamination during transit, often accompanied by dehydration and electrolyte imbalance [10] [14]. Cholera is rare at arrival but outbreaks in origin or transit areas highlight upstream vulnerability [9,12] [41].

6.2.4. *Vector-borne infections*

Malaria reflects exposure in origin or transit regions and is generally detected early after landing [13] [42,43]. Arboviral infections [dengue, chikungunya, West Nile] require symptom onset during transit and remain exceptional [5] [44,45].

6.2.5. Other conditions

Burns, immersion injuries, trauma, rhabdomyolysis and sexual violence increase risk of secondary bacterial infections and underdiagnosed sexually transmitted infections; structured STI screening is rarely implemented [10] [13] [45].

6.3. Why these conditions represent a generally low public-health risk for Europe

Although clinically significant for individuals, conditions at arrival do not appear to increase public-health risk to European populations under typical post-arrival conditions [10] [16].

1. Common, not exotic, syndromes: Skin infections, scabies, respiratory illness and gastrointestinal disease are already circulating in Europe; malaria and arboviruses have negligible onward-transmission potential due to ecological constraints [5] [22] [12].
2. Low transmissibility in European settings: Drivers of transmission during migration—overcrowding, poor ventilation, heat stress—are absent after arrival. Contagious tuberculosis is uncommon and typically detected early [16,18,19].
3. Strong health-system buffering capacity: European systems have robust diagnostic and containment mechanisms, with no evidence of migrant-driven outbreaks even in high-arrival years [16,18,19].
4. Migrants as vulnerable recipients: Increased infectious risk reflects deprivation, trauma, malnutrition and interrupted care—not introduction of novel pathogens [10] [14].
5. Time–place mismatch: Many infections have incubation periods that elapse before arrival; others require ecological conditions not present in Europe [5,6] [20,21].

Infectious presentations on Lampedusa reflect upstream epidemiological pressures and hazardous transit, not threats to European public health. This interpretation is consistent with surveillance data from European health systems, which show limited sustained secondary transmission in community settings despite high arrival volumes.

The island's relevance lies in revealing early indicators of climate instability and health-system fragility beyond Europe's borders. Strengthening surveillance on Lampedusa could enhance preparedness for emerging climate-sensitive health threats.

7. Discussion

Climate change, population mobility and fragile health systems interact to shape infectious-disease patterns at Europe's southern frontier. This analysis integrates climate instability, epidemiological pressures and migration-related vulnerabilities into a unified framework to interpret clinical signals emerging at frontline Central Mediterranean entry points, using Lampedusa as an illustrative example. The figures are intended as conceptual representations of the proposed framework and are not designed to provide quantitative estimates.

7.1. Climate shocks and ecological change at origin

Rising temperatures, recurrent droughts, flooding and vector habitat shifts across the Sahel, West Africa and the Horn of Africa increase climate-sensitive infectious-disease burdens and destabilise fragile health systems [1–4] [9] [34]. These upstream pressures sustain a high prevalence of tuberculosis, malaria, enteric and respiratory infections, dermatologic conditions, and vaccine-preventable diseases, many of which remain untreated before departure [46].

These patterns include vector-borne diseases such as malaria, waterborne and enteric infections associated with inadequate sanitation, respiratory infections linked to overcrowding, and vaccine-preventable diseases reflecting disrupted immunisation programmes. The relative contribution of these conditions varies across regions, with malaria and enteric infections more prominent in West Africa, tuberculosis in the Horn of Africa, and vaccine-preventable diseases reflecting local health-system disruptions across multiple settings [34].

7.2. Transit as an epidemiological amplifier

Along the Central Mediterranean route, overcrowding, poor ventilation, unsafe water, inadequate sanitation, trauma and chronic stress intensify transmission and exacerbate pre-existing conditions [10] [13]. Transit does not introduce novel pathogens but magnifies vulnerabilities and converts latent or subclinical infections into acute presentations.

7.3. Arrival points as sentinel interfaces

Frontline islands and entry points capture the cumulative effects of upstream climate instability and transit-related exposures. Predominant clinical presentations—skin and soft-tissue infections, respiratory illness, diarrhoea, dehydration and trauma-related complications—reflect cumulative deprivation rather than exotic or highly transmissible pathogens [15] [18,19] [37]. These patterns often mirror climate-linked fluctuations occurring weeks or months earlier in regions of origin.

7.4. Downstream European health security

Despite the clinical burden observed at arrival, these conditions appear to pose a generally low public-health risk to European populations under typical post-arrival conditions. Low transmissibility in community settings, strong diagnostic capacity and ecological barriers buffer onward risk [16,18,19]. This interpretation is consistent with surveillance data from European health systems, which report limited sustained secondary transmission in community settings despite high arrival volumes. The relevance of frontline entry points lies not in detecting imported epidemics but in signalling early indicators of climate-related instability beyond Europe's borders.

7.5. Strengths and limitations

Strengths of this analysis include integration of climate science, epidemiology and migration health into a conceptual framework applicable to frontline reception settings. Limitations involve reliance on heterogeneous data sources, variable surveillance quality in origin and transit regions and the absence of systematic clinical datasets from Lampedusa. These constraints reflect structural gaps in global-health monitoring rather than methodological weakness and underscore the need for improved cross-Mediterranean data systems.

In particular, the absence of systematic clinical datasets from Lampedusa precludes estimation of syndrome prevalence, seasonality, trend detection performance, and quantitative comparison with other Mediterranean entry points.

7.6. Implications

Strengthening syndromic surveillance, diagnostic capacity and environmental monitoring across frontline entry points could transform these settings into effective early-warning nodes. Integrating climate indicators into preparedness strategies and enhancing cross-Mediterranean epidemiological collaboration would support anticipatory capacity as climate instability accelerates. Recognising the climate–migration–infection continuum is essential for a science-based, non-stigmatising European health strategy. These elements can be operationalised through structured syndromic surveillance and data integration at first medical contact.

To enhance practical applicability, the proposed framework is translated into operational components at first medical contact, as summarised in Table 1, providing a structured basis for implementation

Table 1
Operationalisation of the Climate–Migration–Infection Sentinel Interface Model at first medical contact in Central Mediterranean entry points.

Domain	Operational component	Minimum feasible implementation at hotspot level	Surveillance objective	Potential trigger signals
Syndromic surveillance	Core clinical syndromes at first contact	Standardised triage recording of: febrile illness, respiratory syndromes, acute gastrointestinal disease, skin and soft-tissue infections, ectoparasitic infestations, trauma-related conditions	Early detection of shifts in clinical patterns associated with upstream climate and migration dynamics	Unusual increase in specific syndromes; clustering of febrile or respiratory illness; seasonal anomalies
Diagnostic capacity	Basic point-of-care and laboratory support	Rapid tests (malaria, COVID-19/influenza where available), basic blood tests, wound assessment, dehydration markers	Support syndromic interpretation and identify conditions requiring isolation or referral	Increased detection of malaria, severe dehydration, or respiratory compromise
Data collection	Structured and standardised data capture	Simple dataset (digital or paper-based) including demographics, country of origin, transit history, and presenting syndrome	Enable trend analysis and linkage with upstream epidemiological patterns	Sudden change in origin distribution associated with specific syndromes
Reporting and integration	Linkage with national and European surveillance systems	Regular reporting to regional public health authorities and integration with ECDC or national surveillance platforms	Strengthen early-warning capacity beyond local setting	Signal amplification across multiple entry points
Environmental and contextual data	Integration of climate and migration indicators	Use of available data on temperature anomalies, extreme weather events, and migration flows from origin regions	Contextualise clinical signals within climate-driven risk patterns	Temporal association between climate events and clinical trends
Response capacity	Clinical and public-health response readiness	Isolation capability (when needed), hydration and infection management, referral pathways	Rapid containment of clinically relevant conditions and reduction of morbidity	Increased need for escalation of care or transfer to higher-level facilities

and future evaluation in frontline settings.

8. Conclusion

Climate change, fragile health systems and hazardous migration conditions interact to shape the infectious-disease patterns observed at Europe's southern frontier [46]. Clinical presentations at first medical contact largely reflect cumulative vulnerability and disrupted care acquired before and during migration rather than the introduction of novel or highly transmissible pathogens. Downstream transmission risk to European populations appears generally low under typical post-arrival conditions due to ecological constraints and robust health-system buffering capacity.

Frontline Central Mediterranean entry points such as Lampedusa function as sentinel interfaces where climate- and mobility-driven vulnerability becomes clinically visible earlier than in mainland Europe. Strengthening syndromic surveillance, improving reception conditions, expanding diagnostic capacity and integrating climate indicators into preparedness planning could enhance early-warning capability across the Euro-Mediterranean region. The proposed sentinel interface model should be considered a hypothesis-generating framework requiring prospective validation through structured epidemiological data, temporal analyses, and comparison with downstream healthcare settings. As climate instability accelerates, coordinated cross-Mediterranean cooperation and research on climate–migration–infection dynamics—including antimicrobial resistance and upstream outbreak detection—will be essential to support evidence-based, non-stigmatising European health-security strategies [47].

Sex- and gender-specific analyses were not performed due to inconsistent sex-disaggregated reporting in the included sources; future studies should prioritise sex- and gender-responsive surveillance.

CRediT authorship contribution statement

Giuseppe Accurso: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Giorgia Corpora:** Visualization, Conceptualization. **Luigi Profera:** Visualization. **Flavia Faranda:** Visualization, Methodology. **Marco Palmeri:** Visualization, Supervision. **Fabio Genco:** Visualization, Supervision. **Antonino Giarratano:** Visualization. **Santi Maurizio Raineri:** Visualization, Validation.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Availability of data and materials

Not applicable. Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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List of abbreviations

AMR	antimicrobial resistance
ECDC	European Centre for Disease Prevention and Control
ESBL	extended-spectrum beta-lactamase
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
MedECC	Mediterranean Experts on Climate and Environmental Change
MSF	Médecins Sans Frontières
STI	sexually transmitted infections
UNHCR	United Nations High Commissioner for Refugees
WHO	World Health Organization
WNV	West Nile virus

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tmaid.2026.102985.

References

[1] McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. Lancet 2006 Mar 11;367(9513):859–69. https://doi.org/10.1016/S0140-6736[06]68079-3. PubMed PMID: 16530580.

[2] Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature 2008 Feb;451(7181):990–3. https://doi.org/10.1038/nature06536.

[3] Semenza JC, Menne B. Climate change and infectious diseases in Europe. Lancet Infect Dis 2009 Jun;9(6):365–75. https://doi.org/10.1016/S1473-3099[09]70104-5. PubMed PMID: 19467476.

[4] Climate and environmental change in the Mediterranean Basin - current situation and risks for the future. First Mediterranean Assessment Report. MedECC [Internet]. [cited 2026 Mar 21]. Available from: https://www.medecc.org/medecc-reports/climate-and-environmental-change-in-the-mediterranean-basin-current-situation-and-risks-for-the-future-1st-mediterranean-assessment-report/.

[5] [Internet] Climate change, impacts and vulnerability in Europe 2016. 2017 [cited 2026 Mar 21]. Available from: https://www.eea.europa.eu/en/analysis/publications/climate-change-impacts-and-vulnerability-2016.

[6] Danovaro R, Umani SF, Pusceddu A. Climate change and the potential spreading of marine mucilage and microbial pathogens in the Mediterranean Sea. PLoS One 2009 Sep 16;4(9):e7006. https://doi.org/10.1371/journal.pone.0007006.

[7] World migration report. 2024 [Internet]. 2020 May 21 [cited 2026 Mar 21]. Available from: https://publications.iom.int/books/world-migration-report-2024.

[8] global-trends-report-2024. pdf [Internet]. [cited 2026 Mar 21]. Available from: https://www.unhcr.org/sites/default/files/2025-06/global-trends-report-2024.pdf.

[9] Appeal - Horn of Africa [Internet]. [cited 2026 Mar 21]. Available from: https://www.who.int/emergencies/funding/health-emergency-appeals/2022/2023/2023-appeals/appeal-horn-of-africa.

[10] van Boetzelaer E, Fotso A, Angelova I, Huisman G, Thorson T, Hadj-Sahraoui H, et al. Health conditions of migrants, refugees and asylum seekers on search and rescue vessels on the central Mediterranean Sea, 2016-2019: a retrospective analysis. BMJ Open 2022 Jan 11;12(1):e053661. https://doi.org/10.1136/bmjopen-2021-053661. PubMed PMID: 35017249; PubMed Central PMCID: PMC8753406.

[11] Uwishema O, Masunga DS, Naisikye KM, Bhanji FG, Rapheal AJ, Mbwana R, et al. Impacts of environmental and climatic changes on future infectious diseases. Int J Surg 2023 Jan 24;109(2):167–70. https://doi.org/10.1097/JS9.0000000000000160. PubMed PMID: 36799840; PubMed Central PMCID: PMC10389506.

[12] Ceccarelli G, Branda F, Scarpa F, Albanese M, d'Ettorre G, Giovanetti M, et al. Rethinking scabies in Europe: an ECDC prevention framework approach. Trav Med Infect Dis 2025 Jan;63:102786. https://doi.org/10.1016/j.tmaid.2024.102786.

[13] Kuehne A, Boetzelaer E van, Alfani P, Fotso A, Elhammali H, Khamala T, et al. Health of migrants, refugees and asylum seekers in detention in tripoli, Libya, 2018-2019: retrospective analysis of routine medical programme data. PLoS One 2021 Jun 4;16(6):e0252460. https://doi.org/10.1371/journal.pone.0252460.

[14] Trovato A, Reid A, Takarinda KC, Montaldo C, Decroo T, Owiti P, et al. Dangerous crossing: demographic and clinical features of rescued sea migrants seen in 2014 at an outpatient clinic at Augusta harbor, Italy. Conflict Health 2016 Jun 15;10(1):14. https://doi.org/10.1186/s13031-016-0080-y.

[15] Napoli C, Riccardo F, Declich S, Dente MG, Pompa MG, Rizzo C, et al. An early warning system based on syndromic surveillance to detect potential health emergencies among migrants: results of a two-year experience in Italy. Int J Environ Res Publ Health 2014 Aug;11(8):8529–41. https://doi.org/10.3390/ijerph110808529. PubMed PMID: 25140999; PubMed Central PMCID: PMC4143875.

[16] Aslam B, Khurshid M, Arshad MI, Muzammil S, Rasool M, Yasmeen N, et al. Antibiotic resistance: one health one world outlook. Front Cell Infect Microbiol 2021;11:771510. https://doi.org/10.3389/fcimb.2021.771510. PubMed PMID: 34900756; PubMed Central PMCID: PMC8656695.

[17] World Migration Report | International Organization for Migration, IOM [Internet]. [cited 2026 Mar 21]. Available from: https://worldmigrationreport.iom.int/.

[18] Desai AN, Mohareb AM, Hauser N, Abbara A. Antimicrobial resistance and human mobility. Infect Drug Resist 2022;15:127–33. https://doi.org/10.2147/IDR.S305078. PubMed PMID: 35046676; PubMed Central PMCID: PMC8763254.

[19] Bokhary H, Pangesti KNA, Rashid H, Abd El Ghany M, Hill-Cawthorne GA. Travel-related antimicrobial resistance: a systematic review. Trop Med Infect Dis 2021 Jan 16;6(1):11. https://doi.org/10.3390/tropicalmed6010011. PubMed PMID: 33467065; PubMed Central PMCID: PMC7838817.

[20] Pastor F, Paredes-Fortuny L, Khodayar S. Mediterranean marine heatwaves intensify in the presence of concurrent atmospheric heatwaves. Commun Earth Environ 2024 Dec 31;5(1):797. https://doi.org/10.1038/s43247-024-01982-8.

[21] Caminade C, Medlock JM, Ducheyne E, McIntyre KM, Leach S, Baylis M, et al. Suitability of European climate for the Asian tiger mosquito aedes albopictus: recent trends and future scenarios. J R Soc Interface 2012 Oct 7;9(75). https://doi.org/10.1098/rsif.2012.0138. 2708–17, PubMed PMID: 22535696; PubMed Central PMCID: PMC3427500.

[22] Medlock JM, Hansford KM, Schaffner F, Versteirt V, Hendrickx G, Zeller H, et al. A review of the invasive mosquitoes in Europe: ecology, public health risks, and control options. Vector Borne Zoonotic Dis 2012 Jun;12(6):435–47. https://doi.org/10.1089/vbz.2011.0814. PubMed PMID: 22448724; PubMed Central PMCID: PMC3366101.

[23] Murgue B, Murri S, Triki H, Deubel V, Zeller HG. West nile in the Mediterranean basin: 1950-2000. Ann N Y Acad Sci 2001 Dec;951:117–26. https://doi.org/10.1111/j.1749-6632.2001.tb02690.x. PubMed PMID: 11797769.

[24] Baker-Austin C, Trinanes JA, Taylor NGH, Hartnell R, Siitonen A, Martinez-Urtaza J. Correction: corrigendum: emerging Vibrio risk at high latitudes in response to ocean warming. Nat Clim Change 2016 Aug;6(8). https://doi.org/10.1038/nclimate3024. 802–802.

[25] Vezzulli L, Grande C, Reid PC, Hélaouët P, Edwards M, Höfle MG, et al. Climate influence on vibrio and associated human diseases during the past half-century in the coastal North Atlantic. Proc Natl Acad Sci U S A 2016 Aug 23;(34):113. https://doi.org/10.1073/pnas.1609157113. E5062-5071, PubMed PMID: 27503882; PubMed Central PMCID: PMC5003230.

[26] Semenza JC, Ko AI. Waterborne diseases that are sensitive to climate variability and climate change. N Engl J Med 2023 Dec 7;389(23):2175–87. https://doi.org/10.1056/NEJMra2300794. PubMed PMID: 38055254.

[27] Fisman DN. Seasonality of infectious diseases. Annu Rev Publ Health 2007;28:127–43. https://doi.org/10.1146/annurev.publhealth.28.021406.144128. PubMed PMID: 17222079.

[28] van Bavel B, Berrang-Ford L, Moon K, Gudda F, Thornton AJ, Robinson RFS, et al. Intersections between climate change and antimicrobial resistance: a systematic scoping review. Lancet Planet Health 2024 Dec;8(12):e1118–28. https://doi.org/10.1016/S2542-5196[24]00273-0. PubMed PMID: 39674199.

[29] Magnano San Lio R, Favara G, Maugeri A, Barchitta M, Agodi A. How antimicrobial resistance is linked to climate change: an overview of two intertwined global challenges. Int J Environ Res Publ Health 2023 Jan 17;20(3):1681. https://doi.org/10.3390/ijerph20031681. PubMed PMID: 36767043; PubMed Central PMCID: PMC9914631.

[30] Kraemer SA, Ramachandran A, Perron GG. Antibiotic pollution in the environment: from microbial ecology to public Policy. Microorganisms 2019 Jun 22;7(6):180. https://doi.org/10.3390/microorganisms7060180. PubMed PMID: 31234491; PubMed Central PMCID: PMC6616856.

[31] Fernández Salgueiro M, Cernuda Martínez JA, Gan RK, Arcos González P. Climate change and antibiotic resistance: a scoping review. Environ Microbiol Rep 2024 Oct;16(5):e70008. https://doi.org/10.1111/1758-2229.70008. PubMed PMID: 39267332; PubMed Central PMCID: PMC11393301.

[32] Zambrano MM. Interplay between antimicrobial resistance and global environmental change. Annu Rev Genet 2023 Nov 27;57:275–96. https://doi.org/10.1146/annurev-genet-022123-113904. PubMed PMID: 37708420.

[33] Mirsaeidi M, Motahari H, Taghizadeh Khamesi M, Sharifi A, Campos M, Schraufnagel DE. Climate change and respiratory infections. Ann Am Thorac Soc 2016 Aug;13(8):1223–30. https://doi.org/10.1513/AnnalsATS.201511-729PS. PubMed PMID: 27300144.

[34] Eboreime E, Anjorin O, Obi-Jeff C, Ojo TM, Hertelendy A. Climate, conflict and displacement in the Sahel. Bull World Health Organ 2025 Apr 1;103(4). https://doi.org/10.2471/BLT.24.292700. 230-230A PubMed PMID: 40207246; PubMed Central PMCID: PMC11978414.

[35] Ciccozzi M, Cella E, Ceccarelli G, Vita S, Dicuonzo G, Lopalco M, et al. Sentinel surveillance data from Eritrean migrants in Italy: the theory of "Healthy Migrants". Trav Med Infect Dis 2018 Mar 1;22:58–65. https://doi.org/10.1016/j.tmaid.2017.09.004.

[36] Barnett ED, Wheelock AB, MacLeod WB, McCarthy AE, Walker PF, Coyle CM, et al. Infections with long latency in international refugees, immigrants, and migrants seen at GeoSentinel sites, 2016–2018. Trav Med Infect Dis 2023 Nov 1;56:102653. https://doi.org/10.1016/j.tmaid.2023.102653.

[37] Di Meco E, Di Napoli A, Amato LM, Fortino A, Costanzo G, Rossi A, et al. Infectious and dermatological diseases among arriving migrants on the Italian coasts. Eur J Publ Health 2018 Oct 1;28(5):910–6. https://doi.org/10.1093/eurpub/cky126. PubMed PMID: 30010744.

[38] UNHCR. Global trends report 2024 [Internet]. [cited 2026 Mar 21], https://www.unhcr.org/global-trends-report-2024.

[39] Maatoug T, Seedat F, Elafef E, Ouahchi A, Mtiraoui A, Evangelidou S, et al. Burden, clinical outcomes, and characteristics of tuberculosis in migrant populations in the middle East and North African region: a systematic review and meta-analyses. Trav Med Infect Dis 2025 Jul 1;66:102872. https://doi.org/10.1016/j.tmaid.2025.102872.

[40] Marrone R, Mazzi C, Ouattara H, Cammilli M, Pontillo D, Perandin F, et al. Screening for Neglected tropical diseases and other infections in African refugees and asylum seekers in rome and Lazio region, Italy. Trav Med Infect Dis 2023 Nov 1;56:102649. https://doi.org/10.1016/j.tmaid.2023.102649.

[41] Varo R, Rodó X, Bassat Q. Climate change, cyclones and cholera - implications for travel medicine and infectious diseases. Trav Med Infect Dis 2019 May 1;29:6–7. https://doi.org/10.1016/j.tmaid.2019.04.007.

[42] Corbacho-Loarte MD, Crespillo-Andújar C, Chamorro-Tojeiro S, Norman F, Pérez-Molina JA, Martín O, et al. Screening of imported malaria infection in asymptomatic migrants from Sub-Saharan Africa: a retrospective analysis of a 2010–2019 cohort. Trav Med Infect Dis 2022 Sep 1;49:102411. https://doi.org/10.1016/j.tmaid.2022.102411.

[43] Caronni S, Pieruzzi ME, Salari F, Behring AH, Rizzo A, Poloni A, et al. High rate of undiagnosed cases of fever among returning travelers from tropical areas tested for malaria: a single-center retrospective study. Trav Med Infect Dis 2026 May 1;71:102967. https://doi.org/10.1016/j.tmaid.2026.102967.

[44] García-Carrasco JM, Muñoz AR, Olivero J, Segura M, Real R. An African west nile virus risk map for travellers and clinicians. Trav Med Infect Dis 2023 Mar 1;52:102529. https://doi.org/10.1016/j.tmaid.2022.102529.

[45] Mwanyika GO, Moir M, Musa AO, Poongavanan J, Dor G, Wilkinson E, et al. A decade of dengue disease burden in Africa [2013–2023]: a systematic review.

Trav Med Infect Dis 2025 Sep 1;67:102897. https://doi.org/10.1016/j.tmaid.2025.102897.

[46] Focus Adriano L, Nazir A, Uwishema O. The devastating effect of cyclone freddy amidst the deadliest cholera outbreak in Malawi: a double burden for an already weak healthcare system—short communication. Ann Med Surg [Lond] 2023 Jun 16;85(7):3761–3. https://doi.org/10.1097/MS9.0000000000000961. PubMed PMID: 37427161; PubMed Central PMCID: PMC10328608.

[47] Uwishema O, Adriano LF, Torbati T, Onyeaka H. Measles crisis in Africa amidst the COVID-19 pandemic: delayed measles vaccine administration may cause a measles outbreak in Africa. J Med Virol 2021 Oct;93(10):5697–9. https://doi.org/10.1002/jmv.27150. PubMed PMID: 34181289.