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A recent history of disease outbreaks in Kenya, 2007–2022: Findings from routine surveillance data

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Abstract

Background Africa reports the highest number of outbreaks globally, accounting for 39% of all outbreaks in 2022. The Integrated Disease Surveillance and Response strategy in Kenya ensures the reporting of outbreaks up to the national level. We present a summary of the burden of reported disease outbreaks in Kenya, 2007–2022.

Methods We reviewed historical surveillance data, 2007–2022, summarized the annual caseload and deaths of reported outbreaks, and classified the outbreaks into 3 categories, that is high, moderate, and low burden. A nested Poisson regression model was fit to determine whether there was a significant increase in the number of diseases and counties reporting outbreaks over time.

Results Twenty-three diseases were reported. COVID-19, cholera, epidemic malaria, kala-azar, and measles were associated with a high disease burden. The highest number of diseases reported in a single year was 10. We observed an increase in the number of outbreaks over time (IRR = 1.26, 95% CI [1.22–1.29], $p < 0.001$), and an increase in the number of counties reporting outbreaks over time ($r = 0.97$, $p < 0.001$).

Conclusion There was an increase in the frequency and geographic occurrence of outbreaks. The differences in outbreak occurrence between counties necessitate targeted and enhanced preventive, preparedness, and response interventions at the sub-national level to reduce the burden of outbreaks.

Keywords Priority disease, Outbreak, Surveillance, Burden, Kenya

Introduction

Disease outbreaks cause significant health concerns globally, however, the occurrence of these outbreaks disproportionately affects world regions. Africa reports the highest number of outbreaks in the world, accounting for 39% of all disease outbreaks in 2022 [1]. In Africa, common causes of epidemics are Vaccine-Preventable Diseases (VPDs), vector-borne, water-borne, and zoonotic diseases [2].

The incidence and impact of diseases vary over time. Despite a rising trend in non-communicable conditions worldwide, the relative burden of infectious diseases is continually changing [3]. Specific infectious diseases may be more

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significant at the regional, national, or sub-national level while decreasing in importance globally [4, 5]. These differences are best captured by surveillance. Better awareness of the diseases most commonly affecting an area can lead to more accurate disease occurrence maps informed by local data. Ultimately, this leads to better preparedness and a more efficient allocation of resources for prevention and control strategies.

Surveillance in Kenya is conducted through the Integrated Disease Surveillance and Response (IDSR) strategy adapted from the World Health Organization. The strategy is designed to collect health data for multiple diseases and public health events using standardized data collection tools, which are uploaded onto the Kenya Health Information System (KHIS2), a robust platform derived from the District Health Information Software 2 (DHIS2) to support the aggregation and dissemination of health data [6]. DHIS2 is used in the surveillance of priority diseases, the Early Warning, Alert, and Response system, and managing health emergencies, in line with the International Health Regulations (IHR) requirements [7].

We present a summary of the burden of disease outbreaks in Kenya, 2007–2022, reported as part of the IDSR strategy. Our findings will provide information for the development of sub-national disease occurrence maps and contribute to more efficient use of resources at the county level to inform public health prevention, preparedness, and response measures.

Methods

In 2023, we reviewed historical surveillance data held by the Disease Surveillance and Response Unit (DSRU) of the Ministry of Health, Kenya, 2007–2022, using the list of priority diseases (Table 1).

Table 1 List of priority diseases adapted from Kenya's integrated disease surveillance and response framework, 2021

Epidemic Prone Diseases	Diseases targeted for eradication and elimination	Diseases, conditions, and events of Public Health Importance
Acute flaccid paralysis (Poliomyelitis)	Guinea worm Disease (Dracunculiasis)	Acute Malnutrition
Anthrax	Human African Trypanosomiasis	Adverse events following immunization (AEFI)
Brucellosis	Leprosy	Aflatoxicosis
Bacterial Meningitis	Lymphatic filariasis	Animal Bites (including Dog bites, snake bites, wild animals)
Chikungunya	Malaria***	Cancers
Cholera	Measles	Diabetes Mellitus (New cases)
Dengue Fever	Neonatal tetanus	Diarrhea with dehydration in children < 5 years of age
Diarrhoea with blood (Shigella)	Onchocerciasis	Epilepsy
Ebola/Marburg Haemorrhagic Fever	Rabies	Hepatitis A/B/C/E
Leishmaniasis (kala-azar) *	Trachoma	Hypertension (New cases)
Plague		Maternal Death
Rift Valley Fever (RVF)		Neonatal death
Smallpox (Variola)		Newly diagnosed HIV infection****
Typhoid Fever		Sexually transmitted infections (Gonorrhoea, Syphilis, Chlamydia, Herpes genitalia)
Yellow fever		Schistosomiasis
Influenza Like Illness		Severe Pneumonia in Children under five-years-old
Influenza due to a new subtype		Soil-transmitted helminths
SARS**		Substance Abuse including Alcohol and other Drugs
Severe Acute Respiratory Infections		Suicides/ attempted suicides
Bacterial Meningitis		Trauma (Road traffic injury/ Fatality)
		Tuberculosis (MDR /XDR)
Any public health event of national/regional/international concern (infectious, zoonotic, foodborne, chemical, radio-nuclear, or due to an unknown condition)		

* Visceral leishmaniasis outbreaks were reported in DHIS2 as opposed to the cutaneous forms. While Kenya has both cutaneous and visceral leishmaniasis, most outbreaks are due to visceral leishmaniasis (kala-azar)

** COVID-19 is listed under SARS

*** For this manuscript epidemic malaria data was collected from malaria epidemic-prone counties. Seasonal malaria data from endemic counties is reported separately

**** HIV is no longer considered an outbreak, there have been several reports of its surveillance such as KENPHIA 2018 [8]. A consistent decline in new HIV infections and AIDS-related deaths has been observed over the years, due to effective intervention strategies, therefore, shifting HIV from being considered an outbreak to a more managed and controlled public health issue in Kenya

When a suspected case of an outbreak is detected at the community or health facility level, a Community Health Promoter or healthcare worker reports to the surveillance officer, who notifies the Sub-County Disease Surveillance Coordinator (SCDSC). The SCDSC then reports to the County Disease Surveillance Coordinator, who informs the national-level DSRU within 24 h of the initial report. Line listing is initiated as soon as an outbreak is confirmed. An outbreak is confirmed when the number of cases exceeds the predefined action threshold, and it is considered over when no new cases are reported within two incubation periods. For endemic diseases, an outbreak is over when the number of cases declines below the action threshold [9]. The reported outbreak alert and action thresholds are listed in Table 2.

We summarized the archived data from 2007 to 2022 on the annual number of diseases, outbreak reports, caseload, and deaths per outbreak in each of the 47 counties. A disease outbreak was defined as the occurrence of any priority diseases within a county in a specified year. If one disease occurred several times within a year in a county, this was considered a single outbreak, however, if one disease occurred in two counties, this was considered as two separate outbreak reports. We abstracted the outbreak data into an electronic spreadsheet.

Diseases, outbreak reports, and counties were ranked according to the frequency of outbreak occurrences, cases, and deaths. To classify the diseases into 3 categories of burden, i.e., high, moderate, and low burden, we obtained the median caseload and deaths per outbreak and used these values to classify each outbreak into one of the 3 categories. High-burden outbreaks had both the caseload and deaths above the median. Moderate-burden outbreaks had either the caseload or deaths higher than the median. Low-burden outbreaks had both the caseload and deaths lower than the median. A nested Poisson regression model was fitted with the year as a fixed effect to determine whether there was a significant increase in

Table 2 List of reported disease outbreaks alert and action thresholds, adapted from Kenya's integrated disease surveillance and response framework, 2021

Disease	Alert Threshold	Action Threshold
Acute flaccid paralysis	1 suspected case	1 confirmed case
Aflatoxicosis	1 suspected case	1 confirmed case
Anthrax	1 suspected case	1 confirmed case
Chikungunya	1 suspected case	1 confirmed case
Cholera	1 suspected case	1 confirmed case
COVID-19	3 confirmed cases within 2 weeks in a previously unaffected area	Positivity rate > 5%
Dengue fever	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Influenza A	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Kala-azar*	1 suspected case	1 confirmed case
Malaria	Unusual increase in the number of new malaria cases or deaths as compared to the same period in the previous years	The number of new cases exceeds the upper limit of cases seen in a previous non-epidemic period in previous years
Measles	Five or more cases of suspected measles in a sub-county or health facility in one month	Three or more cases laboratory confirmed as Immunoglobulin M positive in a sub-county or health facility in a month
Mumps	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Pertussis	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Q-fever	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Rabies	1 suspected case	1 confirmed case
Rift Valley Fever (RVF)	1 suspected case	1 confirmed case
SARI	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Schistosomiasis	Cases above 1 standard deviation from the 5-year mean data per geographical area	Cases above 2 standard deviations from the 5-year mean data per geographical area
Typhoid fever	1 suspected case	Double endemic threshold
Viral Hepatitis	Hepatitis A – 1 suspected case	If there are more than 2 cases of jaundice in a village or an urban unit (of 1000 population) within a week.
Yellow fever	1 suspected case	1 confirmed case

Table 3 Ranking of reported priority diseases by number of cases and deaths in Kenya, 2007–2022

Disease	Number of cases	Proportion of cases (%)	Ranking for case numbers	Number of deaths	Proportion of deaths (%)	Ranking for deaths	Number of outbreak reports
Aflatoxicosis	31	0.01	20	10	0.15	11	2
AFP	34	0.01	19	0	0	18	3
Anthrax	207	0.04	14	11	0.17	10	10
Chikungunya	3504	0.76	8	1	0.02	17	6
Cholera	43,205	9.31	2	571	8.68	2	131
COVID-19	353,878	76.27	1	5687	86.49	1	141
cVDPV2	2	0	23	0	0	18	1
Dengue Fever	4468	0.96	6	3	0.05	15	16
Epidemic Malaria	40,116	8.65	3	36	0.55	5	6
Hepatitis A	334	0.07	12	0	0	18	3
Hepatitis B	4986	1.07	5	2	0.03	16	10
Hepatitis E	491	0.11	11	4	0.06	14	1
Influenza A	1374	0.3	9	2	0.03	16	3
Kala-azar	5878	1.27	4	68	1.03	4	22
Measles	4061	0.88	7	21	0.32	7	64
Mumps	21	0	21	13	0.2	8	1
Pertussis	43	0.01	17	1	0.02	17	7
Q Fever	37	0.01	18	6	0.09	12	1
Rabies	17	0	22	1	0.02	17	1
RVF	232	0.05	13	27	0.41	6	12
SARI	823	0.18	10	94	1.43	3	1
Typhoid Fever	123	0.03	16	5	0.08	13	2
Yellow Fever	143	0.03	15	12	0.18	9	13
Total	**464,008**			**6575**			**457**

the number of diseases and counties reporting over time. Random effects were included to account for the variability between counties and within counties across the different years. Statistical significance was considered at $p<0.05$. Analysis was conducted using Microsoft Excel and R version 4.2 [10].

Results

There were 457 outbreak reports for 23 diseases from 2007 to 2022. Seven (7) entries in 2012, 2013, and 2014 had missing information on the counties affected. More than half, ($n=13$, 59%) of the diseases were epidemic-prone: COVID-19, cholera, epidemic malaria, kala-azar, dengue fever, measles, chikungunya, influenza A, severe acute respiratory illness (SARI), Rift Valley Fever (RVF), anthrax, yellow fever, and typhoid fever. Seven 32%) of the diseases; hepatitis A, B, and E, pertussis, aflatoxicosis, mumps, and Q-fever were diseases of public health importance. Two (9%) of the diseases were targeted for eradication and elimination: rabies and poliomyelitis, including (acute flaccid paralysis [AFP] and vaccine-derived poliovirus 2 [VDPV2]).

Disease-specific caseload and mortality

Overall, 464,008 cases and 6,575 deaths were reported. The highest caseload and deaths were attributed to COVID-19, cholera, epidemic malaria, and kala-azar. COVID-19 overwhelmingly contributed to morbidity and mortality, representing 76% of the caseload and 86% of the deaths (Table 3).

COVID-19 was first detected in 2020, with most cases reported in 2021. All counties reported COVID-19 cases, with Nairobi reporting most cases (145,766 [41%]). Cholera was reported annually, except in 2011. Garissa had the most frequent annual reports of cholera, while Nairobi had the highest cumulative number of reported cholera cases 6,623(15%). Of the 40,116 epidemic malaria cases, 36,123 (82.0%) were reported from Elgeyo Marakwet in 2020. Kala-azar was reported in 2014, 2016, and annually since 2019, with the highest number of cases, 2,858 (49%), detected in Marsabit. Most cases of hepatitis B were reported in 2019, with West Pokot having the highest caseload of 2,433 (47%). Dengue cases were reported in alternate years beginning in 2011 and were largely limited to Mombasa, Mandera, and Wajir counties. Chikungunya was first reported in 2016, then every 1–3 years, and was limited to Mandera, Mombasa, Wajir, Lamu, and Kilifi counties. Measles was reported yearly

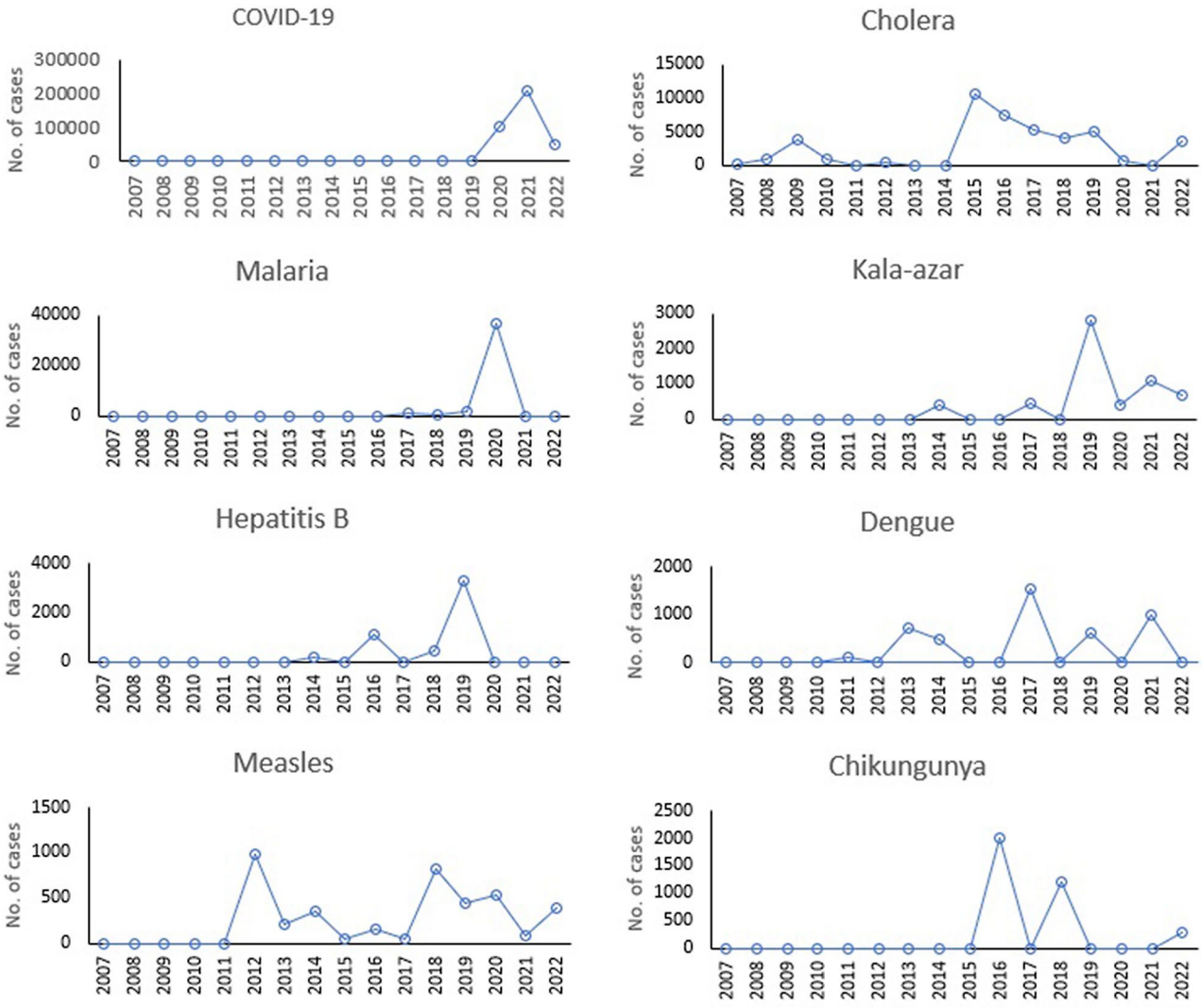

Fig. 1 Disease occurrence over time for outbreaks with the highest number of cases in Kenya, 2007–2022

since 2012, with peaks in reporting in 2014, 2018, and 2020. The annual trends in the number of cases detected for diseases with the highest caseloads are presented in Fig. 1.

Categorization of disease burden

We obtained a median caseload of 334 cases and six deaths. When classified into 4 categories, we observed that COVID-19, cholera, epidemic malaria, kala-azar, measles, and SARI were associated with a high disease burden. Typhoid fever, pertussis, rabies, and poliomyelitis were associated with the lowest burden of disease (Fig. 2).

Annual trends in outbreak reporting

The country reported outbreaks of at least one disease each year between 2007 and 2022. In the first two years, only cholera was reported. Over time, the number of reported diseases gradually increased, except for sporadic declines in reporting in 5 of the 16 years of surveillance. Overall, we observed an increasing trend in the number of outbreaks reported over time (IRR = 1.26, 95% CI [1.22–1.29], $p < 0.001$. By 2022, there were 93 outbreak reports in 2022, compared to 4 outbreak reports in 2007. The trends are shown in Fig. 3.

In 2007, four counties reported outbreaks, in 2011, this number had dropped to just one. A notable increase in reports began in 2012, culminating in all counties reporting outbreaks from 2020 to 2022, largely due to COVID-19. We observed an overall increase in the number of counties reporting outbreaks over time ($r = 0.97$, $p < 0.001$). The trends are shown in Fig. 4.

Distribution of outbreaks by county

Since 2007, all 47 counties reported at least one outbreak. Garissa, Nairobi, Nakuru, Wajir, Mandera, and Mombasa

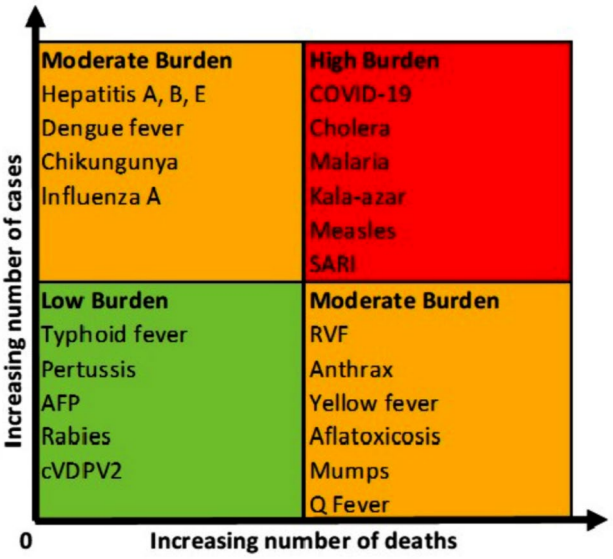

Fig. 2 Categorization of disease outbreak burden in Kenya 2007–2022

accounted for a quarter of the 457 reports. The average number of outbreaks reported per county was four. Nairobi reported the highest number of cases and deaths of all the outbreaks, with approximately a third of the cases and a quarter of the deaths. Samburu reported the lowest number of cases, 331(0.07%) for the surveillance period. The summary is shown in Fig. 5.

Discussion

Over 16 years, 457 outbreaks of 23 diseases were reported across all counties in Kenya. The variation in outbreak reports between counties highlights Kenya's complex public health landscape. The frequent occurrence of epidemic-prone diseases illustrates the vulnerability to potentially large disease outbreaks. We also detected diseases earmarked for elimination and eradication, although these diseases were not associated with high caseloads. VPDs contributed to the highest morbidity and mortality.

Over time, there was an increase in the magnitude, frequency, and geographical occurrence of outbreaks. This increase may be due to several reasons: (i) revision of the IDSR technical guidelines with an increase in the number of priority diseases, conditions, and events for surveillance from 18 to 55; (ii) improvements in surveillance activities may have occurred after the transition to a devolved system of governance in 2013; (iii) enforced regular reporting of COVID-19, which resulted to all counties reporting COVID-19 cases. This suggests that improved surveillance and changes in surveillance, rather than an increase in the occurrence of diseases, could have contributed to the rise in reports over time.

While the COVID-19 pandemic may have contributed to improved surveillance activities, it also led to disruptions in other essential health services, in both developing and developed countries [11]. With limited resources redirected to manage COVID-19, essential health services including, routine vaccinations, and prevention programs for epidemic-prone diseases such as kala-azar were neglected [12]. Although we observed a slight increase in reported measles cases in Kenya after the emergence of the COVID-19 pandemic, we did not observe as many cases as in previous years. This may be explained by the fact that although COVID-19 disrupted the provision of essential services in Kenya, the disruption was only experienced for a limited time [13, 14]. The inadequacies of our health systems exposed by the pandemic should be addressed to prevent foreseeable increases in disease burden and medico-legal issues during future pandemics [15].

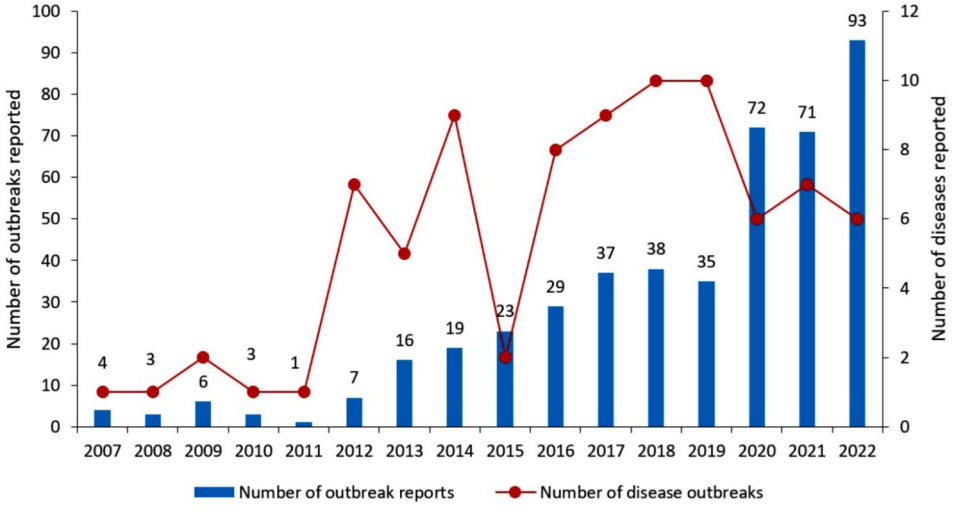

Fig. 3 Trends of number of outbreaks and diseases reported from surveillance data in Kenya, 2007–2022

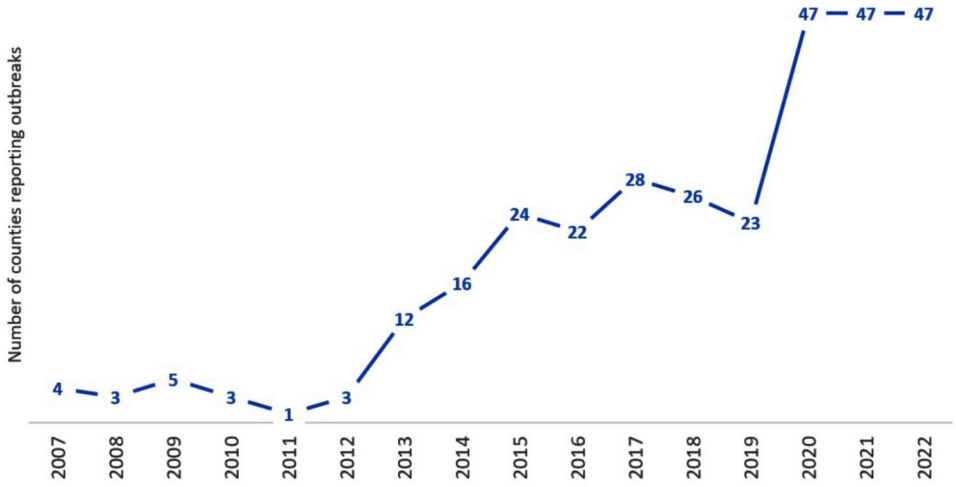

Fig. 4 Number of counties reporting outbreaks in Kenya, 2007–2022

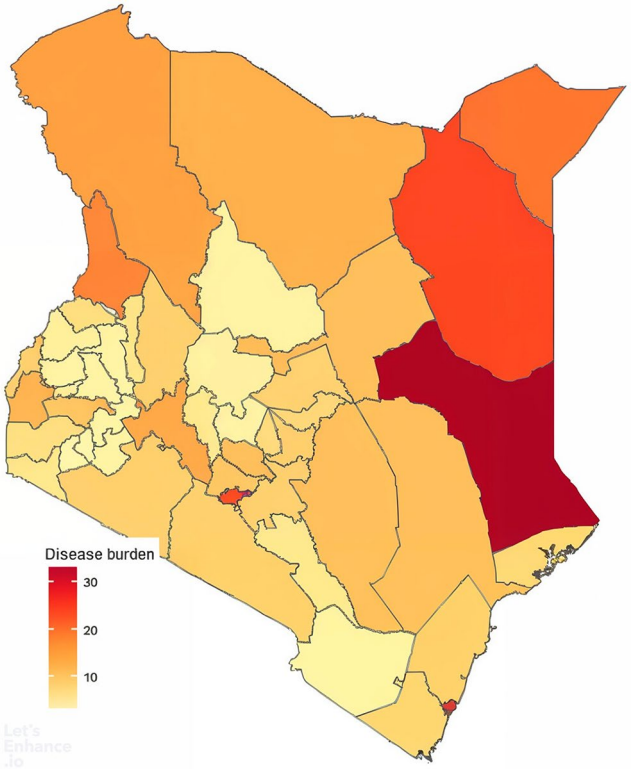

Fig. 5 Frequency of disease outbreaks reported by county in Kenya, 2007–2022

We observed the highest disease burden in both urban and rural counties. The ports of entry, attract a constant influx of people from countries experiencing active disease outbreaks. There are overcrowded refugee camps, which increases the risk of disease outbreaks [16, 17]. The country's susceptibility to frequent outbreaks is further worsened by inadequate access to safe water and sanitation, internal conflicts, food insecurity, limited access to health services, poor socio-economic status, and environmental conditions [2, 18]. While laboratories can generally detect high-incidence diseases, scarce diagnostic resources can compromise their ability to detect outbreaks, such as the case of inadequate malaria diagnostics which hindered the outbreak response in Isiolo County during a concurrent yellow fever outbreak [19, 20].

Our data differed slightly from global statistics and did not fully align with previous national priorities. Globally, the infectious diseases that have caused the highest number of outbreaks between 1996 and 2022, in order of magnitude, are COVID-19, pandemic influenza virus,

cholera, acute poliomyelitis, and yellow fever [1]. Nationally, COVID-19, cholera, malaria, kala-azar, measles, and SARI were the most frequent causes of illness and death due to infectious diseases. Although in 2015, anthrax, trypanosomiasis, rabies, brucellosis, and RVF were identified as the top priority zoonotic diseases in Kenya, influenza-A, dengue, and chikungunya were the more commonly occurring zoonotic diseases in the recent past [21].

Our findings reflect the need for frequent review of national and sub-national data to determine the current causes of disease burden in a county.

Limitations

Routine surveillance data is affected by reporting rates, surveillance performance across counties, and the practice of long-term data archiving, all of which could have affected our findings. The detection of diseases is limited by the availability of diagnostic commodities, which may affect the reporting of some diseases.

Conclusion

The increasing burden of disease outbreaks in Kenya necessitates targeted prevention and preparedness at the county level. The prevalence of VPDs underscores the urgency to strengthen immunization programs. Additionally, the frequency of diseases prone to epidemics highlights the critical need for an early warning and response system to manage outbreaks effectively.

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Author contributions

E.O conceptualized the manuscript. F.G, J.D, J.G, and F.H, wrote the main manuscript, analyzed the data, and data visualization. F.G, J.D, J.G, S.K, F.H and E.O reviewed the manuscript.

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Data availability

The data supporting the findings of this study are not publicly available due to the Ministry of Health, Kenya data protection regulations. Data are however available from the authors upon reasonable request and with permission of the Ministry of Health Kenya.

Declarations

Ethics approval and consent to participate

This study used aggregate data that did not contain personal information about the participants, therefore, obtaining participants' consent was not applicable. This was not an experimental study and direct human data was not used, therefore, obtaining ethical approval is not applicable. The Disease Surveillance and Response Unit head approved the use of the data for the manuscript.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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