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Original Research Article

Integrated epidemiological surveillance in Chad: data from 2010 to 2024

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ABSTRACT

Background: Despite the adoption of the integrated disease surveillance and response strategy (IDSRS), Chad faces various health challenges, particularly regarding the detection and recording of events; case notification; data collection, processing and transmission; and response. The main of this study is to analyse the evolution and effectiveness of the integrated epidemiological surveillance system in Chad between 2010 and 2024.
Methods: This is a retrospective descriptive study. It considers the 6 priority diseases with epidemic potential under surveillance in Chad between 2010 and 2024. The main indicator for monitoring the epidemiological situation is the annual case fatality.
Results: Between 2010 and 2024 in Chad, meningitis mortality doubled from 6% to 12% despite a decline in cases, while measles (1.1% mortality before 2019) experienced a surge linked to COVID-19, which was quickly brought under control. There were four cholera outbreaks with fatality rates of 3% (2010-2011), 5.8% (2014), 6.4% (2017) and 4.1% (2019). Neonatal tetanus remained rare but highly fatal (approximately 30% mortality on average), and yellow fever had an average mortality rate of 2.7%. Malaria causes approximately 1,843 deaths each year out of more than 1.2 million suspected cases (mortality rate=0.15%).
Conclusions: To strengthen Chad's resilience to epidemiological threats, it is crucial to improve the integration and representativeness of real-time data, training, vaccination coverage, access to difficult areas, infrastructure, and intersectoral coordination, while regularly evaluating the integrated surveillance system.

Keywords: Integrated epidemiological surveillance, Chad, Meningitis mortality

INTRODUCTION

The integrated disease surveillance and response strategy (IDSRS) strategy to improve disease surveillance was adopted by the world health organization African Region (WHO-AFRO) in 1998.[1] The latter was adopted and developed in response to a range of emerging and re-emerging diseases that have caused a large number of deaths of people in the African region.[2-5] The status of the implementation of the IDSRS differs by country in the region for the texts of the IDSR and the international health regulations (IHR) provide low-income countries with the opportunity to leverage their limited resources to continuously improve their disease surveillance and response systems.[2,6] It is in this sense that Chad has undertaken several initiatives to strengthen its

epidemiological surveillance system, which is essential for detecting and responding effectively to health threats. It should be noted that The effectiveness of a health surveillance system lies in its ability to adequately monitor health events in order to generate quality information that can be used to carry out appropriate public health actions.[7,8] Data from the WHO Health Emergencies Programme's annual report for 2016 revealed that more than 100 major public health events had been reported to the WHO Regional Office for Africa.[9] These events included: epidemics, cholera, outbreaks of Ebola, Lassa fever, measles, typhoid fever, yellow fever and cholera, yellow fever and Zika virus; acute malnutrition; climate-sensitive diseases, such as chikungunya, dengue fever and Rift Valley fever; humanitarian crises, with associated displacement, injury, illness and death; and accidents.[9]

In addition to the list of events mentioned above, there is the coronavirus disease 2019 (COVID-19) pandemic, where there are also some weaknesses, such as insufficient surveillance at points of entry, the existence of social representations of the COVID-19 disease and the lack of means for surveillance.[10,11]

The evaluation of the integrated epidemiological surveillance system is of particular importance and a good understanding of the epidemiological situation is essential for the implementation of effective prevention and control measures.[12] Therefore, a robust system would allow data to be collected, analyzed and interpreted in a fast and accurate manner, thus facilitating a rapid response to outbreaks.[13] Also, regular monitoring ensures the relevance and effectiveness of the system, identifying strengths and weaknesses to allow continuous improvements. One of the key requirements of the IDSR is the development and dissemination of information products to inform policymakers' decision-making.[14]

Despite the adoption and implementation of the IDSRS, Chad faces various health challenges, including diseases that have a high epidemic potential in Africa such as cholera, meningitis, measles, poliomyelitis, yellow fever, malaria and emerging diseases.[15] These observations highlight the limitations such as the delay in the detection of epidemics due to the inadequacy of the implementation of integrated epidemiological surveillance activities (problems of accessibility in certain localities, especially in the rainy season, means of travel, motivation, etc.) and a weakness in the health information leading to weak coordination of response activities, especially cross-cutting ones, and insufficient or delayed resource mobilization. Like other observations, there are also event detection and recording; case notification; data collection, processing, transmission and response, which are core functions of the IDSRS. It therefore seemed important to us to study is to analyse the evolution and effectiveness of the integrated epidemiological surveillance system in Chad between 2010 and 2024.

METHODS

Study type, population and sampling

This is a retrospective descriptive study. The study population is made up of all diseases that are reported and that are under epidemiological surveillance in Chad. The selected sample is made up of the 6 priority diseases under integrated epidemiological surveillance in Chad during the years 2020 to 2024. According to the Ministry of Public Health and partners such as WHO and UNICEF, Chad actively monitors the following diseases: Meningitis, measles, yellow fever, malaria, neonatal tetanus and cholera. They are prioritized for surveillance in Chad based on their high burden of morbidity and preventable deaths, their epidemic potential if left uncontrolled, the availability of effective vaccines or treatments, and their alignment with national and international public health objectives.

Data collection procedure

The data were collected by consulting the Intrusion Detection System (IDS) databases and by consulting the summaries of the activities of the National Technical Committee for the Control of Epidemics (NTCCE). These basic consultations are done on a weekly basis, i.e. from the first week (W1) to the last week (W52 or W53) during each year of our study period, and this depends on the provincial health delegations and functional health districts of the country. The information was collected at the level of the health facilities by two hundred and ninety-nine (299) focal points who were trained for the work. Reports were sent to the health district on a weekly basis. Data on diseases with epidemic potential and diseases to be eradicated are transmitted as soon as they are reported. At the district level, data received from health facilities is being compiled and analysed. A report is then produced and sent to the provincial health delegation, which proceeds in the same way by compiling data from all the health districts. The report from the province is sent each week directly to the Directorate of Integrated Epidemiological Surveillance (DIES), which is housed within the Ministry of Public Health.

Nature of the data collected

For each of the diseases, the indicators monitored are mainly the total annual number of suspected cases, recovered and deaths. The choice of these two indicators is mainly justified by the need to assess the evolution of the lethality (measured by the case fatality rate) of the disease under surveillance over the study period. According to Médecins Sans Frontières, the case fatality rate (CFR) is the proportion of deaths due to a disease in relation to the total number of diagnosed cases of that disease over the period.[16] The case fatality rate is expressed as a percentage (between 1 and 100%). Thus, for disease m, the lethality at period t is given by: CFR_t^d

$$CFR_t^d = \frac{\text{Number of deaths due to the desease d at year t}}{\text{Total number of detected cases of the desease d at year t}} \times 100$$

Where $d = \{\text{list of seven priority deseases selected}\}$ and $t = \{2010, 2011, \dots, 2024\}$

Data processing

The data was extracted and pre-processed with R Diversity V4.2.0. Missing data on cases and deaths have not been cleared due to the sensitivity of the epidemiological data and the seasonal or episodic nature of some of the diseases under surveillance. The data processing consisted mainly of calculating the lethality series of each disease and processing the extreme values. Indeed, the exploration of the database found that only one case of prenatal tetanus was detected in 2019 and this case died, i.e. a 100% fatality. This value, although real, is absurd and could have distorted the trend of evolution of the lethality of the said disease over the period considered. To this end, we have chosen to consider that no case of neonatal tetanus has been detected this year. The data was processed using the excel 2019 software

Data analysis

Data analysis started by the descriptive analysis. For each priority disease selected, a bivariate bar chart (stacked) was designed. Each bar represents the total number of total suspected cases in year t, broken down by the number of recoveries and deaths whose surfaces are stacked in the bar. The higher the number of deaths, the larger the reserved area and the more the total surface area of the bar. A third axis has been added to the graph to represent the lethality curve. The excel 2019 software was used for this purpose.

Ethical considerations

Before any investigation and/or documentary research for the collection of data in the framework of this study, we have obtained written authorization from the Secretary General of the Ministry of Public Health and Prevention of Chad under No. 2185/MSPP/SE/SG/2024 of April 26, 2024. This authorization attests to the consideration of all the ethical provisions in force in terms of public health research in Chad.

RESULTS

Evolution of the lethality of meningitis in Chad from 2010 to 2024

Over the last 15 years, the lethality of meningitis varies considerably between 4% (2012) and 14% (2015), following a two-phase cycle. The first covers the period from 2010 to 2012, which was characterized by an exponential surge in new cases, with an average of 4,152 suspected cases per year. Despite this surge in cases, the case fatality rate of meningitis decreased over this period, from 9% in 2010 to 4% in 2011 (on average 6%). The second phase, which covers the period 2013-2024, is countercyclical to the first. Indeed, from 2013 onwards, the number of suspected cases did not reach 1000 over the entire period (an average of 347), while the case fatality rate was twice as high (on average 12%) compared to the previous phase (see Figure 1).

In other words, compared to the first phase, meningitis caused 2 times more deaths on average per year, with 13 times fewer suspected cases between 2013 and 2024. These statistics reveal structural limitations in the management of meningitis in Chad since 2013.

Evolution of measles lethality in Chad from 2010 to 2024

The analysis of Figure 2 below reveals two key phases of the measles epidemiological situation. The first was from 2010 to the pre-COVID period (2017-2018), during which Chad went from 10,283 cases in 2010 to 349 cases (i.e. a third) in 2017. On the other hand, over the same period, the case fatality rate of measles increased from 1.2% in 2010 to 1.8% in 2018, i.e. an annual growth of 90% on average. The second phase concerns the Covid period, characterised by an explosion of cases-from 5336 cases in 2018 to 26,623 suspected cases in 2019, almost five times in one year-and the post-covid period, characterised by a sharp decrease in suspected cases.

Despite the one-off growth in cases in 2019, the case fatality rate of measles increased from 1.8% to 1% in 2019. This trend continued until 2023, when the case fatality rate reached its lowest level in the last 15 years (0.1%). This phase demonstrates that the monitoring system would have been more effective in taking over this period compared to the previous phase.

Evolution of cholera lethality in Chad from 2010 to 2024

The analysis of this figure 3 below confirms the episodic nature of cholera. Indeed, Chad has experienced four episodes of cholera in the last 15 years. The first-which lasted two years (2010-2011)-is the one with the highest incidence (20,880 cumulative cases), but the least dangerous with an average fatality rate of 3%. The second episode occurred in 2014 with 172 cases recorded for 10 deaths, i.e. a fatality rate of 5.8%.

The third took place in 2017 and was the most dangerous of all with a case fatality rate of 6.4% for 1254 recorded cases). The last episode of cholera in Chad in the last 15 years occurred during COVID-19 with nearly 100 cases recorded, for a case fatality rate of the 4.1%, more dangerous than that of 2010 to 2011, with the 21 times fewer cases.

Evolution of neonatal tetanus lethality in Chad from 2010 to 2024

According to Figure 4 below, neonatal tetanus has a low incidence compared to other diseases, with fewer than 300 cases recorded per year (except for 2023), but is very dangerous in view of its consistently high lethality over the period. The cases recorded over the last 15 years have a U-shaped evolution, from 289 cases in 2010 to 172 cases in 2016, then to 275 cases in 2024. The lethality of neonatal tetanus fluctuates around 30% over the period, with an (exceptional) minimum of 6% in 2011 and a maximum of 33% reached in 2023, i.e. an average of 26.2% for an average of 214 cases recorded per year. In other words, over the past 15 years, on average just over one in four suspected cases of neonatal tetanus in Chad has died, illustrating the persistent severity of this disease, despite its relatively low incidence. These statistics reveal structural gaps in the management of suspected cases of neonatal tetanus by the surveillance system in Chad.

Evolution of yellow fever lethality in Chad from 2010 to 2024

The incidence and lethality of yellow fever in Chad have intersecting trends over the past 15 years. Indeed, the number of suspected cases is growing in a staircase with three identifiable steps. The first period covers the period 2010-2013, during which an average of 122 cases of yellow fever were recorded, with a particularly high case fatality rate of 6% on average (12% in 2012). The second step covers the period from 2014 to 2020, during which the average number of confirmed yellow fever cases quadrupled (from 122 to 476 on average) compared to the previous phase. On the other hand, the fatality rate fell over this period, with an average of 1.5%, a quarter of the previous period. Last step runs from 2021-2024, with an average of 1,300 confirmed cases, almost double previous phase and 10 times more than in 1st phase. Case fatality rate remains low but increased by 0.5 points compared to the previous period, from 1.5-2% on average (Figure 5).

Evolution of malaria lethality in Chad from 2010 to 2024

Malaria has had a worrying, low but deceptive lethality rate over the past 15 years (see Figure 6). Indeed, the analysis of this figure reveals a five-year cycle of evolution. Every 5 years, the number of confirmed cases of malaria increases from a minimum number in the first year to a peak in the fifth year, then drops sharply and the cycle begins again. Over the first five-year period, Chad recorded an average of 1,001,000 suspected cases of malaria, with a minimum of 357,533 cases in 2011 and an average annual growth of 55%. A total of 5,037,203 people died of malaria over the period, or an average of 1,007,441 deaths per year, for an apparently low average case fatality rate (0.21%). It should be noted that just over 3500 people died of malaria in 2015, the first peak in cases recorded in the last 15 years. During the second five-year term (2016-2020), the cycle repeats itself with more incidence, with an average of 1,607,429 cases recorded per year (compared to 1,001,000 in the previous five-year period) and relatively less serious with an average case fatality rate of 0.12% (compared to 0.21% in the previous five-year period). It should be noted that nearly 2500 people died of malaria in 2019, the second peak of cases recorded since 2015. The trend is identical for the current five-year term (2021-2025) with less incidence (1,255,841 cases recorded) and a similar severity (with a case fatality rate of 0.13%) compared to those of the previous five-year term.

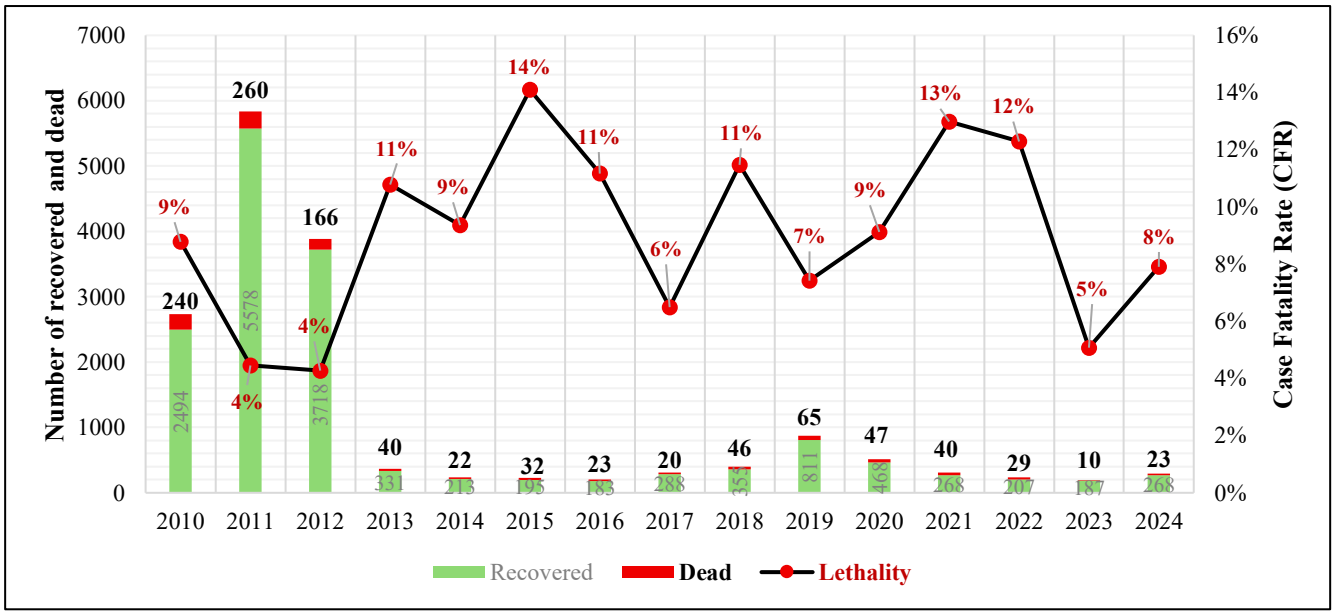

Figure 1: Evolution of the lethality of meningitis in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

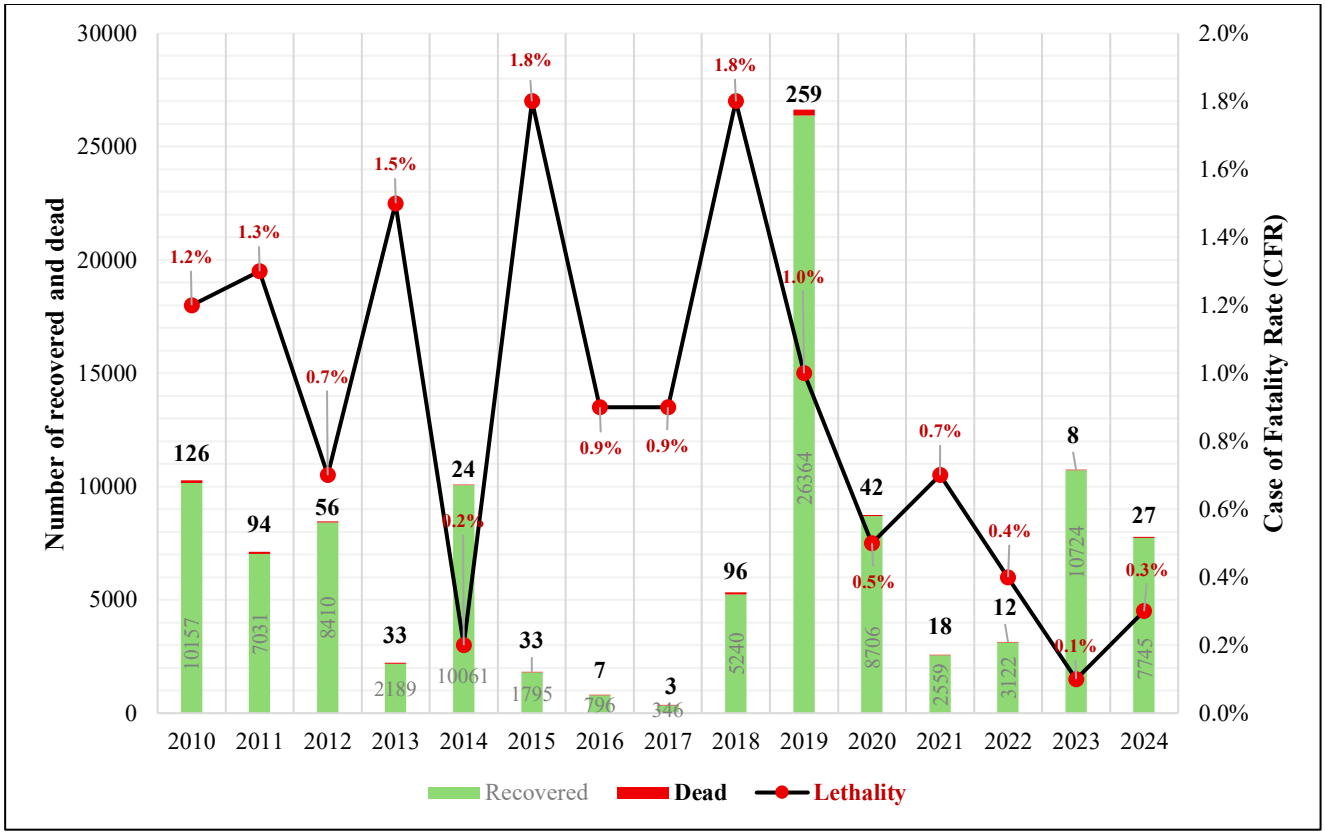

Figure 2: Evolution of measles lethality in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

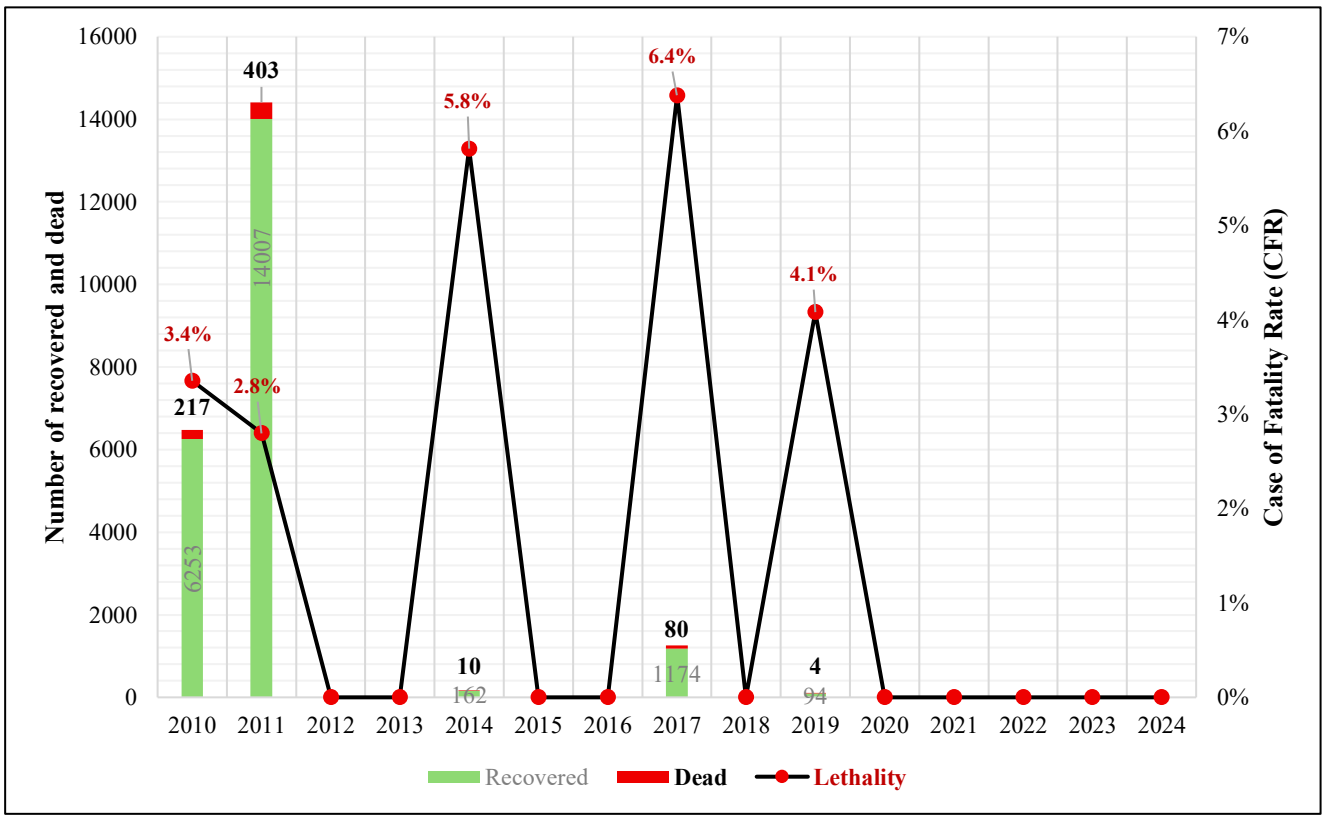

Figure 3: Evolution of cholera lethality in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

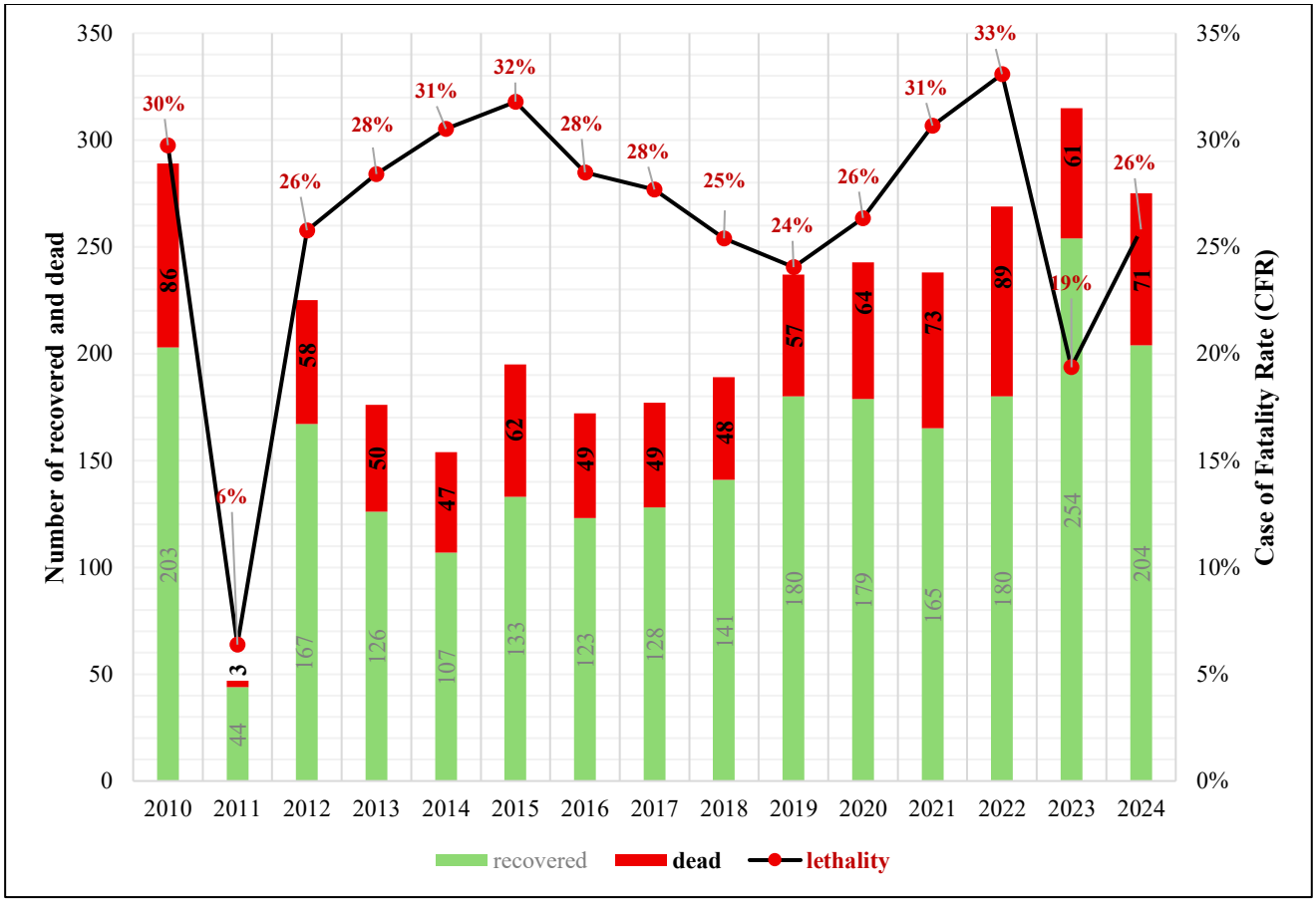

Figure 4 : Evolution of neonatal tetanus lethality in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

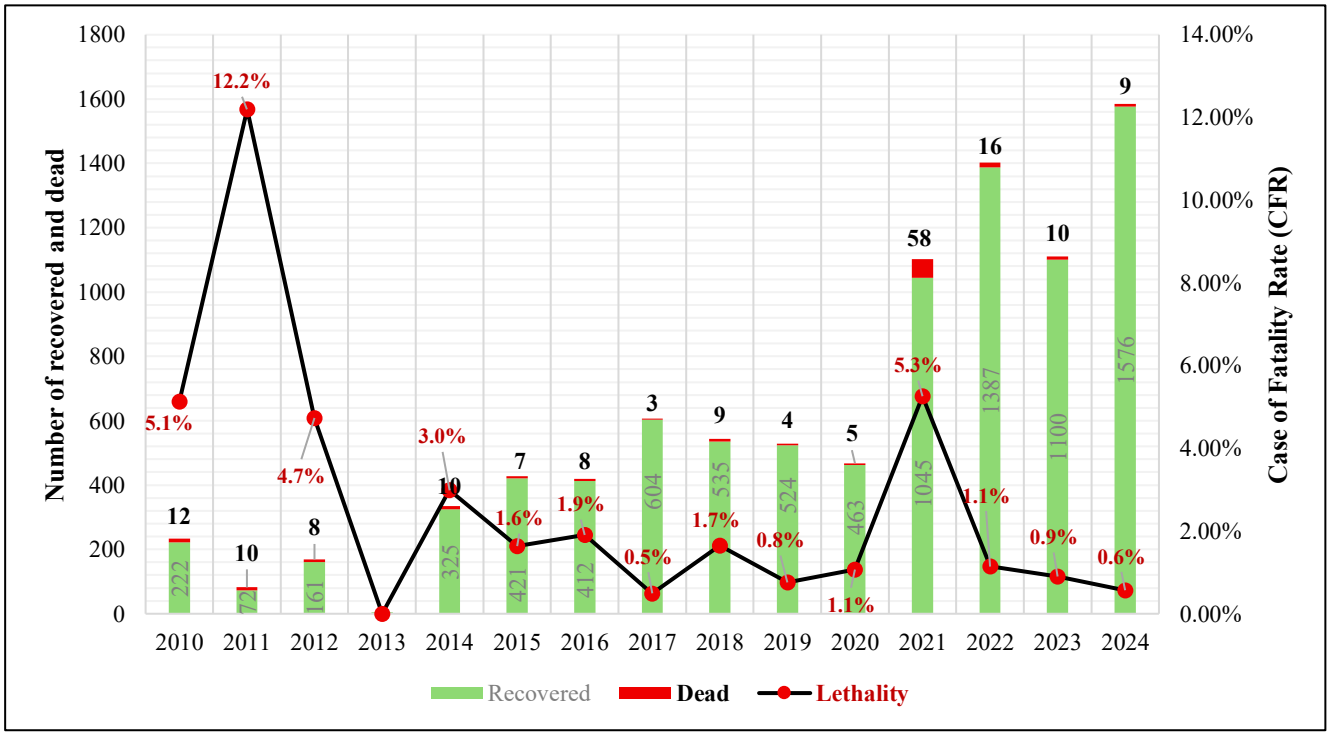

Figure 5: Evolution of the lethality of yellow fever in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

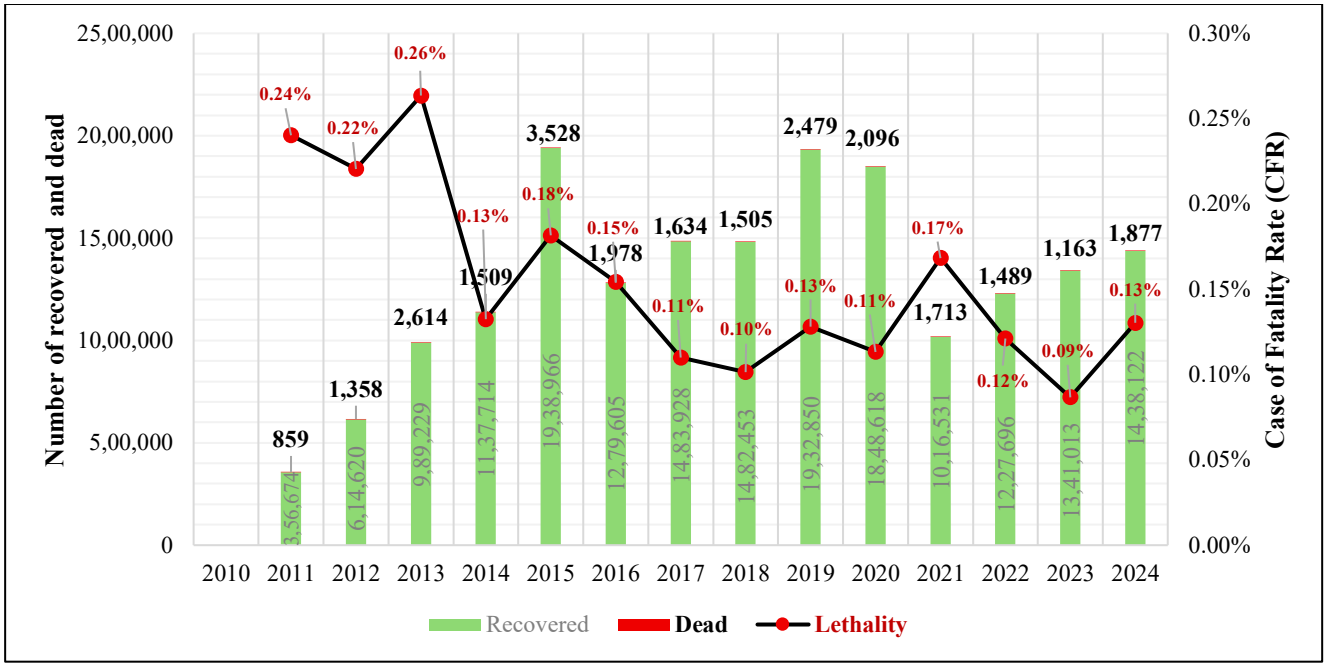

Figure 6: Evolution of malaria lethality in Chad between 2010 and 2024.

*Source: Chad SSEI data, 2024

DISCUSSION

In Chad, meningitis lethality followed a two-phase cycle between 2010 and 2024. The first period (2010-2012) was marked by a surge in cases, but a decreasing case fatality rate (average of 6%). This explosion of cases is the result of a combination of climatic (harmattan), microbiological (lack of vaccine) and structural (surveillance system under development) factors, in a context of health vulnerability (meningitis belt).[17] The second phase (2013-2024) during which suspected cases fell by 13 times, but with an average case fatality rate twice as high (12%). The drop in cases is linked to the administration of meningococcus A to nearly two million people in three regions of Chad from 2011 onwards.[18] However, the high lethality of meningitis over this period is explained by the structural limitations of the SSEI in the response and management of suspected cases.[19-22]

Before the release of COVID-19 (2010-2019), measles cases in Chad were steadily decreasing, with an average case fatality rate of 1.1%. COVID-19 caused an exceptional surge in measles cases which was immediately brought under control in the post-COVID period with a remarkable decrease in fatality over the period. This trend is significantly higher than that of Mali.[23] The main factors in the resurgence of cases since 2019 are on the one hand the concentration of all health activities and all actors on the management of the COVID-19 pandemic, as well as the restrictive measures and on the other hand, the massive displacement of populations, particularly Sudanese refugees in the east of the country, where vaccination coverage is difficult to maintain.[24,25]

Chad has experienced cholera with case fatality rates of 3% between 2010 and 2011, 5.8% in 2014, 6.4% in 2017 and 4.1% in 2019. The capitalization report of the 2010-2011 episodes reveals that it was a border transmission (Cameroon-Niger-Nigeria).[26] The 2014 and 2017 episodes were localized cholera epidemics, mainly in border regions, with aggravating factors such as limited access to drinking water, population movements and poor hygiene conditions.[27] The 2019 episode is essentially linked to the publication of COVID-19 and the neglect of other epidemics under surveillance.[24]

Between 2010 and 2024, TNN had a low incidence compared to other diseases, with less than 300 cases recorded per year (except for 2023), but remained very dangerous in view of its consistently high lethality over the period (on average 30%). This trend is slightly higher than that observed in Lomé (Togo) between 2008 and 2018, (27%) and slightly lower than that observed in the 90s (32%) in Abidjan (Côte d'Ivoire) that has confirmed its neonatal tetanus elimination status in 2024.[28-30] The maintenance of neonatal tetanus in Chad could be explained by the low coverage of the vaccine among pregnant women or the absence of booster vaccinations, an inadequate delivery environment, especially in vulnerable areas, or the low responsiveness of the surveillance system to suspected cases, given the rapid progression of the disease to serious, often fatal complications without urgent and intensive treatment.[25,28]

Chad has an average case fatality rate of 2.7% of yellow fever over the last 15 years. Although not negligible, this result is much lower than that observed in Côte d'Ivoire between 2012 and 2021. The latter study considers low vaccination coverage and lack of vector control as the

main factors in the high structural lethality of yellow fever.[31] Beyond the endogenous causes, the spread of yellow fever is linked to the cross-border mobility of carriers of the virus, hence the need for a global response.[32]

Over the past 15 years, malaria cases have been recorded every year despite the seasonal distribution of impregnated mosquito nets to families and malaria prevention drugs to children aged 3 to 59 months by the national malaria control programme and its partners. Each year, an average of 1,843 people lose their lives in Chad due to malaria, among an average of 1,293,844 suspected cases recorded, i.e. a low case fatality rate of 0.15% on average per year. Although acceptable, this low lethality is put to the test both in the detection, reporting and reporting of cases and in the analysis and use of data, as in Burkina Faso in 2022.[33] The lack of training and low awareness of health workers had been noted in the final evaluation reports Malaria surveillance systems in Cameroon, Congo and Senegal.[34-36] In addition, we must not neglect climatic (tropical geographical areas), hygienic (unsanitary conditions) and economic (low standard of living) factors aggravated by the worrying humanitarian situation in Chad.[25] It is in response to these various problems of malaria surveillance that in 2016 Dumbo et al reminded us of the importance of malaria surveillance. The failure of the global malaria eradication campaign of the 1950s to draw lessons to rethink Africa's malaria elimination strategy by 2030.[37]

The main limitation of this work is the lack of data disaggregated by sociodemographic characteristics of cases and deaths, by health zones or provinces, and by the associated factors of diseases and events under surveillance. Indeed, the availability of these data would have allowed us to draw up the real epidemiological situation (distribution according to sex, age, etc.) according to the geographical and/or health zones, depending on the associated factors) of the priority diseases and events selected in the framework of this study.

CONCLUSION

Our study focused on several diseases with epidemic potential and health events of public health importance monitored between 2010 and 2024 and highlights the crucial importance of an epidemiological surveillance system set in motion for the detection and notification of cases; data collection, processing and transmission and response to health crises. The results of this study have made it possible to group the events under surveillance in Chad over the past 15 years into three categories. Neonatal tetanus and meningitis make up the duo in the first category. With an average case fatality rate of 26.2% (well over 10%), neonatal tetanus is a disease that the WHO describes as "highly virulent" and requires an immediate response. Meningitis has crossed the WHO alert threshold for humanitarian emergencies or epidemics, with an average case fatality rate of 9% (greater than 5%). The second category is made up of events under surveillance, which, although not having reached the WHO alert threshold, should be monitored closely. These are cholera (4.5%), yellow fever (2.7%) and measles (0.9%). The third category is made up of malaria (0.13%) with a deceptive lethality, negligible, but whose average number of deaths is worrying. In addition, the results showed that there were periods of surge in cases of several diseases under surveillance, such as 2010-2011 and 2019-2020, but also periods of strong mobilization of surveillance systems, thus reducing or stabilizing case fatality rates (post-covid period).

Recommendations

To maximize the effectiveness of the integrated epidemiological surveillance system in Chad, it is essential to improve the integration and representativeness of real-time data, strengthen the training of the actors involved, expand vaccination coverage, expand the surveillance network in hard-to-reach areas, invest in infrastructure, and develop better intersectoral coordination (including economic and security as a priority). There is also an urgent need to evaluate Chad's integrated epidemiological surveillance system.

Specifically, we recommend that national and international actors in epidemiological surveillance in Chad: Improve epidemiological surveillance by establishing a single mechanism for data transmission and confirmation of meningitis cases. Strengthen the expanded routine immunization programme and improve the responsiveness of the surveillance system to measles outbreaks. Establish a mechanism that will consider epidemiological, biological and environmental surveillance that will promote the effectiveness of the cholera surveillance system without forgetting the aspects of One Health. Strengthen epidemiological surveillance through vaccination and vector control against yellow fever and ratify the international agreements for the control of yellow fever. Emphasize routine immunization of pregnant women and neonatal tetanus booster vaccines. Sensitize health workers on the rational use of malaria rapid diagnostic tests and strengthen the malaria surveillance system in Chad with a view to achieving the goal of eliminating malaria in Africa by 2030. Transition from a sentinel surveillance system to an operational, rapid and efficient genomic surveillance platform to promote its flexibility in the event of atypical epidemics such as COVID-19.

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APPENDIX - I

Descriptive statistics

Table 1 below present key statistics on the epidemiological situation of priority diseases under surveillance in Chad between 2010 and 2024.

Chad has recorded an average of 71 (82) deaths from meningitis for an average of 1,108 (1,692) suspected cases per year-including less than 308 over half of the period-i. e. an average annual case fatality rate of 9% (3.1%) over the last 15 years. Measles claimed an average of 56 (67) lives per year for 7,072 (6,517) suspected cases, representing a low annual case fatality rate of less than one percent [0.9 (0.6%)] between 2010 and 2024. Chad has recorded 05 episodes of cholera over the last 15 years. For each of the episodes, an average of 4,481 (6,139) suspected cases were recorded, including an average of 143 (169) deaths, i.e. an average case fatality rate of 4.5% (1.6%). With an average annual case fatality rate of 26.2% (6.5%), tetanus is the most dangerous disease under surveillance in Chad over the study period. Indeed, over the last 15 years, an average of 213 (66) suspected cases of neonatal tetanus have been recorded, including an average of 58 (20) deaths. Although less dangerous, yellow fever has a non-negligible lethality [2.7% (3.2%)]. Each year, an average of 1,843 (679) people lose their lives in Chad due to malaria, among an average of 1,293,844 (1,292,001) suspected cases recorded, i.e. a low case fatality rate of 0.15% (0.05%) on average per year. This weakness is apparent, given that malaria is the disease under surveillance that has been the deadliest (in absolute terms) in Chad over the last 15 years.

Table 1: Descriptive statistics.

Illness	Indicator	N	Minimum	Average	Standard deviation	Median	Maximum
Meningitis	Case	15	197	1108	1692	308	5838
	Death	15	10	71*	82**	40	260
	Lethality	15	4.3%	9.0%	3.1%	9.1%	14.1%
Measles	Case	15	349	7072	6517	7 125	26.623
	Death	15	3	56	67	33	259
	Lethality	15	0.1%	0.9%	0.6%	0.9%	1.8%
Cholera	Case	5	98	4481	6139	1254	14.410
	Death	5	4	143	169	80	403
	Lethality	5	2.8%	4.5%	1.6%	4.1%	6.4%
Neonatal tetanus (NNT)	Case	15	47	213	66	225	315
	Death	15	3	58	20	58	89
	Lethality	15	6.4%	26.2%	6.5%	27.7%	33.1%
Yellow fever	Case	15	5	601	480	468	1585
	Death	15	0	11	13	9	58
	Lethality	15	0%	2.7%	3.2%	1.6%	12.2%
Malaria	Case	14	357533	1293844	461647	1311880	1942494
	Death	14	859	1 843	679	1674	3528
	Lethality	14	0.09%	0.15%	0.05%	0.13%	0.26%

Source: Chad SSEI data, 2024, NB: 71 (82**)=mean (standard deviation)