



Regular Article

Public health challenges in Madagascar: Trends in the 25 most common diseases across 22 regions from 2015 to 2024

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ABSTRACT

This study aims to provide an overview of the 25 most commonly encountered diseases in district reference hospitals (CHRD) across Madagascar's 22 regions from 2015 to 2024, with the goal of better guiding public health policies and improving healthcare delivery. The originality of this study lies in the use of aggregated clinical data from the Health Information System (HIS), centralized through the DHIS2 platform, and validated by data committees at multiple levels (services, hospitals, districts). The methodology relies on the analysis of data collected from CHRDs, gathered both manually and digitally, and validated at different hierarchical levels before being centralized in DHIS2. The geographic and socio-demographic profile of Madagascar, the health pyramid, and the data collection and validation mechanisms are also considered to contextualize the results. Preliminary analyses reveal that the most recurrent diseases include malaria, acute respiratory infections, diarrheal diseases, tuberculosis, and severe malnutrition, with significant regional disparities. For instance, the fatality rate for severe malaria remains high (6%), while neonatal mortality stands at 26%. Consultation rates remain low (37.2% in 2022), especially in rural areas. This study highlights the weaknesses of the Malagasy healthcare system, particularly in terms of prevention and healthcare coverage. It suggests the need for better

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resource allocation, strengthening regional health infrastructure, and rigorous data monitoring to support Universal Health Coverage (UHC).

1. Introduction

Achieving Universal Health Coverage (UHC) has been a central objective of health policy reform in African nations since the Alma-Ata Declaration of 1978, which recognized health as a fundamental human right (World Health Organization (WHO), 2024). Despite decades of commitment, progress toward UHC across Africa remains uneven and fraught with persistent challenges (Afriyie et al., 2025). A narrative review by (Sally et al., 2022) notes that while several African countries have introduced Universal Health Insurance programs, these often fall short in adequately covering informal workers and economically vulnerable populations, thereby limiting equitable access to healthcare services. Similarly, a systematic review by (Ifeagwu et al., 2021; Diop et al., 2018) identified common health financing approaches in Sub-Saharan Africa—including national health insurance schemes, community-based health insurance, tax-based systems, and donor funding—but highlights that these mechanisms frequently encounter barriers such as insufficient funding, inefficient resource allocation, and socio-cultural constraints. An efficiency assessment by Arhin et al. (2023) further underscores that many health systems in the region continue to grapple with suboptimal resource utilization, complicating efforts to achieve UHC by 2030 (Arhin et al., 2023). Collectively, these findings suggest that while policy frameworks for UHC are in place, their successful implementation hinges on overcoming financial limitations, improving health system efficiency, and ensuring the inclusion of marginalized populations.

Nowadays, Sub-Saharan Africa, healthcare coverage remains substantially lower than in other regions of the world (WHO, 2024; Sagna et al., 2016; Edmond, 2012). Over the past decade, the Malagasy population has faced increasing poverty, leading to heightened vulnerability to various infectious and sexually transmitted diseases such as HIV, syphilis, and whooping cough (Kraemer-Mbula & Scerri, 2015; Frenk et al., 2009). The year 2024 marked a strategic milestone for Madagascar, as it concluded the implementation of the Health Sector Development Plan 2020–2024 and initiated the transition toward adopting a new national health policy with corresponding strategies. In this context, updating the data on health expenditures is essential to provide an up-to-date evidence base for informed decision-making and to enhance the effectiveness of health interventions. Over the years, in response to the persistent health vulnerability of the Malagasy population, numerous international organizations, NGOs, and researchers have been engaged in developing strategies aimed at improving public health. These efforts particularly focus on equitable access to care, the prevention of infectious diseases, and the strengthening of the health system at all levels. Ratsimbazafy et al. (2016) conducted a retrospective study in the surgical emergency department in Antananarivo, to analyze the factors influencing patients' choice of healthcare centers. The findings highlighted three main reasons: patients' habits, lack of awareness of services offered by other facilities, and the quality of care, each accounting for 13.3% of the decision factors.

Khan F et al. (2015) focused on rehabilitation services for people with disabilities in Madagascar to identify barriers to implementing the National Action Plan. Through a 14-day workshop, they highlighted key challenges, including limited access to services, a shortage of qualified personnel, and inadequate healthcare infrastructure. In response to these findings, they proposed recommendations to enhance the effectiveness of the plan (Rajaonarifara et al., 2022). assessed the impact of a health system strengthening intervention on the relative contributions of routine immunization and outreach activities in achieving vaccination targets in rural Madagascar. A comparative analysis of health center data from Ifanadiana district between 2014 and 2018 showed a

significant increase in vaccination rates following the HSS intervention. However, despite this initial improvement, a decline in rates was observed over time. Moreover, the researchers emphasized an overall increase in vaccination coverage, a reduction in economic disparities, and improved timely immunization. Nevertheless, geographic inequalities persist, thereby hindering the achievement of international targets (Sobngwi-Tambekou et al., 2021; Rajaonarifara et al., 2022; Health Sector, 2025; Holland & Moss, 2017).

This research work addresses several major challenges within Madagascar's health system, including significant regional inequalities in healthcare access, the persistence of preventable diseases such as malaria and tuberculosis, the low consultation rate, and the lack of a reliable data foundation to support evidence-based health planning. In addition, this study examines the trends of the 25 most common diseases recorded in CHRDS across Madagascar's 23 regions between 2015 and 2024. Using routinely collected clinical data from the national Health Information System (HIS), centralized through the DHIS2 platform and validated at multiple administrative levels, this research provides a structured overview of disease distribution and its regional variability. The ten-year period covered by the study captures important epidemiological shifts and allows for the identification of persistent patterns within the health system. By analysing these longitudinal trends and the geographic disparities they reveal, the study addresses a significant gap in the literature, as few national assessments have systematically combined routine hospital data with regional comparisons to describe Madagascar's evolving health landscape. This analytical framework establishes the foundation for understanding disease dynamics in the country and situates the study within current health sector priorities and monitoring needs.

2. Overview of selected diseases

The 25 diseases examined in this study correspond to the conditions most frequently reported in the CHRDS across Madagascar between 2015 and 2024. These diseases were selected based on their consistent contribution to national hospital morbidity and mortality and their relevance to public health priorities. Below is a concise contextual summary of several major disease categories represented in the CHRDS dataset.

2.1. Malaria

Malaria remains one of the most significant public health threats in Africa, accounting for 249 million global cases in 2022, 94% of which occurred on the African continent (Sharma et al., 2024). Mortality reached 608,000 deaths, concentrated primarily in a few high-burden countries (Sharma et al., 2024). Although long-term declines were observed after 2000, progress has plateaued since the COVID-19 pandemic (Sharma et al., 2024). Madagascar continues to face periodic resurgences, including documented increases in incidence in the southwest (WHO, 2022).

2.2. ENT and ocular infections

Ear–Nose–Throat (ENT) infections are among the most common reasons for pediatric consultation globally, with prevalence ranging from 7% to 49.7% depending on setting (Raobijaona, 2000; Signorelli & Mendes, 2013; Janssens et al., 2020). Ocular infections vary from mild conjunctivitis to severe causes of visual impairment of (Kacimi et al., 2006). In Madagascar, ENT conditions account for 12% of pediatric cases in Mahajanga (Randrianandraina et al., 2020).

2.3. Trauma

Trauma represents a growing cause of hospital admissions in many low- and middle-income countries. Urbanization, transportation expansion, and industrial growth contribute to increasing injury-related morbidity requiring CHRD-level management (Lahouaoui, 2009).

2.4. Tetanus

Tetanus remains endemic in settings with low immunization coverage. Globally, 50,000 to 1,000,000 cases are estimated annually (Beytout et al., 2002, pp. 393–401; Bhatia, 2002), affecting all age groups (Beytout et al., 2002, pp. 393–401).

2.5. Diarrheal diseases

Bloody diarrhea represents approximately 10% of diarrheal episodes in children under five and contributes to 15% of diarrheal mortality, frequently linked to *Shigella* spp. infections (Cancella & Hausfater, 2002; World Health Organization, 2020, 2022). Shigellosis alone is estimated to cause 370,000 deaths annually among young children worldwide. Regional studies from Mali highlight the disproportionate burden among infants from low-income households (Dombia et al., 2020).

2.6. Cardiovascular diseases (CVDs)

Cardiovascular diseases (CVDs) are the leading global cause of death, responsible for 17.7 million deaths annually (31% of all deaths) (GBD 2013; WHO 2017). Hospital mortality varies widely across regions—from 9.2% in U.S. cohorts (Jacob et al., 2019) to over 30% in some African settings (Carsten et al., 2012; Mboliasa et al., 2015). In Madagascar, a study from Fianarantsoa reported a mortality rate of 36%, aligning with trends observed in the broader sub-Saharan African region (Andrianiana et al., 2023).

2.7. Meningitis

Meningitis remains a major cause of death and disability, with 117,000 global deaths in 2014 (Degli, 2014). Sub-Saharan African hospital studies report mortality rates ranging from 8% to 18%, with significantly higher risk for infections caused by *Streptococcus pneumoniae* (Yameogo R.A. et al., 2023; Maiga et al., 2019; Kané et al., 2020). In Madagascar, WHO estimates 2391 meningitis deaths in 2020, representing 1.46% of national mortality.

2.8. Measles

A recent outbreak investigation in Madagascar found a mortality rate of 8.63% among hospitalized children with complicated measles, with only 10% vaccination coverage among cases (Raharinianaso et al., 2020). Nationwide, approximately one over ten children eligible for the vaccination campaign of measles (10.5%) has not received any dose of measles vaccine in their lifetime despite the 2024 vaccination campaign, with significant variation depending on the birth cohort (Ministry of Public Health Madagascar, 2025, p. 69).

3. Methodology

3.1. Madagascar island profile

Madagascar is a large island nation in the southwestern Indian Ocean, with an estimated population of 29 million inhabitants in 2022 (SPHS, 2018; Madagascar National Digital, 2025). The population is predominantly rural, with more than 80% living outside urban centers. Despite significant natural resources, the country faces persistent socio-economic challenges, ranking 173rd of 191 on the Human

Development Index, and over 92% of the population living on less than \$2 per day (UNDP).

The national health system remains fragile, characterized by low service utilization: the outpatient consultation rate was 37.2% in 2022, early prenatal care coverage (16.1%) and institutional delivery rates (33.4%) remain limited (Action Plan for Integration, 2025; National Strategic Plan, 2025). According to the Demographic and Health Survey, 46% of births were attended by a qualified provider and 39% occurred in a health facility. Key health indicators highlight ongoing vulnerabilities, including an infant mortality rate of 47 per 1,000, under-five mortality of 75 per 1,000, neonatal mortality of 26‰, and post-neonatal mortality of 21‰ (Andrianiana et al., 2023). Disease burdens of national concern include severe malaria (case-fatality rate 6%), plague (43 confirmed deaths), acute flaccid paralysis (223 cases in 2021), and COVID-19 (positivity rate 23%).

Given these structural and health system constraints, Madagascar provides a critical context in which CHRD-level hospital data as analyzed in this study represent an essential source of information for understanding national disease patterns.

3.2. Data collection in district reference hospitals (DRH)

There are two categories of (CHRD) in Madagascar: (i) CHRD1 and (ii) CHRD2. Following the Basic Health Centers (CSB), which operate at the commune level, the referral of patients is theoretically directed first to the CHRDs, and then to the Regional Reference Hospitals (CHRR) or University Hospitals (CHU). However, in practice, this referral system is not always strictly followed. Patient referrals often vary depending on individual preferences or convenience, particularly influenced by their income levels. In 2019, Madagascar had 99 CHRDs, and by 2024, this number had increased to 100. Fig. 1 shows a Health Pyramid in Madagascar.

Given that this study relies on routine data reported by CHRDs through the national health information system, it is essential to assess the overall quality of these data. Two standard indicators completeness (proportion of expected reports actually submitted) and timeliness (proportion submitted on time)—provide insight into the reliability and consistency of the CHRD dataset over time.

Table 1 presents the annual completeness and timeliness rates between 2015 and 2024. These indicators help contextualize potential variations in data availability and highlight years where reporting challenges may have influenced disease trends. Although completeness generally remained above 70% in most years, timeliness was consistently lower, ranging from 37.9% to 60%. These patterns underline the structural difficulties of routine reporting in Madagascar and must be taken into account when interpreting long-term epidemiological trends.

3.2.1. Data reporting systems and workflow

As part of the national reform of the Health Information System (HIS), Madagascar has progressively transitioned from multiple parallel reporting tools to a unified digital platform. Until 2019, aggregated routine hospital data were reported using GESIS, an Access-based system that enabled district-level compilation of clinical and administrative indicators (Ministry of Public Health, GESIS User Manual, 2011/2012). Although functional, GESIS operated in isolation and lacked interoperability with other national tools.

Since 2018, the Ministry of Health has adopted District Health Information Software 2 (DHIS2) as the principal platform for storing, validating, and disseminating routine health data. DHIS2 serves as the central repository for aggregated information from all levels of the health pyramid and provides standardized data structures and quality-control mechanisms. The Ministry has also initiated the gradual integration of complementary tools used in Madagascar, such as CommCare, SYGMA, Kobo Toolbox, and Power BI to ensure interoperability and strengthen data-driven decision-making.

Fig. 2 presents an overview of the national HIS architecture and

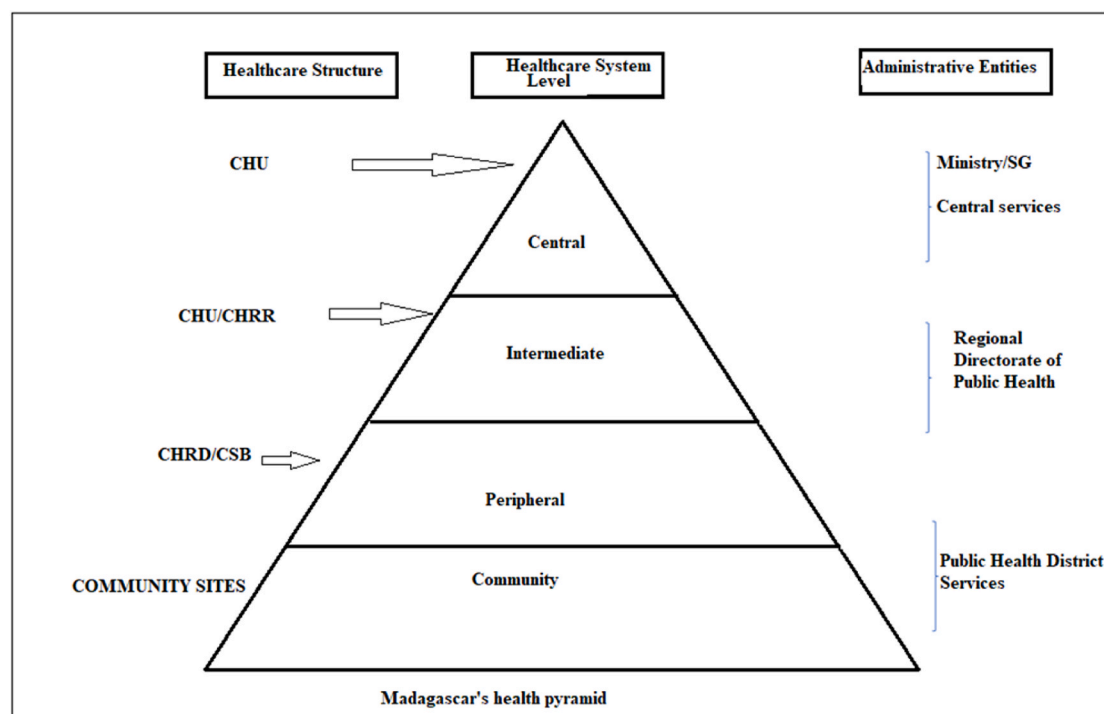


Fig. 1. Health pyramid in Madagascar.

Table 1
Completeness and timeliness of CHRD reporting (2015–2024).

Reporting – District Hospitals (CHRD)		
Year	Completeness Rate	Timeliness Rate
2015	74.5%	51.0%
2016	40.0%	60.0%
2017	75.4	59.8%
2018	80.7%	51.6%
2019	85.70%	50.8%
2020	78.8%	55.8%
2021	72.4%	37.9%
2022	79.08%	49.5%
2023	71.8%	41.5%
2024	79.1%	55.5%

illustrates how data flow from health facilities to the central DHIS2 database and then to users at district, regional, and national levels. Health workers record service delivery data using computers or mobile devices; these data are uploaded to DHIS2, stored on a secure server, analyzed using integrated tools, and subsequently used to inform planning, monitoring, and programmatic decisions.

Within CHRDs, several categories of information are routinely recorded, including administrative, clinical, and resource-management data. For this study, we specifically analyze aggregated clinical indicators related to morbidity and mortality, which constitute the most reliable and consistently reported components of the national CHRD dataset.

3.2.2. Data collection levels, methods, and validation pathway

Data are collected by designated personnel using two primary methods: manually, through registers and paper-based records within the various departments of the CHRD; and digitally, via computerized hospital management systems, where available. A bifolio register and a standardized monthly paper report form (in two copies) are completed by the CHRD's Health HIS officer. Data collection is primarily carried out by several key actors. First, healthcare workers including doctors, nurses, and other medical staff collect patient information directly into

service-level registers, and the department head compiles the data at the end of each month into the designated reporting form. Second, data managers administrative or IT personnel are responsible for entering the data into the management systems or maintaining them in paper formats. Third, a Data Validation Committee, comprising program officers, the hospital director, and the HIS officer, ensures the accuracy and consistency of the collected data. Validation occurs at all levels: within the specific service or program, by the hospital director, and finally by the district-level data validation team at the District Public Health Service before data entry into DHIS2. Feedback is sent back and recorded on one copy of the reporting forms submitted by the CHRD, which is signed and dated to serve as proof of receipt and review, and retained in case future corrections or verifications are needed. Like all health facilities across the national health system, CHRDs are required to submit a monthly activity report. Collected data must be submitted to the respective SDSP within 15 days of completion.

4. Results

4.1. Analysis of case of morbidity and mortality

As shown in Figs. 3 and 4, between 2015 and 2024, morbidity trends in Madagascar reveal notable fluctuations across various disease categories. The highest overall burden was observed for "Other medical conditions," which increased markedly from 14,971 cases in 2015 to 26,194 in 2024, representing a 74.9% rise. Similarly, severe and complicated malaria cases escalated from 9187 to 16,205 during the same period, marking a 76.4% increase and signalling a concerning resurgence of the disease, possibly linked to climatic variations or resistance to treatment. Other respiratory and digestive diseases also demonstrated significant increases of approximately 69.6% and 52%, respectively. Notably, hypertension nearly doubled (+112.1%), highlighting a shift towards non-communicable diseases likely associated with urbanization, dietary transitions, and aging. Conversely, certain diseases showed a marked decline: trauma-related injuries decreased by 51.9%, and neuropsychiatric disorders dropped by 65.3%, although the latter may reflect under-diagnosis or shifting diagnostic priorities rather

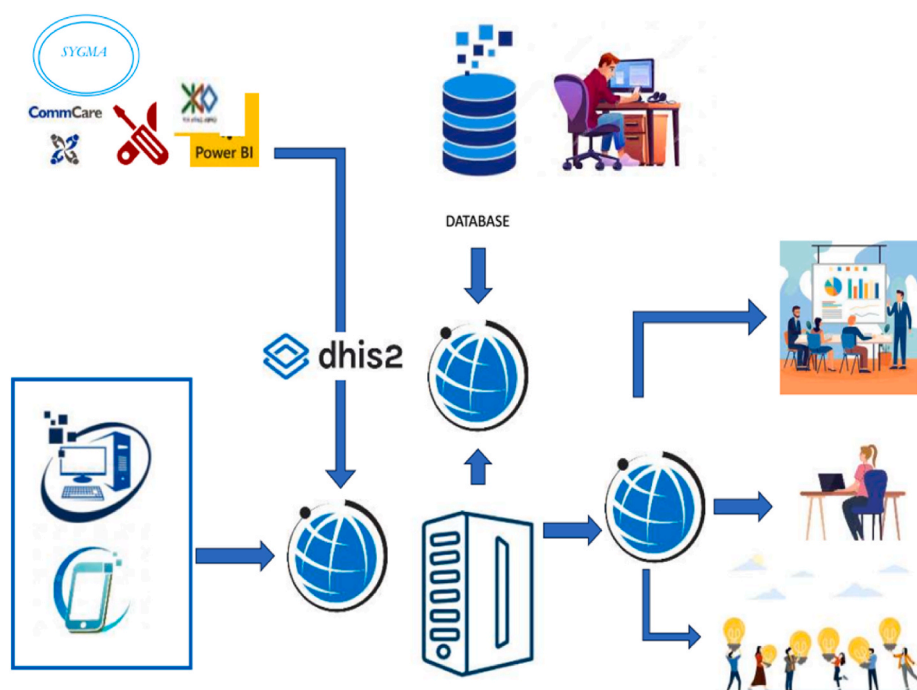


Fig. 2. Components of the health information system in Madagascar.

than an actual reduction. Tuberculosis presented a steady and significant increase, from 1287 cases in 2015 to 2821 in 2024 a 119% rise indicating a persistent challenge for public health. Tetanus, although low in absolute numbers, exhibited sharp peaks, notably 216 cases in 2019, reflecting possible lapses in vaccination or emergency care. Meningitis data fluctuated throughout the decade, with no clear upward or downward trend (from 186 in 2015 to 359 in 2024), suggesting variability in outbreak occurrences or diagnosis. Diseases such as measles showed a sharp peak in 2019 followed by a substantial drop, demonstrating the impact of targeted immunization campaigns. These findings underscore the dual challenge faced by Madagascar's health system: managing persistent infectious diseases while addressing the growing burden of chronic non-communicable conditions. Moreover, inconsistencies in data collection for certain years suggest the need for improved health surveillance and reporting mechanisms.

The comparative analysis of morbidity data between the pre-COVID period (2015–2018) and the pandemic period (2019–2021) reveals notable variations depending on the type of disease. Overall, there was a significant increase in average morbidity during the COVID period for several conditions, particularly ENT disorders (average rising from 1519 to 2293), renal and genitourinary diseases (from 2150 to 2648), as well as other respiratory illnesses (from 8879 to 10,676). This increase can be attributed to both the direct and indirect impacts of the SARS-CoV-2 virus on the respiratory and immune systems, along with increased pressure on health infrastructure, which limited the management of chronic diseases. In contrast, certain conditions such as trauma (injuries) experienced a moderate decrease in the average number of cases (from 2411 to 2,539, though with a higher Standard deviation), likely due to reduced mobility and physical activity during lockdowns. Specific infectious diseases like whooping cough and dysentery remained relatively stable, whereas tuberculosis and severe malnutrition increased, suggesting a weakening of community resilience and basic health services during the health crisis. Standard deviation (SD) and standard error (SE) generally increased for several diseases, reflecting greater year-to-year variability during the pandemic—an indicator of the healthcare system's instability. These findings highlight the importance of strengthening health surveillance and care systems, particularly for chronic diseases and emerging conditions, in the context of global health

crises.

The analysis of morbidity data between the COVID period (2019–2021) and the post-COVID period (2022–2024) reveals contrasting dynamics across different groups of diseases. Some conditions continued to rise significantly after the pandemic. This is particularly true for severe malaria, with average morbidity increasing from 9597 to 10,930 cases a 14% rise accompanied by a high (SD) of 4,470, indicating strong instability. Similarly, severe malnutrition experienced a concerning increase (from an average of 753 to 1211 cases, +61%), highlighting a prolonged impact of the health crisis on food security. Cardiovascular diseases (average rising from 2706 to 2841) and tuberculosis (from 1996 to 2739) also show a steady upward trend, which may be explained by increased detection in the aftermath of the pandemic or a cumulative effect due to the deterioration of preventive care during the crisis.

On the other hand, certain conditions such as other digestive diseases or metabolic disorders showed stagnation or a slight decrease, possibly reflecting improved post-COVID care or temporary effects of lockdown. Notably, neuropsychiatric disorders sharply declined (from an average of 1683 to 1252 cases, –25%), though this drop may reflect under-reporting or a shift toward non-medical forms of stress and anxiety management. Although rare, tetanus showed atypical peaks (e.g., 216 cases in 2019), suggesting occasional failures in vaccination campaigns. Meningitis, meanwhile, remains variable with no clear trend. The high values of standard deviation and standard error for some diseases indicate persistent heterogeneity in the regional or temporal distribution of cases. Overall, these results highlight the long-lasting residual effects of the pandemic on morbidity in Madagascar, calling for strategies to strengthen the resilience of the healthcare system and to enhance epidemiological surveillance particularly for infectious and nutritional diseases. Over the entire period from 2015 to 2024, the longitudinal analysis of morbidity data in Madagascar highlights differentiated trends depending on the disease categories. Some diseases show a general upward trend, often marked and progressive, such as tuberculosis (+119% between 2015 and 2024), severe malaria (+76%), and severe malnutrition (+164%), indicating persistent structural deficits in public health and an increasing vulnerability of the population. Other diseases, such as ENT disorders, kidney diseases, and digestive diseases, have also

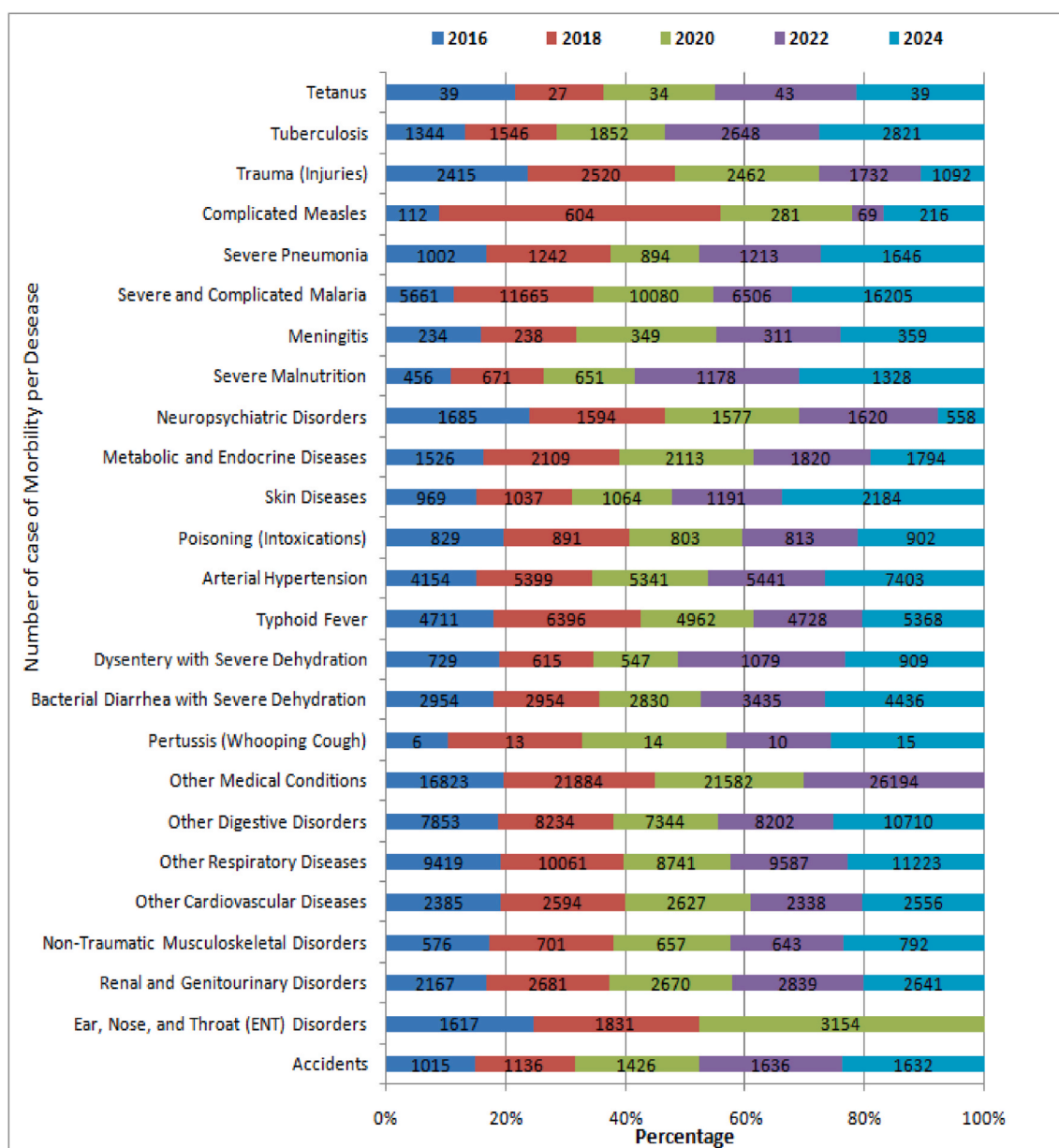


Fig. 3. Number of case of Morbidity for each of 25 diseases (2016, 2018, 2020, 2022 and 2024), in Madagascar.

seen a significant increase, partly due to population growth and urbanization. In contrast, conditions like neuropsychiatric disorders or trauma show more unstable trends, with gradual decreases or high variability, suggesting multiple influencing factors, such as changes in social behaviors, mobility restrictions, or shifting public health priorities. The analysis of (SD), (SE), and rates of variation reveals high volatility during the pandemic, followed by some post-COVID rebalancing, although the overall levels of morbidity remain higher than those before 2019 for most of the diseases studied. The lethality frequency is shown in Fig. 5.

The analysis of case fatality rates (mortality/morbidity ratio) by disease in Madagascar between 2015 and 2024 reveals significant epidemiological trends (see Fig. 5). Some diseases have shown a clear decrease in lethality, likely reflecting improvements in prevention strategies and healthcare management. This is particularly evident in severe and complicated malaria, whose fatality rate dropped from 6.69 in 2015 to 3.6 in 2024, and in other cardiovascular diseases, which steadily declined from 17.09 to 11.66 over the same period. Similarly, the fatality rate for neuropsychiatric disorders significantly decreased

after peaking in 2019, reaching 1.79 in 2024. In contrast, certain diseases have seen alarming increases, such as tetanus, which surged dramatically to 51.28 in 2024, after an earlier peak of 28.21 in 2016 and a spike at 44.44 in 2018. A similar trend is observed for poisonings, which sharply increased in 2022 (11.69), and skin diseases, which rose from 0.09 in 2020 to 5.22 in 2024. Sporadic epidemic outbreaks were also observed: pertussis (whooping cough) had an exceptionally high fatality rate of 50 in 2016 and 2017 before disappearing entirely, while complicated measles saw irregular peaks in 2016 (11.61) and 2022 (8.7), then dropped to 1.39 in 2024. Additionally, trauma-related cases and certain digestive disorders showed sudden increases, possibly indicating environmental, social, or systemic changes affecting public health. These fluctuating dynamics highlight the critical need for ongoing surveillance and the continuous adaptation of health policies to respond effectively to the evolving epidemiological landscape in Madagascar. Fig. 6 showed the number of case of disease in each region between 2015 and 2020.

Fig. 6 analyzes the regional and comparative distribution of several types of diseases in the 22 regions of Madagascar between 2015 and

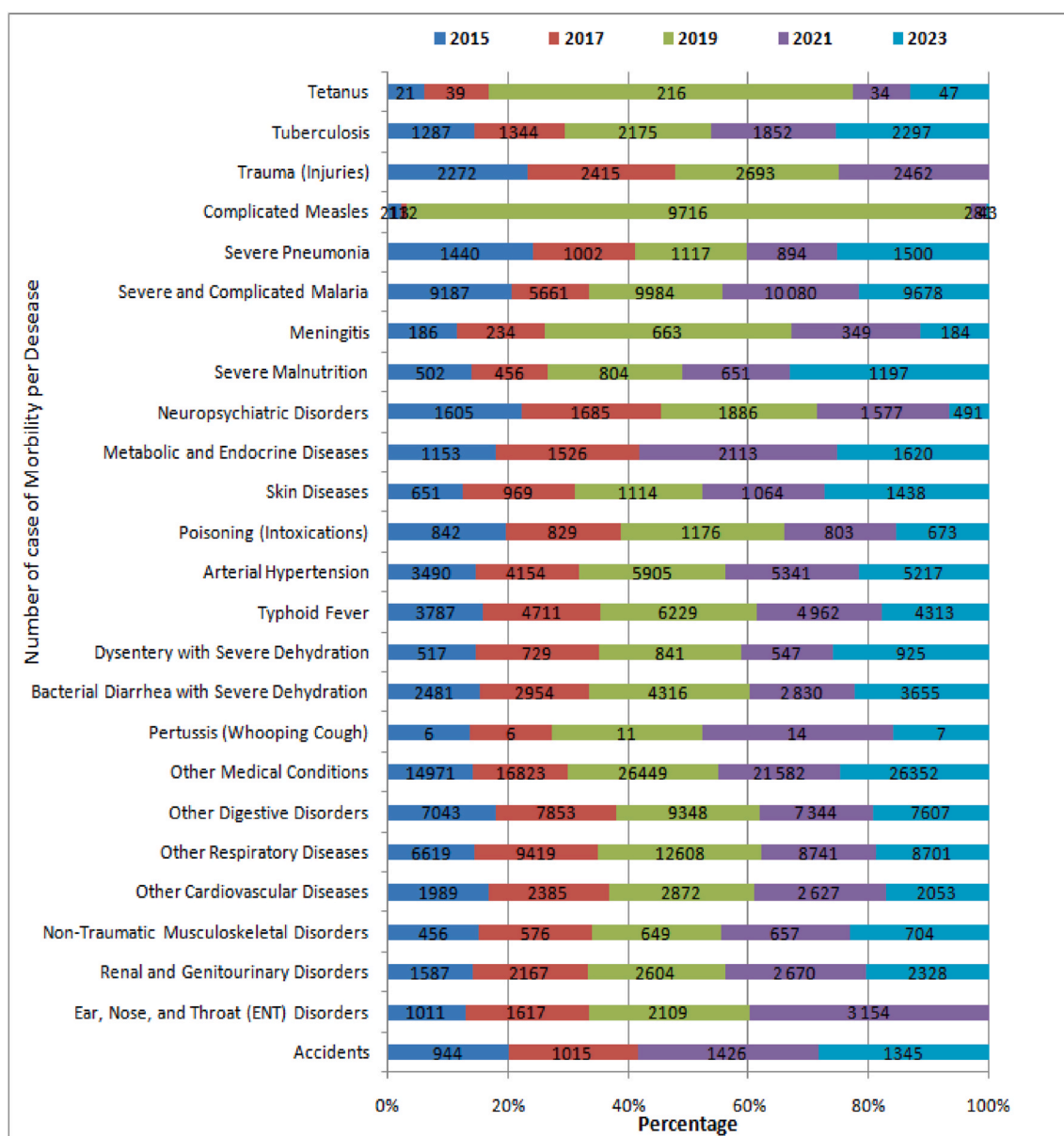


Fig. 4. Number of case of Morbidity for each of 25 diseases (2015, 2017, 2019, 2021 and 2023), in Madagascar.

2020, in order to identify: the most affected regions overall; the most frequent diseases; critical diseases by region and possible trends or anomalies.

A total number of disease cases by region is shown in the following Table 2.

The data analysis reveals that the three most affected regions by diseases in Madagascar are DIANA, Vakinankaratra, and Atsimo Andrefana, while the least affected regions are Bongolava, Melaky, and Betsiboka. Nationally, the most prevalent diseases include: *other* medical pathologies (116,003 cases), digestive conditions (61,705), severe and complicated malaria (59,078), bacterial diarrhea with severe dehydration (35,034), typhoid fever (35,872), skin diseases (12,980), trauma (14,194), and high blood pressure (43,281). The DIANA region reports extremely high figures for several pathologies, particularly typhoid, malaria, and metabolic diseases, which may either reflect a higher diagnostic capacity or a genuinely higher prevalence. Similarly, Vakinankaratra displays a strong concentration of digestive disorders, hypertension, and typhoid cases. In Atsimo Andrefana, the number of cases of diarrhea, typhoid, and malaria is alarmingly high, likely due to poor

hygiene conditions, unsafe water, or limited access to healthcare services. Conversely, the western regions – Melaky, Betsiboka, and Bongolava – are markedly underrepresented, which could be explained by weak healthcare coverage or underreporting. Notably, DIANA, Vakinankaratra, and Atsimo Andrefana are among the most densely populated or economically active regions, which may increase disease transmission risks. It is also important to consider that the low incidence reported in certain regions may not indicate a lower disease burden but rather reflect a lack of medical infrastructure. The prevalence of malaria and typhoid appears to be heavily influenced by climatic factors, especially in humid or stagnant-water areas. Additionally, there are notable regional disparities in malnutrition and diarrheal diseases, with Sofia and Atsimo Atsinanana particularly affected. Overall, this analysis highlights a striking regional inequality in disease distribution across Madagascar. The most affected areas require targeted interventions in prevention, hygiene, medical infrastructure, and access to care. At the same time, underreported regions should not be overlooked, as they may hide a more critical public health situation.

The comparative statistical analysis between the three most affected

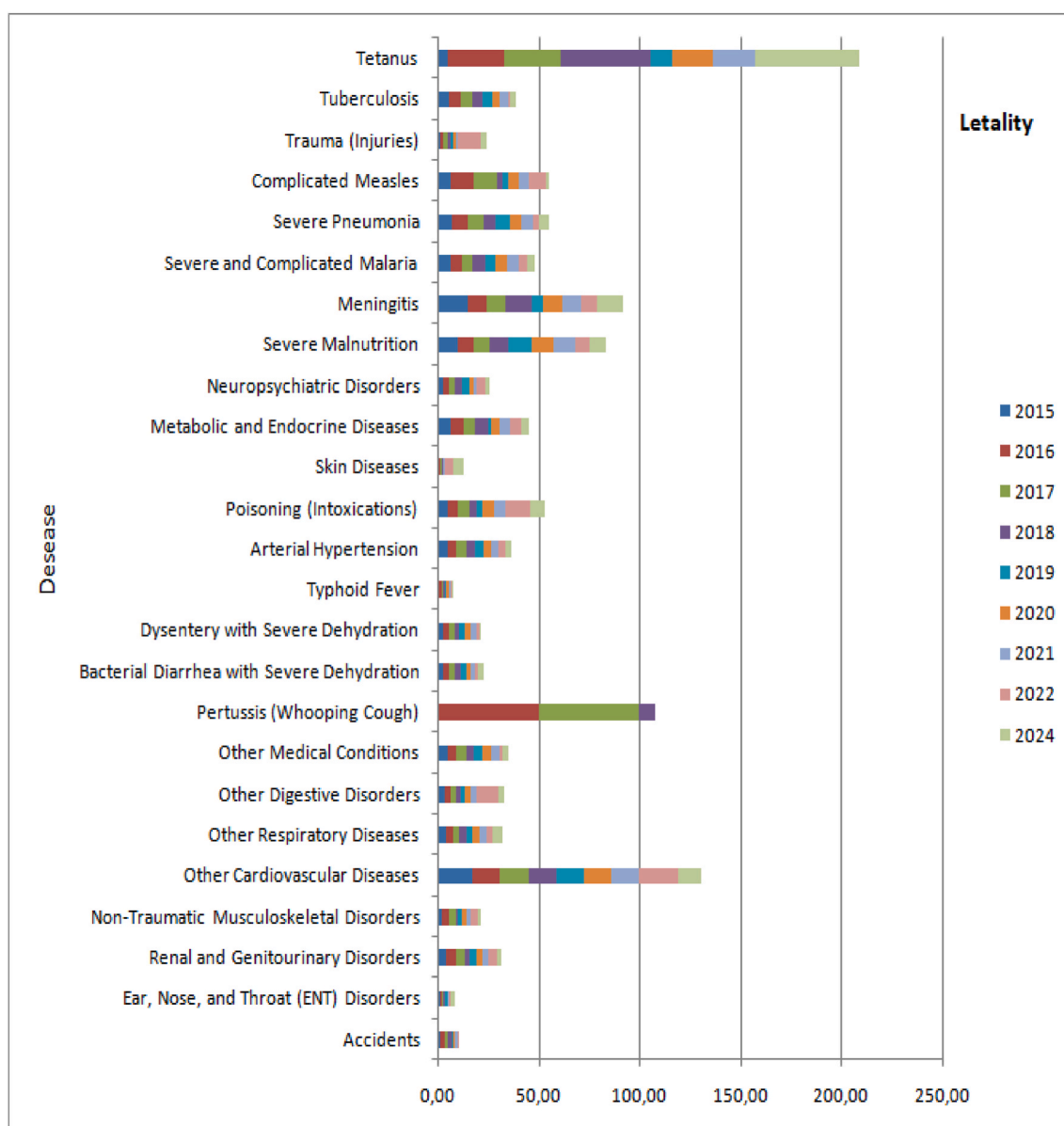


Fig. 5. Frequency of Lethality for 25 diseases between 2015 and 2025 in Madagascar.

regions by diseases (Vakinankaratra, DIANA, and Analamanga) and the three least affected regions (Melaky, Bongolava, and Anosy) in Madagascar between 2015 and 2020 reveals significant health disparities. The most affected regions recorded an average of 60,484.67 cases, with a (SD) of 3509.36, indicating a high concentration of cases in these areas. In contrast, the least affected regions reported a considerably lower average of 2636.67 cases, with a SD of 932.03, reflecting both lower variability and a more limited health impact. The (SE) supports this trend, with values of 2026.13 and 538.11 for the most and least affected regions, respectively, indicating acceptable statistical precision. Furthermore, the calculated Mean Relative Difference (MRD) of 1.83 suggests that the most affected regions report, on average, 183% more cases than the least affected ones. These results highlight the inequality in the distribution of diseases across the country and underscore the need for targeted public health policies to strengthen healthcare systems in the most vulnerable regions. The Number of case of Mortality is showed in Fig. 7.

The statistical analysis of mortality data related to major medical pathologies in Madagascar between 2015 and 2020 reveals significant health disparities across the country's regions. The national average

number of deaths from all causes stands at 923 cases, with a high standard deviation of 818, reflecting substantial interregional variability. The standard error of 174 indicates acceptable statistical precision for comparative analysis. The most affected regions are SAVA (2527 deaths), SOFIA (2376 deaths), and DIANA (2352 deaths), which bear the highest health burdens in the country. In contrast, the least affected regions are Androy (154 deaths), Melaky (163 deaths), and Anosy (210 deaths), highlighting a major disparity in the geographical distribution of mortality. The (MRD) of 13.77 indicates that the most affected regions recorded, on average, nearly 14 times more deaths than the least affected ones. This disparity suggests notable imbalances in access to healthcare, socio-environmental conditions, and health resources between regions. These findings underscore the urgent need to implement more equitable and targeted public health policies, especially in high-mortality areas, to strengthen local health systems and improve resilience to diseases.

4.2. Analysis and comparison of health expenses between 2019 and 2022

The distribution of health expenses between 2019 and 2022 is

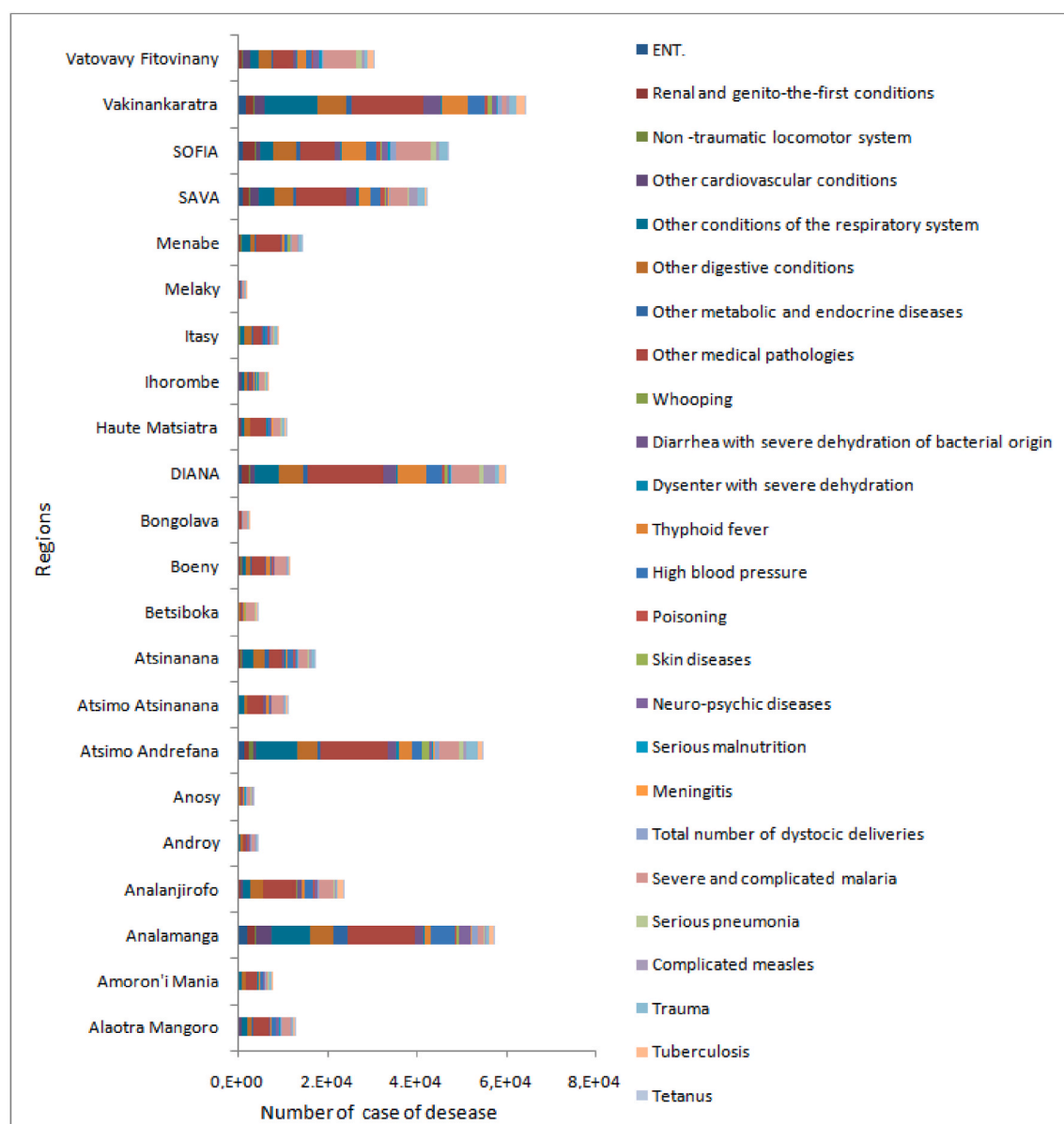


Fig. 6. Number of cases of disease in each region from 2015 to 2020.

showed in Fig. 8.

Between 2019 and 2022, the distribution of current health expenditures in Madagascar reveals significant disparities across sources of financing. On average, the "Rest of the World" (foreign aid) contributed the highest share of health funding, with a mean of \$39.35 billion (SD = 6.66; SE = 3.33), peaking at \$45.6 billion in 2020 likely due to increased global support during the COVID-19 pandemic before sharply declining to \$30.4 billion in 2022. In contrast, household out-of-pocket expenses ("residence") consistently represented the second-largest source, with an average of \$34.05 billion (SD = 3.15; SE = 1.58), indicating a high financial burden on citizens. Public administration expenditures remained relatively stable (mean = \$20.525B; SD = 2.38; SE = 1.19), showing limited government flexibility or expansion in health budgeting. Industry contributions, though minimal, showed a slight upward trend from \$5.1B in 2019 to \$6.3B in 2022, with the lowest variability (SD = 0.68), suggesting a stable but modest private sector involvement. Non-profit institutions provided the smallest share overall (mean = \$0.85B), but their contribution more than doubled from 2019 to 2022, signaling growing engagement from civil society. The dominance of external funding raises sustainability concerns, while the

substantial role of household expenditures highlights the need for improved financial protection mechanisms in Madagascar's health system. These patterns call for policy reforms to strengthen domestic resource mobilization and reduce dependency on volatile foreign aid.

5. Discussion

The analysis of morbidity and mortality trends from 2015 to 2024 reveals several major developments. Notably, there has been an overall decline in mortality rates across various regions, accompanied by an increase in life expectancy. This trend appears to be strongly correlated with improved access to healthcare, the introduction of new medical technologies, and the implementation of national and international prevention policies. Our findings are consistent with those reported by GBD (Diseases and Injuries Collaborators, 2020; Nematchoua et al., 2026; Romain et al., 2018), who highlighted a significant decrease in premature mortality in many parts of the world due to advancements in public health, particularly in combating communicable diseases. On the other hand, the rise in non-communicable diseases such as cardiovascular diseases, diabetes, and certain cancers has been confirmed,

Table 2

Total number of disease cases by region between 2015 and 2020.

Region	Number of case
DIANA	74,243
Vakinankaratra	72,158
Atsimo Andrefana	62,822
Analamanga	59,134
SAVA	48,725
SOFIA	48,003
Atsinanana	20,748
Menabe	18,636
Analanjirifo	18,267
Haute Matsiatra	12,237
Amoron'i Mania	9274
Itasy	8744
Ihorombe	7374
Boeny	7193
Vatovavy Fitovinany	7142
Anosy	3083
Androy	3016
Alaotra Mangoro	12,297
Bongolava	1719
Melaky	1670
Atsimo Atsinanana	23775
Betsiboka	2792

echoing the conclusions of (Beaglehole R. et al., 2011; Tifha et al., 2018; Organisation mondiale de la santé, 2019) regarding the global epidemiological transition.

The study also highlights pronounced regional disparities, especially between high-income and low-income countries. While some high-income nations have experienced a stabilization or even a reduction in the prevalence of NCDs, several countries in Sub-Saharan Africa and South Asia continue to face a dual burden of disease (communicable + non-communicable diseases). This observation aligns with the findings of (Frenk J. et al., 2009; Simon et al., 2017; Kpoda et al., 2022), who emphasize the critical role of social determinants of health and inequalities in access to care. Another concerning trend is the resurgence of certain infectious diseases, such as multidrug-resistant tuberculosis and malaria, in some developing countries. These results support the findings of (WHO, 2025) which highlighted the limitations of some vaccination campaigns and the impact of climate change on the re-emergence of specific diseases. Finally, the 2020–2022 period saw a significant spike in mortality linked to the COVID-19 pandemic. This phenomenon is consistent with the analyses of (Wang et al., 2022; GBD Mortality & Causes of Death Collaborators, 2015), who documented excess mortality directly and indirectly attributable to the pandemic, disproportionately affecting vulnerable populations and overstretched health systems. These findings suggest that, despite notable progress in various areas of public health, concerted efforts are still needed to reduce inequalities, strengthen epidemiological surveillance systems, and promote an integrated approach to managing chronic and infectious diseases.

6. Limitations and implications

This study provides valuable insights into the epidemiological trends of the 25 most common diseases reported in CHRd across Madagascar from 2015 to 2024. However, several limitations must be acknowledged to accurately frame the scope of the findings.

First, the analysis relies exclusively on data collected from CHRds. These facilities represent the intermediate level of the Malagasy health pyramid and primarily manage cases requiring more advanced care than what is provided in primary health centers (CSB I and CSB II). As a result, the data included in this study may not fully capture the total burden of disease in the population. Common illnesses that are treated at community or primary-care levels, as well as conditions that do not reach the

level of referral care, are likely underrepresented. Conversely, diseases reported in CHRds may reflect a higher severity profile compared to those seen in primary care settings. Therefore, the results may overestimate the relative weight of severe conditions while underestimating the prevalence of less severe or more community-managed diseases.

Second, the exclusive use of CHRd data introduces potential bias in the geographic distribution of diseases. Consultation behaviours vary widely across regions, with rural and remote populations often experiencing barriers to accessing district hospitals—such as long travel distances, transportation challenges, and financial constraints. Consequently, regions with limited access to CHRds may appear to have lower disease incidence, not due to lower prevalence, but because of reduced healthcare utilization. This limitation affects the comparability between regions and may obscure the true burden of disease in underserved areas.

Third, although the data analyzed were validated at multiple administrative levels and centralized in DHIS2, inconsistencies may still arise due to variations in reporting practices, digitalization levels, and staff capacity across districts. Such disparities can influence the completeness and accuracy of disease reporting.

6.1. Implications for interpretation and policy

Despite these limitations, the findings remain highly informative for understanding disease patterns at the level of district hospitals, which play a critical role in Madagascar's healthcare system. The results should, however, be interpreted as reflective of hospital-level morbidity rather than population-level prevalence. Public health authorities should consider complementing CHRd-based surveillance with data from primary health centers and community-level reporting systems to obtain a more comprehensive picture of national disease burden.

Furthermore, the differences observed between regions underscore the need to strengthen health information systems, improve accessibility to CHRd services, and enhance data integration across all tiers of the health pyramid. Expanding routine data collection beyond district hospitals would provide more robust evidence to inform resource allocation, prevention strategies, and progress toward Universal Health Coverage (UHC).

7. Conclusion

This study provides an in-depth analysis of morbidity and mortality trends across Madagascar's 22 regions from 2015 to 2024. The results reveal both encouraging improvements and ongoing public health challenges. Overall, the national mortality rate has decreased by approximately 10.6% over the ten-year period, while life expectancy has increased by an average of 2.8 years, demonstrating the impact of targeted health interventions, vaccination campaigns, and improved access to primary care services in several regions. However, significant disparities persist between urban and rural areas. For instance, while Analamanga and Atsinanana regions recorded a mortality reduction of over 15%, remote regions such as Melaky and Androy shown only marginal improvements, with reductions below 5%, mainly due to limited healthcare infrastructure and socioeconomic constraints. Non-communicable diseases (NCDs) have become increasingly prevalent, now accounting for approximately 64% of all deaths in 2024 compared to 58% in 2015, indicating a shift in the disease burden. In contrast, deaths from infectious diseases like malaria and tuberculosis have declined significantly in some regions thanks to intensified public health campaigns. The COVID-19 pandemic had a considerable impact, particularly in 2020–2021, causing a temporary increase in mortality in several regions, especially in urban centers. Excess mortality linked to the pandemic was estimated at over 25,000 deaths nationally during this period, which stressed the need for resilient and decentralized health systems. To sustain and accelerate progress, Madagascar must strengthen its regional health capacities, improve health data systems,

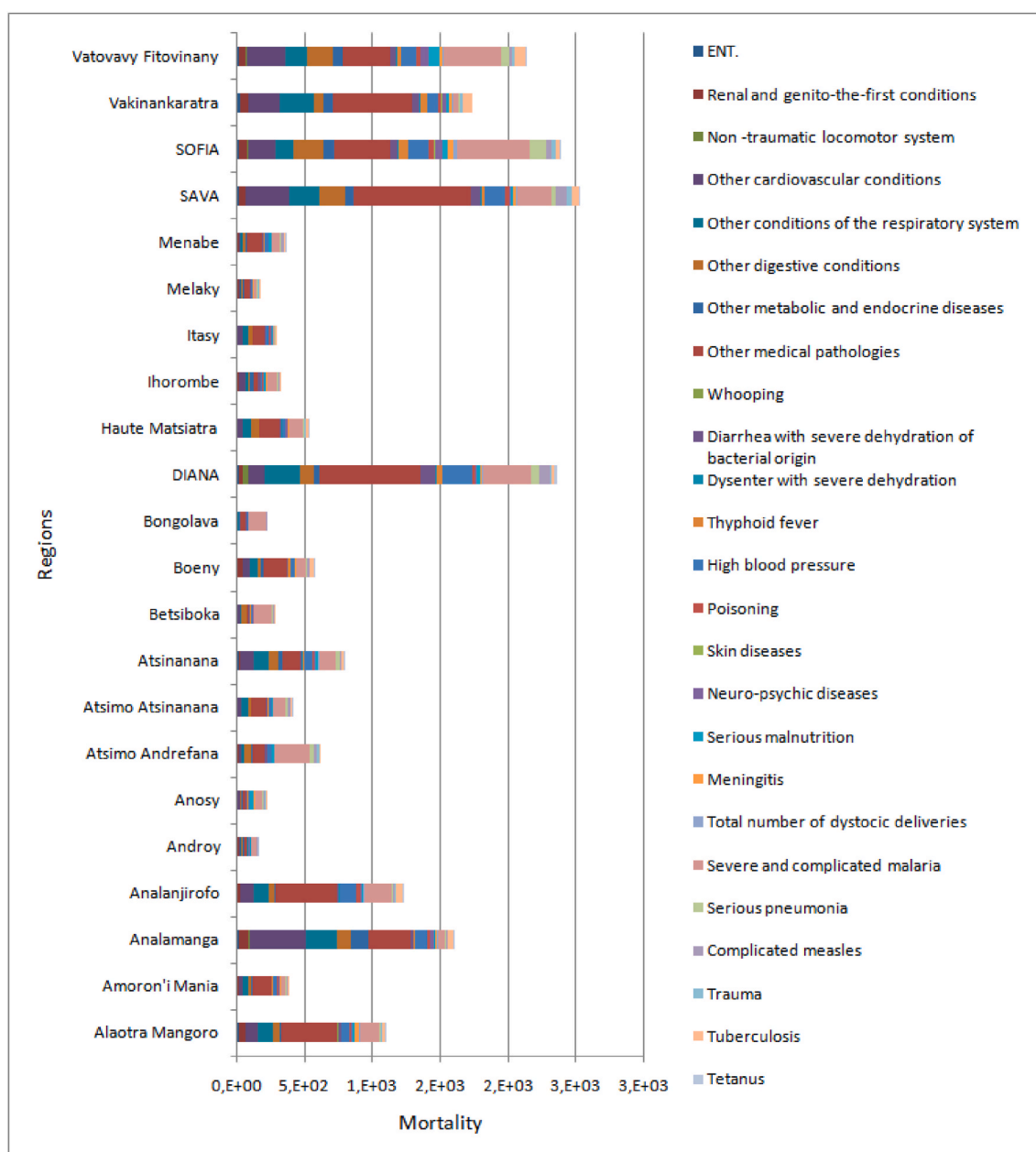


Fig. 7. Number of cases of Mortality for 25 diseases in each region between 2015 and 2020.

and address social determinants of health such as poverty, education, and access to clean water. Investing in preventive care, digital health solutions, and equitable resource distribution will be critical to reducing health disparities across regions. Future research should focus on regional case studies, exploring the socio-environmental and behavioural factors influencing health outcomes, and supporting the development of data-driven policies aligned with the country's Vision 2030 and the Sustainable Development Goals.

Consent to participate

Not applicable. The study did not involve any direct participation of human subjects.

Data availability

Due to the sensitive nature of the data, they are not publicly available but can be made accessible upon justified request and with permission

from Ministry of Public Health.

Ethics approval

This study involved the use of publicly available aggregated health data and did not involve any direct experimentation on humans or animals. As such, ethics approval was not required according to institutional and national guidelines.

Consent for publication

Not applicable. The manuscript does not contain any individual person's data in any form.

Declaration of the use of AI

AI has not been used in this research.

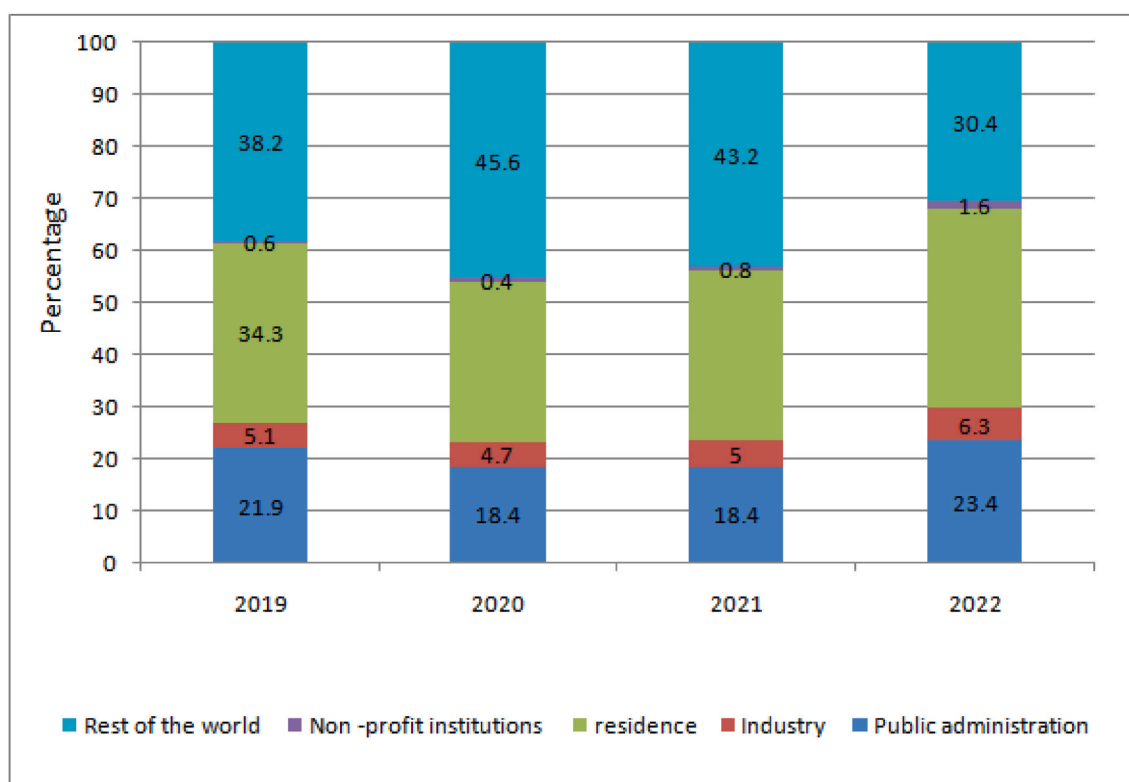


Fig. 8. Distribution of current health expenses by source of financing (in Billion \$) from 2019 to 2022.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Modeste Kameni nematchoua reports was provided by University of Antsiranana. No conflict of interest If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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