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Epidemiological Surveillance of Notifiable Communicable Diseases: A Multi-Center Cross-Sectional Analysis

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ABSTRACT

Purpose: The aim of this study to examined notifiable disease surveillance data from multiple healthcare facilities in Zawia, Libya, spanning January to October 2024.

Materials and Methods: A retrospective analysis was conducted on surveillance records from eight facilities under the Zawia Center for Communicable Diseases. Data extraction encompassed 42 notifiable diseases categorized under the Integrated Disease Surveillance and Response (IDSR) framework. Analyses addressed temporal trends, geographic distribution, demographic characteristics, and reporting completeness.

Results: Viral hepatitis B and C exhibited the highest notification rates, with 65 and 30 cases reported, respectively. Influenza-like illness displayed pronounced seasonal variation, peaking during August–September 2024 with 62 cases documented at Zawia Central facility alone. Trachoma, chickenpox, and gastroenteritis demonstrated sporadic occurrence with facility-specific clustering. Strikingly, 28 diseases (66.7%) recorded zero cases across all facilities throughout the surveillance period, prompting consideration of whether this reflects genuine disease absence or surveillance system deficiencies. Zawia Central facility and Juddaim Primary Healthcare Center maintained the most consistent reporting patterns, whereas several peripheral facilities exhibited considerable reporting gaps.

Conclusion: This multi-center analysis reveals substantial heterogeneity in disease surveillance performance throughout Zawia's healthcare network. While specific communicable diseases indicate active transmission warranting targeted intervention, the predominance of zero-reporting for the majority of notifiable conditions suggests either effective disease control or, more plausibly, systematic under-detection. Enhancing surveillance infrastructure particularly at peripheral facilities and instituting routine system evaluations constitute essential priorities for strengthening Libya's capacity to detect and respond to public health threats in alignment with International Health Regulations (2005) requirements. (*Open J Biomed Res 2026;5:3-11*)

Keywords: Disease surveillance, Notifiable diseases, Multi-center analysis, Epidemiology, Public health infrastructure.

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AUDIOABSTRACT

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INTRODUCTION

Effective disease surveillance systems constitute the cornerstone of national public health security, providing the essential infrastructure for detecting, monitoring, and responding to infectious disease threats.[1] The International Health Regulations (IHR) of 2005

obligate all World Health Organization member states to develop and maintain core capacities for surveillance and response, including the capacity to detect, assess, notify, and report public health events of international concern.[1] However, in conflict-affected and post-conflict settings, the establishment and maintenance of robust surveillance systems presents formidable challenges, including damaged health infrastructure, displaced populations, disrupted supply chains, and compromised data quality. [2,3]

Libya represents a particularly complex case for disease surveillance, having experienced prolonged armed conflict that has severely disrupted its health system since 2011. The fragmentation of governance structures has resulted in parallel health systems operating in different regions, with consequent challenges for coordinated surveillance and response.[4,5] Despite these obstacles, the Libyan Ministry of Health, in collaboration with international partners including the World Health Organization, has endeavored to maintain and strengthen disease surveillance capabilities, particularly through the National Centre for Disease Control and the Early Warning Alert and Response Network (EWARN) system.[6]

Zawia city is located in northwestern Libya, represents a critical surveillance node given its substantial population, strategic location, and the presence of multiple healthcare facilities serving both local residents and displaced populations. The Zawia Center for Communicable Diseases coordinates surveillance activities across a network of healthcare facilities, collecting data on notifiable diseases according to standardized case definitions and reporting protocols. Understanding the patterns of disease occurrence and surveillance system performance in this setting provides valuable insights for public health planning and resource allocation.

This study presents a comprehensive analysis of surveillance data from multiple healthcare facilities in Zawia during the period January-October 2024. Our objectives were to: characterize the epidemiological patterns of notifiable diseases across the surveillance network as well as assess variations in disease reporting by facility type and geographic location moreover evaluate demographic patterns of disease occurrence by age and sex and identify potential gaps in surveillance system performance requiring targeted intervention.

MATERIALS AND METHODS

Study Setting and Surveillance System

Zawia is a municipality in northwestern Libya with an estimated population exceeding 300,000. The healthcare infrastructure includes tertiary hospitals, primary healthcare centers, and specialized clinics operating under the administrative oversight of the Zawia Center for Communicable Diseases. The surveillance system follows the Integrated Disease Surveillance and Response (IDSR) framework, which emphasizes the integration of multiple data sources, standardized case definitions, and timely reporting for public health action.[7]

The surveillance network analyzed in this study comprised eight reporting sites: (1) Juddaim Primary Healthcare Center; (2) Bir Hassan Hospital; (3) Zawia Central facility; (4) Zawiya North facility; (5) Al-Nasr Primary Healthcare Unit; (6) Umar ibn Abd al-Aziz facility; (7) Saadun Primary Healthcare Unit; and (8) additional peripheral facilities including Al-Sayyida Aisha, Za'mit Clinic, Salah al-Din Clinic, and others. These facilities represent diverse levels of the health system, from community-based primary care to hospital-based services.

Data Collection and Management

Surveillance data were collected prospectively according to standardized protocols established by the Libyan Ministry of Health. Healthcare workers at each facility recorded suspected and confirmed cases of notifiable diseases in dedicated registers, with subsequent compilation and transmission to the Zawia Center for Communicable Diseases. The surveillance period encompassed January 1 through October 31, 2024, with monthly reporting cycles.

The surveillance system monitored 42 notifiable diseases and conditions, categorized as follows: epidemic-prone diseases requiring immediate notification (including cholera, plague, anthrax, neonatal tetanus, diphtheria, meningococcal meningitis, epidemic typhus, acute flaccid paralysis, yellow fever, viral

hemorrhagic fevers, measles, and COVID-19); diseases targeted for elimination or eradication (including tuberculosis, brucellosis, leprosy, and other tetanus); diseases of public health importance (including typhoid/paratyphoid fever, shigellosis, amoebiasis, gastroenteritis, whooping cough, syphilis, gonococcal infection, trachoma, rickettsioses, rabies, chickenpox, hepatitis A/B/C, HIV/AIDS, mumps, malaria, leishmaniasis, schistosomiasis, echinococcosis, streptococcal pharyngitis, unspecified meningitis, rheumatic fever, and influenza); and other conditions of surveillance interest.

For each reported case, data included: disease classification; reporting period; total case count; sex distribution (male/female); nationality (Libyan/non-Libyan); age stratification (under 5 years, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, over 50 years); municipality; and specific reporting facility.

Data Analysis

We conducted descriptive analyses of surveillance data, calculating frequencies and proportions for categorical variables and measures of central tendency for continuous variables where applicable. Temporal analysis examined monthly disease trends across the surveillance period. Geographic analysis compared reporting patterns across facilities, assessing both disease occurrence and reporting completeness. Demographic analysis examined age and sex distributions for selected diseases with sufficient case numbers.

Data quality assessment focused on three key surveillance attributes: completeness (proportion of expected reports submitted), timeliness (proportion of reports submitted within specified timeframes), and zero-reporting patterns (facilities consistently reporting zero cases for specific diseases). These indicators align with standard surveillance evaluation frameworks established by the Centers for Disease Control and Prevention (CDC, 2001) and the World Health Organization (2010). [7]

Analysis was performed using standard statistical software, with results presented as frequencies, percentages, and temporal trends. Mapping of disease distribution utilized facility-level geographic identifiers to visualize spatial patterns.

Ethical Considerations

This study utilized routinely collected surveillance data aggregated at facility level without individual patient identifiers. The analysis was conducted as part of routine surveillance system evaluation for public health quality improvement purposes. No individual-level data were accessed, and all results are presented in aggregate form to protect confidentiality.

RESULTS

Overall Surveillance System Performance

During the ten-month surveillance period, the eight reporting facilities submitted surveillance reports covering 42 notifiable diseases, resulting in 336 facility-disease-month combinations for analysis. Complete reporting (submission of all expected monthly reports) varied substantially by facility, with Zawia Central and Juddaim demonstrating the most consistent performance, while several peripheral facilities showed intermittent reporting patterns.

Zero-reporting predominated across the surveillance system. Of the 42 diseases under surveillance, 28 diseases (66.7%) recorded zero cases across all facilities throughout the entire surveillance period. These included high-consequence pathogens such as cholera, plague, anthrax, diphtheria, meningococcal meningitis, yellow fever, viral hemorrhagic fevers, measles, and COVID-19. While zero-reporting may reflect genuine disease absence for certain conditions, the comprehensive nature of zero reports across diverse pathogen types suggests potential surveillance system limitations.

Disease-Specific Epidemiological Patterns

Viral Hepatitis

Viral hepatitis B and C emerged as the most frequently reported conditions, with epidemiological patterns indicating active transmission requiring public health intervention. Acute Hepatitis B accounted for 65 total cases across the surveillance period, with marked variation by facility and month. Zawia Central reported the highest burden (45 cases),

followed by Juddaim (10 cases) and other peripheral facilities. Temporal analysis revealed consistent reporting throughout the period, with peaks in May (20 cases from Zawia Central) and July (19 cases from Zawia Central) (Fig 1).

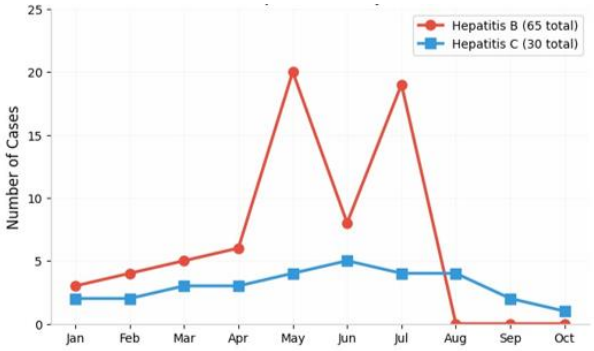


Fig. 1: Viral Hepatitis cases by month.

Age distribution analysis for Hepatitis B cases where data were available (primarily from Zawia Central) demonstrated concentration in older age groups, with substantial proportions in the 30-50-year range, consistent with historical transmission patterns and the natural history of chronic infection. Sex distribution showed male predominance (approximately 70% of reported cases), reflecting both biological susceptibility factors and potential healthcare-seeking differences.

Acute Hepatitis C accounted for 30 total cases, similarly concentrated at Zawia Central (22 cases). The co-occurrence of Hepatitis B and C reporting suggests shared risk factors and transmission dynamics, potentially related to healthcare-associated transmission, injection drug use, or other blood-borne exposure routes. The geographic clustering of hepatitis cases in the central facility, with limited reporting from peripheral sites, raises questions about referral patterns versus true disease distribution.

Influenza and Influenza-Like Illness

Influenza "seasonal influenza" demonstrated pronounced seasonal variation consistent with expected epidemiological patterns. Total reported cases across all facilities reached 389 for the surveillance period, with marked monthly fluctuations. The epidemic curve showed progressive increase from January through August, peaking in August-September with 114 cases (52 from Zawia Central, 45 from Juddaim, 7 from Zawia North, and 10 distributed across other facilities), followed by decline in October (Fig 2).

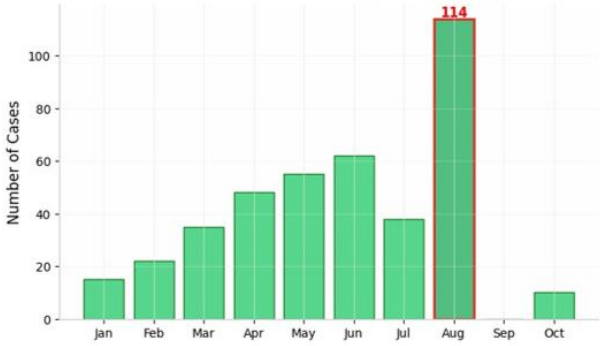


Fig. 2: Influenza seasonal pattern (389 total cases).

Age distribution data, available primarily from Zawia Central and Juddaim, demonstrated concentration in younger age groups, with substantial proportions in the 5-20-year range and 20-30-year range, consistent with influenza epidemiology in populations with partial immunity. Sex distribution showed slight female predominance in some reporting periods, though patterns varied by facility and month.

The seasonal pattern, with peak activity during late summer and early autumn, differs somewhat from typical Northern Hemisphere influenza seasonality, potentially reflecting regional climatic factors, population mobility patterns, or surveillance artifact. The relatively robust reporting of influenza compared to other conditions suggests either higher disease burden, greater clinical recognition, or specific surveillance emphasis on respiratory diseases.

Trachoma

Trachoma showed sporadic occurrence with 17 total cases reported across the surveillance period. Cases were distributed across multiple facilities including Zawia Central, Juddaim, Al-Sayyida Aisha, and peripheral sites, suggesting focal transmission rather than widespread community circulation. The majority of cases (14 of 17, 82%) were reported from female patients, consistent with the known epidemiology of trachoma, where women typically experience higher infection rates due to close contact with infected children.

Age distribution, where recorded, showed concentration in adult age groups (30-50 years), which may represent chronic sequelae

or reactivation rather than acute infection. The scattered geographic distribution and relatively low case numbers suggest that trachoma persists as a focal public health concern in Zawia, warranting targeted screening and treatment interventions aligned with WHO SAFE strategy recommendations.

Chickenpox (Varicella)

Chickenpox accounted for 34 total cases, with marked facility-specific clustering. Zawia Central reported the highest number (20 cases), with temporal concentration in February-April 2024 (12 cases) (Fig 3). Pediatric age groups predominated, with the majority of cases in children under 15 years, consistent with typical varicella epidemiology. The relatively localized occurrence suggests that varicella transmission occurs in community settings with periodic introduction into healthcare facilities, rather than representing a sustained outbreak.

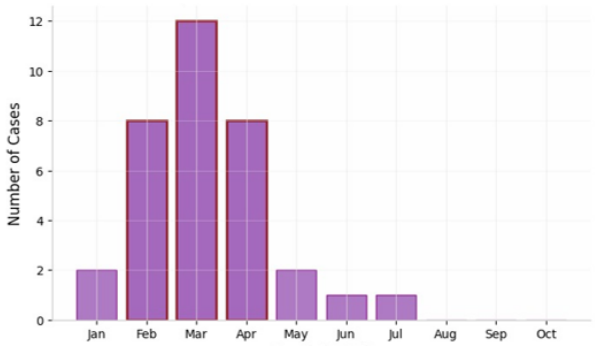


Fig. 3: Chickenpox cases, pediatric concentration (34 total cases).

Gastroenteritis and Foodborne Illness

Acute gastroenteritis showed sporadic reporting with 41 total cases, concentrated in August 2024 (37 cases, primarily from Zawia Central and Juddaim) (Fig 4). This temporal clustering suggests a potential outbreak or increased transmission during summer months, possibly related to food safety challenges, water quality issues, or increased social gatherings during holiday periods. The age distribution showed concentration in pediatric and young adult groups.

Foodborne intoxication showed minimal reporting (4 cases total), which likely represents substantial under-detection given the expected frequency of foodborne illness in community settings. The discrepancy between gastroenteritis reporting and specific foodborne disease attribution highlights limitations in diagnostic capacity and epidemiological investigation.

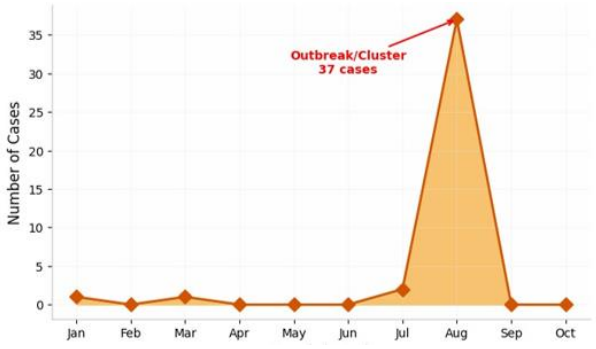


Fig. 4: Acute gastroenteritis, August clustering (41 total cases).

Other Notifiable Diseases

Tuberculosis (respiratory and extrapulmonary) showed minimal reporting (2 cases total), which almost certainly represents substantial under-detection given Libya's documented tuberculosis burden and the challenges of tuberculosis diagnosis in resource-limited settings.[8] HIV/AIDS reporting was limited (8 cases total), with demographic data suggesting adult predominance and male predominance, though case numbers were insufficient for robust epidemiological characterization.

Emerging and re-emerging diseases of high international concern, including COVID-19, measles, and viral hemorrhagic fevers, recorded zero cases throughout the surveillance period. While COVID-19 reporting may reflect genuine low incidence following pandemic waves, the absence of measles reporting is concerning given suboptimal vaccination coverage in conflict-affected settings and the highly transmissible nature of this pathogen.

Facility-Level Surveillance Performance

Analysis of reporting patterns by facility revealed substantial heterogeneity in surveillance system performance. Zawia Central, as the primary referral facility, demonstrated the most comprehensive reporting across disease categories, accounting for the majority of reported cases for hepatitis, influenza, and other conditions. This concentration likely reflects both higher disease burden due to

patient referral patterns and more robust surveillance infrastructure.

Juddaim Primary Healthcare Center showed consistent reporting for influenza and some other conditions, but limited reporting for hepatitis and other laboratory-diagnosed conditions, suggesting differential diagnostic capacity. Peripheral facilities including Al-Sayyida Aisha, Za'mit Clinic, and Salah al-Din Clinic showed intermittent reporting with predominance of zero reports, raising concerns about either limited healthcare access, reduced diagnostic capacity, or incomplete surveillance implementation.

The pattern of case concentration at the central facility with minimal peripheral reporting suggests a "surveillance funnel" effect, where cases are either referred to central facilities for diagnosis and treatment, or surveillance activities are inadequately implemented at peripheral levels. This pattern has significant implications for outbreak detection, as community transmission may remain undetected until cases present at central facilities.

Demographic Patterns

Sex distribution analysis for diseases with sufficient case numbers revealed disease-specific patterns. Hepatitis B showed consistent male predominance (approximately 70%), while trachoma showed female predominance (approximately 82%). Influenza showed relatively balanced sex distribution with slight variations by facility and time period. These patterns generally align with known disease epidemiology, though the magnitude of sex differences may reflect healthcare-seeking behavior as well as biological susceptibility.

Age distribution data, where available, showed expected patterns: influenza concentration in school-age children and young adults; hepatitis concentration in middle-aged adults reflecting historical exposure; and trachoma in adult women consistent with childcare-associated transmission. However, age data completeness varied substantially by facility, with Zawia Central providing the most detailed stratification and peripheral facilities often reporting aggregate totals only.

DISCUSSION

This multi-center analysis of disease surveillance data from Zawia, Libya, reveals a surveillance system characterized by heterogeneous performance across facilities and disease categories, with concerning patterns of zero-reporting for the majority of notifiable conditions. While certain diseases notably viral hepatitis and seasonal influenza demonstrate active transmission with recognizable epidemiological patterns, the comprehensive absence of reporting for high-consequence pathogens raises fundamental questions about surveillance system sensitivity and representativeness.

The predominance of zero-reporting for 28 of 42 notifiable diseases (66.7%) represents the most striking finding of this analysis. In surveillance system evaluation, zero-reporting can indicate either genuine disease absence or system failure to detect, diagnose, and report cases (CDC, 2001). For diseases such as plague, anthrax, and viral hemorrhagic fevers, genuine absence is plausible given historical epidemiology. However, for conditions such as measles, tuberculosis, and COVID-19, zero-reporting almost certainly reflects surveillance limitations rather than true disease absence. Research from comparable conflict-affected settings has documented substantial gaps in disease detection, with surveillance systems often capturing only a fraction of true disease burden.[9]

The concentration of reported cases at Zawia Central facility, with limited peripheral reporting, suggests a surveillance system heavily dependent on referral hospital capacity. This pattern aligns with findings from Bangladesh and other resource-limited settings, where hospital-based surveillance demonstrates distance-dependent sensitivity, with detection probabilities decreasing markedly with distance from surveillance hospitals.[9] The implications for outbreak detection are significant: community transmission may proceed undetected until cases present at central facilities, potentially delaying public health response.

Viral hepatitis emerges from this analysis as the most substantial communicable disease burden in Zawia, with 95 total cases of Hepatitis B and C reported. This finding is consistent with regional epidemiology; the Eastern Mediterranean Region experiences intermediate to high hepatitis B and C prevalence, with Libya historically reporting substantial burdens.[6] The age and sex

distribution patterns male predominance and concentration in middle-aged groups suggest historical transmission with ongoing chronic disease, rather than acute outbreak dynamics. The co-occurrence of Hepatitis B and C reporting raises concerns about healthcare-associated transmission, particularly given documented challenges in infection control and injection safety in conflict-affected health systems.[8]

The seasonal influenza pattern, with peak activity in August-September, warrants consideration in the context of regional influenza epidemiology. While typical Northern Hemisphere influenza seasonality peaks during winter months, subtropical and tropical regions may experience different patterns, and conflict-related population displacement can disrupt typical transmission dynamics.[6] The relatively robust influenza reporting compared to other conditions may reflect greater clinical recognition of respiratory illness, availability of rapid diagnostic tests, or specific surveillance emphasis during the post-COVID-19 period.

The sporadic occurrence of trachoma, with female predominance and adult age distribution, suggests persistent focal transmission requiring targeted intervention. Libya has reported trachoma as a public health concern, and the WHO Eastern Mediterranean Region has prioritized trachoma elimination through the SAFE strategy (Surgery, Antibiotics, Facial cleanliness, Environmental improvement).[6] The identification of trachoma cases through routine surveillance, despite limited overall surveillance sensitivity, indicates ongoing transmission that warrants enhanced screening and treatment activities.

The minimal reporting of tuberculosis and HIV/AIDS conditions with documented substantial burdens in Libya represents a critical surveillance gap. Daw and colleagues [8] documented that armed conflict in Libya facilitated the dissemination of HIV strains through population displacement, with Benghazi acting as a significant exporter of viral transmission to other regions. The absence of measles reporting is especially concerning given the highly transmissible nature of this pathogen and the documented risks of vaccine-preventable disease outbreaks in conflict-affected settings with suboptimal immunization coverage. [2]

From a surveillance system perspective, these findings align with documented challenges in implementing IDSR in conflict settings. Marou and colleagues[2] systematically reviewed the impact of conflict on infectious disease surveillance, finding that armed conflicts disrupt disease surveillance systems and facilitate disease transmission through population displacement and health infrastructure destruction. The Zawia surveillance system demonstrates characteristics of surveillance breakdowns commonly observed in conflict settings: limited detection capacity at peripheral facilities, inconsistent reporting completeness, and potential delays in response given the concentration of cases at referral facilities.

The heterogeneity in facility-level performance observed in this study mirrors findings from surveillance system evaluations in other resource-limited settings. Research on the Nigerian IDSR system documented substantial variations in reporting completeness across states, with zero-reporting common for diseases perceived as rare or difficult to diagnose.[10] Similar to, evaluation of Rwanda's IDSR implementation found that while core surveillance capacities were established, surveillance and response core functions were not yet fully functional in rural areas. [11] These findings suggest that the challenges observed in Zawia reflect broader patterns in surveillance system implementation in challenging contexts, rather than Libya-specific limitations alone.

The implications for Libya's compliance with International Health Regulations[1] are significant. The IHR requires states to develop and maintain core capacities for surveillance and response, including the capacity to detect events involving disease or death above expected levels and to report these events to WHO through established channels.[1] The surveillance gaps documented in this analysis particularly the absence of reporting for high-consequence pathogens and the concentration of detection capacity at central facilities suggest that Libya's surveillance system may not currently meet IHR core capacity requirements. This finding aligns with broader assessments of IHR implementation in the Eastern Mediterranean Region, where conflict and political instability have impeded surveillance strengthening efforts. [6]

Strengthening surveillance in Zawia and comparable settings requires multi-faceted interventions addressing infrastructure, human resources, and system design. Experience from Bangladesh's Disease Surveillance Network suggests that hospital-based surveillance can be successfully scaled up through systematic capacity building, though sensitivity remains distance-dependent.[9] The WHO's IDSR framework emphasizes the importance of integrating surveillance activities across health system levels, from community-based detection to national reporting, with particular attention to timeliness and completeness.[6] For Libya, priorities should include: enhancing diagnostic capacity at peripheral facilities; implementing regular supervision and data quality assurance; establishing community-based event-based surveillance to complement facility-based indicator surveillance; and ensuring sustainable financing for surveillance operations.

This study has several limitations that should inform interpretation of findings. The analysis relies on routinely collected surveillance data subject to reporting biases, incomplete case ascertainment, and variable data quality. The predominance of aggregate reporting (case counts rather than line lists) limits the granularity of epidemiological analysis. Zero-reporting may reflect genuine disease absence for certain conditions, and we cannot definitively distinguish absence from under-detection without supplementary investigation. The surveillance period (January-October 2024) captures less than one full year, potentially missing seasonal patterns for certain diseases. Finally, the analysis does not incorporate laboratory confirmation data, which would strengthen the validity of disease classification.

Despite these limitations, this analysis provides valuable insights into the functioning of disease surveillance in a challenging post-conflict setting. The identification of active hepatitis transmission, seasonal influenza patterns, and focal trachoma occurrence alongside the concerning absence of reporting for other conditions enables evidence-based prioritization of surveillance strengthening activities. The multi-center design allows comparison across facility types and geographic locations, identifying specific gaps requiring targeted intervention.

CONCLUSION

This multi-center analysis of disease surveillance data from Zawia, Libya, reveals a surveillance system with heterogeneous performance, demonstrating capacity to detect and report certain communicable diseases notably viral hepatitis and influenza while exhibiting substantial gaps for the majority of notifiable conditions. The predominance of zero-reporting for 66.7% of diseases under surveillance raises fundamental concerns about system sensitivity and Libya's capacity to detect public health threats in accordance with International Health Regulations requirements.

The concentration of reported cases at central facilities, with limited peripheral detection capacity, creates vulnerability for delayed outbreak recognition and response. Strengthening surveillance infrastructure, particularly at primary healthcare level, represents an urgent priority. Specific interventions should focus on: enhancing diagnostic capacity for priority diseases; implementing regular supervision and data quality assurance; establishing community-based event-based surveillance; and ensuring sustainable financing for surveillance operations.

The ongoing transmission of viral hepatitis, seasonal influenza, and focal trachoma documented in this analysis demonstrates that Libya continues to face substantial communicable disease burdens requiring public health response. The surveillance system, despite its limitations, provides a foundation for disease monitoring that can be built upon through systematic strengthening activities. International support for Libya's surveillance system aligned with the IDSR framework and IHR requirements remains essential for protecting both national and regional public health security.

As Libya progresse toward health system recovery and stabilization, investment in disease surveillance infrastructure will yield dividends in outbreak prevention and response capacity. The findings of this analysis provide a baseline for monitoring surveillance system performance over time and identifying priorities for technical assistance and resource allocation. The experience of Zawia offers lessons for other conflict-affected settings

where surveillance system strengthening must proceed alongside broader health system reconstruction efforts.

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