



Global Public Health

An International Journal for Research, Policy and Practice

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/rgph20>

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To cite this article: Eva Pilot , G.V.S. Murthy & Vasileios Nittas (2020) Understanding India's urban dengue surveillance: A qualitative policy analysis of Hyderabad district, *Global Public Health*, 15:11, 1702-1717, DOI: [10.1080/17441692.2020.1767674](https://doi.org/10.1080/17441692.2020.1767674)

To link to this article: <https://doi.org/10.1080/17441692.2020.1767674>



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Understanding India's urban dengue surveillance: A qualitative policy analysis of Hyderabad district

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ABSTRACT

Dengue's re-emerging epidemiology poses a major global health threat. India contributes significantly to the global communicable disease burden has been declared highly dengue-endemic, exposing public health authorities to severe challenges. Our study aims to provide a deeper understanding of India's urban dengue surveillance policies as well as to explore the organisation, functioning and integration of existing disease control pillars. We conducted a qualitative regional case study, consisting of semi-structured expert interviews and observational data, covering the urban region of Hyderabad in South India. Our findings indicate that Hyderabad's dengue surveillance system predominantly relies on public reporting units, neglecting India's large private health sector. The surveillance system requires further strengthening and additional efforts to efficiently integrate existing governmental initiatives at all geographical levels and administrative boundaries. We concluded with recommendations for improved consistency, accuracy, efficiency and reduction of system fragmentation to enhance the integration of dengue surveillance and improved health information in urban India. Finally, our study underlines India's overall need to increase investment in public health and health infrastructures. That requires coordinated and multi-level action targeting the development of a competent, effective and motivated public health cadre, as well as truly integrated surveillance and epidemic response infrastructure, for dengue and beyond.

ARTICLE HISTORY

Received 4 May 2019
Accepted 27 April 2020


KEYWORDS


dengue; urban health; India; surveillance; policy integration; health information; International Health Regulations

Background

Dengue in a global context

Dengue is a rapidly expanding vector-borne disease with more than half of the global population living in dengue-endemic areas (Messina et al., 2019). In the last decades, dengue's incidence has

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 Supplemental data for this article can be accessed at <https://doi.org/10.1080/17441692.2020.1767674>.

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seen a 30-fold increase, with a current estimation of 390 million annual infections. In the last year alone, the European Centre for Disease Prevention and Control reported a substantial increase in dengue incidence, with particularly high numbers in the Americas and the Caribbean (Angelo et al., 2020; ECDC, 2019; WHO, 2012).

Dengue is a mosquito-borne viral infection with a spectrum that ranges from subclinical (people are not even aware that they are infected) to severe flu-like manifestations. The WHO classifies an infection into 'dengue' and 'severe dengue'. The latter is less common and is often associated with severe bleeding, organ impairment and/or plasma leakage. The dengue virus (DENV) has four types (DENV1, DENV2, DENV3 and DENV4), meaning that the same person can be infected four times before full immunity can be established (WHO, 2019a).

Dengue transmission is following distinct seasonal (within a year) and cyclical (outbreaks in certain years) patterns, reflecting multiple interactions with climatic conditions (temperature and rainfall), vectors, the circulating virus, and a population's immunity status (Castro et al., 2017). Dengue's transmission occurs through the highly urban adapted *Aedes* mosquito and is facilitated by rapidly expanding urban environments. The risk is primarily increased by poor housing, the absence of piped water supply and insufficient waste management, providing ideal mosquito breeding conditions (Arunachalam et al., 2010; Modi & Vaishnav, 2018). According to the International Health Regulations, dengue becomes a notifiable disease of international concern if the event is serious and unexpected, including a significant risk of international spread or requiring travel and trade restrictions for containment (WHO, 2008). Signatory states are obliged to provide detection of elevated disease and death rates, facilitate the instant implementation of control measures, and ensure a timely reporting to the World Health Organisation (WHO) (WHO, 2005). The regional and national implementation of the International Health Regulations face serious challenges on various administrative levels.

New and evidence-based strategies are needed to reverse dengue's emerging trend (WHO, 2018). Key to its containment is the quantification of disease burden which enables policy makers to set priorities, allocate funding, decide on prevention and control strategies and evaluate the cost-effectiveness of interventions. The real challenge is that only very few dengue-endemic countries have functioning health information and surveillance systems in place (Castro et al., 2017). This leads to uncertainties in current estimates and thus in comparisons of the dengue burden between regions and countries. India, being the focus of this study, is a highly dengue-endemic country with high fluctuations of reported cases across government sectors (Das et al., 2014).

Dengue surveillance in India

India reflects 34% of dengue's global burden (Chakravarti et al., 2012). According to India's National Vector Borne Disease Control Programme (NVBDCP), the number of reported cases and deaths escalated from about 28,000 cases and 110 deaths in 2010 to 129,000 cases and 245 deaths in 2016 (NVBDCP, 2017). These figures merely consist of data from government hospitals, entirely neglecting India's large private health sector, which covers approximately 80% of all dengue-related healthcare visits (Modi & Vaishnav, 2018; Mohaya Chaudhuri, 2013; Shepard et al., 2014). Regional comparisons suggest vast underreporting of dengue cases across India (Halasa et al., 2011; Shepard et al., 2014). Considering its re-emergence, rapid spread and the increasing need for richer information, such as spatially segregated data that allow the identification of exact outbreak occurrence and spread, dengue is a disease that requires enhanced public health research and surveillance (Bhatt et al., 2013; Gupta & Reddy, 2013; Sivagnaname et al., 2012). An enhanced public health surveillance system, based on accurate and timely data, is essential to the prediction and detection of dengue outbreaks and ultimately to overall disease containment (Daude & Mazumdar, 2016; Murray, 2007; Pilot et al., 2017).

This study focuses on dengue surveillance in the urban region of Hyderabad, contributing towards a 'reality check' on the implementation status of the International Health Regulations in

India. Disease surveillance has been and remains a challenging public health task across the subcontinent (Ministry of Health & Family Welfare, 2015). Particularly complex surveillance elements include the accurate monitoring of disease burden and trends, as well as the detection, confirmation and control of outbreaks before disproportional spread and damage (Angelo et al., 2008; Pilot et al., 2017). India's administrative organisation is divided into several layers, consisting of national, state and district units, as well as villages and blocks in rural areas or municipal local bodies and wards in urban regions. One way the Government of India aims to address health challenges is through the implementation of national health programmes. The country currently maintains two separate and independently operating national surveillance programmes, both reporting dengue data parallel to other infectious diseases. These programmes consist of the Integrated Disease Surveillance Programme (IDSP) and National Vector Borne Disease Control Programme (NVBDCP) (Ministry of Health and Family Welfare, 2018; NVBDCP, 2018). On the local urban level, municipal infectious disease reporting authorities operate as an additional surveillance and vector control layer. Thus, in the context of dengue, the stakes are divided among IDSP, NVBDCP and municipal authorities.

The effective implementation of such programmes relies on the integration of various stakeholders, inter-sectoral coordination, evidence-based planning, public-private partnerships, cross-programme cooperation and strong primary health care and public health leadership (Lenka & Kar, 2012; Pilot et al., 2017). The WHO highlights the need to implement national health programmes in ways that are integrative, foster synergies and increase effectiveness, ultimately contributing to the Sustainable Development Goals (Lenka & Kar, 2012). Nonetheless, India's surveillance activities are primarily implemented within vertically operating centralised disease control programmes (e.g. IDSP, NVBDCP). Although centralised health programmes can be effective, in the case of India they are often limited by several drawbacks and weaknesses; firstly, their fragmented nature (i.e. lack of coordination and comprehensive public health approaches among vertical programmes) inevitably constrains their capacities for timely and optimal outbreak detection. Secondly, their strong functional autonomy leads to avoidable duplications of efforts. Thirdly, their limited integration and flexibility ultimately restrict benefits of cross-sectoral collaboration and communication (Duran et al., 2014; Phalkey, Shukla, et al., 2013; Pilot et al., 2019).

Surveillance types

The WHO distinguishes broadly among three types of surveillance: passive, active and sentinel. Passive surveillance receives data from all potential reporting units. A disease case is only captured if the patient decides to seek health care. Passive surveillance systems rely on very broad networks, with all facilities that involve patient contact being required to report cases at regular intervals. Passive surveillance is the most common and least expensive form of surveillance, however, it is often burdened by weaknesses due to (1) full dependence on the cooperation of an extensive network and (2) unequal distribution of skills and case detection resources within the network, often leading to incomplete and/or delayed reporting (WHO, 2019b).

In an active surveillance context, disease cases are captured through the healthcare system's active screening activities, such as in-person visits of medical facilities, screening of medical records and physical examinations. Identified cases are then directly investigated and reported by active surveillance providers, which is costly but often ensures a timely and targeted approach (WHO, 2019b).

Instead of trying to gather surveillance data from all healthcare facilities, a sentinel surveillance system is based on selected (randomly or intentionally) reporting units. These units should ideally capture a significant amount of cases and be equipped with good laboratory facilities and qualified staff. While very useful to predict trends and outbreaks, sentinel surveillance systems only capture cases within selected areas and are thus not ideal for detecting rare diseases or diseases outside the catchment area (WHO, 2019b).

Dengue surveillance in Hyderabad district

To understand the complexity of dengue surveillance and health information availability in urban India, this paper draws on a case study of Hyderabad city. Hyderabad is the largest city and capital of the state of Telangana (see map in supplementary material). The Greater Hyderabad Municipal Corporation (GHMC) was created in 2007 and has an estimated population of around 10 million, spanning across 650 square kilometres (Government of Telangana, 2019; World Population Review, 2020). The dengue incidence of Hyderabad city has been continuously rising (from 147 cases in 2017 to 1043 cases in 2019) (Mk, 2019; TelanganaToday, 2019). Local officials admit that the reported numbers could be a gross underestimation of actual incidence, providing a misleading picture of the actual dengue burden (Mk, 2019).

Hyderabad's district-level dengue surveillance activities are primarily divided among three publicly funded organisational pillars. Two pillars of dengue surveillance consist of the previously mentioned national health programmes, IDSP and NVBDCP, while the third pillar consists of the Greater Hyderabad Municipal Corporation's (GHMC) health wing. The first pillar, the IDSP, operating under the National Centre for Disease Control and Director General of Health Services of the Ministry of Health and Family Welfare, was launched in 2004 and aims to improve India's regional and national disease surveillance and response. Its key objectives consist of enabling the timely surveillance of epidemic-prone diseases, monitoring disease trends, facilitating the timely response to outbreaks, as well as integrating vertically operating surveillance efforts. Additionally, the IDSP is responsible for the reporting of presumptive, suspected and confirmed dengue cases (Ministry of Health and Family Welfare, 2018). The second pillar, NVBDCP, is the government's central nodal agency for the prevention and control of vector-borne diseases, as well as one of the technical departments of the Directorate General of Health Services of the Ministry of Health and Family Welfare (NVBDCP, 2018). The NVBDCP is responsible for synthesising reports on suspected and confirmed dengue cases, initiating prevention activities, facilitating health awareness and ensuring immediate outbreak response. The third pillar, GHMC's urban health wing, covers Hyderabad and minor parts of three surrounding districts (GHMC, 2018). GHMC's urban health wing is state-detached, self-funded and responsible for sanitation, as well as preventive and emergency-driven vector control measures. In addition, GHMC's urban malaria scheme (also covering dengue) is responsible for a parallel collection of suspected and confirmed dengue cases, while developing and distributing awareness material.

All three agencies are operating within the same municipal boundaries and are collecting dengue information independently, in parallel and at different scales. [Figure 1](#) shows an overview of the three responsible authorities and their main activities.

This study aims to contribute to an improved understanding of India's national dengue surveillance policies, their implementation within urban regions and the complex interactions between responsible municipal and national health authorities. Using the city of Hyderabad as an urban case study, the study's leading research questions are:

- (1) How is dengue surveillance organised, functioning and integrated in the urban district of Hyderabad?
- (2) How do urban district and state government authorities communicate, coordinate and interlink dengue information reporting?

Materials and method

Our methodology followed a qualitative policy analysis approach, consisting of expert interviews and field visit observations. Our conceptual and analytical basis was built upon McNabb's et al. framework of public health surveillance and action, which offers a structured overview of major

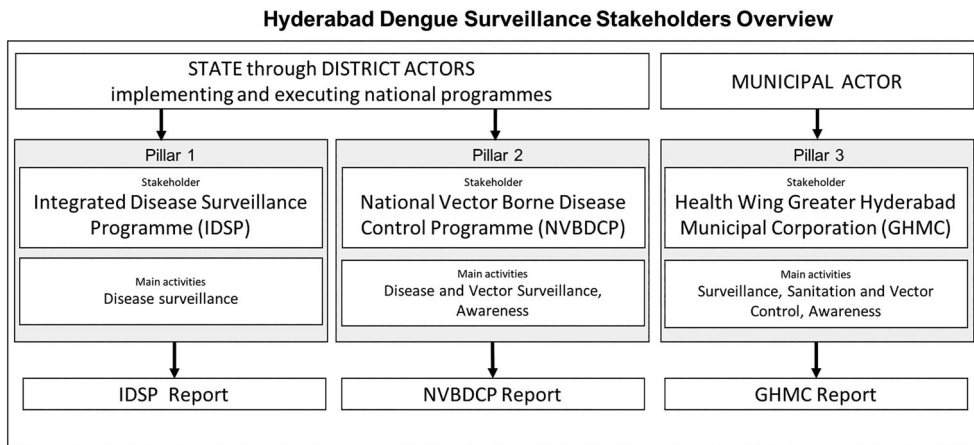


Figure 1. Overview of dengue surveillance stakeholders in Hyderabad, India.

surveillance and response activities (McNabb et al., 2002). The framework identifies two separate, though interdependent processes, embedded within an open system of continuous information and activity flow. The first process is that of ‘public health surveillance’, subdivided into six inter-linked primary activities. Those are case (1) detection, (2) registration, (3) laboratory confirmation, (4) reporting, (5) data analysis and (6) feedback. The second process is that of ‘public health action’, referring to planned or unplanned activities of maintaining, improving and protecting population health. Further, supportive activities that apply to both processes equally include the presence of communication channels, availability of staff training, supervision processes and the provision of adequate resources. Beyond serving as the study’s conceptual basis, we applied the model as a guiding framework for data retrieval, analysis and interpretation (McNabb et al., 2002).

We initially performed 14 semi-structured interviews (supplementary Table S 1) of experts and stakeholders, operating within Hyderabad’s dengue surveillance system. These were complemented and confirmed by observational data that were retrieved in parallel during extensive field visits. The interviews were designed to predominantly capture elements of the organisation, functioning and integration of dengue surveillance activities across Hyderabad’s municipal area. Questions were framed on the basis of McNabb’s et al. conceptual framework, addressing core surveillance elements, consequent public health action and relevant supportive resources. Interviewee selection followed the principles of purposive, as well as ‘snowball’ sampling, justified on occupational position within IDSP, NVBSCP or GHMC, or on being a regional surveillance expert. Table S 2 (supplementary material) provides an overview of the interviewed informants. The underlying study population is the Hyderabad municipal population.

This study relied on information provided consensually by experts, as well as official and published data. An ethical clearance was therefore not required. All interviews took place between February and June 2016. To update the study reconfirmation about reporting units and function were obtained in early 2020 through reach out to some of the stakeholders previously interviewed.

Data analysis

Our starting point was an already established conceptual framework, for which our analysis followed deductive qualitative principles (Saldaña, 2016). We developed three overall codes, each corresponding to the conceptual framework’s thematic clusters of public health surveillance, public health action and supportive activities. These codes were used on all transcribed interviews to broadly divide them into three categories. This was followed by a thorough thematic analysis, iteratively

identifying subthemes (attached to sub-codes), as well as overall linkages and patterns. Interview sections that did not fit into one of the overall categories were attached to iteratively developed secondary categories. The same procedure was applied to all observational data (OD). All interviews were attached to ID numbers (ID1, ID2 ...), which were subsequently used as references throughout the results section.

Results

The following three sections provide an account on the organisation and functioning of Hyderabad's three surveillance pillars (IDSP, NVBDCP, GHMC) individually, while the fourth section assesses the current integration and cooperation activities across these. Each pillar is reported individual as all three operate predominantly isolated.

Pillar 1: The Integrated Disease Surveillance Programme (IDSP)

The organisation of IDSP

The IDSP's district surveillance office of Hyderabad consists of four key positions. Head of the office is the district surveillance officer, who is simultaneously recruited by the NVBDCP. The remaining positions consist of one epidemiologist, one data operator and one data manager, with the last position being vacant at the point of interview. Four additional data operators are outsourced in four governmental tertiary health institutions, simultaneously operating as dengue sentinel surveillance units. While the four sentinel surveillance units are responsible for confirming dengue cases, IDSP's dengue surveillance is passive. IDSP's dengue reports are received from a broad network of health facilities across Hyderabad. The sentinel surveillance units merely act as confirmation agents. We keep the term 'sentinel units' across the manuscript because it is the commonly used term within IDSP, though not all of them have all required resources a sentinel unit should ideally have.

The functioning of IDSP

Reporting: Reporting constitutes a major and crucial IDSP component and is embedded in a web of reporting units across all healthcare levels. Reported cases can be suspected, presumptive or laboratory-confirmed. S-forms (suspected cases) are completed by auxiliary nursing midwives, conducting field and primary healthcare work. P-forms (presumptive cases) fall under the responsibility of medical officers and L-forms (laboratory-confirmed cases) under the responsibility of laboratory staff. IDSP receives reports from 107 public (85 Urban Primary Health Centres, 9 Urban Community Health Centres, 4 Community Dispensaries, 1 District Hospital, 3 Area Hospitals, 1 Institute of Preventive Medicine, 4 Medical Colleges) and 18 private hospitals. Six reporting units are described as sentinel. Two major reporting challenges include the completeness and accuracy of data. With only 18 out of 863 recognised municipal private hospitals regularly reporting to IDSP, the system captures only about 30% of the municipal population. Experts attribute that gap to a lack of information, missing governmental enforcement and pure irresponsibility (ID 1; ID 2). Beyond that, evidence suggests low validity of suspected and presumptive data, primarily linked to purposively reduced numbers, as well as incomplete outpatient registration. Interviewees indicate that many low-level healthcare staff intentionally reduce the number of reported cases due to fears of negative feedback from superiors. The higher the number of reported cases, the more likely it is for a superior to express concerns, dissatisfaction and negative feedback. With lacking instructions on how to validate suspected and presumptive dengue cases, district-level outbreak analysis is primarily restricted to confirmed cases (ID 1, ID 2). A fair volume of reporting remains paper-based, which is described as burdensome and unnecessarily resourceful (OD, ID 8). Reports include the age, gender, address and name of each patient. While reports are perceived as adequate, they are often not complete enough to categorise the severity of each case (ID 6, ID 3).

Confirmation: Accurate, timely and reliable disease confirmation is a crucial component of any disease surveillance system. In Hyderabad, and within IDSP, dengue confirmation exclusively occurs through a network of six sentinel laboratory-reporting units, linked to tertiary healthcare services (ID 1). Primary health centres are excluded from any confirmatory activity, despite being the most accessible and utilised facilities. The combination of a disproportional population size and a limited number of laboratories ultimately leaves a significant number of dengue cases unconfirmed, indicating the need to strengthen primary level confirmatory capacities (ID 1, ID 2). Similarly, there are indications of a weak compliance to national regulations on dengue confirmation procedures, primarily by the few private healthcare facilities, which fail to utilise the IDSP-accepted MAC-ELISA tests (ID 2). Thus, the few private reports entering the IDSP surveillance system require time-consuming and costly cross-checks before entering the IDSP reports. One MAC-ELISA kit can be used for up to 96 samples, incentivising many laboratories to reduce waste by conducting tests in three- to four-day circles, inevitably causing delays and reducing the system's effectiveness (ID 7, ID 2).

Analysis: Following reporting, the district epidemiologist, district medical officer and data operator are responsible for appropriate analysis. Based on most reliable L-data (laboratory-confirmed), analysis occurs according to geographical and time parameters. A three-year outbreak peak pattern was identified and presents a successful step towards improved prediction and preparedness. Analysis is described as basic, periodical and primarily intensified during endemic periods. The missing provision of Geographic Information System (GIS) tools for spatial analysis has been mentioned as a major analytical weakness of IDSP's district unit (ID 1).

Action: During dengue outbreaks, the IDSP's responsibilities remain significantly limited to triggering the surveillance data-driven response (ID 1). The district surveillance officer of Hyderabad, simultaneously responsible for the NVBDCP, initially confirms the outbreak, supported by an external microbiologist (ID 2). While the IDSP's pro-active and preventive activities remain insufficient, emergency-driven responses, consisting of mobilising the NVBDCP and the GHMC, are described as functioning and effective (ID 1).

Supportive Surveillance Functions: Hyderabad's IDSP lacks dedicated mobility measures, human resources, IT equipment and financial support (ID 1, ID 14). While sentinel testing and reporting units receive regular stocks and have sufficient human and material resources, smaller laboratories face severe infrastructural gaps (ID 6, ID 7, ID 13). With missing equipment and no officially established mode of communication, the exchange of information between IDSP staff remains dependent on personal means and is largely informal. The provision of free Wi-Fi is described as highly beneficial for speeding up communication during emergencies (ID 1). On the contrary, sentinel surveillance laboratories are well connected, including functioning internet and e-mail services. An IDSP-wide, fully functioning telecommunication system remains to be established (ID 6, ID 13, ID 14, OD)

On district surveillance level, internal supervision of general, as well as dengue-related surveillance activities are perceived as existing and adequate (ID 1). However, external supervision, specifically targeting quality maintenance of sentinel dengue surveillance laboratories remains non-existent. A previously established and highly beneficial external quality assurance scheme was operated for six months and discontinued (ID 6). A summary of our core findings on the IDSP's organisation and functioning in Hyderabad is provided by [Box 1](#).

Box 1. Key Findings on Integrated Disease Surveillance Programme's Functioning in Hyderabad.

- Key responsibility is passive surveillance
- 107 public and 18 private reporting units report on a weekly basis
- Dengue case confirmation is restricted to six sentinel units
- Weak reporting accuracy, completeness, timeliness and reliability
- Reporting is staff intensive, with a mix of paper and electronic reporting channels
- Low validity of presumptive and suspected dengue cases
- Low coverage of reporting by private healthcare institutions

- Weak confirmatory capacities
- Basic and periodical epidemiological analysis
- Insufficient manpower, mobility, IT and financial resources
- Primarily informal internal communication
- Adequate internal but lacking external supervision

Pillar 2: The National Vector Borne Disease Control Programme (NVBDCP)

The organisation of NVBDCP

Under the NVBDCP, the district is divided into six subunits, each headed by one subunit officer. Units are further subdivided into 33 sectors, headed by multi-purpose health supervisors, and 75 sections, filled with active and passive multi-purpose health assistants. NVBDCP is primarily performing vector and disease surveillance. NVBDCP's dengue reporting is entirely based on confirmed cases, retrieved from four sentinel laboratories. NVBDCP was built upon the former the malaria programme and some descriptions are still malaria-related (e.g. malaria workers, malaria units). Active agents are responsible for field work surveillance, while passive agents are positioned in malaria units within larger governmental health facilities, taking dengue samples after patient referral. These field level agents, also known as 'malaria workers', are entirely excluded from any involvement in dengue testing and confirmatory activities (ID 5, ID 10). With no ground-level availability of dengue tests, suspected cases of dengue or other vector-borne diseases are referred to higher levels with adequate laboratory facilities (ID 4).

The functioning of NVBDCP

Reporting: NVBDCP reports flow electronically on a daily and weekly routine, initiated at the units and then sent to district and state authorities on a monthly basis (ID 10, ID 13, ID 14). NVBDCP's vertical and non-integrated operation restricts reporting to a selected network of sentinel laboratories. Primary and secondary facilities are entirely excluded from dengue reporting (ID 5). Similar to IDSP, low levels of private hospital participation constitute a major challenge for the system's accuracy.

Action: Beyond reporting, the NVBDCP holds primary responsibility for the implementation of dengue outbreak responses. The programme's activities primarily consist of symptom-based fever surveillance and vector sample collection, conducted in and around a patient's house. In addition, the NVBDCP is responsible for primary prevention activities and health awareness. A repeatedly emphasised example is the 'Friday Dry-Day' campaign, incentivising community measures for the weekly removal of unnecessary vector breeding sites (ID 10, ID 12). Key dengue-related weaknesses are induced by missing efforts to upgrade, improve and expand the skills of field workers. Traditional techniques and outdated technical equipment require replacement by novel approaches and modern technology, ultimately targeting health awareness and prevention. Human resources are scarce, especially on health worker level, with more than 50% of sanctioned positions remaining vacant. Nonetheless, the good sentinel surveillance network has been mentioned as the system's main strength (ID 4, ID 10). A summary of our core findings on NVBDCP's organisation and functioning in Hyderabad is provided by [Box 2](#).

Box 2. Key Findings on National Vector Borne Disease Control Programme's Functioning in Hyderabad.

- Key district actor for dengue outbreak response and mitigation
- Dengue confirmation based on four sentinel units
- No coverage of reporting by private healthcare institutions
- Fully electronic reporting, via e-mail
- Responses primarily consist of fever-based surveillance, vector control and sample collection
- Additionally responsible for primary prevention and health awareness
- Vertical and malaria-focused field surveillance activities
- Lacking human resources and modern surveillance equipment

Pillar 3: The Greater Hyderabad Municipal Corporation (GHMC)

The organisation of GHMC

The GHMC area is administratively divided into five zones (north, east, south, west, central), 24 circles and 150 wards. The health wing's head office is supervised by the municipality's chief medical officer who is responsible for sanitation activities, as well as a chief entomologist who is responsible for vector control throughout the municipal area. Each zone is headed by a senior entomologist, and each circle by an assistant medical officer and an assistant entomologist. GHMC's surveillance approach is primarily passive sentinel.

The functioning of GHMC

Reporting: The vector control department of the GHMC's health wing is the key municipal actor in Hyderabad's dengue surveillance initiatives. It maintains a separate reporting system for suspected and confirmed dengue cases, including 52 private and 8 governmental reporting units. Approximately 80% of integrated private facilities are large corporate (municipal) hospitals, ranging between 100 and 1500 beds. In 2014, the GHMC developed an online portal, dedicated to private reporting of malaria and dengue; the portal failed soon after due to technical difficulties. Currently, reporting occurs exclusively via e-mail. Governmental reports not reaching the GHMC's health wing are retrieved by the NVBDCP's district malaria offices. Reporting is perceived as being not fully consistent, while most of smaller corporate hospitals remain non-integrated (ID 11).

Action: Routine GHMC activities are divided into, reporting, prevention, outbreak response and awareness. Preventive measures refer to anti-larval activities, occurring domestically during inter-endemic and outbreak-prone periods (ID 11, ID 12). Although efforts are evident, preventive measures fail to cover all areas, such as wards of higher socio-economic status as they often refuse anti-larval operations. Awareness-raising activities target the general public through the distribution of simple information material and school programmes (ID 11). Responsive action is taken in the case of suspected or confirmed reports. Operations target larvae, as well as adult mosquitos through the use of pyrethrum sprays and fogging. Opinions on the GHMC's preventive measures vary and are internally perceived as a major strength, while externally evaluated as non-existent and inadequate (ID 3, ID 11). A core inadequacy of the current surveillance system is the complete absence of active surveillance data across the municipal area. A potential surveillance asset is the GHMC's dedicated GIS department, regularly used by health wing entomologists for mapping of dengue and malaria cases. The integration of large corporate hospitals and the creation of a circle level committee for monthly reviews of municipal vector control activities are additional surveillance strengths (ID 11, ID 14). A summary of core findings on GHMC's organisation and functioning in Hyderabad is provided by [Box 3](#).

Box 3. Key Findings on Greater Hyderabad Municipal Corporation's Functioning in Hyderabad

- Key municipal actor for reporting, prevention, response and awareness
- Maintains an independent (separate from NVBDCP and IDSP) reporting infrastructure
- Reporting units include 52 public and 8 private facilities
- Electronic reporting, via e-mail
- Preventive, anti-larval activities fail to cover all areas in need
- Awareness targets the general public
- Missing active surveillance activities
- Regular use of GIS mapping for surveillance needs

Connecting the Pillars: Integration of Surveillance Activities

The integration of dengue surveillance activities in urban Hyderabad has been assessed within, as well as across the IDSP, NVBDCP and GHMC, while additionally considering various administrative

levels. Efforts to establish integrated reporting structures and facilitate the inclusion of private facilities have been subject to particular focus. [Figure 2](#) provides an overview of the administrative integration and reporting structure of IDSP, NVBDCP and GHMC.

Administrative integration

In terms of administrative organisation, district-level integration or at least coordination is evident only between the IDSP and NVBDCP, as both national programmes share one district surveillance officer (ID 1). At district level, integration is limited to administrative processes and information exchange, while concrete outbreak-related activities remain a NVBDCP responsibility (ID 10). Nonetheless, the administrative merger is perceived as significantly facilitating cooperation and report uniformity (ID1, ID 2). The GHMC is administratively fully detached from the other two pillars. Nonetheless, respondents referred to an outbreak-driven cooperation between the GHMC and NVBDCP, with the first being responsible for mosquito control and the second for vector surveillance measures (ID11, ID12). In strong contrast, there seems to be no cooperation between the IDSP and GHMC (ID 2, ID 11).

Reporting integration

The integration of dengue reports between the IDSP and NVBDCP is limited to laboratory-confirmed data (L-forms). Suspected and presumptive cases (S-forms and P-forms) are considered as relatively unreliable therefore not shared with NVBDCP, neither used for outbreak analysis (ID 1, ID 14). Reporting procedures remain non-integrated, with IDSP reports captured in standardised forms, electronically and on paper, while NVBDCP reports flow via format less e-mails (ID 6). Data are merged after reaching the common district surveillance office. Despite that, comparative analyses of reports indicate small discrepancies in confirmed dengue cases, attributable to differences in inclusion criteria. The NVBDCP excludes all patients that are not resident in the district of Hyderabad, leading to a difference of 7 cases in 2014 and 21 cases in 2015 (ID 1). Finally, the municipal health wing maintains a separate dengue reporting system, operating via e-mail on a weekly basis, which is in fact linked with the NVBDCP's reporting through regular data exchange, aiming for a unification of GHMC and NVBDCP reports. A direct integration between the GHMC and IDSP dengue reports does not exist, however, could potentially occur indirectly via the NVBDCP (ID 11). Efforts for an overall, comprehensive integration of dengue reporting are not evident.

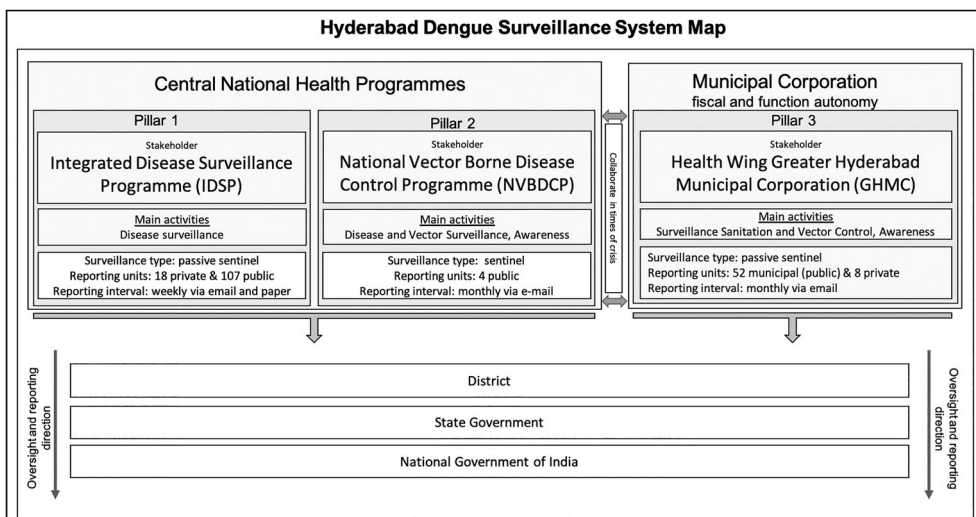


Figure 2. Dengue surveillance system map of Hyderabad, India.

Integration of private actors

Experts suggest that approximately 80% of Hyderabad's citizens seek private healthcare, highlighting the paramount significance of integrating private actors within state and municipal surveillance approaches (ID 1, ID 13, ID 14). The integration of private reporting units into the IDSP and NVBDCP has been a repeatedly mentioned and largely neglected limitation. In fact, only 2% (18 out of 863) of private hospitals in Hyderabad report dengue cases to IDSP, which is rather irregular and informal (ID 1). The non-integration of private facilities is attributed to lacking responsibility, communication and legal enforcement (ID 2). One respondent estimated that the programme currently captures less than half of all actually occurring dengue infections, leaving a large proportion unaccounted for (ID 1). The municipal health wing shows a slightly better integration of private healthcare providers, with approximately 8% of registered private facilities reporting dengue cases. A summary of core findings on Hyderabad dengue surveillance integration is provided by [Box 4](#).

Box 4. Key Findings on Hyderabad's Dengue Surveillance Integration

- Administrative integration only between state programmes of the IDSP and NVBDCP, leaving municipal dengue surveillance activities detached
- Integration of reports between the IDSP and NVBDCP limited to laboratory data
- Actual reporting procedures remain non-integrated
- Report-inclusion criteria vary between the IDSP, NVBDCP and GHMC
- Information exchange only occurs between the NVBDCP and GHMC
- Only 2% of all recognised private healthcare facilities report to IDSP/NVBDCP
- Lacking integration of private facilities potentially leaves more than 50% of dengue burden unidentified by the IDSP/NVBDCP
- Cross-checking of private samples by the state lab potentially captures a portion of private data into the IDSP's/NVBDCP's surveillance system
- 8% of recognised private health care facilities report to GHMC's surveillance system
- Reporting efforts overlap and an integrated approach is missing

Discussion

Hyderabad's dengue surveillance activities are divided across three distinct, as well as independently functioning pillars. That division ultimately evolves in a complex administrative, procedural and infrastructural web. The two national surveillance programmes and the regionally bound municipal health wing operate on various levels, depend on separate funding mechanisms and rely on distinct resources, adding to the system's complexity.

Previous research on India's surveillance system suggests inconsistent, unreliable and generally weak reporting, which was confirmed by our findings (Gaikwad et al., 2008). Our findings suggest remaining fragmentation, unnecessary duplication of reporting efforts and avoidable inefficiencies. A shift from staff-intensive and slow paper-based reporting towards electronic approaches could enhance transparency, efficiency, communication and data quality. The lacking accuracy of current data could be addressed by adequately involving reporting by private healthcare providers. Currently, only 2% and 8% of Hyderabad's private hospitals report dengue cases to the IDSP, NVBDCP and the GHMC respectively. Although the ratio remains small, it is essential to consider that a substantial number of private hospitals most probably do not have dengue confirmation capacities. Thus, excluding those from the denominator would potentially improve the previously indicated percentages. Nonetheless, that does not justify their total absence from Hyderabad's surveillance system, as reporting does not necessarily have to be confirmatory. Mere presumptive reporting of potential cases would certainly be more valuable to effective dengue surveillance than the current situation. Even if the number of integrated private facilities is to be increased; establishing continuous, reliable and regular reporting is the key to success. Also, the inclusion of primary healthcare with improved detection and reporting capacity would benefit the surveillance system.

India's dengue policies are often heavily autonomous and subject to little integration, which ultimately leads to complex and inefficient data reporting at all administrative levels. This is clearly visible when analysing the current operation of Hyderabad's three surveillance pillars. These mainly operate in silos, with little or no cross-pillar interaction and coordination. Although the IDSP's core objective is the integration of vertical and parallel operating programmes, there is little evidence that this objective has been achieved (Bachani, 2006; Srivastava et al., 2009). Although the district offices are administratively merged, the IDSP's and NVBDCP's integration is merely limited to reporting of laboratory-confirmed cases. Paradoxically, both pillars maintain separate reporting streams that are only merged on state level. Finally, full integration of dengue surveillance requires the consistent involvement of municipal activities. While the IDSP's extensive governmental reporting network is potentially beneficial to municipal activities and the GHMC's private reporting units are highly valuable for the IDSP, cooperation remains absent. Ties between state and municipal authorities are limited to emergency-driven cooperation.

Previous research suggests weak and inconsistent analysis of incoming surveillance data (Raut & Bhola, 2014; Suresh, 2008), which is also confirmed by our findings. Experts point towards missing technology, such as GIS spatial mapping tools, as well as insufficient data analysis during and between endemic periods. The toolkit for national dengue burden estimation, developed by the WHO, can be a standardised way to estimate the hidden dengue burden in Hyderabad (WHO, 2018). Dengue's rapidly emerging nature and relatively novel occurrence in Hyderabad require a predominantly prevention-based approach. Standardised routine processes, technical support and cooperation with the GHMC's dedicated GIS department constitute essential, yet missing improvement opportunities. The existing network is by far not sufficient to provide comprehensive coverage of Hyderabad's disproportionately large population. This clearly constrains the system's detection capacities: calculating the ratio of all 189 listed reporting units (combining passive, active and sentinel) to the general population (10 Million) of Hyderabad would provide a theoretical coverage of around 53,000 persons per reporting unit. However, this does not provide an accurate picture, as many reporting units are not reporting at all, or only do so irregularly. Therefore, building a comprehensive surveillance system would require major investments in qualified staff and sufficiently equipped surveillance units.

Several studies on India's surveillance capacities indicate resource-related challenges, including lacking equipment, tests and human capacities (Gupta & Reddy, 2013; Phalkey, Bhosale, et al., 2013; Pilot et al., 2017; Pilot et al., 2019; Raut & Bhola, 2014; Srivastava et al., 2009; Suresh, 2008). Our findings confirm these resource limitations. While the IDSP faces shortages in technical equipment, mobility, data managers and field workers, the NVBDCP is primarily challenged by field-level human resource deficits. The availability of test-kits is sufficient for sentinel reporting units, however, remains non-existent for surveillance workers. Contrary, being self-funded, the municipal health wing is relatively advantaged on all resource levels. A comprehensive understanding of those differences and structural challenges may help in establishing cooperation ties and in overcoming the current fragmentation.

Placing our findings in the context of existing surveillance evaluation indicators reveals several implications. A system's sensitivity to detect an emerging outbreak is undoubtedly a key strength and effectiveness indicator, which in Hyderabad's context is affected by multiple of the identified weaknesses (Drewe et al., 2012). The low accuracy and completeness of reporting, insufficient surveillance resources (e.g. manpower), missing active surveillance elements, lacking private healthcare sector involvement and missing coordination among the three surveillance pillars have an inevitably negative impact on dengue surveillance sensitivity. In order to be able to adequately act on an emerging outbreak, the timeliness of a surveillance system (the gap between outbreak start and outbreak detection) is a further key effectiveness indicator (Drewe et al., 2012). In the case of Hyderabad, the missing active surveillance elements in combination with inefficient and non-streamlined reporting procedures (e.g. paper-based reporting) have a potentially negative impact on dengue surveillance timeliness. Furthermore, missing active surveillance, as well as lacking reinforcement and

supervision likely hinder the system's acceptability (the compliance of stakeholders). Similarly, the identified non-integration of the three surveillance pillars reduces the simplicity and flexibility of the system, further impacting the effectiveness of dengue surveillance in Hyderabad (Buehler et al., 2004; Drewe et al., 2012).

In light of the International Health Regulation's recommendations on dengue reporting, India would benefit from additional efforts to improve its current surveillance capacities (WHO, 2008). To ensure a timely and reliable reporting of dengue incidence, our findings suggest an urgent need to foster collaboration and integration across administrative boundaries and current surveillance systems (Gopichandran & Subramaniam, 2020; Pilot et al., 2017).

Our findings have to be viewed in consideration of the following limitations. A large proportion of our findings is derived from expert interviews. Expert opinions and views are not free from subjectivity and distortion, especially within the highly hierarchical Indian setting. Whenever possible, interview results were reconfirmed through triangulation. Our analysis also revealed that a clear and concise distinction among active, passive and sentinel reporting is difficult, especially when internal definitions and practices are incoherent and subject to frequent changes.

Conclusion and recommendations

Hyderabad's dengue surveillance is spread across three independent and parallel operating surveillance pillars. Cross-pillar cooperation, communication and integration are evident, however, limited to specific surveillance activities and far from comprehensive. Achieving efficient cooperation and reducing the unnecessary waste of valuable resources require continuous and dedicated efforts from all stakeholders involved.

Existing data exchange should be shifted to a complete merge of reporting procedures, ideally fully transferred under the IDSP's responsibility. The potential benefits of a close cooperation with the GHMC's entomological and GIS department highlight the need to develop long-term plans for continuous cooperation and mutual support. The IDSP's main strength is reflected in its extensive network, the NVBDCP's asset is its surveillance and outbreak expertise, while the GHMC is specialised in vector control and awareness. As indicated by the conceptual model of McNabb et al., combining those strengths can ultimately result in a comprehensively integrated and powerful surveillance approach. Therefore, collaboration across all government sectors is needed to contribute to effective surveillance, environment management and enhanced health outcome.

Overall resources, whether governmental or municipal, should be shifted towards preventive, as well as proactive initiatives. Surveillance is not a static, isolated or independent phenomenon. Effective surveillance is active, continuous, flexible, adaptive and interdependent. In light of the current COVID-19 outbreak, Zika and other emerging diseases, India can ensure a healthier future by removing boundaries and facilitating a public health surveillance that is truly comprehensive, particularly in high-burden urban areas, that require more effort and a stronger focus. Although the Indian government has integrated the rural and urban health mission into the one health mission, a holistic approach to fostering integrated policy making seems to be missing (D'Silva, 2013).

To improve surveillance data and ultimately our understanding of a disease, it is essential to have continuous evaluations of public health measures in place (Franklinos et al., 2019). Adequate diagnostic equipment and a positive political attitude are urgently required if timely disease detection and reduced fear of reporting are to be achieved. The strengthening of the dengue surveillance will ultimately contribute to the consolidation of the surveillance and response capacities of India in the context of the International Health Regulations (Franklinos et al., 2019; Suthar et al., 2018; WHO, 2005).

Finally, our study underlines the overall need for India to increase investment in public health and health infrastructures. That requires coordinated and multi-level action targeting the development of a competent, effective and motivated public health cadre, as well as truly integrated surveillance and epidemic response infrastructure, for dengue and beyond.

Ethical approval and consent to participate

The entire research involves official and published data, as well as information given by experts with informed consent. Thus, ethical clearance beyond the standards of ethical conduct outlined by the Indian Council of Medical Research and the Netherlands Code of Conduct for Research Integrity and as agreed under the collaboration agreement between the two collaborating main research institutes (Maastricht University and Public Health Foundation of India), was deemed not necessary.

Acknowledgements

The research presented in this article is embedded within the Memorandum of Understanding (MoU) between the Public Health Foundation of India and Maastricht University. The authors thank Bart Penders, Anja Krumeich, and David Townsend for input on the final draft. Further the authors would like to thank Hyderabad Municipality, the Hyderabad district IDSP and NVDSP for their contribution and input to the study. E.P. and V.N. contributed to the conception, design, analysis, and interpretation of data. E.P. and V.N. drafted the manuscript. G.V.S.M. substantially revised it; all authors have approved the submitted version and agree to be personally accountable for their own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated, resolved, and documented in the literature.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

Qualitative interview data is not made available due to privacy concern.

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