Fall 2019

An Analysis of the Rajasthan Public Health System's Response to the 2019 Dengue Insurgence

Luke Bryan
SIT Study Abroad

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By Luke Bryan

12 December 2019

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List of Abbreviations:

ANM -Auxiliary Nursing Midwife

BTI -Bacillus Thuringiensis subspecies Israelensis

CHC -Community Health Center

CSU -Central Surveillance Unit

DEN-'X' - the 'X' serotype of the dengue virus

DEO -Data Entry Operator

DHF -Dengue Hemorrhagic Fever

DHMS-Directorate of Health and Medical Services

DSS -Dengue Shock Syndrome

DSU -District Surveillance Unit

ELISA -Enzyme-Linked Immunosorbent Assay

EWS -Early Warming Signal

GIS -Geographic Information System

IDSP -Integrated Disease Surveillance Programme

JMM -Joint Monitoring Mission

MLO -Mosquito Larvicidal Oil

PHC -Primary Health Center

RRT -Rapid Response Team

SC -Sub Health Center

SSU -State Surveillance Unit

WHO - World Health Organization

Abstract

Dengue virus is in a pandemic status and is a major public health issue in the modern world. The mosquito-borne disease is largely prevalent in Asia and specifically India, where more than half of the states are considered to have complete presence of the dengue virus. The intricate infrastructure of the Indian public health system looks for dengue cases at all levels and reports to the integrated disease surveillance programme (IDSP).

Analyses of the IDSP and trends of dengue cases was done in response to dengue outbreaks throughout the state. Geographic information system (GIS) maps were created to evaluate a geographic distribution of dengue cases;however, significant issues arose when collecting data. The first data set, the state level IDSP's primary data source, was missing a significant number of cases. The other source of data, a line list compiled from Rajasthan's eight medical college, had significantly many more cases than the prior, but was also incomplete and did not have features that allowed it to be categorized on a week by week setting, like the district reported data.

The analysis showed that men made up 69% of dengue patients in medical colleges. The medical college data also showed the ages most at risk for contracting dengue were between 15 and 29. In both sets of data, Jaipur, Kota and Jodhpur were the three most affected districts. However, there was a strong lack of symmetry between these two data sets after these top three districts. Many of the districts were found to have severely under reported their cases.Three districts in particular reported zero dengue cases when each district had over 100 cases reported by medical colleges. Despite this, the investigation done for this paper found the IDSP to still have had a significant impact on reducing the burdens of dengue due to the strong interventions by rapid response teams.

Intro

Dengue the Virus:

Dengue is one of the world's largest pandemics. In 1970, dengue fever was listed as endemic in nine counties.[1] As of 2012 that number had grown to 128.[2] The virus, which has no cure or vaccination, causesapproximately 96 million clinical cases worldwide, with estimates of the number of infections per year being as high as 390 million.[3] Estimations of the population at risk are around 3.9 billion, making up more than half of the global population.[4]Beyond this, not only is dengue spreading to new regions, but epidemics and outbreaks have been increasing in areas where dengue is already endemic.[5] The WHO released a statement saying "incidence of dengue has increased 30-fold over the last 50 years."While the typical cases of dengue fever are already harmful, some cases develop complications ofsevere dengue, referred to as Dengue Hemorrhagic Fever (DHF). These cases can have further complications of Dengue Shock Syndrome (DSS). The WHO hasstated "an estimated 500 000 people with severe dengue require hospitalization each year, and with an estimated 2.5% case fatality." While these statistics indicate 12,500 dengue-related deaths annually, The WHO also promotes another study naming dengue as the cause of over 25,000 deaths worldwide annually.[6] While the exact figures are unknown, it is very clear that the virus is a public health crisis and should be treated as such.

The disease commonly known as dengue fever is the human reaction to the dengue virus. There are five serotypes of the dengue virus: DEN-1, DEN-1, DEN-3, DEN-4, and DEN-5,

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[1]Brady, O.J., et al., "Refining the global spatial limits of dengue", 2012. 6(8): p. e1760
[2] Ibid
[3]Bhatt, S., et al., "The global distribution and burden of dengue". Nature, 2013. 496(7446): p. 504–507
[4]*Brady, O.J, global dengue, 2012.*
[5]Gubler DJ. Dengue and dengue hemorrhagic fever. *Clin Microbiol Rev*. 1998;11(3):480–496. Available:
[6] World Health Organization. Dengue and Severe Dengue. 4 November 2019

withthe fifth serotype only being discovered in 2013.[7] The virus is from the genus *flavivirus*, the same genus as the yellow fever virus and zika virus. Similar to yellow fever and zika, dengue fever is a vector-borne disease.[8] The virus can be carried by a number of mosquitoes in the *Aedes scutellaris* group, though the *Aedes aegypti* species is known to be the primary carrier of dengue fever globally. Both *Aedes albopictus* and *Aedes polynesiensis* are known to frequently carry the virus as well.[9] Because of its vector borne nature, dengue is a very seasonal disease. High seasonal temperature and precipitation are among the largest indicators for dengue.[10] [11] This is not surprising, as the vector mosquitoes lay their eggs in water and typically rely on temperatures above 10℃.[12] These species typically live in low elevation tropical climates between 35°N and 35°S, and hence dengue is mostly found in tropical latitudes and climates.[13] [14]

As mosquitoes will lay their eggs in water, manmade water tanks and sceptic tanks can serve as great breeding grounds for mosquitoes. For households that keep water storage tanks, there is an increased risk of mosquitoes being born in close proximity to humans, particularly within Asia and Africa.[15] As *Aedes* mosquitoes only have lifespans of 3-4 weeks, they do not travel far from their place of birth,meaning having dengue carrying mosquito larvae inside or near a house can significantly increases the risk of dengue to those who live there.[16] Hence, this is why one confirmed case of dengue fever in an area where dengue is not known to be endemic is a significant trigger, and requires immediate action.[17]

[7] Lt. Col. Mustafa, et al. "Discovery of a Fifth Serotype" *Armed Forces of India.* Jan 2015.
[8] World Health Organization. "Dengue Guidelines for Diagnosis, Treatment, Prevention and Control". 2009
[9] ibid
[10] World Health Organization. Dengue Increase Likely During Rainy Season. WHO warns. 11 June 2019
[11] Gubler DJ. "Dengue and dengue hemorrhagic fever". *Clin Microbiol Rev*. 1998;11(3):480–496
[12] Dengue Transmission" *Nature News,* 2014
[13] "Dengue Transmission." *Nature News*, Nature Publishing Group, 2014.
[12] Sewe, Maquins Odhiambo, et al. "Remotely Sensed Environmental in Western Kenya." *Plos One*, vol. 11, (2016)
[15] Gubler DJ. "Dengue and dengue hemorrhagic fever". *Clin Microbiol Rev*. 1998;11(3):480–496
[16] "Dengue Transmission" *Nature News,* 2014
[17] Integrated Disease Surveillance Programme. "Training Manual for Medical Officers". *NCDC*. 22-23

As a vector borne disease, dengue is transmitted back and forth between vectors and hosts.[18] The onset of exposure occurs when a dengue carrying mosquito bites a human and the mosquito's virus contaminated saliva enters the human's bloodstream. After a 2 to 10-day acute febrile period, the dengue virus will be present in the human's circulating blood, and can be transmitted to an *Aedes aegypti* mosquito in the form of a mosquito bite.[19] It takes 8-12 days for the virus to be present in the *Aedes aegypti*'s saliva, but after that time period has passed, the mosquito will carry and be able to transmit the virus for life.[20] For human hosts, the virus will stay in the hosts blood for a period of roughly 4-5 days,until antibodies have been produced and the dengue virus has been removed from the person's system.[21] Fortunately, after a human has developed antibodies for dengue, they will keep these antibodies for life, providing immunity to other exposuresto the virus.[22] However, antibodies are serotype specific, so a human can stillcontract dengue fever again from the other 4 serotypes of the virus.[23]

About 25% of people exposed to the dengue virus will develop dengue fever.[24] The onset of dengue fever is typically 3-14 days (average 4-7 days) after exposure.[25] The fever, which in most cases is 40°F or higher, is often accompanied by a large rash and joint pain. Additional symptoms of dengue include headache, swollen glands, nausea, vomiting, and pain behind the eyes.[26] Many of these symptoms are flu-like, making dengue hard to identify without laboratory testing. Despite the fact that there is no specific treatment for those affected by dengue fever,

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[18] ibid
[19] Gubler D J, Suharyono W, Tan R, Abidin M, Sie A. "Viremia in patients with dengue". 1981;623–630
[20] Gubler DJ. "Dengue" *Clin Microbiol Rev*. 480–496
[21] ibid
[22] World Health Organization. Dengue and Severe Dengue. 4 November 2019.
[23] Gubler DJ. "Dengue" *Clin Microbiol Rev*. 480–496
[24] Center for Disease Control. "Dengue Symptoms and Treatments". Accessed: 25 November 2019
[25] Siler J F,et al. Dengue, its history, epidemiology, transmission, and prevention.1926;29:1–304
[26] WHO. "Dengue and Severe Dengue". 4 November 2019

medical attention is recommended, as complications of DHF or DSS can manifest within a few hours.[27]

Approximately 4% of people who get dengue fever will develop the complications of severe dengue.[28] Severe dengue is characterized by "plasma leaking, fluid accumulation, respiratory distress, severe bleeding, or organ impairment".[29] The symptoms ofsevere dengue are fatigue, recurrent vomiting, blood in gums and vomit, and severe abdominal pain. Upon onset of these symptoms, medical help should be sought out immediately, as severedengue is life threatening.[30] What causes severe dengue to develop is not completely known. However, there have been correlations between infecting serotype and probability of developing severe dengue; both DEN-2 and DEN-3 are statistically more likely to have hemorrhagic manifestation.[31]

As there is no cure for dengue, treatment is performed by symptom management. At all levels, rest and hydration are highly recommended in order to aid the body in fighting the infection. For all cases of dengue, talking to a medical provider is highly recommended, as severe dengue develops very quickly.[32] In the Indian public health system, Paracetamol is often given to patients to manage symptoms; however, blood thinners like aspirin or ibuprofen are not given due to the risks associated with severe dengue and are highly recommended against.[33] [34] For patients who develop severe dengue, admission to a hospital is urgent. Severe dengue cases are life threatening, but admission to a hospital can reduce the probability of death by more than

[27] CDC. "Dengue Symptoms and Treatments". 25 November 2019
[28] CDC. "Dengue Symptoms and Treatments". 25 November 2019
[29] WHO, "Dengue and Severe Dengue". 4 November 2019
[30] CDC. "Dengue Symptoms and Treatments". 25 November 2019
[31] Kumaria, Rajni. "Spectrum among Four Dengue Serotypes." *Brazilian Journal of Infectious Diseases*, vol. 14, no 2.
[32] WHO, "Dengue and Severe Dengue". 4 November 2019
[33] ibid
[34] IDSP. "Training Manual for Medical Officers". *NCDC*. 22-23

twenty fold.[35] Due to the blood loss and dehydration caused by severe dengue, cases are mostly treated these cases with services such as intravenous therapy and blood transfusions.[36]

Estimations for the burden of dengue vary regionally based on availability and cost of treatments. A study done in India from 2006-2012 evaluated the hospital costs of treatingdengue patients in ten tertiary hospitals. The costs were calculated based on the cost to the hospital in terms of staff payments and input costs. The study found an average cost of US$197.03 per case of dengue in the public sector and an average cost of US$248.11 in the private sector. When scaled up to all hospitalized denguecases in India, an estimated US$547 million was spent.[37] These economic estimations do not even account for the disease burdens of patients: the human suffering that occurs, the days or weeks taken off work due to severe dengue, and the grave cases resulting in patient deaths. All in all, the burden of dengue is very high and demands global attention.

Dengue in Rajasthan and the Public Health System:

While the dengue virus is the source of problems globally, many areas and regions are disproportionately affected. Firstly, the dengue carrying mosquitoes tend to live and reproduce in tropical latitudes when the temperature is above 10℃.[38] Additionally it is known that mosquitoes lay their eggs in water and that the onset of a rainy season is a huge risk factor for dengue. Hence, it is not surprising that "high levels of precipitation and temperature suitability for dengue transmission [is] most strongly associated among the variables considered with elevated

[35] WHO, "Dengue and Severe Dengue". 4 November 2019
[36] IDSP. "Training Manual for Medical Officers". *NCDC*. 22-23
[37] Shepard DS, et al. Economic and disease burden of dengue in India. American Society of Tropical Medicine; 2014.
[38] "Dengue Transmission" *Nature News,* 2014

dengue risk,"[39] which implies the largest risk factor for dengue is based solely on locality. Because of this, much of Asia and specifically Southeast Asia and Indian states are at risk. Estimates suggestAsia is home to 70% of all clinical dengue cases (68 million annually) of which India hosts almost half (33 million annually) with an estimated 34% of all clinical dengue cases.[40] In another global study of dengue where states were assigned a risk evaluation with respect to dengue, over half of India's 28 states were listed as having a complete presence of dengue.[41] Furthermore, all of the states that were not listed as having complete presence of dengue were either north of Himachal Pradesh, or east of Chhattisgarh, which are the regions with conditions less suitable to the dengue carrying mosquitoes.[42] [43]

Rajasthan, as well as all of its neighboring states, was listed as having a complete presence of dengue.[44] This is not surprising, as the state reports lab-confirmed cases year-round. Additionally, in 2018 Rajasthan was faced with a zika virus epidemic, which is of the same family as the dengue virus and is also carried by the *Aedes* mosquito.[45] [46] Aware of its disposition, the Rajasthan health care system is ready to respond to a dengue outbreak at all times.

Rajasthan's public health system has an intricate structure, designed to provide medical services at all levels of the community. This is administered through all levels of the public and private sectors. The entire public health system is interconnected despite its huge size: 14,378 Sub Centers (SC), 2,141 Primary Health Centers (PHCs), 606 Community Health Centers

[39] *Bhatt, S., et al., "*burden of dengue*". Nature, 2013. 496(7446): p. 504–507*
[40] ibid
[41] Brady, O.J," global dengue", 2012.
[42] "Dengue Transmission." *Nature News*, Nature Publishing Group, 2014.
[43] Brady, O.J, "global dengue", 2012.
[44] Ibid
[45] Singh R, Gupta V, Malhotra B*, et al. "*Cluster containment strategy: addressing Zika in Rajasthan, India *BMJ* 2019;
[46] "Dengue Transmission." *Nature News*, Nature Publishing Group, 2014.

(CHCs), 190 dispensaries, 33 district hospitals, 62sub-district and satellite hospitals, and eight medical colleges. Due to the wide range of services available at each of these different levels, the Rajasthan public health system divides their surveillance records into symptomatic, presumptive, and lab confirmed cases. Dengue fever is categorized at each of the levels: symptomatic dengue is fever with rash or fever with joint pain, presumptive cases of dengue are given a category of their own, and lab confirmed cases of dengue are standardized under the enzyme-linked immunosorbent assay(ELISA) test.

The symptomatic cases are recorded at the SC level, where an Auxiliary Nursing Midwife (ANM) is present. The Indian public health system defines symptomatic dengue as a fever with rash or a fever with joint pain. If an ANM encounters a patient with these symptoms, she will treat the symptoms, typically with paracetamol. The patient will be warned and informed about the risks of dengue and will be referred to the nearest PHC or CHC where a serum can be taken for testing. Additionally, the patient will be told to seek emergency medical care if they start to show the signs of severe dengue. At the end of the week, the ANM submits an ‘S-form’, which categorizes the patients she saw into syndromic groups, to the local PHC or CHC, where it will be compiled with the other SCs, tracking all of the syndromes of SC patients throughout the PHC’s jurisdiction.

At the PHC and CHC level, the ‘P-form’ or ‘Presumptive form’ is filled out. Here the doctor categorizes each patient visit onto a sheet with 22 potential causes of illness, one of which is dengue. Typically, patient with fever and rash or fever and joint pain are considered to be presumptive dengue patients, and have a serum collected for lab testing. PHCs are meant to cater to populations between 20,000 and 30,000, so patients should not have to leave their community to get tested for dengue.[47] The doctor assigns each patient a presumptive cause, which is tallied onto the weekly P-form. The P-forms and S-forms are sent to and compiled at the head of the block, which often include 15-20 PHCs and CHCs. From here, the block data is sent to the district surveillance unit (DSU) of the Integrated Disease Surveillance Programme (IDSP). This data is evaluated at the block, IDSP district, and IDSP state levels, to look for data trends and outbreaks that require responses.

L-forms are turned in directly from the government and private funded labs to the IDSP. Each reporting lab and hospital has an employed data entry operator(DEO) who creates a line list of patients and submits this directly to the DSU, where the information is put on the IDSP portal. The IDSP portal also gives the DSU the ability to fill out the L-form in both tally format and line list format. It should be noted that there is minimal standardization in the lab reported line lists,so the data fields of each hospital's specific line list differ. These line lists are kept for the hospitals' records and are also sent directly to the state surveillance unit (SSU).In reporting lab confirmed cases of dengue, the only test reported is the ELISA test. This test is highly standardized in Rajasthan's public sector as it is the only test dengue test that is administered. In the private sector, there are some hospitals that utilize other tests, but this is relatively rare. In these cases, no additions are made to the L-form, even if the dengue test is positive.

This is an intricate system, but it is not without flaws. It is not uncommon for dengue patients to be missed. For instance, patients who are referred to hospitals with a fever of unknown origin (PUO), a different division of the P-form, are later tested for dengue and found to be positive.[48] This implies that there is a significantly larger number of dengue patients who sought medical help, but were never tested for the virus.

[47] Ministry of Health and Family Welfare. "Guidelines for Primary Health Centres". Revised 2012; 1-15.
[48] Shepard DS, et al. "Burden of Dengue in India"; 2014.

For cases where outbreaks are identified, Rapid Response Teams (RRTs) are set up at the state, district, and block level to react and provide services to the community. Actions taken against vector borne diseases like dengue, malaria, and chikungunya are the most frequent as mosquito populations are very large and incidences of these diseases in the state are very high. In response to dengue specifically, the primary intervention done by RRTs is larval source reduction. This is the most effective way to combat the dengue virus, as it focuses on prevention of future cases and can quickly treat a large area.[49] When performing larval source reduction, there are three interventions the RRTs will choose from. The first and most common is temephos, a treatment used in larvae contaminated drinking water containers. It is the most common treatment, as most houses have containers for drinking water that are regularly unchecked and prone to housing mosquito larvae. The other two treatments for killing mosquito larvae are mosquito larvicidal oil(MLO) and bacillus thuringiensis subspecies israelensis (BTI), both of which are used in water sources that are outside and not for drinking purposes. These treatments are used when larvae are found outside the house and are in non-drinking water containers. In all of these treatments, larvae are collected and tested for the disease being surveyed, often dengue, so the RRT canassess which areas are most at risk and require more intervention. The remaining interventions performed are for live mosquito reduction. These activities are done in areas where it is known the vector borne diseases is present due to larval source reductions and mapping of clinical cases. The two interventions done are fogging and focal spray. Both of these interventions involve densely applying an insecticide spray to closed building void of people to kill all disease carrying mosquitoes in the building. Both sprays use

[49]Gubler DJ. "Dengue" *Clin Microbiol Rev*. 480–496

pyrethroids, or fast acting pesticides, so the process can be done quickly. Focal spray is made of 5% pyrethroids and 95% kerosene, while fogging used 5% pyrethroids and 95% diesel.

The Integrated Disease Surveillance Programme:

In November 2004 the first version of the modern IDSP was created. This initial program was organized with the intention to "detect and respond to diseases outbreaks quickly."[50] The system was set up at the DSU and SSU levels, both of which surveyregions' numbers of cases and intervene when necessary. This was the first time in India's history that the tracking of diseases was implemented at such a large scale level. This initial project was set up in nine states and was intended to run until March 2010, though due to its success it was extended until March 2012. While 26 of India's states and territories began this project on their own domestic budgets, extra funding for this first installment of the IDSP was provided to nine states that were deemed most in need: Uttarakhand, Rajasthan, Punjab, Maharashtra, Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh and West Bengal.[51]

Currently, the IDSP is monitoring every district in India. The DSU and SSU infrastructure still exists; but now the states have the ability to report to the Central Surveillance Unit (CSU) for epidemics that pose a large threat and/or may effect a region larger than the state. RRTsare now functioning and responding in all 35 states and union territories of India. The surveillance is based on syndromes seen (S) and presumptive causes (P), and lab-confirmed cases (L), which are filled out into S, P and L-forms. These weekly forms are compiled at the DSUs and shared with the SSUs and CSU from there. Additionally, the IDSP has completed

[50] Ministry of Health & Family. "Integrated Disease Surveillance Programme (IDSP)." *IDSP*, 2019.
[51] Ibid

projects such as a text alert system, whichgives community members the ability to receive phone notifications if their district is undergoing or at risk for a specified outbreak.[52]

However, today's IDSP is far from perfect. With such a large population to monitor, the relatively small IDSP certainly has a human resources scarcity. As of March 2015, the IDSP reported employing under 600 professionals in the fields of epidemiology and microbiology: an alarmingly low number given the population of India.[53] According to this statistic, there is only one professional for every twenty lakhs, or two million, population.[54] Beyond the scope of the professionals, issues have been noticed with other key stakeholders. In the Joint Monitoring Mission (JMM) 2015 report, which evaluated the functioning of the IDSP, one observation was that "[while] key national level leaders have recognized the importance of surveillance for public health, surveillance is often perceived as a low-priority area within the state and local governments as well as health care providers."[55] This notes two separate issues from two different stakeholders. Firstly, the lack of priority from the state and local governments can result in underfunded facilities and a lack of resources, as all IDSP funding now comes from domestic budgets. At the same time, lack of priority from health care providers creates a whole new spectrum of concern as this puts into jeopardy the validity of the data the IDSP is working with.

However, the not all of the 2015 JMM report's criticisms are relevant to this study. For instance,the report discussed the IDSP's lack of collaboration with veterinary and wildlife departments, which are limited their data and surveillance of zoonotic diseases, butin 2017 the IDSP issued a new veterinary consultant position at the SSU level responsible for coordinating

[52]Ibid
[53]Ministry of Health & Family. "(IDSP).", 2019.
[54] United States, Congress, "World Population Prospects." *United Nations*, 2019.
[55]"Joint Monitoring Mission Report". *Integrated Disease Surveillance Programme*. 2015

and working with these animal-based departments and organizations.[56] [57] Furthermore, the report had criticisms of the IDSP data systems for not tracking mortality, however, this was not a universal problem, as in at least the state of Rajasthan, mortality has been tracked since the creation of the IDSP.[58] [59]

<u>IDSP Data Compilation and Use</u>:

The IDSP's data compilation looks very different at different levels. The blocks almost exclusivelycollect physical copies of the S and P-forms, as no computer use is required at the SC, PHC, and CHC level. Once at the block level, both paper copies and computers are used to transfer the data to the DSU. The DSU then has one week to compile all of the data and to look for trends and indications that interventions are needed. This is the closest level of IDSP surveillance that exists, as while similar work is often done at the block level, it is not mandatory and is outside the IDSP's jurisdiction. After one week of evaluation, the DEO of the DSU submits the information compiled onto the IDSP portal so it can be accessed by the SSU.At the SSU the data obtained is again compiled, evaluated and analyzed for a week. After this week, reports are sent to the CSU, where they are mostly stored for government reference. Here, the data is used to inform policymakers on the issues faced by the public health system so they can make decisions, such as where funding should go. When the SSU observes abnormalities in the data, their findings are reported back to the districts and public health system to warn and prepare these stakeholders. If the situation is at risk for spreading, the DSU or SSU will give instructions and details to the RRTs so interventions can be done.

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[56] ibid
[57] Ministry of Health & Family. "(IDSP).", 2019.
[58] "JMM Report". *IDSP*. 2015
[59] Dr. Ruchi Singh. *Interview*. November 2019.

This system, while great in theory, can lowball the number of cases for various reasons. The primary reason given for under-reported statistics is the "freezing" nature of the portal. Data at the district level is compiled all week, with the week starting Monday and ending on Sunday. While the DSU has one week to analyze the data and a few days of the next week to submit it, if the district finds any missing cases after this time, there is no way to update their reports to the IDSP portal. These issues occur more often when tracking patients who wentto medical colleges outside the district, as there is not a strong system for tracking these cases.

A second possible reason is based around the reality that IDSP has a human resources scarcity. Most DSUs only are employed with 3-4 employees, putting a strain on the work they are feasibly able to do. Hence, despite this being a mandatory report, it is possible that districts may under-report their data due to the time crunch caused by a human resource scarcity. The same under-reporting problem is also possible for the block level and below and there is little to no way to ensure all cases are being reported to the IDSP. Hence, while the data compiled into the IDSP is true, it is very possible that it is not complete.

Body

Observations of the Indian Public Health System and IDSP:

As a part of this study, the researcher went to the Directorate of Health and Medical Services in Rajasthan for four weeks. The purpose of this was to observe and evaluate the functioning of the Indian public health system, specifically within the IDSP. Frequent trips to the IDSP SSU were done to observe the work done as well as the culture of the employees. In particular, the aim was to examine the data collection, management, and usage systems. On top of this, there were multiple trips of fieldwork and days outside the state to further observe the public health system in place. This involved. travelling with a DSU epidemiologist, visiting aSC and a CHC block head, attending a state laboratory conference, following the cross-verifying process, investigating a case study of scrub typhus, and larval reduction and surveillance fieldwork.These experiences provided insight into how the IDSP functions and the challenges it faces from a qualitative point of view.

There were plenty of indications that would suggest the IDSP is facing a lack of resources, especially in technology. Firstly, while the computers in the state office were up to date, this was not the case for all district offices. Many of the district offices have not had their computers updated since the inception of the IDSP in 2004. Working with computers that are this old and outdated can be problematic for a data-based office like the IDSP. Computers like this are not meant to handle the large data files that the IDSP works with. Hence, it is not surprising that many of the districts have reported their computers being very slow to the point where work is inhibited. As of recently, all districts report their data via the brand new IDSP webpage portal. This is somewhat risky to rely on the fact that the portal will work smoothly on computers that are at least 15 years old. While a slow process of updating these computers is in process, this will not be complete for at least a few years.

On top of using outdated computers, the IDSP relies very heavily on outdated software. All of the computers in the state headquarters use Microsoft Office 2007, a computer software that was updated nine years ago. While it certainly works, the updated versions of these programs are designed to work faster and handle larger amounts of data: functions that would benefit the IDSP. Additionally, there are difficulties that occur when transferring files from the updated versions of MS Office, like Microsoft Word 2016, to Microsoft Word 2007 and vice versa, as the two versions have technical differences. These issues manifested in the form of format changes, space deletions, and other minor issues that make documents appear poorly written or unprofessional. However, if MS Office 2007 is used for the documents sent to the IDSP and is used on the district computers that read the state's documents, this problem is not as large as it could be.

Beyond all of this, whenever the IDSP does any mapping with their reports, it is done on Microsoft Paint. While possible, this is not an accurate, nor efficient way to display data. Not only are the maps they use spotted with frayed drawn edges and tiny holes of white, but the majority of maps had simply taken the number of cases, arbitrarily divided the districts into three levels, and gave stoplight colors (red, green, and yellow) to each third. In almost every single map they have, the most populated states are painted red because there are not population based adjustments. Furthermore, the maps were often grouped poorly, as the three levels only determined the top 11 states, middle 11 states, and bottom 11 states. Some of the other maps simply took states that were determined at risk and gave each a unique color and a label, a visual method that does very little to make significance of the color, which is meant to be used to display a trend. Two IDSP employees had shown interest in acquiring a software that could read and display geographic information system (GIS) files for accurate and automatic visualizations; however, they were unable to find a software that could fit inside the IDSP's budget.

Another issue the IDSP faced isbased on the fact that there is not a set language for all documents. All of the information from the portal, training manuals, and larger reports were typed in English, while the everyday working documents and weekly reports were mostly in Hindi.The financial documents were even messier, with half of the documents being written in English and half in Sanskrit. While yes, this caused minor issues such as difficulty for the data manager to track all cases from one district, there were more issues in the construction of documents.Only two people in the office can proficientlytype in Hindi on a QWERTY keyboard. Hence, the employee responsible for creating thedocument, letter, or memo sits with another employee and instructs them in typing the final product. This is not the most efficient system, as it requires two people to create one document, which is typically seen as a job for one person. However, unless actions are taken to teach all employees to type in Hindi or to get another keyboard, this system will likely stay in place.

With this current set up, there are a variety of work roles in the IDSP. As stated before, two people in the office assisted in typing up documents in Hindi. At times, they were seen helping employees from other offices type their documents, but not at the cost of making an IDSP employee wait. The employee in charge of finances often worked on budgeting reports and calculating expenses. Additionally, there were three doctors in the office who were the state epidemiologist, state entomologist, and state microbiologist. They had a wide range of responsibilities that mostly stemmed from management. Often they could be found typing up documents, either in English or assisted Hindi, as they were most responsible for communicating the SSU's work. Because of this responsibility, they frequently were communicating with officials from the DSUs, whether in person, by email, or by phone. Additionally, these three women were often missing from the office, as they did many cross-verifications of the DSUs and reporting units.

The remainder of the work done in the IDSP SSU was done with data compilation and management. This was primarily done by the data manager, who would copy the district reported data from the portal, paste them into his own excel sheets, clean the data and perform the analysis process. In this system, he had to manually pull up and copy all of the fields of the S, P, and L-forms, which means working with and evaluating more than 50 different files. For the data cleaning process of S and P-forms, the only process that was done was looking for numbers that appeared to be mistyped or mistallied, a problem that was seen multiple times throughout the four weeks. However, for the L-forms, he would evaluate the district line lists, an optional field for the DSU, checking for duplicate cases of patients that received multiple lab tests in different districts. Often a few cases would be found like this, and the data would be adjusted. The following analysis step took the last 5-6 weeks of the data by district, and would create a column chart looking for rises and falls in the data. Population data is used, as the district data is being compared against prior weeks of the same place. This was done for all non-empty fields on the S, P and L-forms. If a rise in cases seemed possible, a further analysis of the same data is done to detect for early warning signals (EWSs). Here, current and future outbreaks are looked for in terms of presumptive causes. Each presumptive cause has its specific EWS triggers for syndromic, presumptive, and lab-confirmed data. Additionally, as many of the EWSs are population dependent, the district population data is used to determine the outbreak status of the presumptive cause.

The usage of the population statistics seemed odd. In all reports generated from the IDSP portal, the column after the district's name is designated for the district's population. This standardized part of the portal, which is used in all Indian states and Union Territories, is designed so that epidemiological statistics like incidence and prevalence can be easily calculated. However, the data generated by this section is incredibly unreliable and inaccurate. Many of the populations listed are severely wrong and two of the districts don't even have any population statistics listed. However,these statistics, estimate from growth rates and the 2011 census, exist in the DMHSand are frequently for calculations for EWSs. It is difficult to follow the reasoning why the automatically generated field has not been updated, as this could quicken the process of analyzing EWSs, but for whatever reason it has not.

A final insight that was explained but not observed was regarding some of the inherent flaws to the DSU reported data. A district epidemiologist explained that of the units that report to the block, many report on only a near weekly basis. It was stated that each medical facility, including SCs, PHCs, CHCs, and potentially even labs only submit their data to the block around 85-90% of the time. Some of the reasons provided for this were lacks human resources, weeks that were too busy, and difficulties for centers to make up for sick days, especially in SCs and PHCs where there is often only one employee who works with reporting.

<u>Dengue in Rajasthan in 2019</u>:

The number of Dengue cases in Rajasthan were alarmingly high this year. As of the 19st of November, there had been 12,770 lab-confirmed cases and 14 deaths reported in medical hospitals. By this time, the Rajasthan IDSP had already recorded more cases in all of 2018. In 2018, there were only 89,974 lab-confirmed cases throughout all of India.[60]

The IDSP portal is able to provide a week by week breakdown of all the reported cases by each district from each S, P, and L forms submitted by the DSUs. This is the data that is used by the SSU and CSU for all of their reports and analyses. According to the portal, syndromic, presumptive, and lab-confirmed cases of dengue had been seen in every week throughout the year as of November 17th, though mostly in relatively low numbers.From week 3 to week 29, there was an average of 14.2 cases per week with week 25 having the most with 21 cases. The majority of these cases came from the SMS medical college reporting unit in Jaipur; there was only an average of 4.4 cases per week outside of the SMS reporting unit, never with more than 10 cases.It should be noted that due to its prestige SMS medical college is known to attract people from far away districts. Thus this doesn't necessarily indicate an outbreak. The fact that there were no other cases reported in any other Jaipur hospitals suggests that the Jaipur population was likely not the source of all these cases. As a seasonal disease, it is expected that dengue cases will be lower during this time of year, as the *Aedes* mosquito populations generally increase once the rainy season starts. However, it is rather significant that lab confirmed cases throughout the year occur, and not in one singular cluster; as this implies any area in the state could be susceptible to an outbreak.

From weeks 30-35 gradual increases started to occur.Week 30 had 31 cases of lab confirmed dengue, but in week 35, there were 83 cases across the state. This increase of weekly cases of more than 250% over a six-week period is certainly alarming, but not overwhelming, as this is the beginning of dengue season for most to all of South Asia.[61] Prior to this period, no

[60] NHP Admin. "National Dengue Day 2019". *National Health Portal of India,* 13 May 2019.
[61] World Health Organization. Dengue Increase Likely During Rainy Season. WHO warns. 11 June 2019

district other than Jaipur had had more than 4 lab-confirmed cases in a week since January. Districts such as Bikaner, Kota, Jaipur, and Ajmer all reported jumps from less than four cases to 8-12 casesper week in successive weeks. These jumps are incrediblysignificant, as these were four of the districts most effected by dengue this year. However, it was very difficult to predict which districts were going to make these jumps; many districts saw 1-3 cases per week frequently, just like the four districts listed above.According to the district reports, none of these jumps appeared uncontrolled, as in all of theseincreases were followed by a decrease in number of cases in the following week or two.

This period showed a strong rise in cases, though it is what happened after week 35 that was alarming. Cases continued to escalate rapidly. For week 39, the IDSP portal reported508 dengue lab confirmedcases; week 42 reported 1,089, a 1312% increase from week 35. The peak so was in week 45, when the DSUs across the state reported 1,117 cases. By the end of week 46 (Sunday, November 17th), 7,974 cases of lab-confirmed dengue had been reported from the DSUs to the SSU.

However, this information does not provide an accurate telling of what happened this year. On November 19st, the line lists from the 8 Rajasthan medical colleges were collected and compiled into one document. As of then, these eight medical colleges had issued 139,323 dengue ELISA tests, with 12,150 cases (8.72 %) being lab-confirmed as positive for the dengue virus. 11,533 of these cases were dated to Sunday, November 17th or before. This is incredibly alarming. Not only is this number larger than the number reported by the DSUs, but it does not even include the cases from the remaining 49 laboratory reporting units.So as the medical colleges only make up a part of the reporting system to the DSU, this number should be significantly <u>smaller</u> than the number reported by the district, but instead is significantly larger.

Hence, in assessing dengue cases from this past year, it is known that there were at least 12,150 cases of lab-confirmed dengue as of November 19th, but it is very difficult to estimate the ceiling of how many dengue cases could have existed. Without a full investigation and analysis of all labs' line lists, it is impossible to know.

Summary of Responses and Anti Dengue Measures Taken:

In order to counter this year's insurgence, many anti-dengue measure have been taken by the public health system. Firstly, all public health officials were notified and put on alert for dengue. While all levels of the public health system have played an active role in promoting the health, safety and well-being of the people of Rajasthan, some of the most quantifiable actions are the actions taken on by RRTs. RRTs took on many actions to reduce mosquito populations and ensure the future safety of the Rajasthan population. Additionally, many actions have been taken to educate and inform the population about vector borne diseases.

Till 27 November 2019, 400,734 RRTshad been issued to combat the insurgence of dengue cases reported to the public health system. These teams inspected 13,647,893 houses searching for mosquito larvae in 23,188,540 containers.Treatments were issued by the RRTs based on observed and suspected larvae. RRTs provided 2,526,835 treatments of Temephos to rid water containers of mosquito larvae. Additionally, 738,056 treatments MLO and 21,988 BTI treatments were issued in other non-drinking water containers found outside houses surveyed. Of these containers, 2,438,555 were treated for the mosquito larvae that were already there. For the houses that did not approve of these chemical treatments, source reduction treatments were done. 401,706 (16.5%) of the containers with larvae were confirmed to be have dengue-carrying larvae, making up 1.7% of all containers surveyed. In total, RRT larval reduction interventions cleared 368,320 houses of dengue carrying larvae.

RRT interventions designed to kill live mosquitoes were also used. 77,177 treatments of focal spray were issued, along with 16,666 fogging treatments. These treatments were done in the highest risk areas, where cases had already been reported and it was believed that dengue carrying mosquitoes were already present.

However, not all of the public health system's interventions were reactionary; Rajasthan, and the department of vector borne diseases specifically, has taken on a huge series of preventative measures against dengue and diseases like it. For one, all health professionals were informed about the state's situation. Every public health official talked to over the four weeks in Rajasthan was familiar with this, a population that ranged from the state nodal officer to ASHAs. Professionally instructed health educationincluding information about dengue and other vector borne diseases is taught in 52,864 schools across the state. The course objectives of this initiative includes teaching awareness, symptoms, precautions, and dangers of dengue, malaria, zika and chikungunya. There are also SMS text alerts to warn and educate the general population about vector borne diseases. This year, messages have frequently been sent out about topics such as the symptoms of dengue fever, what to do if someone shows these symptoms, and the importance of cleaning water tanks for mosquito larvae. At the district level, posters, banners, TV ads, and messages via FM radio have been posted regarding similar dengue-related topics: educating and promoting awareness about dengue.

Data Visualization, Mapping, and Analysis:

Analysis was done on the laboratory confirmed dengue case data accessed from two primary sources of data;the firstof which was the data accessible on the IDSP portal compiled by the weekly reports submitted by the DSU.The L-form data updated to week 46 was used in this analysis, meaningtill November 17th all DSU reported cases are included in this data. 7,974 dengue lab confirmed cases had been reported and were displayed on the IDSP portal. Information regarding syndromic and presumptive dengue cases could have also been analyzed, but these analyses would not have the same certainty regarding the presence of dengue. Additionally, there are no other data sets to compare the DSU reported syndromic and presumptive dengue case data to.While it has already been stated the DSU lab confirmedcases were severely under-reported, this data should still provide a lot of insight. Firstly, and perhaps most importantly, this is the data accessed and used by the SSU and CSU, meaning this data directly influences state interventions and national policymaking. Hence, any analysis that can provide insight to the reliability of the data is very influential. Secondly, as this data can track the number of cases on a time scale, it can provide insight into the seasonality of dengue, the rise of cases, and when specific districts saw drastic changes. Similarly, this was the only data source accessible capable of separating the data to the block level.

Before the analysis took place, the districts were graphically coded on a GIS file. In making this file, the primary goal ensure districts were positioned properly and no borders between districts were omitted. Using Tableau software, the GIS file was then cross-linked to an excel spreadsheet that contained the DSU reported week by week data. The first visualizationplotted the total number of cases in each district and created a gradual red-green color scale based on number of cases, with a green color representing low numbers of cases and red representing high. This direct color scale (figure 1) did not display as much information as hoped, as the outlier Jaipur district made it difficult to see differences between the other districts. A modification was made so the color scale was centered on 250 cases, allowing the differences between the other districts to be better seen. This visualization can be found below as figure 2.

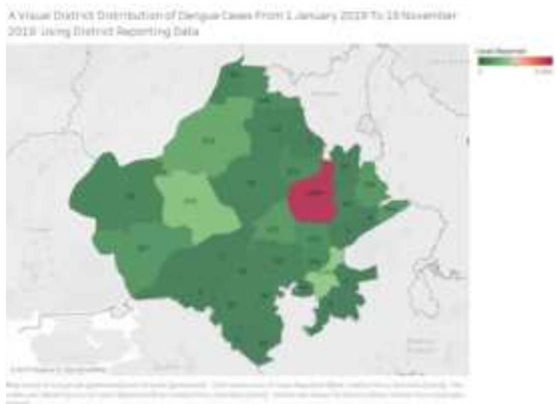


Figure 1

Figure 2

While this perspective illustrated a side by side comparison of districts, a second project was taken on to categorize the districts into groups based on the number of cases. As seen in figure 3 below, this visualization also has the number of cases in the district labeled, but also colors each district based on whether it falls into the 0-75, 76-150, 151-250,… or 2000-4000 classification. While like the first two maps, this feature makes certain districts appear more comparable to each other. Additionally, this feature can be particularly useful in comparing two different sources of dengue case data. A preview of figure 3 can be found on the next page as well as the larger copy in the appendix.

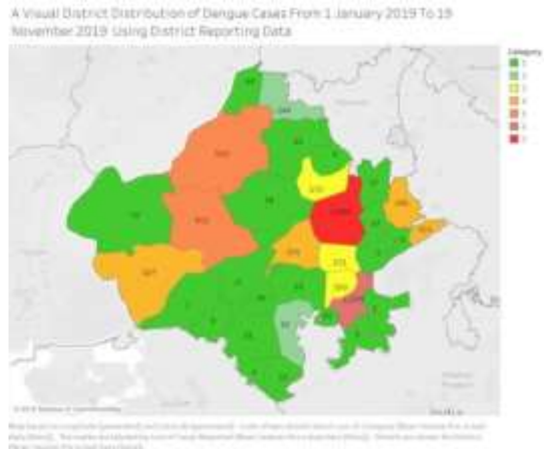


Figure 3

To evaluate the rise in cases in late summer, another project was taken on. Using the same GIS file as in the first three visualizations, a new map was made for each of the weeks between week 29-35, where the biggest rises in cases were seen. Each map labeled the number of cases per district for that week, and used a gradual red-green color scale to further display the number of cases. Furthermore, each of the color scales was manually set so rises in number of cases could be seen without a changing point of reference. The project was completed by grouping all the maps together in week order. The visualization can be found as figure 4.

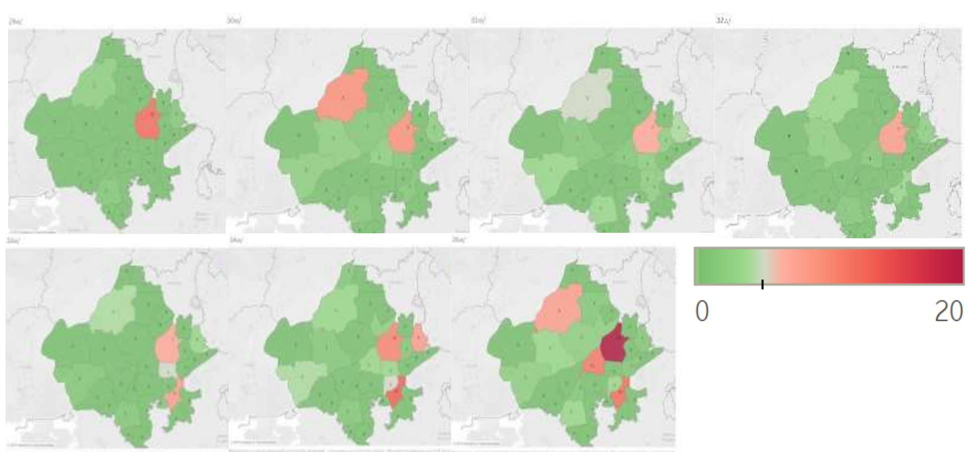


Figure 4

From these analyses, it is easy to see the Jaipur DSU reported far more cases than any other district. Using the IDSP portal, the block by block data for only Jaipur district was obtained, split up by reporting units. This data provided a breakdown of the cases in Jaipur district by blocks and other reporting units. Another GIS file was created, mapping Jaipur district by each of its blocks and three reporting units (Jaipur-I, Jaipur-II, and SMS medical college). Then the GIS map was used to display the total number of cases seen in each reporting unit. The number of cases was labelled on a categorical color scale, similar to figure 3. In the full image view, it is difficult to read the information near the Jaipur-II and SMS reporting units, so a zoomed in version of the visualization was made. The zoomed version can be found below (figure 5) while the standard version is labeled in the appendix as figure 6.

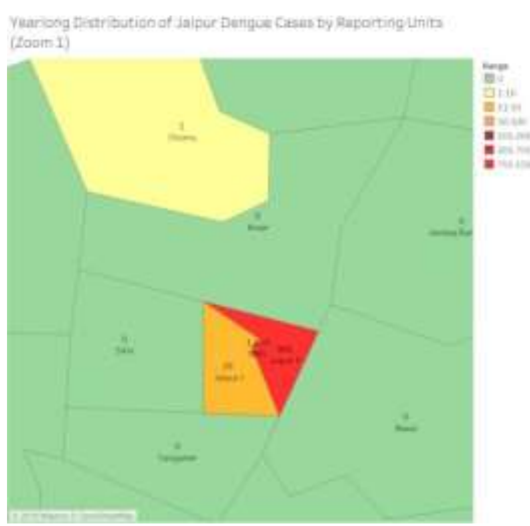


Figure 5

All the visualizations thus far, have been done using the information collected from the portal, even though it is known this data is under-reported. By the end of week 46 (Sunday, November17th) there were 7,974 dengue lab-confirmed cases on the IDSP portal. This was compared to a compilation of the line lists of dengue ELISA tests from the eight medical colleges. The results were disturbing, asthere were 12,150 cases, 11,533 of which were dated to the 17th of November or before. This is despite the fact that the DSU reported data for lab-confirmed cases should include all of the medical hospital cases, as well as the cases from the other 49 reporting laboratories. Hence, not only does the district reported data not encapsulate all ofthe medical college cases, but there should be many other cases from labs throughout the state that should have been reported.

Each of the hospital's line lists had a different format. There was a lot of variability in the data fields present on the form, and hence there were very few data fields that were shared by all eight. Age and gender were some of the few fields present on every form. Date and district, two other fields that would be helpful in analysis, were present in the large majority, but not all. Fortunately, in the one hospital that did not have a district data field, an address field was present. It is for this reason that only age, gender, and district were analyzed, and that a timewise distribution could not be accurately done.

Age was a field that was present and mostly filled out on every form. There were dengue cases in all ages from of 0-88,while the oldest patient was 95. Additionally, in 102 cases an age was not listed, meaning all the data only includes 12,048 patients. Before the next steps were taken, one oddity was noticed. When the cases were listed by age opposed to age range, a trend emerged. The multiples of five were almost always significantly higher than one year above and one year below. This odd trend did not seem to apply for ages below 20. No additional information indicated why this was the case.

The first analysis done was upon request of Dr. Ruchi Singh. It sought to break down which of the following age groups were most affected: 0-5, 6-15, 16-24, 25-45, and 46+. This condensed set of data was filtered into table 1. The largest of these groups was the 16-24 age group with 4,419 cases. It was found the reproductive age groups were most at risk, as 67% of cases occurred in patients between the ages of 16 and 45. There was little to no concern over the fact that each of the age groups listed were of different sizes. The visual can be found below as figure 7.

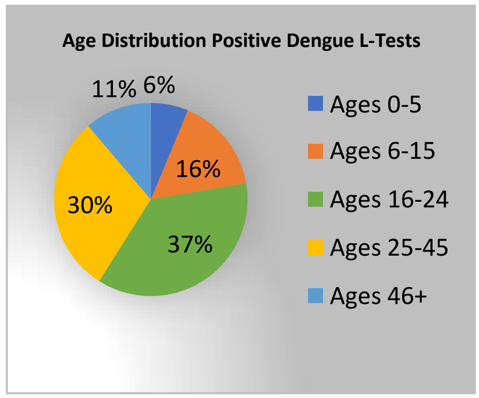
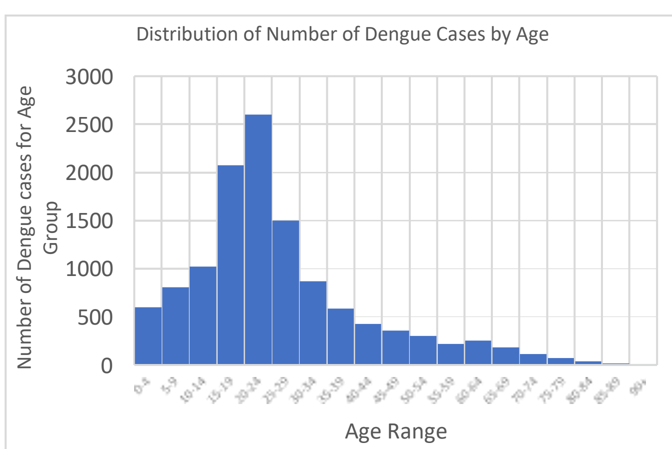


Figure 7

The second age analysis was done using a breakdown by 5-year age groups. This categorized all cases into age groups from 0-4, 5-9,… and is referred to as table 2. The data was made into a column chart, where it could be seen the results evaluating age resemble bell curve.The largest concentration of patients was within the 20-24 age group, as 21.4% (2601) of cases with an age listed were in this age group. The next two highest concentrations were 15-19 and 25-29 which made up 17.1% (2074) and 12.3% (1500) of cases respectively.It is clear that people who are in this young to middle-aged category made up a disproportionate amount of the cases, but it is unclear why. The visual representation of this data can be found below as figure 8.

Figure 8



Gender was also a data field listed on every form. It appeared to be typed manually, as there were many spelling errors that made it difficult to solidify and clean the data. Patient gender was categorized as male, female, or transgender, as these are the three genders officially recognized by the Indian government. Of the gender information filled out on the Lab-confirmed forms, 8,358 patients identified as male, 3,703 identified as female, and 4 identified as transgender. There were 85 cases where a gender was not recorded. This information is displayed as a pie chart below in figure 9. There is a clear disparity of over 4500 cases between male and female lab confirmed cases. There is too little data to confirm why this trend emerged.

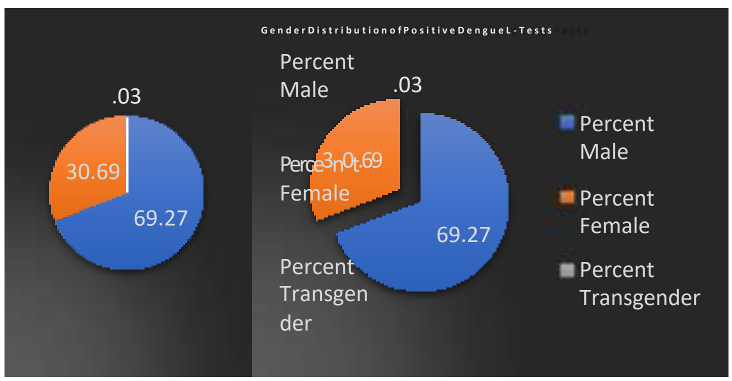


Figure 9

While age and gender were listed on every form, district was listed on all except the SMS hospital line list. Fortunately, the SMS list did have a field listing the address of the patient, making a complete distribution by district still possible. Hence, the district distribution from the line lists was done slightly differently from the age and gender distributions. The line lists were separated into a main group and the SMS list. While the same process was done for the main list, an Excel "Countif" function was used to find the district names listed in the addresses. This is not a perfect system, as there are minor sources of error that arise using this method. Of the 4,858 cases from SMS hospital, the district classification for 4,531 patients were obtained using this method. It should be noted that in the SMS line list, as well as many other hospitals' line lists, there were many patients for Madhya Pradesh and Haryana, meaning the district classifications should not sum up to the total number of patients. The general line list information was then combined with the SMS data to create a relatively accurate district distribution. This can be found below as table 3.

The data showed that Jaipur had by far the most number of lab-confirmed cases with 3,641 (30.0%). Jodhpur and Kota were the next two districts most affected with 1049 (8.6%) and 766 (6.4%) lab confirmed cases respectively. Alwar, Tonk, Barmer, Dholpur, Dausa and Bikaner were also all high in cases, as all had more than 450 cases. 11,359 cases were associated with a district, 93.5% of the 12,150 cases. All the district information, was then plotted onto the district GIS map to display the distribution of cases visually.A categorical coloration identical to the scale in figure 2 was added. This can be found as figure 10.

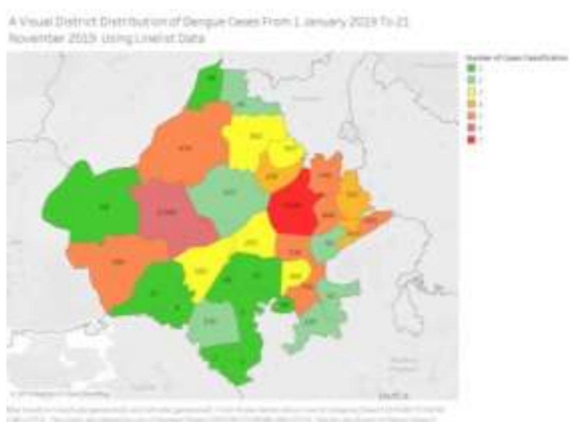


Figure 10:

Further analysis can be done by comparing between the DSU reported data and the district distribution data found in the medical college line lists. These data fields were put side by side and compared. These two data fields were also compared via percentages to display what proportion of cases were not reported. Some DSUs were close to the line list figure from the

DISTRICT	DIST DATA	LINE LIST		DIFFERENCE	PCTG DIF
Ajmer	371	205		-166	-44.7%
Alwar	**17**	**546**		**529**	**3111.8%**
Baran	**1**	**92**		**91**	**9100.0%**
Bharatpur	336	355		19	5.7%
Bhilwara	33	37		4	12.1%
Bikaner	553	479		-74	-13.4%
Barmer	**327**	**496**		**169**	**51.7%**
Bundi	160	160		0	0.0%
Banswara	11	8		-3	-27.3%
Chittorgarh	82	56		-26	-31.7%
Churu	**13**	**162**		**149**	**1146.2%**
Dausa	**47**	**484**		**437**	**929.8%**
Dungarpur	0	2		2	#DIV/0!
Dholpur*	**353**	**493**		**140**	**39.7%**
Ganganagar	64	58		-6	-9.4%
Hanumangarh	144	94		-50	-34.7%
Jodhpur	953	1049		96	10.1%
Jalore	7	13		6	85.7%
Jaipur	2844	3641		797	28.0%
Jaisalmer	70	68		-2	-2.9%
Jhunjhunu	**6**	**197**		**191**	**3183.3%**
Jhalawar	**0**	**124**		**124**	**#DIV/0!**
Karauli	**0**	**349**		**349**	**#DIV/0!**
Kota	1059	766		-293	-27.7%
Nagaur	**54**	**137**		**83**	**153.7%**
Pali	**0**	**165**		**165**	**#DIV/0!**
Pratapgarh	10	10		0	0.0%
Rajsamand	42	66		24	57.1%
Sikar	**172**	**339**		**167**	**97.1%**
Sawai Madhopur	**3**	**95**		**92**	**3066.7%**
Sirohi	**0**	**9**		9	#DIV/0!
Tonk	**211**	**530**		**319**	**151.2%**
Udaipur	**31**	**130**		**99**	**319.4%**
TOTAL	7974	11415		3441	43.2%

Table 4

medical colleges and others were not. The districts that had the largest proportional and direct differences were bolded. This can be found to the left as well as in the appendix as table 4.

Conclusion

Evaluation of Observations and Data:

The IDSP is an integral part of the Indian public health system that plays a vital role in protecting the general population from outbreaks of diseases like dengue. The program, has evolved significantly since its inception in 2004, having developed a state-funded sustainability, a weekly reporting system and an intricate network of communication between SCs, private hospitals, andanimal-based departments. That does not mean the IDSP does not have a long way to go, there are still many things lacking from the system as is, including but not limited to technological updates and an increase in human resources.

While it was used as the primary source of information for the beginning of the analysis, the DSU reported data provided limited insight. It was unable to provide a complete picture of the dengue lab confirmed cases throughout the year. Additionally, it was inconsistent from district to district, as some DSU reported figures close to or greater than the medical college lists' while others were significantly below. This increases difficulty in attempting to estimate an actual number of cases. It cannot be overstated how critical this is to the paper's findings, as this is the information used by the SSU and CSU for action, policy, and national data.

Despite its inaccuracies, the three districts with the most cases were the same in the DSU data as in the medical college line list data. Additionally, the DSU data when mapped displayed clustering of cases in the south east districts. This was a product of the GIS usage, was without this visual insight, the regional clustering was not apparent. However, it should be noted that population, which is not accounted for, could very well be a reason for this.

From the week by week analysis (figure 4) it was clear that between weeks 29 and 35, there were very few dengue cases, and these cases were spread throughout the state. Many of the districts that saw small rises of more than 4-5 cases during this time ended up having a high number of cases, which suggests these small bumps tracked by the IDSP were indicators for outbreaks. However, it should still be noted that this could also be due to population size, as population was not used as a metric in this study.

The line list data clearly showed that most of the lab confirmed cases were from teenagers to middle age adults. It is uncertain why this is. On one hand, dengue patients have a lifelong serotype specific immunity after having the virus, which provides rationale for why older age groups are less likely to contract dengue.[62] Additionally, only 21.7% of India's population is 45 of above, while 30.2% of the population is in the age range 15-29.[63] However, this only addresses one half of the situation. There is still the fact that children were less likely to contract dengue than people in the 15-29 age group. This could potentially be due to a trend of proximity to vector mosquitoes. If indoor areas where children spend the majority of their time, like classrooms, have lower mosquito densities than workplace areas, it would follow that children would have proportionately less dengue cases. This could be a significant factor, as the *Aedes Aegypti* mosquito feeds mostly during the day.[64] However, these explanations are purely theoretical and a much larger study would be needed in order to get a better explanation.

The fact that multiples of 5 were significantly more common to be listed for an age than its neighboring numbers should also be discussed. This pattern was very consistent for all ages from 20 to 85. It should be noted that all of these cases were from the line list compilation and were therefore from medical colleges, which are known for being incredibly busy. One speculative explanation could be that staff in the medical colleges simply round the patient's age

[62]Mayer, Sandra V et al. "The emergence of arthropod-borne viral diseases." *Actatropica* vol. 166, 2017.
[63]Directorate General of Health Services. "National Health Profile 2019". *Indian CBHI*, 2019, pp. 30–36,
[64]Aedes Aegypti." *Dengue Transmission by Aedes Aegypti* Mosquito, 2019.

or give an age estimate in an effort to conserve time. This proposition has no basis in proof and is simply an idea. A further investigation would be needed to acquire a less speculative answer.

There were significantly more men with positive dengue ELISA tests than women in the medical college line list data. It is true that more men live in Rajasthan than women. The population of men is approximately 39,602,000 while the population of women is around 36,227,000.[65] However, the difference between two groups is much larger than this, as more than twice as many men had positive L-tests. It is unclear why this disparity is. There are many different aspects to gender roles and social norms that could potentially be the cause of this difference: household roles, dress, type of work done, and help seeking behavior just to name a few. Additionally, the gender based statistics are very difficult to track for transgender people. It is even unclear what the transgender population of Rajasthan is, so determining whether the cases of transgender patients is high or low, is not feasible. It could also be noted that of the four times transgender was written in the line lists, three of the timethe word was misspelled. This could indicate and stem from a lack of familiarity with and inclusion of patients with a transgender identity from medical and health professionals.

Some of the most intriguing findings were in table 4, where the DSU data was directly compared to the medical college line list data. There were many districts without much of a difference between the two data sets and many with a greater DSU reported number; however, this was not the case across the board. The five districts that reported 0 cases throughout the year were beyond alarming, as there was blatant lacks of coordination and communication from many of the DSUs. Because of this, the SSU and CSU do not have any information to referring to this region as dengue endemic. The most dengue progress inhibiting DSUs were Jhalawar, Pali, and

[65]Directorate General of Health Services. "National Health Profile 2019". 2019, pp. 30–36,

Karauli, which despite reporting zero cases for the entire year, had 124, 165, and 349 respectively. When data reporting units have a lack of performance and activity like this, it severely limits the functions of the SSU and CSU and diminishes the reasons for having a disease surveillance program. The differences between the two maps can be seen below.

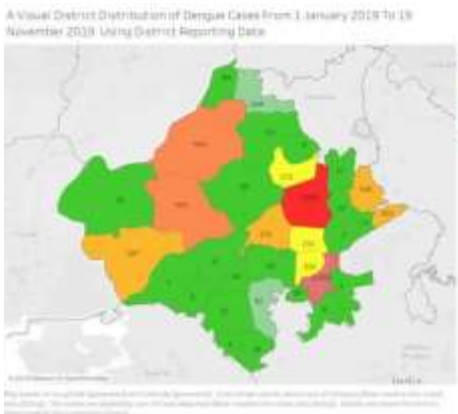


Figure 3

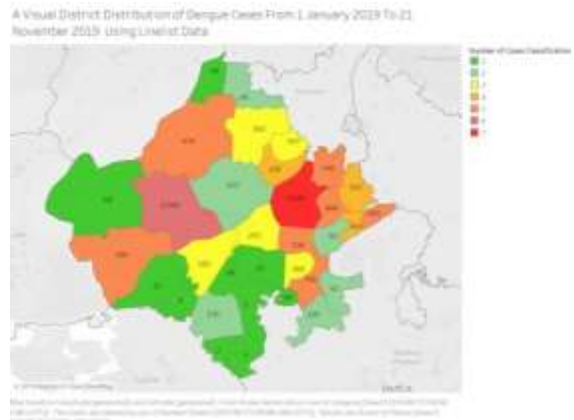


Figure 10

An additional concern that arose was the lack of concern that was observed when IDSP SSU employees were shown these finding. In the two situations where this was observed, the employees were very quick to suggest rationales for why this happened beyond a lack of submissions from the DEO and displayed a very low level of concern regarding these findings. Of the 8-10 rationales, the most emphasized were the inability for DSUs receiving cases after their weekly submissionand their inability to edit their data at this time, cases where one patient going to two different hospitals and had two different lab tests, and even the possibility that the medical college line lists could have accidentally been duplicated. These explanations seemed to imply an unwillingness or a lack of desire to look into this information further, despite the fact that these problems significantly limit the IDSP in its growth.

Despite these reporting issues, the IDSP did have a critical role in the Rajasthan public health system's successes of combating dengue this past year. This is most evident in the RRT interventions that took place. The work of the IDSP was able to target at risk population and locations. Interventions of temephos, MLO, BTI, focal spray, and fogging took place throughout the state, and decreased people's risks of contracting dengue. While more accurate DSU reported data would have been helpful in providing assistance to certain districts, this should not diminish the value of the interventions done by the SSU RRT. Furthermore, since there are RRTs at the block and DSU levels, SSU involvement is not always necessary for short term actions. While it is difficult to estimate how many cases were prevented via these direct interventions, the facts that more than 350,000 households had dengue carrying mosquitoes removed and over 90,000 highly at risk houses underwent a spray treatment imply that IDSP promoted RRT interventions were extremely significant factors in reducing the burden of dengue on the state of Rajasthan.

Additionally, while clearly the IDSP system is not functioning perfectly, the cross-verifying system in place is designed to improve the current system. By having SSU and DSU employees observe and advise their reporting units, suggestions and standardizations can be made that may help the IDSP in reporting accurately. Similarly, these visits can help ensure the reporting unit understands the importance of accurate surveillance. This feature of the IDSP's work has the ability to significantly improve standardization and accurate surveillance at all levels, but clearly has a ways to go. The programs to further develop the IDSP are there and the next steps to an improved IDSP are not very far from the current status.

Limitations of this Study:

There were many limitations to this paper. In evaluating the IDSP system as a whole, it is difficult to eliminate SSU-based bias, as the vast majority of the work done for this paper was done by working with the Rajasthan SSU. Furthermore, while some DSU employees (3) were talked to and provided some perspective into the functioning of the DSU, this never occurred without an SSU employee present. Furthermore, no contact was made with the CSU, in evaluating issues associated with the data submitted by the SSU.

There are obvious limitations in the data used for this study. It is still unclear how many cases had occurred in the state of Rajasthan as of 17 November 2019. While the data collected indicates at least 12,770 cases occurred, it is not very feasible to get an upper bound of this statistic. This uncertainty cannot be understated. There could be twice as many cases in the state of Rajasthan and this data could be identical. Additionally, in discussing this uncertainty, it would make sense that patients in districts with a medical college would be more likely to go to be tested at a medical college opposed to another lab. Hence, it should not be surprising that Kota, Jaipur, and Jodhpur had some of the highest numbers of cases in medical colleges, as there are medical colleges in all of these states.

This study was also limited by the lack of population statistics used. This was intended to be a new insight, as the much of SSU data analysis does not use population statistics but instead uses trends; however, a lack of access to this data inhibited this examination. For the first three weeks, any time population data was referred to, it was often said that the data was not reliable and was not used. The speaker, whose primary language is Hindi, was referring to the data listed on the IDSP portal and not the accurate population statistics the IDSP has access to. This was a result of the language barrier that existed in this study. This barrier made the obtaining of information, like this population data, significantly more difficult.

There are also the limitations caused by the method of extracting data from the medical college line lists. In tracking gender and age, many measures were done to find misspelled or odd cases. For age, many of the babies were listed in terms of months instead of years. These patients then had to be changed in terms of year. Additionally, entries that patients as 1.5, 2.5 or 3.5 years had to be corrected in the data cleaning process. Gender had many misspellings, making it difficult to enumerate the cases. Furthermore, in over 500 cases, both age and gender were listed in the same data field: another error which had to be corrected in the data cleaning stage. While careful measures were taken to ensure the accuracy and integrity of the data, it is possible that some odd cases could have been missed or miscounted, which is a limitation of the study.

There was error in tracking the districts as well. Many of the districts were found under two or more spellings. While attempts were made to find every spelling, it is possible that cases were missed on the basis of spelling differences or errors. Additionally, there is uncertainty in the method that counted districts from SMS medical college. While the errors caused by spelling are also relevant, there is another layer of error caused by this method. If the address contained a district's name in a street name (i.e. Jaipur Rd), then an extra case would be counted for that district. While this was not likely a huge component of error, it does add a limitation to the data used in this study.

Acknowledgements:

I would like to first thank head microbiologist Dr. Ruchi Singh and Additional DirectorDr. Ravi Prakash Sharma for approving my study at the IDSP and DHMS. Without their help none of this work would have been possible. Additionally, I would like to thank the staff in the IDSP office for allowing me to sit in and observe their day to day work. Not only was I warmly greeted, but I was shown by many people what the work process looks like, where information comes from, and what is done with their findings

Additionally, I would like to thank the staff of SIT, School of International Training, in New Delhi, India.The program staff, including Dr. Azim Khan, Mr. Abid Siraj, Ms. Bhavna Singh, Ms. Archna Merh, and Mr. Goutam Merh, were pivotal in assisting me find and contact the Rajasthan IDSP. I cannot thank each of them enough.

Appendix:

Age Group	Number of cases	Percent of Cases
0-5	757	6.28 %
6-15	1930	16.02 %
16-24	4419	36.68 %
25-45	3591	29.81 %
46+	1351	11.21 %
Total:	12048	
Cases w/o age listed:	102	

Table 1: General Age Distribution of Cases According to Medical College Line List Data

Age	Number of Cases	Age	Number of Cases	Age	Number of Cases	Age	Number of Cases	Age	Number of Cases
0	141	20	710	40	253	60	120	80	30
1	143	21	520	41	35	61	31	81	2
2	78	22	598	42	65	62	41	82	3
3	117	23	390	43	35	63	34	83	4
4	122	24	383	44	36	64	24	84	2
5	156	25	611	45	214	65	99	85	10
6	194	26	299	46	30	66	24	86	0
7	159	27	202	47	47	67	16	87	2
8	153	28	276	48	49	68	24	88	2
9	147	29	112	49	18	69	22	89	0
10	218	30	430	50	162	70	66	90	4
11	171	31	67	51	38	71	8	91	0
12	227	32	219	52	46	72	13	92	3
13	199	33	73	53	22	73	10	93	2
14	206	34	80	54	31	74	14	94	1
15	256	35	324	55	92	75	43	95	2
16	292	36	73	56	36	76	7		
17	437	37	50	57	18	77	9		
18	634	38	100	58	51	78	12		
19	455	39	37	59	23	79	4		

Table 2: Age Distribution of Cases by 5-Year Age Groups According to Medical College Line List Data

District	Cases from outside SMS	Cases from SMS	Total
Ajmer	154	51	205
Alwar	242	304	546
Baran	82	10	92
Bharatpur	166	189	355
Bhilwara	23	14	37
Bikaner	458	21	479
Barmer	474	22	496
Bundi	130	30	160
Banswara	1	4	5
Chittorgarh	0	3	3
Churu	118	44	162
Dausa	162	322	484
Dungarpur	1	1	2
Dholpur*	362	131	493
Ganganagar	42	16	58
Hanumangarh	58	36	94
Jodhpur	1041	8	1049
Jalore	7	6	13
Jaipur	1332	2309	3641
Jaisalmer	55	13	68
Jhunjhunu	58	139	197
Jhalawar	123	1	124
Karauli	97	252	349
Kota	754	12	766
Nagaur	62	75	137
Pali	156	9	165
Pratapgarh	8	2	10
Rajsamand	63	3	66
Sikar	165	174	339
Sawai Madhopur	71	24	95
Sirohi	9	0	9
Tonk	247	283	530
Udaipur	107	23	130
Total:	**6828**	**4531**	**11359**

Table 3: District Distribution of Cases According to Medical College Line List Data

DISTRICT	DIST DATA	LINE LIST DATA		DIFFERENCE	PCTG DIF
Ajmer	371	205		-166	-44.7%
Alwar	**17**	**546**		**529**	**3111.8%**
Baran	**1**	**92**		**91**	**9100.0%**
Bharatpur	336	355		19	5.7%
Bhilwara	33	37		4	12.1%
Bikaner	553	479		-74	-13.4%
Barmer	**327**	**496**		**169**	**51.7%**
Bundi	160	160		0	0.0%
Banswara	11	8		-3	-27.3%
Chittorgarh	82	56		-26	-31.7%
Churu	**13**	**162**		**149**	**1146.2%**
Dausa	**47**	**484**		**437**	**929.8%**
Dungarpur	0	2		2	#DIV/0!
Dholpur*	**353**	**493**		**140**	**39.7%**
Ganganagar	64	58		-6	-9.4%
Hanumangarh	144	94		-50	-34.7%
Jodhpur	953	1049		96	10.1%
Jalore	7	13		6	85.7%
Jaipur	2844	3641		797	28.0%
Jaisalmer	70	68		-2	-2.9%
Jhunjhunu	**6**	**197**		**191**	**3183.3%**

Jhalawar	**0**	**124**		**124**	**#DIV/0!**
Karauli	**0**	**349**		**349**	**#DIV/0!**
Kota	1059	766		-293	-27.7%
Nagaur	**54**	**137**		**83**	**153.7%**
Pali	**0**	**165**		**165**	**#DIV/0!**
Pratapgarh	10	10		0	0.0%
Rajsamand	42	66		24	57.1%
Sikar	**172**	**339**		**167**	**97.1%**
Sawai Madhopur	**3**	**95**		**92**	**3066.7%**
Sirohi	**0**	**9**		9	#DIV/0!
Tonk	**211**	**530**		**319**	**151.2%**
Udaipur	**31**	**130**		**99**	**319.4%**
TOTAL	7974	11415		3441	43.2%

Table 4: Comparison of DSU Reported Cases with Medical College Line List Cases by District

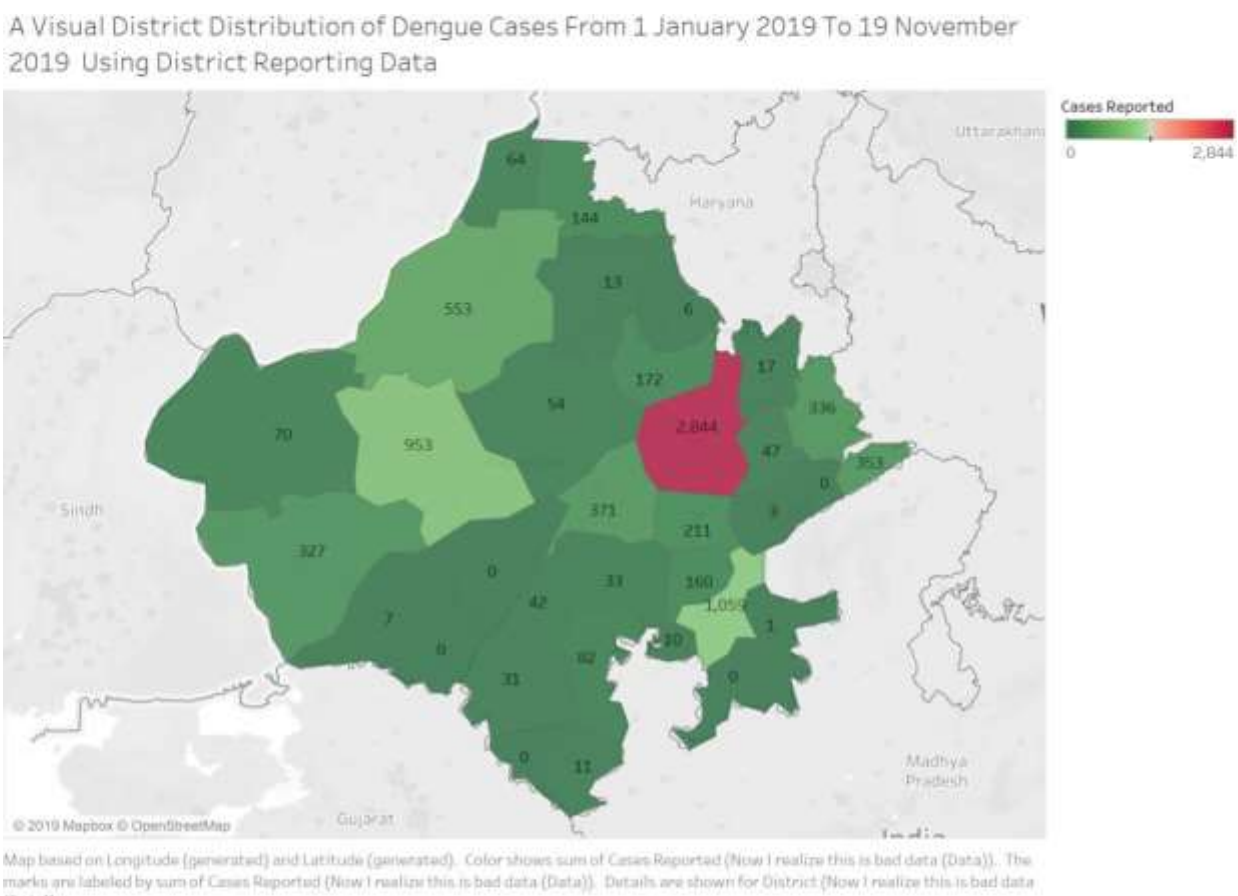


Figure 1: Geographic Distribution of 2019 DSU Reported Dengue Cases by District with a Gradual Color Scale

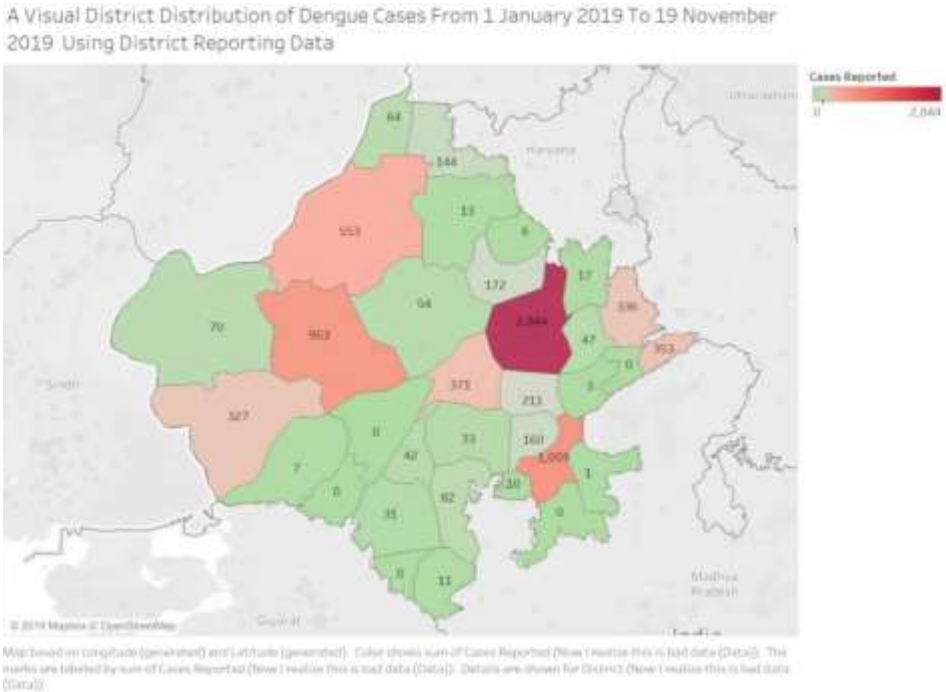


Figure 2: Geographic Distribution of 2019 DSU Reported Dengue Cases by District with an Adjusted Gradual Color Scale

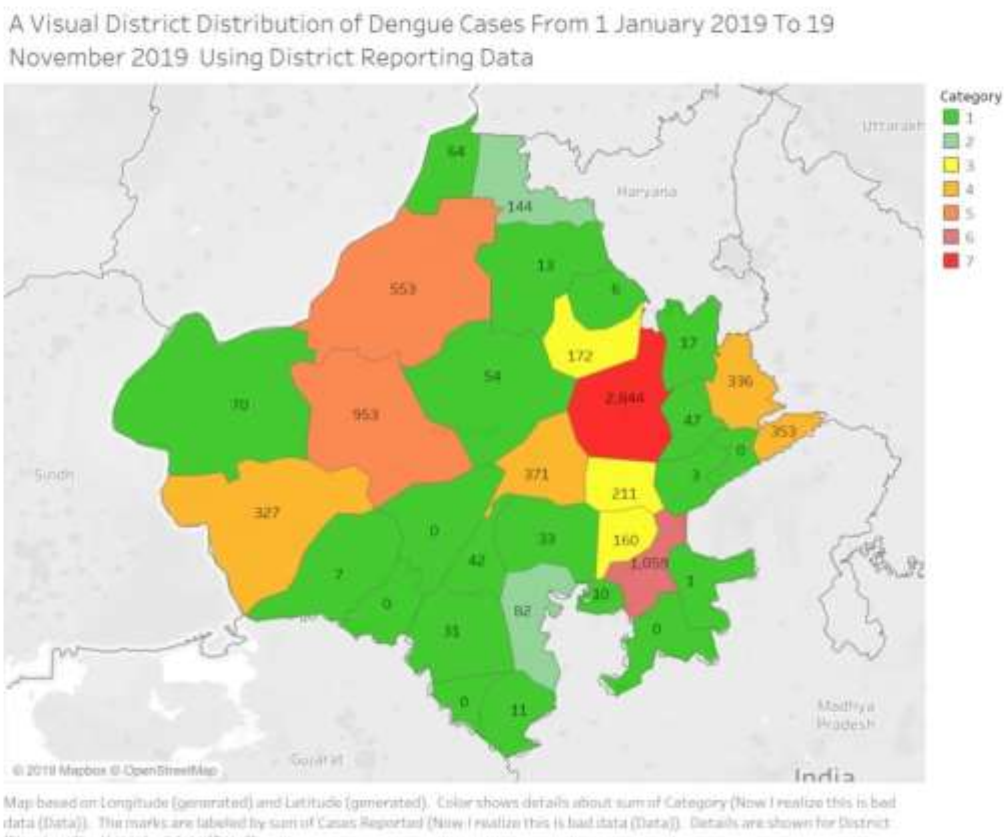


Figure 3: Geographic Distribution of 2019 DSU Reported Dengue Cases by District with a Colored Classification System

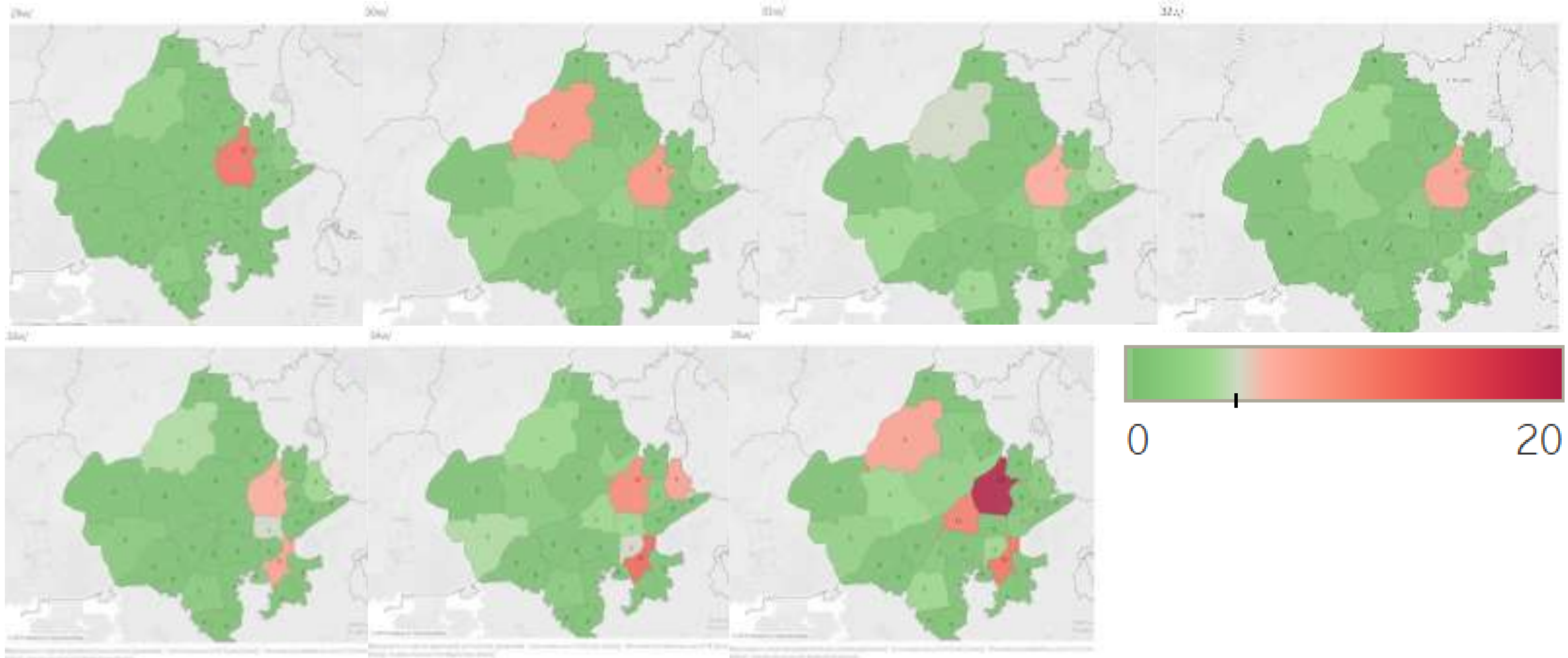


Figure 4: Geographic Distributions of the Number of Dengue Cases by District by Week for Weeks 29 through Week 35 with a Set Color Scale from District Reported Data

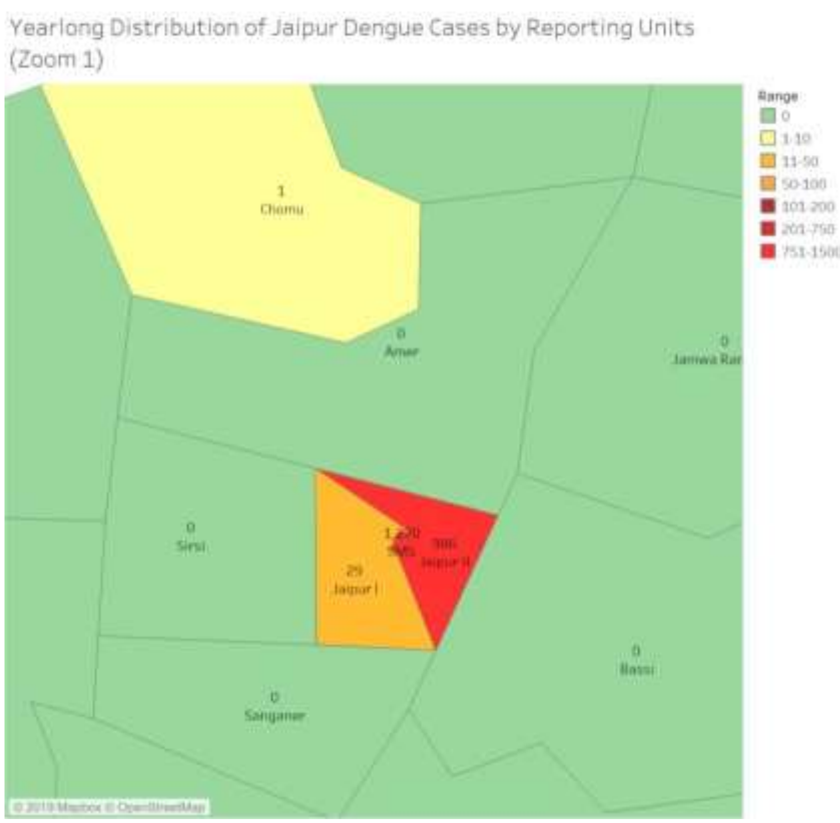


Figure 5: Geographic Distribution of Dengue Cases by Jaipur Reporting Unit with a Number of Cases Classification Color Scale from Jaipur DSU Reported Data: With Zoom

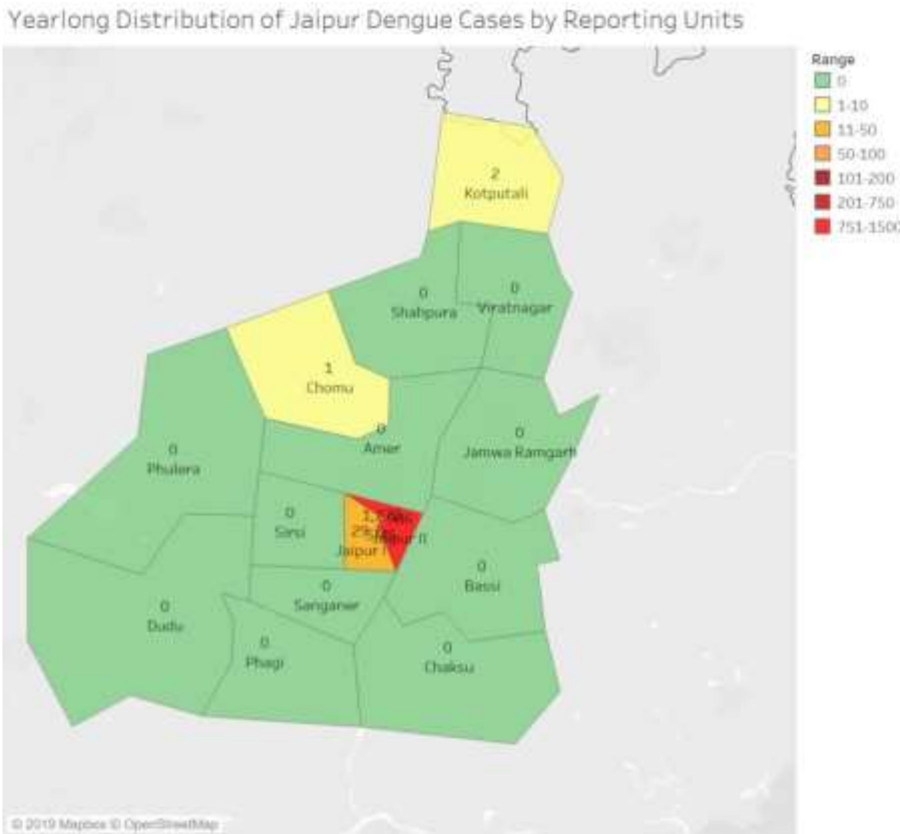


Figure 6: Geographic Distribution of Dengue Cases by Jaipur Reporting Unit with a Number of Cases Classification Color Scale from Jaipur DSU Reported Data: Standard View

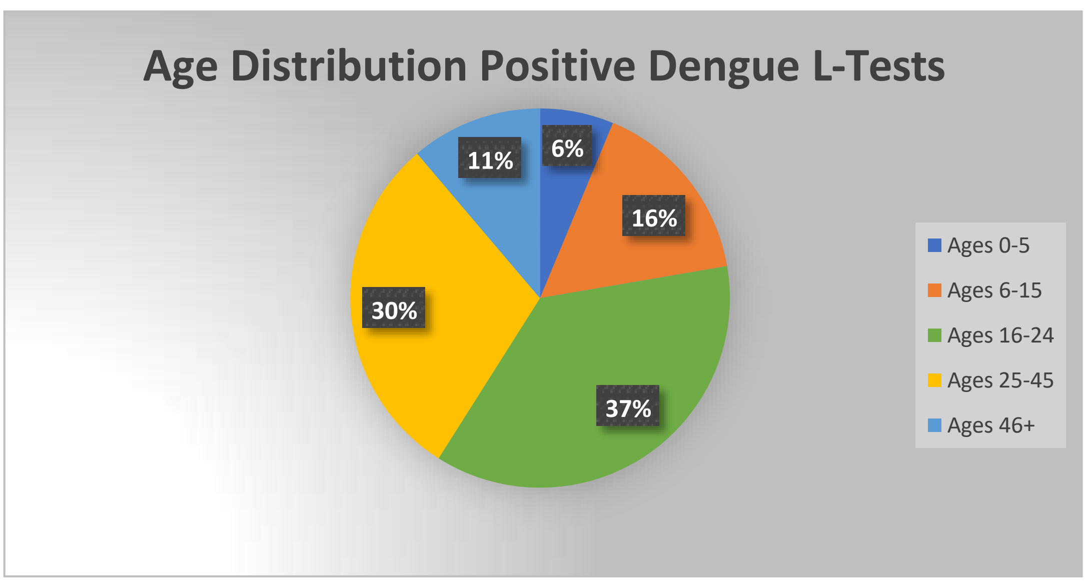


Figure 7: Age Distribution of 2019 Positive Dengue L-Tests from Medical College Line Lists Using General Age Classifications

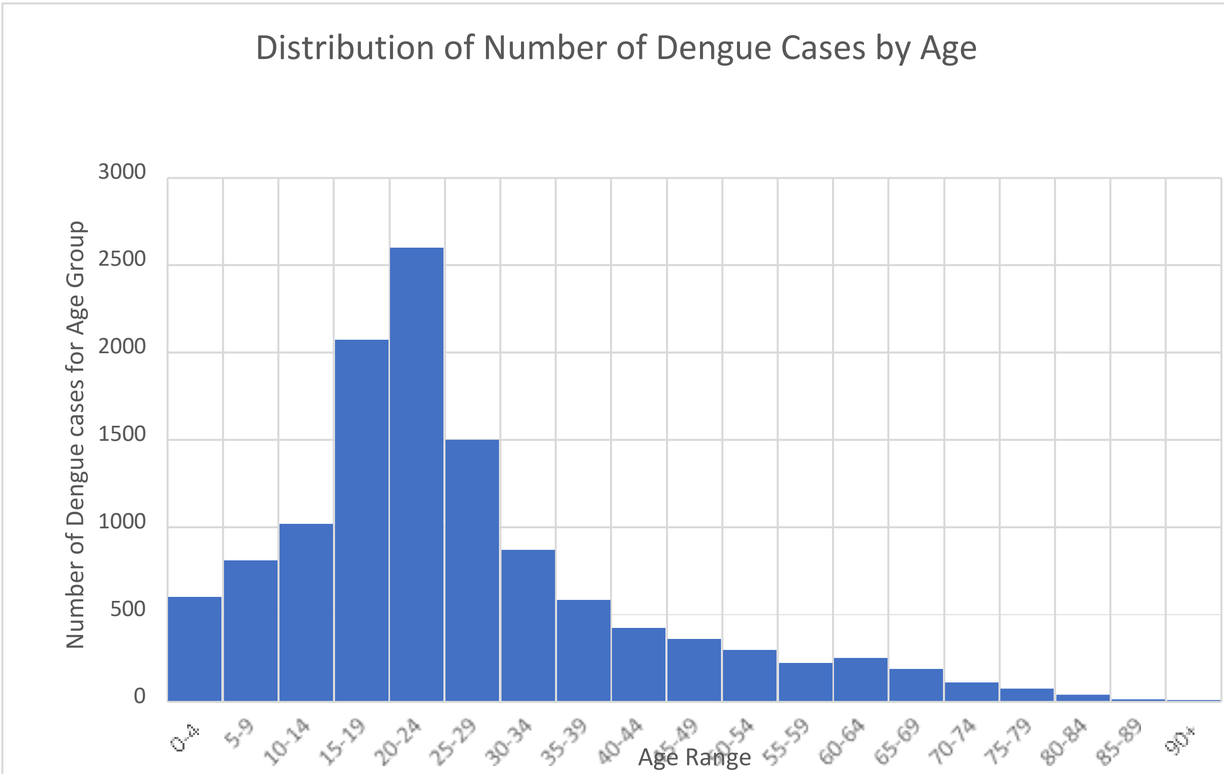


Figure 8: Age Distribution of 2019 Positive Dengue L-Tests Using 5-Year Age Classifications from Medical College Line Lists

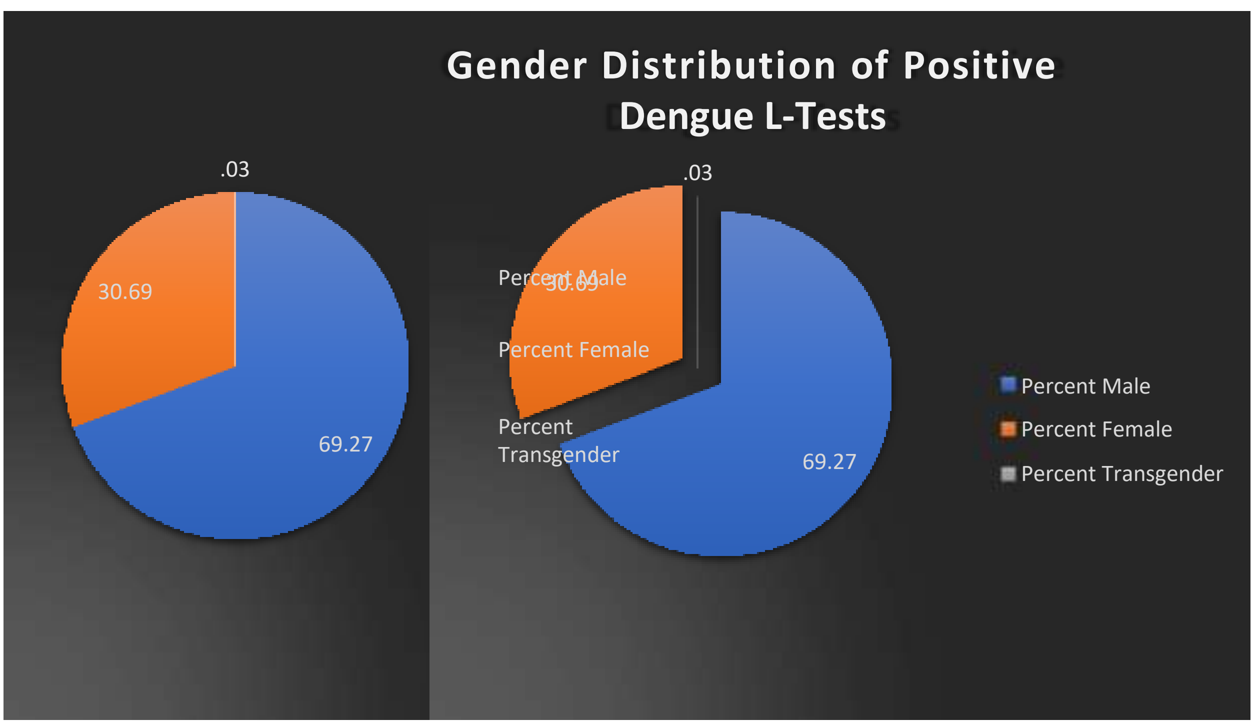


Figure 9: Gender Distribution of 2019 Positive Dengue L-Tests from Medical College Line Lists

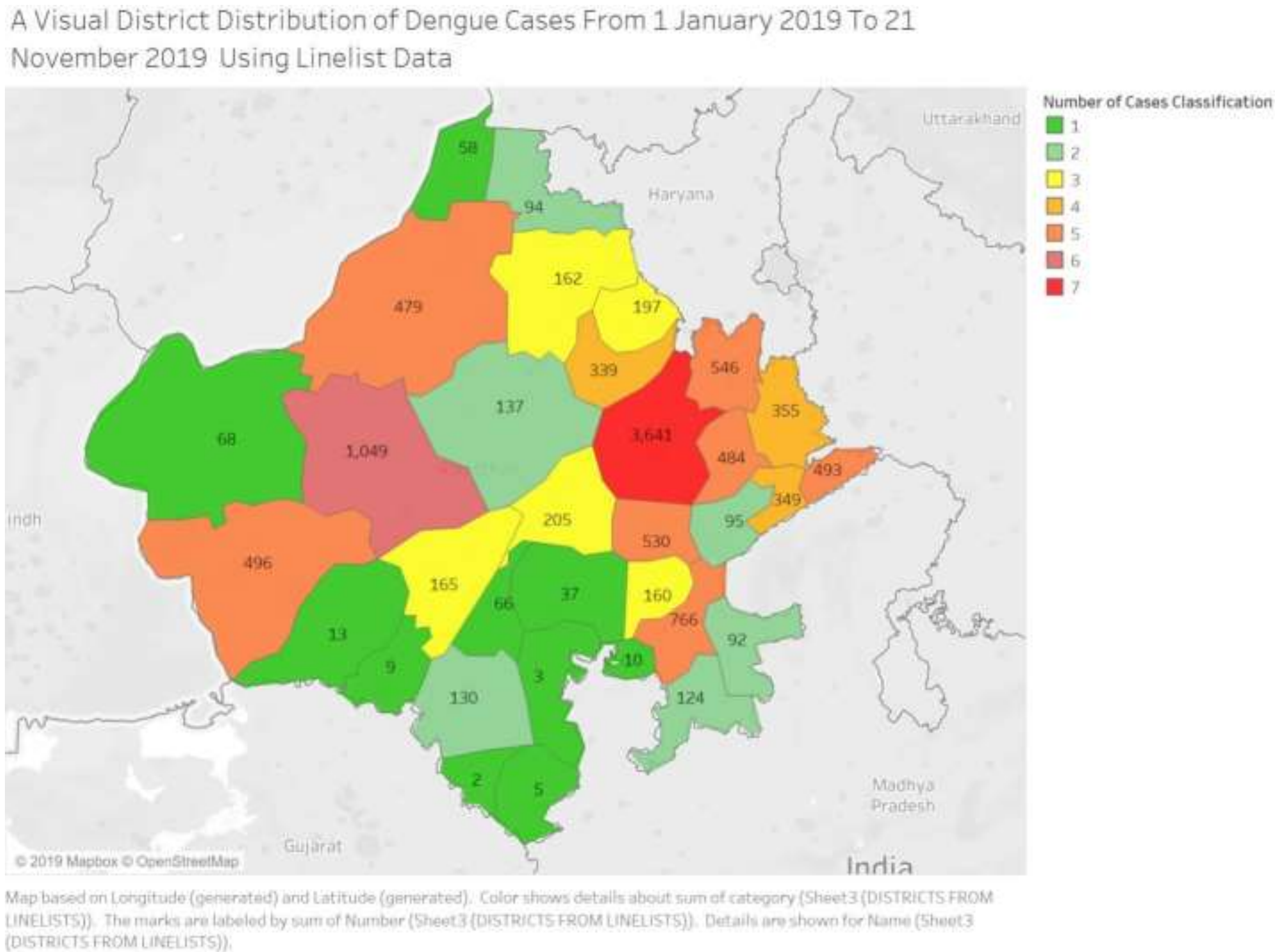


Figure 10: Geographic Distribution of 2019 Dengue Cases by District with a Number of Cases Classification Color Scale from Medical College Line List Data

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