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# Assessment of COVID-19 pandemic healthcare infrastructure of Mizoram, India

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***Abstract***---The deadly COVID-19 outbreak emerged in the city of Wuhan, China at the end of 2019 and developed into a global pandemic during March 2020. According to Ministry of Health and Family Welfare, Govt. of India report of 2021, recovery rate of the state capital of Mizoram is very low while the positivity rate is high during the second wave compared to the national average. Therefore this present study aimed to analyze the spatial pattern of Covid Care Centers, infrastructural details and different Covid Care Service area with the help of GIS using Nearest Neighbour Analysis (NNA) and Weighted Linear Combined Model (WLCM) in Aizawl district of Mizoram. The result shows that Covid Care Centers are mainly clustered in city areas and infrastructure is not adequate. There is dearth of COVID care facilities in the district and the major chunk of facilities are located only in the capital city of Aizawl leaving the rest of the district in a weak zone facility wise. Only city and its surrounding areas have very high and high Covid Care Service. The overall scenario is indicating a poor condition towards the village areas. So, this present study will help the policymakers of health authorities to take some remedial measures in inaccessible and underdeveloped Covid healthcare service areas to improve Covid Care services of the district.

***Keywords***---COVID-19, Aizawl, DCH, CCC, covid center infrastructure, covid care service zone.

## Introduction

The World Health Organization (WHO) recognized Coronavirus Disease-2019 (COVID-19) on February 11, 2020, as it emerged in late December 2019 and was characterized by fever, dry cough, exhaustion, and sporadic gastrointestinal symptoms. This virus caused a significant outbreak in China that spread to other countries creating a pandemic situation (WHO, 2020). COVID-19 is a sporadic type of virus that infects human and mainly causes respiratory infection which differs from ordinary cold to severe acute respiratory syndrome (SARS). Covid-19 virus has resulted in an enormous number of deaths both in India and rest of the world. The clinical findings of COVID-19 pandemic have reported pneumonia, fever, difficulty in breathing and coughing as some of the major symptoms, whereas it also causes failure of kidney and death in severe stage (Tosepu et al. 2020). WHO also states that children under the age of six, women between the ages of 15 and 49, the elderly over the age of 60, and people with disabilities are more vulnerable to COVID-19, thus requiring quality healthcare services preferably in close proximity. The variants of the virus - the Delta and Omicron variant of corona virus has also been found in the different provinces and regions of India (WHO, 2020). The disease soon spread its tentacles in the far north eastern, relatively remote part of India. Aizawl, the district capital of the state of Mizoram, saw a huge spurt of the disease (Biswas et al., 2021). There have been 1,22,521 confirmed cases of COVID-19 and 441 deaths as on 04.30.2022 and the numbers are increasing daily (DIPR Mizoram).

During this COVID-19 pandemic situation, quality COVID healthcare service is most important to all of us for a long and healthy life. Life expectancy and living quality are closely linked with the perceived quality of healthcare services (Dejen et al., 2019). Therefore, maintaining the standard of healthcare services is considered to be the best investment in creating a healthy society. (Nghiem & Connelly, 2017; Saksena et al., 2011). Providing quality healthcare service to individuals in this COVID situation is a big challenge in most developing countries, like India, with a large diverse population and an equally vast area. Healthcare institutions are responsible for providing various services like disease control and management, health education and prevention, along with medical and nursing facilities for early diagnosis and treatment of different diseases (Ghazban, 2003). Thus, the aim of healthcare institutions is to provide diverse and timely healthcare facilities (Murad, 2006) even in remote locations. The onus on the healthcare institutions and personnel raises manifold when it comes to Covid -19 care in any region. Thus proper attention by the policymakers and planners is required for rendering Covid care services. These services include the availability of primary Covid care centers, location of Covid care centers, population, level of consciousness regarding health issues and health status, their attribute to the available health services, social and economic condition, and also the spatial accessibility to the existing healthcare centers (Ã & Qi, 2009; Luo & Wang, 2003; Oliver & Mossialos, 2004). So, to provide quality healthcare services in this COVID-19 pandemic situation to all residents, it is very important to know the location of all healthcare centers undertaking COVID-19 care. The proper location of healthcare centers provides some knowledge regarding accessibility to a particular healthcare centre for people in a particular place.

Thus, it is imperative for residents to be aware of the locations of various healthcare facilities in their area.

The relationship between the location of COVID-19 healthcare centers and population distribution determines the case fatality rate and recovery rate (Parker & Campbell, 1998; Patel et al., 2007; Sasaki et al., 2010; Walsh et al., 1991). Earlier studies reveal that distance and travel costs play a vital role in rural healthcare services (Ingram et al., 1978; Muller et al., 1998; Tanser, 2000). A study examined the role of distance in health care associability and found it as the most crucial factor in village areas determining accessibility of rural health care (Noor et al., 2005). A study on healthcare service reveals that healthcare service is affected by many factors like financial, behavioral influences, and information (Aday & Andersen, 1974). Another study analyzes the demand of healthcare services by measuring the difference between having access to health centers and gaining access to health centers to overcome the problem mentioned above (Gulliford et al., 2002). Studies have also focused on the spatial distribution of healthcare institutions, transportation cost, system, socio-economic condition of the population, and numbers of doctors available in the healthcare centers to determine healthcare services (Higgs, 2005).

People in rural areas have to undertake long arduous travel to avail themselves for healthcare services compared to those living in urban areas (Al-taiar et al., 2010). The accessibility to healthcare facilities is topic of concern in hilly terrain like that of the present study. Spanning more than the average distance makes people dishearten about healthcare (Brostrom, 2001; Gold, 1998). The distance between the healthcare centers and the demand point with respective travel time is the prime factor in serving people because the mortality rate or case fatality rate increases with increasing travel time and vice versa (Higgs, 2005). Thus, proximity to healthcare centers reduces the effect of Covid-19 virus. Further identification of the service areas of Covid care centers in a region is beneficial for future planning and to provide equal services in underdeveloped region.

According to Ministry of Health and Family Welfare, Govt. of India report of 2021, recovery rate of the state capital of Mizoram is very low while the positivity rate is high in Aizawl district during the second wave compared to the national average. Aizawl, having a remote geographical location is interspersed with rugged hilly terrain. This puts a pressure on the health care services of the district. Thus it is important to study the healthcare facilities of the state and analyze the availability of quality infrastructure, if any, in the state capital. This is important in understanding the loopholes, if any, in the state health care facility which in turn will help in reducing the COVID-19 fatality rate. Thus the present research tries to find out the varied institutions dealing with COVID care, map the same while making detailed database of the infrastructural availability in each of these. This is an innovative study for the study area and the outcome of the study will help planners and policymakers for future planning with regard to such epidemics in future.

**Study area**

Aizawl district (Fig 1) is one of the eleven districts of Mizoram which is situated in the north eastern part of India. This district is bounded by Assam in the North, Manipur in the North East, Champhai district in the East, Serchhip district in the South, Lunglei district in the South West, Mamit district in the West and Kolasib district in the North West. It occupies an area of 3,577 $Km^2$. The headquarter of the district is Aizawl city, the capital of Mizoram. There are 96 villages and 7 towns in this district. The district has mountainous terrain of tertiary rocks. The mountain ranges are inclined north to south in parallel series. The ranges are separated from one another by deep, narrow river valleys. The elevation ranges from 21 metres at Tlabung to 2,157 metres at Phawngpui. There are only a few small patches of flat land, which are mostly intermontane plains. Aizawl is located north of the Tropic of Cancer in the northern part of Mizoram. It is situated on a ridge at about 1,132 metres (3715 ft) above mean sea level, with the Tlawng river valley to its west and the Tuirial river valley to its east. Aizawl has a mild, sub-tropical climate due to its location and elevation. According to Koppen's climatic classification, the region has a humid subtropical climate (Cwa). In summer, the temperatures remains moderately warm, averaging around 20–30 °C (68–86 °F). In winter, the daytime temperature averages between 11–21 °C (52–70 °F). Rainfall is mostly concentrated between April and October, with the heaviest rainfall occurring in May, June, July, August, and September. According to the 2011 census, Aizawl district has a population of 4,00,309 constituting of 1,99,270 male and 2,01,039 female. The population growth rate is 22.92%. The sex ratio is 1009 females per 1000 males, which is higher than the national average. The study region has high literacy rate of 97.89% (2011 census) male literacy at 98.11% and female literacy rates at 97.67%.

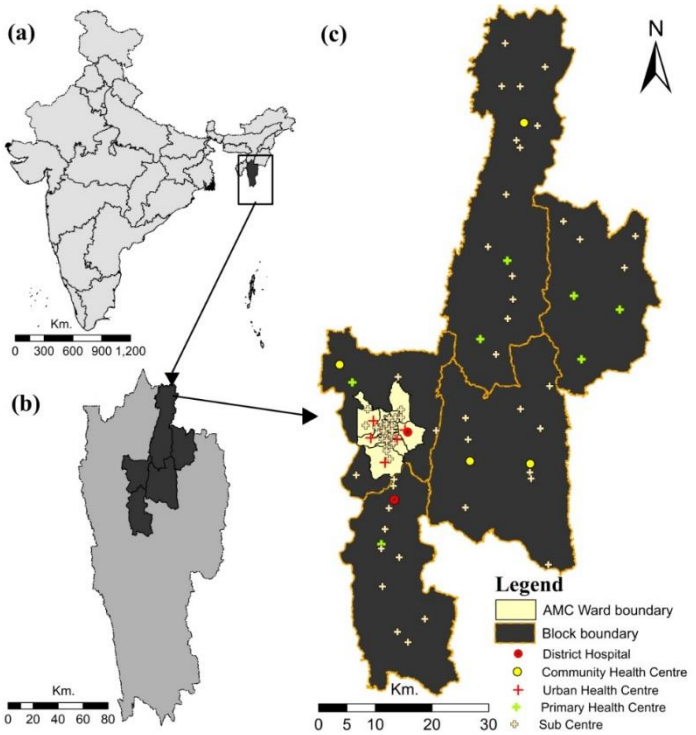


Fig 1. Location of the study area. (a) India, (b) Mizoram (c) Aizawl.

## Materials and Methods

### Data

The present study has been done based on primary and secondary data. Primary data has been collected from various COVID care centers through site visitation and over phone calls. To map the location of different COVID care centers, the authors have collected the coordinates of various Covid care centers using the Global Positioning System (GPS). The secondary data has been collected from IDPR Twitter handles, MoHFW Mizoram, Aizawl East and West CMOH office, e-books and journals. The road network map has been taken from Open Street Map (OSM). Settlement points and medicine shop points have been collected from Google Earth pro. Once the various point data were taken, further analysis was done through Arc GIS software.

### Nearest Neighbor Analysis (NNA)

Nearest neighbor analysis measures the spread or distribution of something over a geographical region (e.g. place). It gives a numerical value which describes the extent to which a set of points are clustered, uniformly distributed or dispersed in nature. After identification of all the healthcare centers and subsequent creation of point features, the nearest neighbor analysis was done between these features to analyze the pattern of healthcare centers undertaking Covid-19 care in Aizawl district. The formula is given in Eq 1-

$$NNA = \frac{adst}{edst} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, 'adst' means actual distance of the healthcare centers and 'edst' means expected distance of the healthcare centers. NNA score <1 indicates clustering pattern and >1 indicates dispersed pattern. 'p' value and 'z' score were computed to fathom whether the value is statistically significant or not. Very low 'p' value (< 0.05) and high 'z' score (> 2.58) indicates statistically significant pattern.

**Recovery Rate**

Recovery rate is a measure to see the prevention of disease. Recovery rate is defined as the number of people recovered from a particular disease divided by total number of confirmed cases in that time period. The recovery rate has been calculated as Eq 2-

$$RR = \frac{Rc}{Cc} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, RR means Recovery rate, 'Rc' means total number of people recovered during particular time period and 'Cc' means total confirmed cases of that particular period.

**Case Fatality Rate (CFR)**

Case Fatality Rate is another measure to find out the intensity of any disease. It is also a measure of destructivity of a disease. Case Fatality Rate is slightly difference from mortality or death rate because mortality rate including all type of deaths of a region among total population of that particular region. But Case Fatality Rate is the proportion of people who die from a specific disease among all individuals diagnosed with the same disease over a certain period of time. It is calculated as Eq 3-

$$CFR = \frac{Dth}{Cc} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, CFR means Case Fatality Rate, 'Dth' means total number of people died from a specific disease during particular time period and 'Cc' means total confirmed cases of that particular period.

**Euclidean distance**

Euclidean distance is the distance between two points in euclidean space. Euclidean space is the length of a line distance among two points. In this study, Euclidean distance is calculated for every Covid healthcare center, medicine shops, settlement point and the roads. It measures real straight line distance estimation between two points in an Euclidean space or along the 'a' axis. It can be calculated using Eq 4-

$$Ed = \sqrt{(a2 - a1)^2 + (b2 - b1)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

But in 'k' dimensional space or in actual-world scenario where every cell has value 'q' for each variable, Pythagoras theorem is difficult to work. So to overcome this problem, Euclidean distance measures the distance between points. This can be calculated using Eq 5-

$$Ed_{ab} = \sum_{m=1}^{k}(q_{ma} - q_{mb})^2 \quad \text{..... (5)}$$

Where, "$ED_{ab}$" is the distance between the points 'a' and 'b' equal to the sum from the first variable (m = 1) to the last variable (k), of the squares of the distance from each dimension.

**Weighted Linear Combined Model (WLCM)**

In this work, the weighted linear combination model is used to determine the weak zone of Covid-19 healthcare services (Parvin et. al. 2021). The weighted linear combination model is a multi-parametric decision model used in multi-criteria evaluation for complex decision-making approaches. Recently WLCM has been widely used to integrate spatial data in geographic information platforms, following the compensatory combination rules (Ghosh & Lepcha, 2018). This model has also been used in other studies, like land-use suitability analysis (Jankowski, 2007), soil erosion suitability analysis (Ghosh & Lepcha, 2018), susceptibility analysis of diseases (Ali, 2019; Ali & Ahmad, 2018). In the present work, the WLCM is used to drive the weak zone map of healthcare centers from spatial datasets. All the supporting raster layers are reclassified with equal intervals, assigned equal weight, and then combined into a healthcare service layer. The weighted linear combined model has been performed using Eq 6-

$$Fw = \sum_{k=1}^{n}(Qk \times Pk) \quad \text{.....(6)}$$

Where: 'Pk' is the selected raster input; 'Qk' is the weight value of deciding factor 'k' and 'n' is the number of selected criteria for decision making.

**Result and Analysis**

**Analysis importance of healthcare centers location in healthcare service**

The right location of healthcare institutions affects the health quality and health system of any region, particularly in mountainous regions. Having the right location of healthcare institutions will serve a quality health service during this COVID-19 pandemic situation. The correct location of a healthcare facility is where a patient's satisfaction and treatment success is met. Healthcare is becomes indirectly proportional to distance from patient location. Thus the location of the healthcare institutes within easy access decreases the fatality rate during epidemics (in this case COVID-19). In the present research, different healthcare centers related to the COVID-19 pandemic in Aizawl district have been classified into four categories (Table.1). The classification hierarchy is – DCH (Dedicated Covid Hospital), DCHC (Dedicated Covid Health Centre), CCC (Covid care center), and CCCC (Community covid care center). CCC has been further sub divided as free CCC, Paid CCC and CCC for Forces and Company Workers only. In Aizawl district, only one dedicated COVID hospital is available- as Zoram

Medical College. The first three categories are maintained by the Aizawl state government, but 4C is maintained by the respective local task force and the indigenous system of 'Young Mizo Association (YMA)'. DCHCs are the different Primary Healthcare Centers. In mountainous region due to rugged topography, high slopes, and elevation, scattered settlements are found in different small villages of Aizawl district, excluding the municipality area. The people living in the villages of Aizawl invariably face more problems during the pandemic time owing to their far flung location and difficult terrain which restricts transportation and movement. Further, during the lockdown period, individual localities were sealed from any inbound or outbound movements by respective task force hindering treatment.. Thus, COVID-19 affected people from these small villages suffered the most than their urban counterparts. However to help the rural folks, the respective task forces along with state medical officials set up Community Covid Care Centers (4c) in almost all the villages by occupying the various educational institutions, community (*Kohran*) Hall, Lodges, and Health Sub Centers.

Table 1
Types of healthcare institutions undertaking Covid-19 healthcare in Aizawl district

| Sl. No. | Facility level | Total No. of Centers | Percentage Share of Centers | No. of Centers in Aizawl East | No. of Centers in Aizawl West | Total No. of Beds | Percentage Share of Beds |
|---|---|---|---|---|---|---|---|
| 1 | DCH | 1 | 0.60 | 0 | 1 | 360 | 6.62 |
| 2 | DCHC | 8 | 4.76 | 2 | 6 | 148 | 2.72 |
| 3 | CCC | 10 | 5.95 | 3 | 7 | 767 | 14.11 |
| 4 | CCC (Forces & Company Workers) Paid | 3 | 1.79 | 3 | 0 | 130 | 2.39 |
| 5 | CCC | 1 | 0.60 | 1 | 0 | 15 | 0.28 |
| 6 | CCCC | 145 | 86.31 | 70 | 75 | 4017 | 73.88 |
| Total | | 168 | 100 | 78 | 90 | 5437 | 100 |

*Source:* DIPR, Mizoram as on 01.03.2022

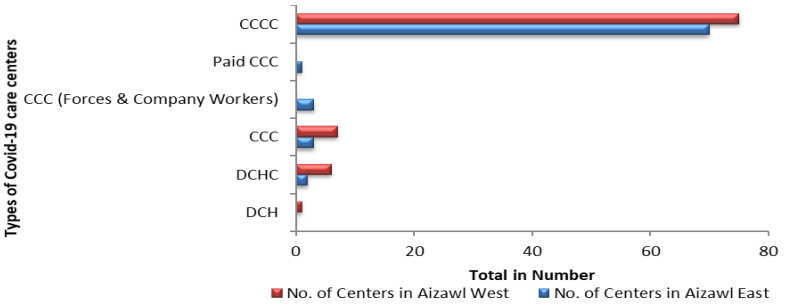


Fig 2. Different Covid -19 healthcare centers share under Aizawl East and Aizawl West CMOH

Area-wise, the Covid-19 healthcare services of Aizawl district were divided into two sub-parts Aizawl East and Aizawl West CMOH. From Fig 2, it is evident that DCHC and 3C are greater in number under Aizawl West CMOH. A total of 168 healthcare institutions have been undertaking Covid-19 pandemic care in Aizawl district, of which Aizawl West has 90 centers (53.57 %) and Aizawl East having 78 (46.43 %) centers (Table 1).

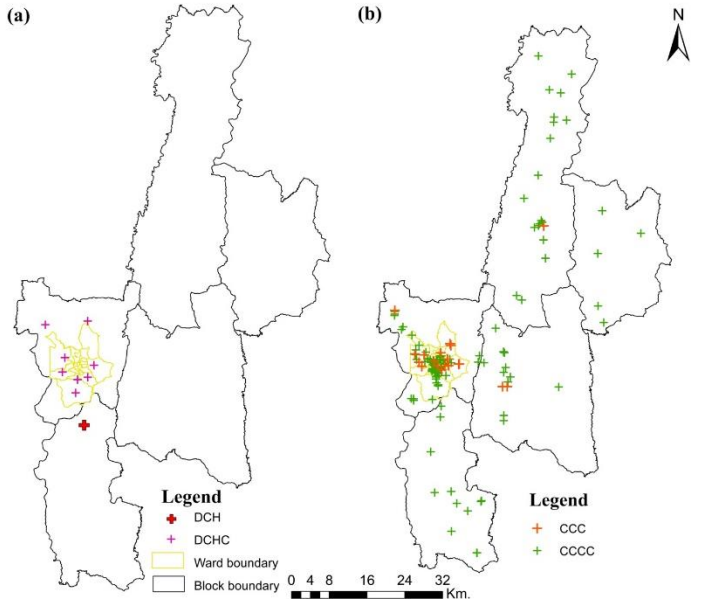


Fig 3. Location map of different types healthcare institutions undertaking Covid-19 in Aizawl district

**Nearest Neighbor analysis of Healthcare institution undertaking Covid-19 pandemic care**

Nearest Neighbor Analysis (NNA) was performed to show the distribution pattern of healthcare centers undertaking Covid-19 pandemic in Aizawl district. Owing to mountainous terrain and lack of transportation frequency, it is quiet challenging for the Covid-19 affected people to undertake long and arduous journey to the healthcare institutions.

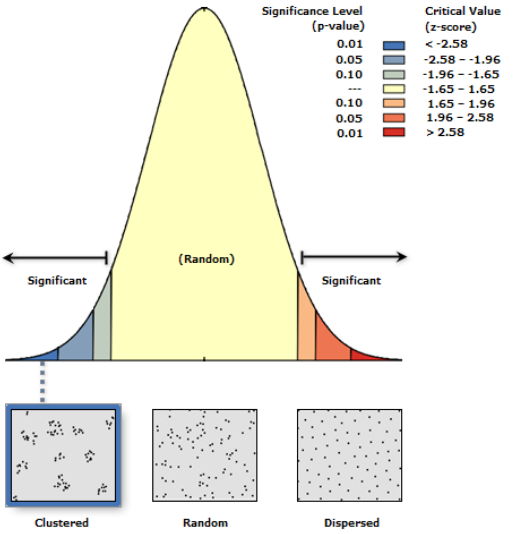


Fig 4. Nearest neighbour summery for the Covid-19 healthcare centers

Table 2
Average Nearest Neighbor statistics

| | |
|---|---|
| Observed Mean Distance: | 1265.34 Meters |
| Expected Mean Distance: | 2615.38 Meters |
| Nearest Neighbor Ratio: | 0.483 |
| z-score: | -11.97 |
| p-value: | 0.00 |

From the Nearest Neighbor Analysis statistics for the healthcare centers it is clearly found that the observed mean distance is 1265.34 meters whereas the expected mean distance is 2615.38 meters (Table 2). The 'p' value and 'z' score indicates statistically significant and insignificant result. Very less 'p' value (<0.05) with high 'z' score value (>2.58) indicates statistically significant pattern and vise-versa. Here the z-score of -11.97 and p value '0' indicates statistically significant pattern (Table 2). The Nearest Neighbour Ratio is 0.483 which means that the distribution pattern of Covid care centers is clustered in nature. Fig 3 is showing that the clustering nature is found within Aizawl municipality region (the urban part of the study area). Only some 3C and 4Cs are dispersedly found in Aizawl district (Fig. 3). But the overall pattern of healthcare centers undertaking Covid-19 pandemic is statically significant as clustered in nature (Fig 4).

**COVID-19 scenario in Aizawl district**

In Aizawl district the whole Covid-19 healthcare system is controlled by two health departments, one is Aizawl East CMOH and other is Aizawl West CMOH. In this sub-point the researchers have examined certain statistics related to Covid-19 scenario of Aizawl district - recovery rate, case fatality rate of each institutions,

percentage distribution of Covid beds, admitted people, recovered people and deaths in different types of Covid care institutions. Fig 5 is showing the trend of daily Covid-19 cases in Aizawl district. It is evident that April 2021 onwards (during the second wave) the daily confirmed cases have been increasing which decreased in December 2021 owing to vaccination but again suddenly increased in January and February 2022 due to the effect of Delta variant of Covid-19 (Fig.5). The same trend has been found for the daily Covid-19 recovered cases and daily death (Fig.5).

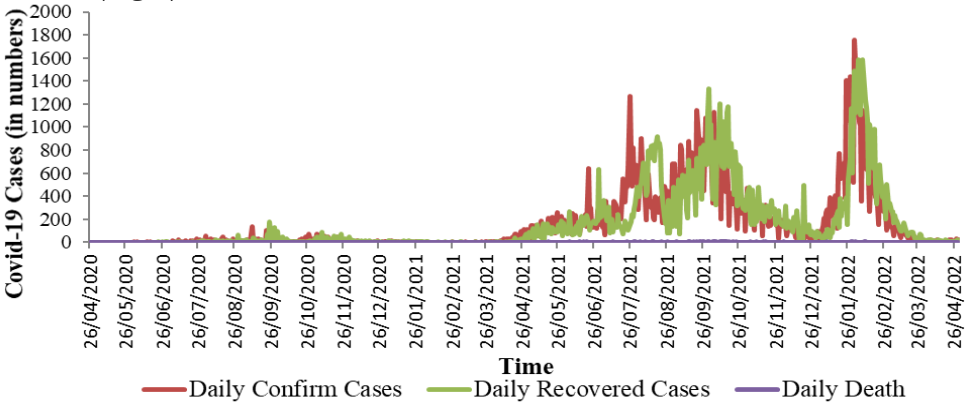


Fig 5. Trend of Covid -19 cases in Aizawl district from 26.04.2020 to 30.04.2022

Fig 5 shows the percentage distribution of (a) Covid beds, (b) admitted patients, (c) recovered patients and (d) deaths in different types of healthcare institutions. 73.88 % of beds have been shared by CCCC whereas 16.77 % bed was shared by CCC and only 6.62 % bed has been shared by DCH (Fig 6). In case of hospitalization of Covid confirmed cases, maximum people have been kept under home isolation (57.01%) whereas only 13.35 %, 1.44 %, 10.08 % and 18.12 % people had been admitted in DCH, DCHC, CCC and CCCC respectively (Fig.6). In case of recovery, maximum people have recovered while in home isolation which is 56.85 %. In Aizawl district 12.99 %, 1.44 %, 10.31% and 18.41% people recovered while under the care of DCH, DCHC, CCC and CCCC respectively (Fig.6). However, maximum percentage of deaths has occurred in DCH and home isolation which is 96.15 % and 3.45 % respectively of the total deaths (Fig.6).

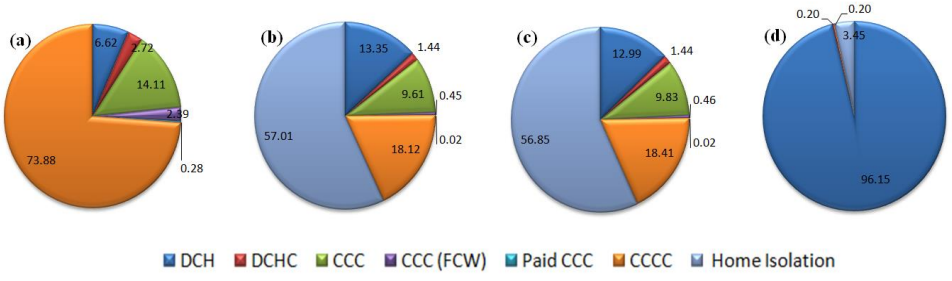


Fig 6. Percentage distribution of (a) Covid beds, (b) admitted patients, (c) recovered patients and (d) deaths in different types of healthcare institutions

Covid care institution wise recovery rate and case fatality rate have also been analyzed. Recovery rate is defined as the ratio between the total numbers of

people who recovered from Covid-19 with that of total number of people affected by Covid-19. The Case Fatality Rate (CFR) is somehow different from general mortality rate, In case of CFR we have only considered people who died due to a particular disease and divided it by the total number of people affected by that particular disease. Fig 7 and 8 shows the recovery rate and case fatality rate of different types of Covid care institutions. From Fig 7, it is clearly seen that the recovery rate in DCH and DCHC is 94.57 % and 97.06 % respectively. In case of all CCC excluding paid and force reserved, the recovery rate is 99.44 % (Fig.7). The recovery rate is 100 % for paid CCC and CCC for forces and company workers (Fig.7). In case of home isolation and CCCC, the recovery rate is 98.75 % and 96.93 %. The overall recovery rate for whole Aizawl district is 97.20 %.

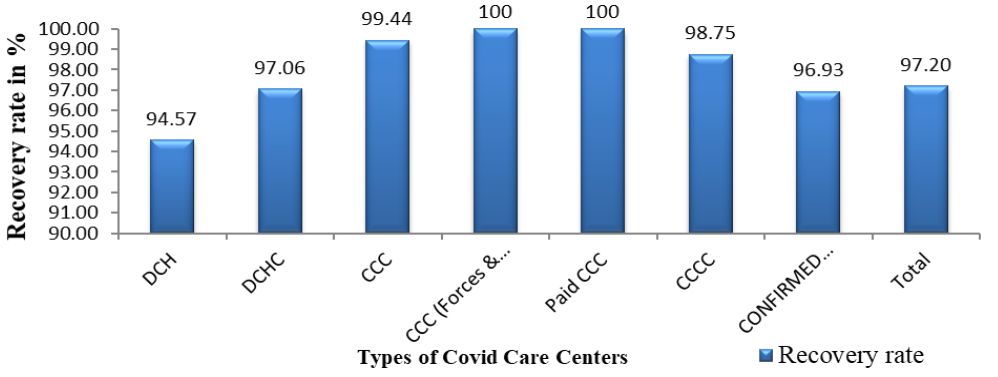


Fig 7. Recovery Rate in different types of Covid care institutions in Aizawl district

From Fig 8 it is clearly seen that the case fatality rate in DCH and DCHC is 4.18 % and 0.08 % respectively. In case of all CCC including paid and force reserved, the case fatality rate is 0 % (Fig.8). In case of home isolation and CCCC the case fatality rate is 0.01 % and 0.04 percent. The overall case fatality rate for whole Aizawl district is 0.58 %.

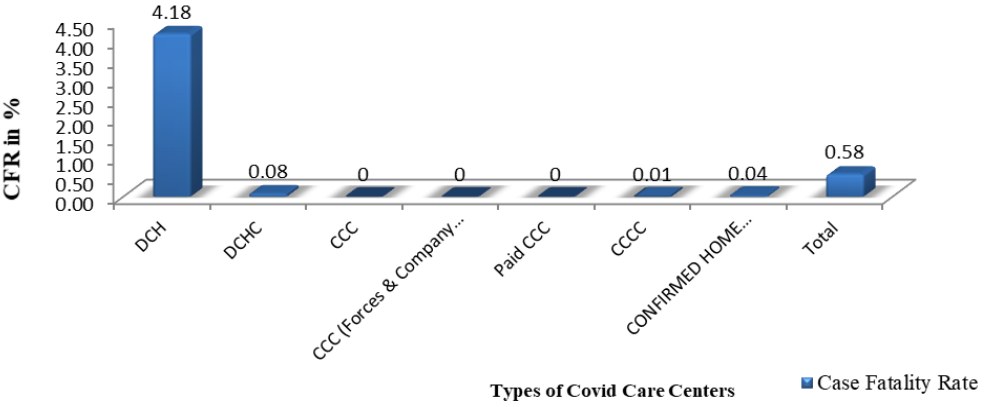


Fig 8. Case Fatality Rate in different types of Covid care institutions in Aizawl district

The detailed Covid-19 summary has been shown in Table 3

Table 3
Summary of dedicated Covid-19 scenario

| Sl. No. | Facility level | Total No. of Beds | Cumulative No. of Isolated patient (till date) | New Admissions | No. of Discharged | Cumulative No. of Discharge (till date) | No of Death during reporting Period | Cumulative No. of Death (till date) | No. of Presently Isolated | No. of Presently Isolated at ICU | No. of Vacant Beds | Recovery rate | Case Fatality Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DCH | 316+44 ICU | 11345 | 13 | 27 | 10729 | 0 | 474 | 142 | 12 | 174 | 94.57 | 4.18 |
| 2 | DCHC | 148 | 1224 | 3 | 14 | 1188 | 0 | 1 | 35 | _ | 113 | 97.06 | 0.08 |
| 3 | CCC | 767 | 8167 | 11 | 21 | 8121 | 0 | 0 | 46 | 0 | 721 | 99.44 | 0 |
| 4 | CCC (Forces & Company Workers) | 130 | 383 | 0 | 0 | 383 | 0 | 0 | 0 | 0 | 130 | 100 | 0 |
| 5 | Paid CCC | 15 | 19 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 15 | 100 | 0 |
| 6 | CCCC | 4017 | 15403 | 9 | 18 | 15211 | 0 | 1 | 191 | 0 | 3826 | 98.75 | 0.01 |
| 7 | CONFIRMED HOME ISOLATION | | 48460 | 17 | 25 | 46974 | 0 | 17 | 1454 | | | 96.93 | 0.04 |
| | Total | 5437 | 85001 | 53 | 105 | 82625 | 0 | 493 | 1868 | 12 | 4979 | 97.20 | 0.58 |

Source**:** DIPR, Mizoram as on *01.03.2022*

**Equipment and other infrastructural details in Covid care health care centers**

To provide quality healthcare during Covid-19 pandemic, necessary equipment and other related quality infrastructure is mandatory. There is no scope of compromise with quality equipments and good infrastructure. In future to provide quality healthcare services it is vital to know the present infrastructure and equipment details for further improvement. So a database has been prepared regarding the available infrastructure and equipments for each type of Covid care health center (Table 4).

Table 4
Summery of infrastructural availability in healthcare institutions undertaking Covid-19 pandemic in Aizawl East and West

| Types of facility* | DCH(N=1) | | DCHC (N=8) | | CCC (N=14) | | CCCC (N=145) | |
|---|---|---|---|---|---|---|---|---|
| | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) |
| Doctor | 100 | 0 | 100 | 0 | 100 | 0 | 60 | 40 |
| Nurse | 100 | 0 | 100 | 0 | 100 | 0 | 62.76 | 37.24 |
| Others Health Worker including Group-D | 100 | 0 | 100 | 0 | 78.57 | 21.43 | 32.42 | 67.58 |
| PPEs | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| N95 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| FFP2 | 100 | 0 | 25 | 75 | 21.43 | 78.57 | 0 | 100 |
| O2 cylinder | 100 | 0 | 100 | 0 | 78.57 | 21.43 | 40 | 60 |
| O2 concentrator | 100 | 0 | 100 | 0 | 100 | 0 | 95.17 | 4.83 |
| Gloves | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Sanitizer | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Face sheild | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |
| Medicines | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ICU Beds | 100 | 0 | 0 | 100 | 0 | 100 | 0 | 100 |
| Ventilators | 100 | 0 | 12.50 | 88.89 | 0 | 100 | 0.69 | 99.31 |
| Free of Cost treatment | 100 | 0 | 25 | 75 | 7.14 | 92.86 | 11.03 | 88.97 |

Source: MoFHW, Mizoram. *Data as on 01.03.2022

Table 4 summarizes the infrastructural and equipment availability of the study region. The tabulated information spans as :(a) number of doctor available, (b) number of nurses and other health workers including Group –D, (c) number of PPEs, N95 mask, FFP2 mask, O2 cylinder and concentrator availability, number of gloves, sanitizer, face shield, ICU beds, Ventilators, Medicines received (Table 4). The cost of covid treatment has been also represented here. In these healthcare centers all covid related treatment is free for below poverty level (BPL) people however patients not under BPL need to pay only medicine cost. However there are certain healthcare centers where all covid related treatment is free for both BPL and above patients. From Table 4 it is clearly understood that in all the DCH, DCHC and CCC doctor is available but in 60 % CCCC doctor is available. Nurses are also available in all types of covid care centers excluding CCCC.

In 62.76 % of the CCCC's nurses are available. PPEs, Gloves, Sanitizer, Medicines and Face Shield are received by all types of covid care centers (Table 4). Only in Zoram Medical College and Hospital (DCH) all types of Covid-19 facilities are available including ICU beds and ventilators system (Table 4). FFP2 mask is distributed in DCH (100%), DCHC (25%), CCC (21.43%) and CCCC (0%) among the total numbers of each type covid care centers (Table 4). ICU bed is only available in DCH. Only 12.5% of DCHC and 0.69% of CCCC have ventilator systems, while no CCC in Aizawl district has a ventilator facility (Table 4). Cylinder and concentrator are the most necessary equipment for COVID care. In Aizawl district, 78.57% of CCC and only 40% of CCCC have $O_2$ cylinders (Table 4). $O_2$ concentrators, on the other hand, are available in all DCH, DCHC, and CCC. The $O_2$ concentrator is present in 95.17% of all CCCC.

**Analyzing different type healthcare service zone**

The aim of this research is also to analyze the different types of healthcare service zones in terms of providing healthcare services and undertaking COVID-19 pandemic in Aizawl district. The strong and weak zones of healthcare facility in Aizawl district could be identified through this analysis. Good and quality healthcare service during the COVID-19 pandemic depends on various factors, such as: location of the source point, location of the demand point, distance from the road, distance from medicine shops, and vaccination center (Fig 9). These are all the qualitative factors for providing quality healthcare services during the COVID-19 pandemic in Aizawl district. There are various methods to determine the strong and weak zones in terms of providing quality healthcare services in a region, e.g., the floating catchment area method (FCA), the analytic hierarchy process (AHP), and the weighted linear combined model (WLCM). In this present study, we used WLCM since all the factors have equal importance in providing quality healthcare service for COVID-19 in Aizawl district.

Distance is measured as distance to healthcare centers (all Covid-19 undertaking healthcare institutions), distance to roads, and distance to medicine shops and vaccination centers. The low value of these factors indicates high accessibility and vice versa. The low value of the Euclidean distance indicates that people need to cover minimum distances to avail Covid care service. Higher value indicates that people must travel more (distance wise) to access COVID-19 health facilities (Fig. 9). Simple weighted method was applied to all the factor layers in Arc GIS environment. The 5 point scale has been used to reclassify the factors, where 1 indicates a very high facility providing zone and 5 indicates a very low facility providing zone or very weak zone. Here, figure 9 clearly shows the driving factors which affect the COVID-19 healthcare facility in Aizawl district.

In the present study of healthcare service provision, the district has been classified into five different categories, e.g. Very high, High, Medium, Low and very low health care service providing area (Fig 10). Place having the facilities of medical institutions, medicine shops, and vaccination centers fall under very high healthcare facility providing zone. In Aizawl district only some of the villages which are located near the city limits are coming under 'very high and high' Covid healthcare service. Fig 10 shows that maximum villages of the study area fall under medium and very low healthcare facility zone.

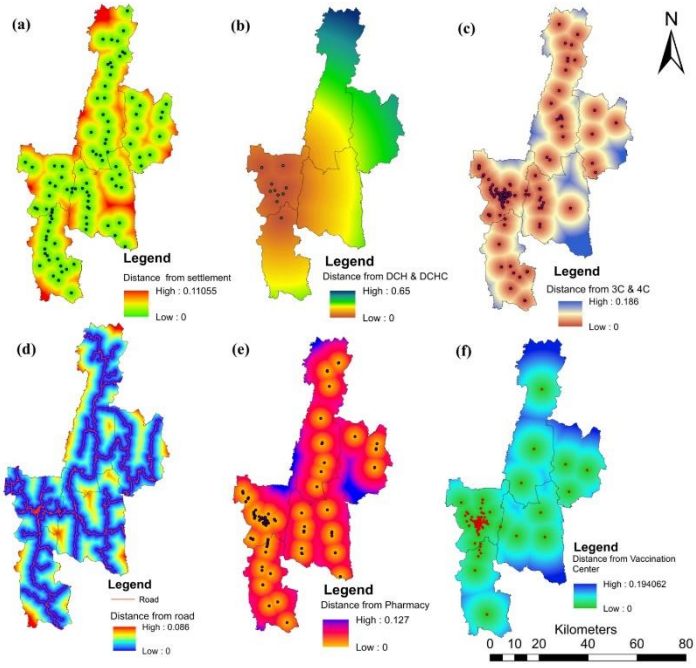


Fig 9. Driving factors affecting the Covid-19 healthcare system

Very high facility zone is found to be in and around the Aizawl municipal area where maximum numbers of DCHC, CCC, CCCC, medicine shops and Covid-19 vaccination centers have been found. The facility goes on decreasing with distance from the main city area limits (Fig 10).

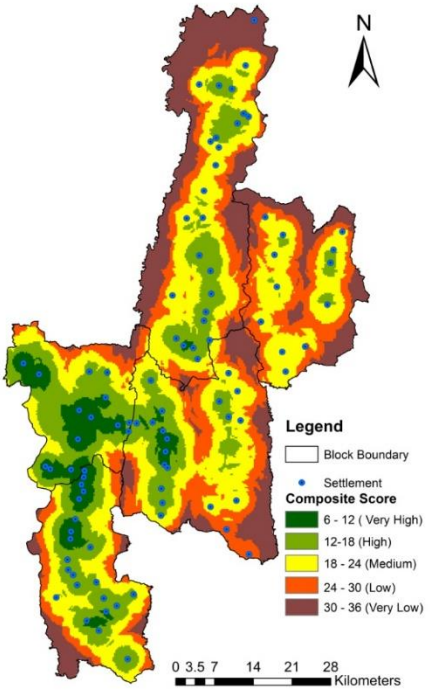


Fig 10. Healthcare facility zone undertaking covid-19 in Aizawl district

Table 5 shows the percentage distribution of areas of different Covid-19 healthcare facility providing zone. The study shows that only 7.94 % area falls under very high Covid-19 healthcare facility zone (Table 5).

Table 5
Area covered by different Covid-19 care facility zone

| Healthcare Facility Zone | Area in Percentage |
|---|---|
| Very High | 7.94 |
| High | 18.65 |
| Moderate | 34.06 |
| Low | 14.43 |
| Very Low | 24.92 |

Source: Computed by the author

Only 18.65 % and 34.06 % of the total study area comes under high and moderate Covid-19 healthcare facility zone respectively (Table 5). The areas which are far from the main city of Aizawl and are located towards the periphery of the Aizawl district falls under low to very low healthcare facility providing zone. Overall observation suggests that the healthcare facility for Covid-19 treatment in Aizawl district varies between medium to low zone category.

**Discussion**

Many scholars have studied different factors to measures healthcare service zone. After careful observation and extensive study, we selected some factors, e.g. (1) spatial distribution and numbers of medical institutions, medicine shops (2) infrastructure availability (3) transport facilities (road) which affect the healthcare accessibility and (4) distance between demand and service point. A study in South Africa reveals the relation between population density and the required number of medical institutions (Mokgalaka, 2014). The study shows that only 10 % population's demand was fulfilled by the existing healthcare services as those are situated in the high and middle-income groups of low-density areas (Mokgalaka, 2014). A study on healthcare service zone in Khuzestan province, South-west Iran, focuses on the infrastructure of healthcare centers and the geographical condition of that place which concludes distribution of healthcare centers have impacts on healthcare service zone (Mohammadi, 2016). A study reveals that most of the districts of the central part of India, districts of the north-eastern part of India are highly vulnerable to Covid-19 (A. Sarkar & P. Chouhan, 2021). Kiadaliri et al. 2011 showed the effective differences in the distribution of health centers in different parts of Iran impacting accessibility. Spatial location is another factor that hinders the quality of health services (Mehryar et al., 2005).

In this present study, we found that maximum Covid care centers are located in Aizawl municipality areas which have impacted the Covid care service. The infrastructural availability in DCH and DCHC is good compared to the other centers. Study revealed that the CCC's and CCCC's have very less number of oxygen cylinder, and concentrators. Except DCH, no ICU beds and ventilators system has been found in other Covid Care centers. For this infrastructure unavailability in other type Covid Care Centers except DCH, only non-critical patients have been treated in DCHC, CCC and CCCC. All critical patients are referred to DCH for better treatment where case fatality rate is 4.57 %. The data signifies that except one DCH located in Aizawl city, all other COVID-19 health care centers distributed in the other parts of the study area are incapable of handling critical patients. This clearly indicates the pressure on the sole DCH of the entire district. Only the city limits fall under the very high and high service zone.

Much of the far flung villages of the study area are located in the hill tops of ridges since Mizo community prefer to stay in high land areas from where there is a dearth of all-weather road and transportation service to the city. The problem becomes more acute during rainy season (the study area has 07 months as rainy) and after evening. Villages, coming under low to very low Covid care service zones, are the worst sufferers. Kanki village of Darlawn block falls under weak zone category of Covid-19 healthcare facility. There are also some villages of Phullen block which falls under the weak zone category. The names of these villages are North Khawlek, Luangpawn, Zawngin, Buhban, and Daido. Similarly in Thingsulthliah block some villages fall under low to very low zone category in terms of providing Covid-19 healthcare services, which are Lenchim, Maite and Tawizo. This is because of the lack of a proper transport system and distance from Covid-19 healthcare centers and other necessary facilities. Thus it can be

said that Aizawl district lacks a whole some Covid healthcare service and suffers from intra-regional infrastructural dearth.

## Conclusion

Addressing a newly emerged pandemic is a challenging task. Where data is not structured and available in such conditions, exploring Covid healthcare service areas and the pattern of Covid care centers require the use of GIS technique. In this present study, the researchers used the Geographic Information System (GIS)-based hybrid decision-making approach to access the different areas of Covid healthcare services. All the factors affecting accessibility were considered for analysis, e.g., distance, location, transport, source and destination, etc. This study aimed to identify the deprived and inaccessible COVID healthcare service areas. The Weighted Linear Combined Model (WLCM) helped to determine the inaccessible spatial areas in the Aizawl district. The medium, low and very low areas have suffered from critical problems during the COVID-19 pandemic because of their location, distance and inadequate infrastructure. So, to provide equal health services in this district, different plans and policies should be taken by the government and policymakers.

The government should focus on the development of new medical institutions in medium-, low-, and very low-income areas along with the far flung block of the study area. Owing to mountainous topography and weather condition, transportation and road network is a perennial problem of Aizawl district, particularly in the distant settlement clusters. The transport system of those areas should also be developed and revamped through the construction of roads and upgrading the un-metalled roads into all-weather roads which can connect people with health centers. Further the infrastructural facilities of the present COVID-19 specified heath care centers are in dire need of development of their infrastructural facilities. Focus should be given on overhauling the present DCHC, CCC (3C), and CCCC (4C) to DCH standards so that much of the area which is now under weak zone category of Covid-19 healthcare facility can be changed to moderate to high zone since providing proper healthcare is the duty of every government and availing timely and adequate healthcare is the need of every citizen. Finally, more research is needed for a more comprehensive outcome in this region to deal with such pandemic type situation in future.

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