

# Evaluation and Construction of Medical Facility Life Circle for "Epidemic Grading Response": A Case Study of Guandu District, Kunming

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**Abstract:** This study takes the main urban area of Guandu District in Kunming City as the research object. Based on the assumption that residents tend to choose the nearest medical facilities, and using network map data, official statistical data, and field research data, the point axis system theory and the core theory of life circle are introduced to comprehensively evaluate the medical facilities in Guandu District from three dimensions: space, time, and society. By using ArcGIS kernel density analysis, cost distance analysis, and location allocation analysis, the current layout status of existing medical facilities in Guandu District was analyzed. The problems of uneven spatial distribution of large comprehensive hospitals and incomplete coverage of primary medical facilities in Guandu District were identified, and a "graded response to the epidemic" living circle model was proposed and constructed. An emergency response system model for sudden public health emergencies in Guandu District was developed, and epidemic prevention routes were formulated for major facilities and areas. Targeted optimization suggestions were proposed for five types of medical facilities, including "new construction, urgent renovation, long-term renovation, not included in planning, and planned reuse". To provide reference for the planning of the emergency response system for public health emergencies in Guandu District, including ensuring sufficient pre hospital space, improving the construction of fever clinics and pre screening triage, planning parking spaces reasonably, and fully considering the combination of epidemic prevention and control.

**Keywords:** Normalization of the Epidemic; Medical Facilities; Response to Epidemic Classification; Core Theory of Life Circle; Guandu District; Kunming City.

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## 1. Introduction

At present, the evaluation of medical facility service coverage in China often ignores factors such as transportation networks and population distribution, which does not match the demand for urban medical and health facility layout and emergency response capabilities due to the normalization of the epidemic. The complex transportation environment in Guandu District, Kunming City has a significant impact on residents' travel ability and modes, increasing the difficulty of medical facility service coverage. Traditional methods are difficult to accurately evaluate it. On the basis of analyzing and comparing the advantages and disadvantages of existing research methods on medical accessibility, this article assumes that residents tend to choose the medical facilities closest to them, and evaluates and optimizes medical facilities in the main urban area of Guandu District, Kunming City [1].

## 2. Related Definitions

### 2.1. Research Scope

Guandu District is located in the eastern part of Kunming City and is an important component of the city. The scope of this study is the main urban built-up area of Guandu District, north to Hongqiao Road and Airport Expressway, south to Huanhu East Road and South Ring Expressway, west to the administrative boundary of Guandu District, and east to the current built-up area of Ala Street in Kunming Economic and Technological Development Zone, with a total area of approximately 138.73 square kilometers.

### 2.2. Research Object

The medical and health institutions studied in this study include four categories: hospitals within the research scope (including general hospitals and specialized hospitals), primary medical and health institutions (including community health service centers and stations), professional public health institutions (including disease control centers, maternal and child health hospitals, emergency centers), and other medical and health institutions [2]. This includes defining the conceptual scope of medical and health facilities, setting requirements for grading and classification, and evaluating and analyzing the layout and setting of medical and health facilities. As the regional center for providing public services, the built-up area of Guandu District's main city not only serves the permanent population of the central urban area, but also radiates all urban and rural populations within the administrative jurisdiction and even the whole province. Therefore, the study emphasizes the calculation and analysis of service allocation based on the actual space of medical and health facilities, which is conducive to alleviating the space shortage problem of designated hospitals during the outbreak of the epidemic.

### 2.3. Research Data and Methods

(1) The research data mainly includes: 1) traffic situation data obtained through Gaode Map (averaged data from May 14th, May 30th, and August 30th, 2021); 2) POI data of medical facilities in Guandu District obtained through software such as Amap and Bigemap; 3) Socio economic statistical data and related planning.

(2) This study constructs a technical roadmap based on the collection of current data and planning concepts. The framework is divided into three parts: research overview, main research content, and optimized construction. The current layout of medical facilities in Guandu District under the normalization of the epidemic is analyzed from the

dimensions of time, space, and society. With the help of accessibility analysis and kernel density analysis methods, the relationship between medical facilities, transportation stations, and parking lots in Guandu District is evaluated. Based on this, optimization suggestions for the construction of emergency medical system are proposed.

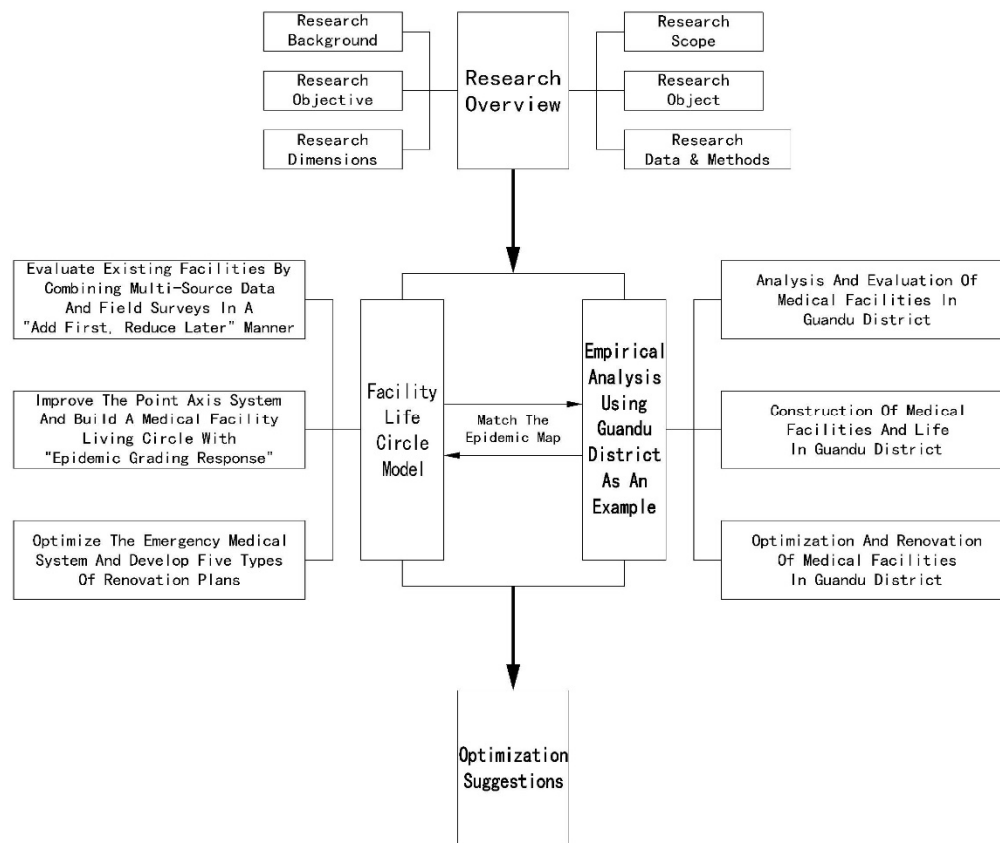


Fig 1. Study Technical Roadmap

### 3. Construction of a Medical Facility Life Circle Model for "Epidemic Grading Response"

#### 3.1. Evaluate Existing Facilities by Combining Multi-Source Data and Field Surveys in A "Add First, Reduce Later" Manner

This study used Gaode's open platform and two development tools, search API and traffic situation, to obtain medical facilities and traffic situation data. Based on field surveys and online research, the current distribution of medical facilities was evaluated and analyzed.

'Add' refers to comparing the obtained basic POI data with the actual situation of medical facilities after field research, and supplementing the incomplete basic POI data.

'Reduction' refers to the screening and cleaning of supplementary current data in accordance with relevant requirements for epidemic prevention and control, removing medical facilities that are not suitable for epidemic prevention and control, and retaining only various hospitals, community health service centers (stations), and disease prevention and control centers.

On this basis, according to the site survey, the hospital level, geographical location, entrance width, arrival mode, fever clinic, nucleic acid detection, pre hospital space, COVID-19

vaccine, immunization vaccine and parking space are analyzed and evaluated as the basis for the classification of current medical facilities.

#### 3.2. Improve The Point Axis System and Build a Medical Facility Living Circle with "Epidemic Grading Response"

This study focuses on the layout of medical facilities. Based on the point axis system theory, it integrates the core theory of the life circle, emphasizes the need for human needs as the guide, and constructs a "graded response to the epidemic" life circle model.

The construction path of the "epidemic grading response" life circle model includes two levels: firstly, defining the circle of the medical circle, and defining the coverage range of each level of medical circle by collecting location data from various community hospitals, comprehensive hospitals, specialized hospitals, etc; Then, by laying out and optimizing medical facility projects within the circle, improving transportation conditions, etc., we ensure the reasonable distribution of medical facilities in space, and enhance residents' medical needs and travel convenience.

The life circle model of "epidemic grading response" includes three levels: the daily service circle (5-minute) is the most important circle that residents come into contact with in

their daily lives, mainly for basic diagnosis and treatment and chronic disease management; The emergency buffer zone (15 minutes) should be equipped with a fever clinic and have the

function of nucleic acid sampling; The strategic reserve circle (30 minutes) is mainly composed of designated hospitals, supplemented by makeshift hospitals.

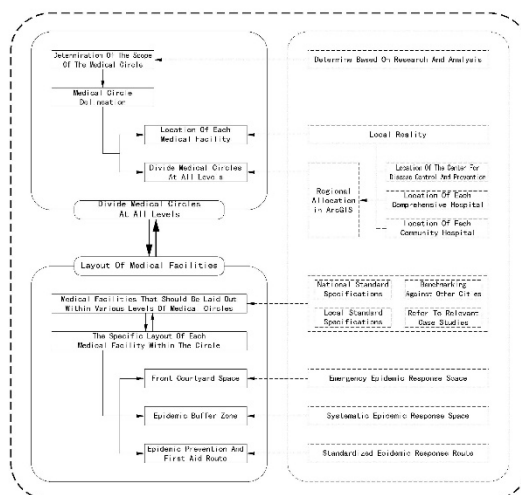


Fig 2. The construction path of the life circle model of "epidemic grading response"

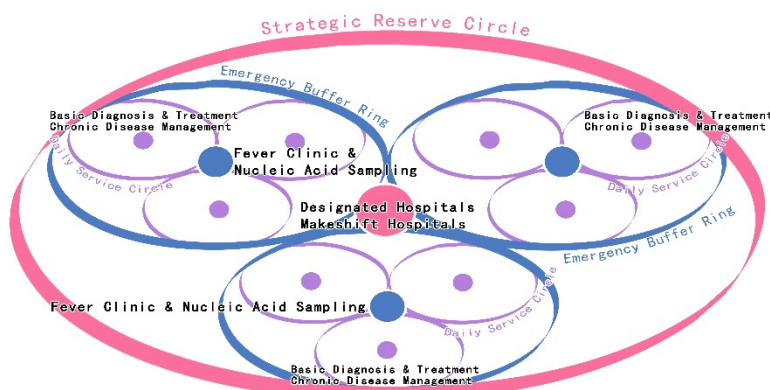


Fig 3. Schematic diagram of the "Epidemic Grading Response" Life Circle Model

### 3.3. Optimize the Emergency Medical System and Develop Five Types of Renovation Plans

According to the experience of China's great achievements in the prevention and control of the COVID-19 epidemic, the emergency medical system is guided by three main bodies: community monitoring, hospitals and disease prevention and control centers. The three major entities each perform their respective duties, divide labor and cooperate to do a good job in emergency response to public health emergencies [3].

The study proposes setting up emergency epidemic prevention nodes in places with sufficient front space, such as large sports venues, exhibition centers, and some home logistics parks. Emergency epidemic prevention nodes should meet the conditions of sufficient pre hospital space, available space, and reasonable pre hospital space. Normally fulfilling its facility function, it serves as a temporary vaccination and observation area in the city during the outbreak of the epidemic, allowing residents to receive vaccines in the shortest possible time and reducing the risk of other infections.

Based on the comprehensive scoring of the current situation survey, four levels of medical points are designated, and five types of renovation plans are formulated according to the classification, including new construction, urgent renovation, relocation, exclusion from planning, and reuse.

## 4. Empirical Analysis

### 4.1. Analysis and Evaluation of Medical Facilities in Guandu District

#### 4.1.1. Medical Facility Data Collection and Screening

The research team collected and screened POI data of medical facilities in Guandu District through a "first add, then subtract" approach, and further verified the current status of medical facilities in Guandu District through on-site inspections.

(1) Add: Compare the obtained basic POI data with the actual situation of medical facilities in Guandu District after field research, and add missing basic POI data. Through on-site investigation, Yunnan Kunhua International Hospital, Yunnan Traditional Chinese Medicine Hospital (Yunnan Ethnic Medicine Hospital), Kunming Sanbo Brain Hospital, Yunnan Maternal and Child Health Hospital (Yunnan Women and Children's Hospital), and Kunming Guandu District Rehabilitation Hospital were newly added from north to south.

(2) Reduction: In accordance with the relevant requirements of epidemic prevention and control, various hospitals, community health service centers (stations), and disease prevention and control centers have been retained, and data from various eye clinics, private clinics, physical examination institutions, obstetrics and gynecology

specialized hospitals, and pharmacies in Guandu District that are not suitable for inclusion in the emergency epidemic prevention system have been deleted.

(3) The main urban built-up area of Guandu District has a total of 3 disease control centers, 9 comprehensive hospitals, 5 specialized hospitals, 2 maternal and child health hospitals, 23 community health service centers, and 64 community health service stations.

Overall, the medical facilities in Taihe, Wujing, and Guanshang streets in the northwest of the main urban built-up area of Guandu District, as well as the Century City and Sports City areas in the central part, are more densely distributed, while there are fewer medical facilities in the north and a lack of medical facilities in the northeast and south regions. Among them, the space of comprehensive hospitals is mainly distributed in the northwest region, extending from the northwest to the southeast, and lacking in the west, south, and northeast; Community health service centers are mainly

distributed in the central, western, and northern regions, with a lack in other areas; There are numerous community health service stations, mainly located in the central and western areas of the built-up area of Guandu District, with sparse distribution in the Ala Street in the northeast.

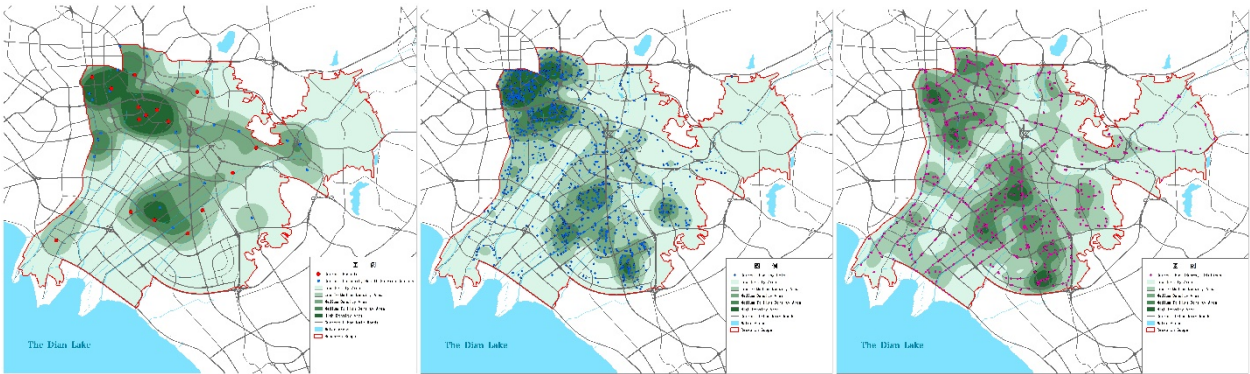
#### 4.1.2. Comprehensive Assessment of Current Situation Based on Spatiotemporal Data

##### (1) Nuclear density analysis

This study conducted kernel density analysis on medical facilities, parking lots, and bus (subway) stations, and analyzed their overall density distribution. The analysis results show that the distribution of medical facilities and parking spaces in Guandu District is concentrated in the northwest and central regions, while lacking in the northeast and southwest regions. Most hospitals are surrounded by densely populated parking lots, as well as areas with dense distribution of bus (subway) stations.

**Table 1.** Comparison of Nuclear Density Analysis of Hospitals, Parking Lots, and Bus (Subway) Stations

| Classification               | Hospital                                                                                                                                                                                 | Parking lot                                                                                                                 | Bus (Subway) stations                                                                                     |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Distribution Characteristics | Punctate                                                                                                                                                                                 | block-shaped                                                                                                                | block-shaped                                                                                              |
| Coverage level               | The hospital's nuclear density is only higher in the central and northwestern regions, and there is no coverage in the northeastern and southwestern regions, resulting in poor coverage | The core density of parking lots mainly covers the northwest and southeast regions, with lower coverage in other directions | The core density of bus stops covers the center of the area, with a range similar to that of parking lots |
| Conclusion                   | The number of hospitals is relatively small and the density is insufficient. Low density areas should be improved as soon as possible                                                    | The spatial distribution of parking lots is uneven, and parking lots should be added to the edge area                       | The distribution of bus stops is limited to the central area, and there are no peripheral areas involved  |



**Fig 4.** Comparison of Core Density of Medical Facilities, Parking Lots, and Bus (Subway) Stations

##### (2) Comparative analysis based on cost distance

This study is based on the assumption that residents tend to choose the nearest medical facilities. A large number of questionnaire surveys have shown that whether it is public transportation or self driving travel, whether it is direct or transit, the demand for accessibility in residents' medical needs is related to parking lots and bus (subway) stations.

The cost distance analysis in this study is based on raster data for spatial analysis of medical facilities. By quantifying the transportation costs during different time periods (weekdays and holidays), the study calculates the minimum cumulative cost path from each residential area in Guandu District to the medical facility space, especially the comprehensive hospital, in order to optimize facility site selection and layout, and further construct a "graded response to the epidemic" medical facility living circle.

After comparing and analyzing the cost distance of

comprehensive hospitals, parking lots, and bus (subway) stations on weekdays and holidays, it was found that: (1) the cost distance of comprehensive hospitals is mainly 10-15 minutes, and there is a significant difference in the range of cost distance within 15 minutes on weekdays and holidays (76.53% on holidays and only 66.28% on weekdays). The distance cost is higher in the northeast and southeast regions of the study area, and the overall cost distance on holidays is lower than on weekdays; (2) The cost distance of the parking lot is mainly 0-5 minutes, with slight differences in the range of cost distance within 5 minutes on weekdays and holidays (68.97% on holidays and 66.61% on weekdays). There are contiguous high distance cost areas on the northeastern edge of the research area, and the overall cost distance on holidays is lower than that on weekdays; (3) The cost distance of bus (subway) stations is mainly 0-5 minutes, with slight differences in the range of cost distance within 5 minutes on

weekdays and holidays (75.03% on holidays and 72.99% on weekdays). The distance cost is higher in the northern and southeastern regions of the study area, and slightly lower on holidays compared to weekdays.

Due to stable traffic data on weekdays and a large number of travelers; During holidays, there is a significant population flow, but urban transportation data may decrease to some extent, while public transportation is less affected by time. Overall, there are relatively few comprehensive hospitals in

the built-up area of Guandu District, especially in the northeast and southwest regions where the density is insufficient. It is necessary to improve the poor areas as soon as possible; There are relatively few parking lots in the northeast region, and public parking lots should be increased; The bus routes in the northern and southeastern regions are not involved, and the public transportation system should be improved.

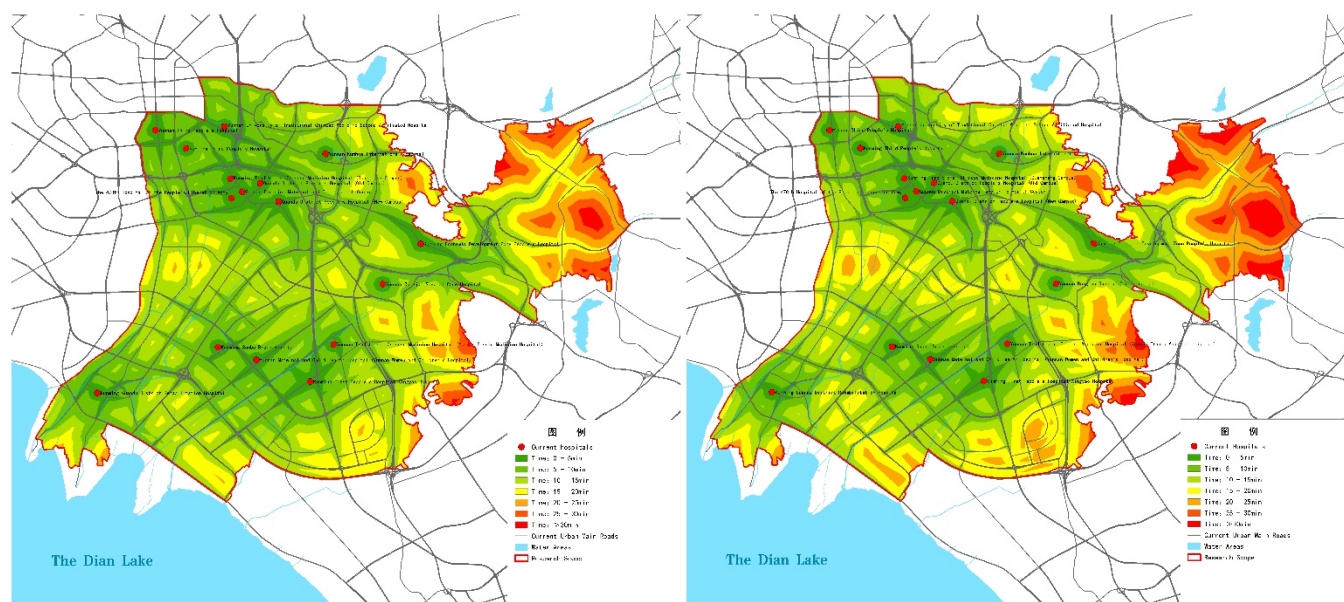


Fig 5. Comparison of Cost Distance between Working Days and Holidays in General Hospitals

#### 4.1.3. Analysis and Evaluation of The Current Situation of Medical Facilities

In this study, the hospital level, geographical location, entrance width, way of arrival, fever clinic, nucleic acid testing, pre hospital space, COVID-19 vaccine, immunization vaccine and parking space settings were respectively graded

according to the site survey (10 points for each item, 100 points for the total), and the scoring results were used as the basis for the current medical facilities to determine the level of detection points. After evaluation, there are a total of 5 first level detection points, 6 second level detection points, 7 third level detection points, and 21 fourth level detection points in the built-up area of Guandu District [5].

Table 2. List of Analysis and Evaluation of Current Status of Medical Facilities

| Name of medical facility                            | Hospital level | Geographic location | Entrance road width | Arrival method | Fever Clinic | Nucleic acid test | Front courtyard space | COVID-19 vaccine | Exemption vaccine | Parking | Sum | level |
|-----------------------------------------------------|----------------|---------------------|---------------------|----------------|--------------|-------------------|-----------------------|------------------|-------------------|---------|-----|-------|
| Kunming First People's Hospital Xingyao Hospital    | 9              | 8                   | 7                   | 9              | 10           | 10                | 0                     | 10               | 10                | 3       | 76  | 2     |
| Kunming Economic Development Zone People's Hospital | 9              | 6                   | 5                   | 6              | 10           | 10                | 10                    | 10               | 10                | 9       | 85  | 1     |
| Guandu District People's Hospital (New Campus)      | 6              | 8                   | 7                   | 6              | 10           | 10                | 10                    | 10               | 10                | 9       | 86  | 1     |
| The 478th Hospital of the People's Liberation Army  | 6              | 4                   | 3                   | 9              | 10           | 10                | 10                    | 10               | 10                | 9       | 81  | 2     |
| Guandu District People's Hospital (Old Campus)      | 6              | 6                   | 5                   | 6              | 10           | 10                | 0                     | 10               | 10                | 7       | 70  | 3     |
| Yunnan Third People's                               | 9              | 8                   | 7                   | 9              | 10           | 10                | 0                     | 10               | 10                | 9       | 82  | 2     |

| Hospital                                                                         |   |   |   |   |    |    |    |    |    |   |    |   |
|----------------------------------------------------------------------------------|---|---|---|---|----|----|----|----|----|---|----|---|
| Yunnan University of Traditional Chinese Medicine Second Affiliated Hospital     | 9 | 8 | 7 | 6 | 10 | 10 | 0  | 10 | 10 | 3 | 73 | 3 |
| Yunnan Traditional Chinese Medicine Hospital (Yunnan Ethnic Medicine Hospital)   | 9 | 6 | 5 | 6 | 10 | 10 | 10 | 10 | 10 | 9 | 85 | 1 |
| Yunnan Kunhua International Hospital                                             | 9 | 6 | 7 | 6 | 10 | 10 | 10 | 10 | 10 | 9 | 87 | 1 |
| Guandu District Maternal and Child Health Center                                 | 6 | 6 | 5 | 6 | 10 | 10 | 0  | 10 | 10 | 3 | 66 | 3 |
| Yunnan Maternal and Child Health Hospital (Yunnan Women and Children's Hospital) | 9 | 8 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 9 | 94 | 1 |
| Yunnan Rongjun Special Care Hospital                                             | 6 | 4 | 3 | 6 | 10 | 10 | 0  | 10 | 10 | 5 | 64 | 3 |
| Kunming Traditional Chinese Medicine Hospital (Guanshang Campus)                 | 6 | 6 | 3 | 9 | 10 | 10 | 0  | 10 | 10 | 3 | 67 | 3 |
| Kunming Third People's Hospital                                                  | 9 | 6 | 3 | 6 | 10 | 10 | 5  | 10 | 10 | 9 | 78 | 2 |
| Kunming Guandu District Rehabilitation Hospital                                  | 6 | 2 | 3 | 6 | 10 | 10 | 10 | 10 | 10 | 9 | 76 | 2 |
| Kunming Sanbo Brain Hospital                                                     | 6 | 6 | 7 | 9 | 0  | 10 | 10 | 10 | 10 | 9 | 77 | 2 |
| Guandu Street Community Health Service Center                                    | 3 | 4 | 1 | 6 | 0  | 10 | 0  | 10 | 10 | 1 | 45 | 4 |
| Export Processing Zone Community Health Service Center                           | 3 | 4 | 3 | 6 | 0  | 10 | 0  | 10 | 10 | 3 | 49 | 4 |
| Liujia Street Community Health Service Center                                    | 3 | 4 | 7 | 3 | 0  | 10 | 0  | 10 | 10 | 5 | 52 | 4 |
| Century City Community Health Service Center                                     | 3 | 6 | 3 | 6 | 0  | 10 | 10 | 10 | 10 | 3 | 61 | 3 |
| Yunxi Community Health                                                           | 3 | 6 | 3 | 9 | 0  | 10 | 10 | 10 | 10 | 7 | 68 | 3 |

|                                                                  |   |   |   |   |   |    |   |    |    |   |    |   |
|------------------------------------------------------------------|---|---|---|---|---|----|---|----|----|---|----|---|
| Service Center, Guandu District                                  |   |   |   |   |   |    |   |    |    |   |    |   |
| Xiaobanqiao Street Community Health Service Center               | 3 | 4 | 3 | 3 | 0 | 10 | 0 | 10 | 10 | 3 | 46 | 4 |
| Aerospace Community Health Service Center                        | 3 | 2 | 3 | 3 | 0 | 10 | 0 | 10 | 10 | 1 | 42 | 4 |
| Yiyuan Community Health Service Center                           | 3 | 6 | 3 | 6 | 0 | 10 | 0 | 10 | 10 | 3 | 51 | 4 |
| Economic Development Community Health Service Center             | 3 | 6 | 5 | 6 | 0 | 10 | 0 | 10 | 10 | 3 | 53 | 4 |
| Ala Community Health Service Center                              | 3 | 2 | 1 | 3 | 0 | 10 | 0 | 10 | 10 | 1 | 40 | 4 |
| Dashiba Community Health Service Center                          | 3 | 2 | 1 | 3 | 0 | 10 | 0 | 10 | 10 | 3 | 42 | 4 |
| Guandu District Xiaojie Community Health Service Center          | 3 | 4 | 3 | 3 | 0 | 10 | 0 | 10 | 10 | 1 | 44 | 4 |
| Fude Community Health Service Center, Guandu District            | 3 | 6 | 7 | 3 | 0 | 10 | 0 | 10 | 10 | 3 | 52 | 4 |
| Guanyu Community Health Service Center, Guandu District          | 3 | 4 | 7 | 3 | 0 | 10 | 0 | 10 | 10 | 1 | 48 | 4 |
| Eight kilometer Community Health Service Center                  | 3 | 4 | 7 | 3 | 0 | 10 | 0 | 10 | 10 | 1 | 48 | 4 |
| Xingde Community Health Service Center, Guandu District          | 3 | 4 | 7 | 3 | 0 | 10 | 0 | 10 | 10 | 5 | 52 | 4 |
| Guandu District Guanshang Street Community Health Service Center | 3 | 8 | 7 | 6 | 0 | 10 | 0 | 10 | 10 | 5 | 59 | 3 |
| Guandu District Taihe Street Community Health Service Center     | 3 | 8 | 5 | 6 | 0 | 10 | 0 | 10 | 10 | 3 | 55 | 3 |

|                                                         |   |   |   |   |    |    |   |    |    |   |    |   |
|---------------------------------------------------------|---|---|---|---|----|----|---|----|----|---|----|---|
| Wujing Community Health Service Center, Guandu District | 3 | 8 | 5 | 3 | 0  | 10 | 0 | 10 | 10 | 1 | 50 | 4 |
| Liangting Community Health Service Center               | 3 | 4 | 1 | 3 | 0  | 10 | 0 | 10 | 10 | 1 | 42 | 4 |
| Jinma Street Community Health Service Center            | 3 | 8 | 3 | 6 | 0  | 10 | 0 | 10 | 10 | 1 | 51 | 4 |
| Donghua Community Health Service Center                 | 3 | 8 | 7 | 3 | 0  | 10 | 0 | 10 | 10 | 1 | 52 | 4 |
| Meizhen Community Health Service Center                 | 3 | 6 | 7 | 6 | 0  | 10 | 0 | 10 | 10 | 1 | 53 | 4 |
| Kunming First People's Hospital Xingyao Hospital        | 9 | 8 | 7 | 9 | 10 | 10 | 0 | 10 | 10 | 3 | 76 | 2 |

## 4.2. Construction of Medical Facility Living Circle in Guandu District

Based on the cost distance analysis of the current comprehensive hospital in Guandu District and the evaluation of the status of medical facilities, combined with the natural segmentation of road traffic, rivers, etc., the medical facility living circle in the main urban built-up area of Guandu District is delineated. In the scope of this study, a total of 30-minute strategic reserve circle (1), 15-minute emergency buffer circles (4), and several 5-minute daily service circles were designated [4].

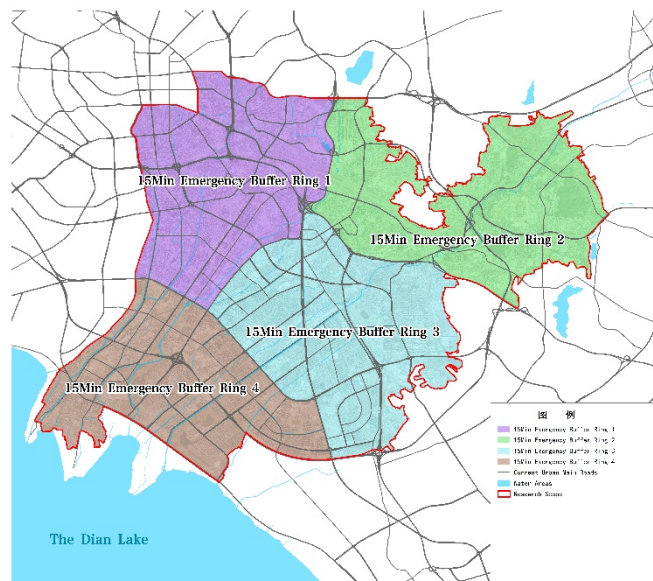


Fig 6. 15-minute emergency buffer zone diagram of medical facilities in Guandu District

## 4.3. Optimization and Renovation of Medical Facilities in Guandu District

### 4.3.1. Optimization of Emergency Medical System in Guandu District

In the emergency medical system of Guandu District, community monitoring, hospitals, and disease prevention and control centers work together to carry out emergency response to public health emergencies in Guandu District. Among them:

Within the 5-minute daily service circle, based on testing by the community health service center, responsible for collecting information and educating community members on prevention knowledge, in order to prevent and warn of infectious diseases. If suspected or confirmed cases are found, emergency response (isolation) and information reporting should be made as soon as possible; Within the 15 minute emergency buffer zone, using comprehensive hospitals or specialized hospitals as carriers for specific diagnosis and treatment, diagnosing cases received by community health service centers or hospitals themselves, and playing a role in isolation, treatment, waste disposal, and information reporting; Within the 30 minute strategic reserve circle, the Center for Disease Control and Prevention has established an emergency response plan team and medical supplies emergency reserve work, leading hospital and community prevention and control work. In the event of specific cases, the hospital provides emergency supplies reserves and promptly sets up isolation and control areas, and organizes the investigation of relevant contacts.

### 4.3.2. Emergency Epidemic Prevention System Planning for Guandu District

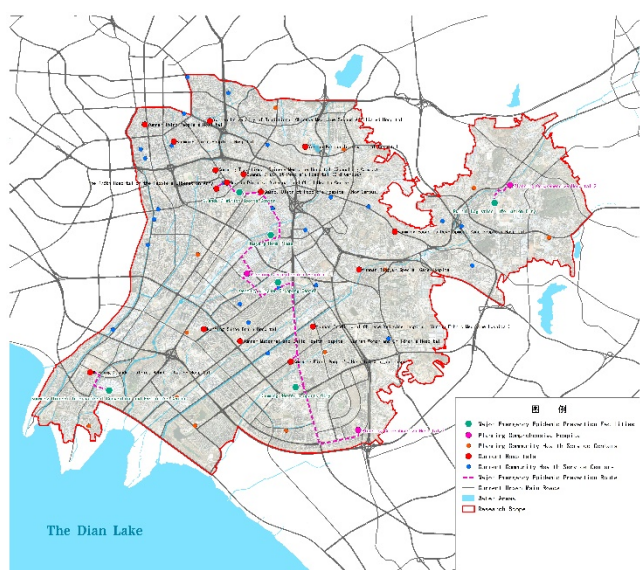
#### (1) Planning of Major Emergency Epidemic Prevention Facilities

Major emergency epidemic prevention facilities should have sufficient pre hospital space and usable space to meet normal functions during normal times. In the event of an outbreak, they should serve as temporary vaccination and

observation areas in the city to ensure that residents receive vaccines in the shortest possible time and are not prone to cross infection. Based on the accessibility of transportation, the layout of the front space of the hospital, and the relationship with the residential area, select the location of major emergency epidemic prevention facilities that combine epidemic prevention and control from the large shopping centers, sports venues, exhibition centers, and some home logistics parks in Guandu District.

## (2)Major emergency epidemic prevention route planning

The optimal route for epidemic prevention is based on distance and time factors, combined with traffic conditions to select the route with the best average road conditions. At the same time, each emergency epidemic prevention department should develop necessary internal epidemic prevention routes and isolation areas, improve their epidemic prevention standards and management measures.



**Fig 7. Emergency Epidemic Prevention Facilities and Route Planning Map of Guandu District**

The selection of major emergency epidemic prevention facilities and routes in Guandu District is as follows:

- 1) Guandu District Sports Center - Pass through Guanjing Road to Guandu District People's Hospital (New Campus) or pass through Shuangqiao Road via Guanjing Road to the 478th Hospital of the People's Liberation Army;
- 2) Huayang Home Plaza - Take Changhong West Road, cross Yulong Road to Guandu District People's Hospital (New Campus), or take Changhong West Road, cross Dongju Road to Planning Comprehensive Hospital 1;
- 3) Century Jinyuan Shopping Center - Take Jinyuan Avenue, cross Yongzhong Road to Planning Comprehensive Hospital 1, or take Jinyuan Avenue, cross Caiyun North Road to Kunming First People's Hospital (Xingyao Hospital);
- 4) Kunming New Asia Sports City - Take Caiyun North Road to Kunming First People's Hospital (Xingyao Hospital) or cross Yunfu Street via Caiyun North Road to Planning Comprehensive Hospital 3;
- 5) Kunming Dianchi International Convention and Exhibition Center - passing through Exhibition West Road and Exhibition North Road to Kunming Guandu District Rehabilitation Hospital;
- 6) Ruihui Logistics Information City - Pass through Dianxin Avenue and G320 auxiliary road to reach the planned

comprehensive hospital 2.

#### 4.3.3. Medical Facility Renovation Plan

Based on the analysis and evaluation results of the current medical facilities, combined with the delineation of the medical facility living circle and on-site investigation and research, five types of renovation plans are planned for the medical facilities in the built-up area of Guandu District, including new construction, urgent renovation, long-term renovation, non inclusion in the plan, and reuse.

- (1) New Construction Category: Based on the current status of the central medical facilities in Guandu District, create a northeast southwest medical facility axis that echoes the current northwest southeast axis, making the medical facility serve a wider range of people. Plan to build 3 comprehensive hospitals and 12 community health service centers in the northeast, west, and south of the research area.
- (2) Urgent Renovation Category: concentrated in the central area of the research scope, the renovation focuses on improving transportation accessibility, planning parking spaces reasonably, improving the front space of the hospital, and enhancing internal facilities and spatial flow organization. The urgently needed renovation of medical facilities includes 1 comprehensive hospital, 3 community health service centers, and 11 community health service stations.
- (3) Long Term Renovation: mainly distributed in the western and central regions of the research scope, the current situation can basically meet the demand, but due to the lack of room for renovation and expansion in the near future, the focus of long-term renovation is mainly on the insufficient space in front of the hospital and the surrounding transportation conditions. The planned long-term renovation of medical facilities includes 5 comprehensive hospitals, 4 community health service centers, and 16 community health service stations.

- (4) Not Included In The Planning Category: the medical facilities not included in the planning are mainly private or maternity hospitals, which do not have the conditions for fever clinics and COVID-19 vaccine and immunization, so they will not be included in the construction of emergency medical system in the planning. There are a total of 15 medical facilities not included in the planning category.

- (5) Planning and Reuse Category: Taking the 478th Hospital of the People's Liberation Army as an example, due to its advantages in scale, front space, and parking spaces, as well as the hospital's large undeveloped land, it is planned to be included in the emergency medical system for reuse. The plan focuses on two aspects for reuse: firstly, setting it as an epidemic isolation point in conjunction with emergency epidemic prevention and control, and secondly, piloting it as a makeshift cabin and prefabricated medical building.

#### 4.4. Comparison Before and after Optimization of Medical Facility Layout

On the basis of the current northwest southeast axis of medical facilities, a new southwest northeast axis of medical facilities will be planned to achieve a more balanced layout of medical facilities, wider coverage, and significantly improved convenience for residents to seek medical treatment.

The construction of a comprehensive hospital and the optimization of the transportation network have significantly improved the accessibility of medical facilities, reduced the time cost for residents to seek medical treatment, and improved the accessibility of medical services. The analysis of the cost distance between working days before and after

the planning of medical facilities in Guandu District shows that the problem of large cost distance in the northeast and

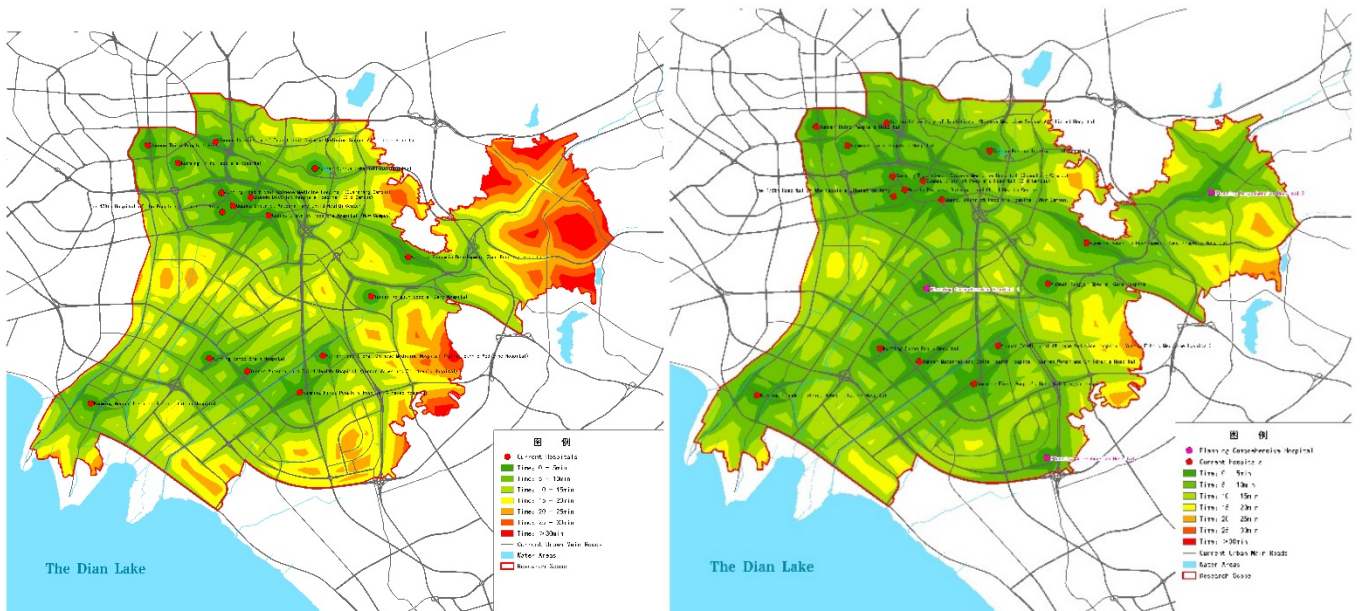
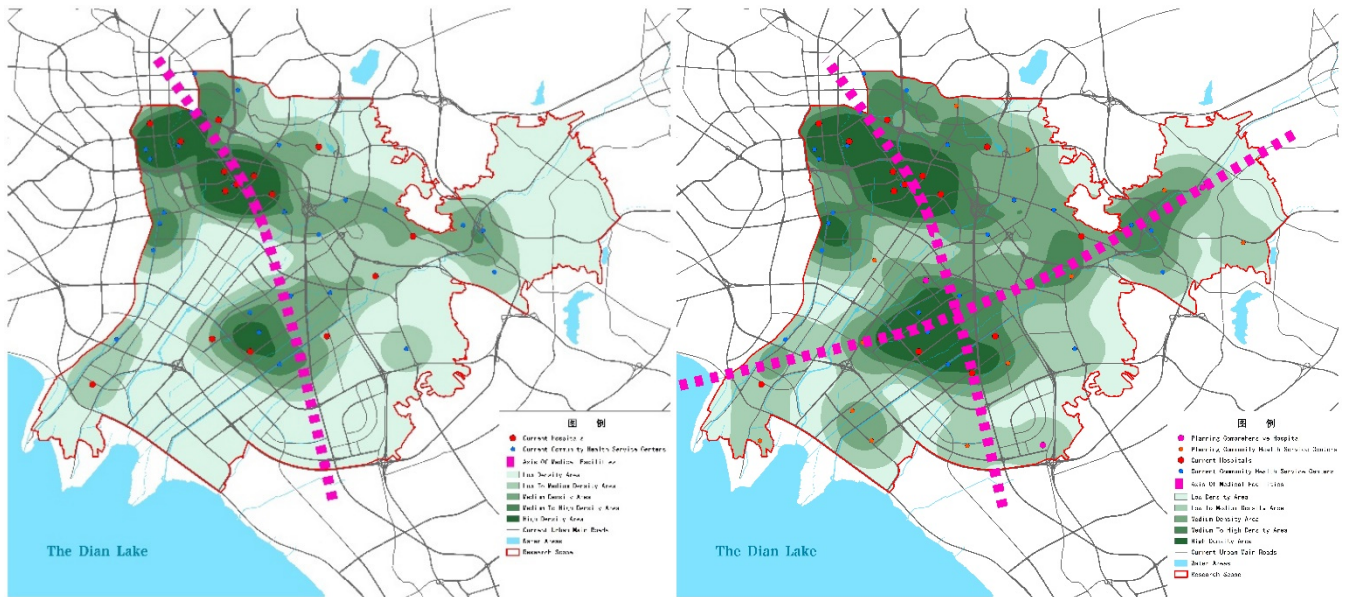
southeast regions of the research scope has been significantly improved.

**Table 3.** Renovation and Utilization of Medical Facilities in Guandu District

| Type of renovation                    | Quantity (Location) | Name of medical facility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reason for renovation                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| New Construction Category             | 3                   | Planning Comprehensive Hospital 1, 2, 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Build a medical facility axis from northeast to southwest to compensate for the lack of low-density medical facilities in the built-up area of the main city of Guandu District                                                                                                                                                                            |
|                                       | 12                  | Planning Community Health Service Center 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                            |
| Urgent Renovation Category            | 15                  | Yunnan University of Traditional Chinese Medicine Second Affiliated Hospital<br>Guandu Street Community Health Service Center, Liangting Community Health Service Center,<br>Longma Community Health Service Station, Puzi Community Health Service Station, Zijun Community Health Service Station, Guandu Street Housuo Community Health Service Station, Guandu Street Xizhuang Community Health Service Station, Xiaobanqiao Street Yangfu Community Health Service Station, Zhibuying Community Health Service Station, Shijiawan Community Health Service Station, Yulong Community Health Service Station, Xiaobanqiao Xiaodong Community Health Service Station, Gongjiacun Community Health Service Station, Taiping Community Health Service Station                                                                                                                                                                                                                                                                                                                                                                                         | The current situation does not allow the vaccination of free vaccine and COVID-19 vaccine; The surrounding environment is chaotic and lacks front courtyard space; Due to the lack of parking lots and inconvenient transportation, the problem of disorderly parking and placement has been verified; Old facilities and poor internal space organization |
| Long Term Renovation Category         | 25                  | Kunming First People's Hospital Xingyao Hospital, Yunnan Third People's Hospital, Kunming Third People's Hospital, Kunming Economic Development People's Hospital, Guandu District People's Hospital (Old Campus)<br>Export Processing Zone Community Health Service Center, Century City Community Health Service Center, Xiaojie Community Health Service Center, Meizhen Community Health Service Center,<br>Fubao Community Health Service Station, New Asia Community Health Service Station, Guandu Street Luoya Community Health Service Station, Yongsheng Community Health Service Station, Liujia Community Health Service Station, Liujia Panlong Community Health Service Station, Yunxi Community Health Service Station, Liujia Chenjia Community Health Service Station, Economic Development Zone Puzhao Community Health Service Station, Shuangfeng Community Health Service Station, Mingquan Community Health Service Station, Tuqiao Community Health Service Station, Niujie Community Health Service Station, Guanshang Street Haiming Road Community Health Service Station, Alaxiang Haizi Health Center, Gaopo Health Center | The current medical facilities can basically meet the demand, but when there is a large flow of people, there will be congestion and a large number of queues. The space in front of the hospital is insufficient, and the overall environmental conditions are average. The surrounding traffic is prone to congestion                                    |
| Not Included In The Planning Category | 15                  | Kunming Yunrui Hospital, Kunming Dongfang Hospital, Kunming Mingzhu Hospital, Kunming Economic Development Zone Yunlan Hospital, Kunming Xinhai Hospital, Kunming Hongde Hospital, Kunming Minsheng Hospital, Kunming Saint Ann Obstetrics and Gynecology Hospital, Kunming Zhongsheng Hospital, Guandu Renhe Hospital, Yingjili Obstetrics and Gynecology Hospital, Kunming Pujian Jinfudi Hospital, Kunming Diankang Hospital, Kunming Chaoyang Hospital, Kunming Yadong Hospital                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Most of these hospitals are private or maternity hospitals, which do not have the conditions to vaccinate COVID-19 vaccine and free vaccine. There is no fever clinic, and the scale of service centers is generally small, lacking pre hospital space.                                                                                                    |
| Planning and Reuse Category           | 1                   | The 478th Hospital of the People's Liberation Army                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Due to the hospital's large scale and sufficient front space, as well as ample parking spaces, it is planned as an epidemic isolation point                                                                                                                                                                                                                |



**Fig 8.** Distribution of Medical Facility Renovation Plan in Guandu District



## 5. Summary

This study evaluates the current situation and optimization planning of medical facilities in Guandu District, Kunming City, proposes targeted optimization suggestions, and constructs an emergency medical facility system of "epidemic grading response", providing scientific basis for the rational layout of medical and health facilities and the improvement of emergency system in Guandu District. However, due to the limitations of data timeliness and scope, the current assessment of medical facilities in Guandu District mainly focuses on the built-up area of the main city, and there is still insufficient coverage of the suburbs. The core theory of the living circle and the point axis system theory focus on the overall direction of the region, and further integration with the overall national spatial planning is needed in the specific layout of medical facilities. Future research will expand its scope to the central urban area of Kunming, in order to study the layout of medical facilities on a larger scale and reduce

errors through continuous traffic situation data. Further research theories and methods should be applied to the traffic situation data of the interval in order to obtain more scientific analysis results.

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