A study on optimal dispatch of medical resources under the situation of COVID-19

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Abstract. In order to improve the efficiency of production, transportation, storage and use of medical resources under COVID-19 pandemic, we propose a simplified model for medical resources supply chain management by mathematical programming. Based on the reserve and demand of medical resources in a given area, the proposed model provides daily real-time transportation decisions and expansion decisions of hospitals, factories and warehouses under epidemic situation by analysing factors such as different regions, duration, factory capacity, warehouse reserves, hospital demand, transportation and expansion costs of factories, warehouses and hospitals. The promo package of Python language is used to formulate a mixed integer linear programming model. In this model, under the conditions of meeting the demand of medical resources in the case of slow development and sudden outbreak of epidemic situation, a commercial solver, CPLEX, is able to provide the solution for each situation with the lowest supply cost within one second CPU time. This model provides a feasible scheme for further solving the complicated forecasting and planning of medical resources dispatch under the situation of pneumonia in COVID-19.

1. Introduction
Coronavirus has been significantly influencing the world after it was discovered and identified in Wuhan, Hubei Province, China, in December 2019. As of 30 August 2020, there has been nearly 25 million confirmed cases and 800,000 deaths worldwide, with more than 1.8 million confirmed cases and 38,000 deaths recorded in the latest week, according to the World Health Organization. Even if COVID-19 is curable, it has posed a challenge to the reliability and efficiency of public medical resources supply chain.
COVID-19 pandemic has greatly impacted public medical resources supply chain. By February 9, 2020, the initial stage of lockdown, Wuhan had a daily demand of 59,000 sets of medical protective suit while the actual supply was only 37,000 sets. The shortage of medical resources in Wuhan has mainly two reasons. The sudden outbreak exceeded the local reserve while the lockdown of Wuhan and the lack of transportation capacity led to the fact that the medical resources donated could not be delivered to local medical institution. The situation highlights the importance of effective management of medical resource supply chain. An efficient supply chain is a prerequisite for enabling plenty of medical resources to be transported timely and accurately to the front lines of the pandemic.

The difficulties brought by the severe epidemic for supply chain management can be summarized as follows:

- Due to concentrated outbreak in some areas, demand of medical resources sharply increased, resulting in mass shortage of medical resources within a short period.
- Due to the outbreak of pandemic and related quarantine measures, there is a shortage in production capacity. To make matters worse, pandemic outbreak took place during Spring Festival, a traditional festival when Chinese spend time for family reunion at hometown. A lot of workers were quarantined before they could get back to work, resulting an even more serious capacity shortage.
- The emergency lockdown of epidemic area has greatly hindered the speed and efficiency of medical resources allocation in the early stage of pandemic.
- The time and location of outbreak is difficult to predict in the early stage of pandemic, which greatly increases the difficulties in the allocation of medical resources. Both lack and overdeployment of medical resources will lead to unfavourable outcomes, including uncontrollable outbreak and waste of resources. Figure 1.2 is an example illustrating the difficulties in accurate forecasting pandemic. It can be seen that there was a rapid outbreak in New York in the early stage. However, the outbreak in New York became under control in the later stage, while the outbreak in Florida sustained.

![Number of COVID-19 cases and deaths reported weekly by WHO region, 30 December to 30 August 2020](image)

Figure 1. Number of COVID-19 cases and deaths reported weekly by WHO region, 30 December to 30 August 2020 [1]
2. Literature Review

2.1. Literature on Supply Chain Management

Before COVID-19 pandemic, the international research and discussion on supply chain management mainly focused on industrial engineering and operational research. Shen, Z. J. M. et al. proposed a mathematical model considering storage location [4]. Shu, J. et al. have considered the randomness in the traffic network and put forward a traffic network and warehouse management method [5]. Santoso, T. et al. adopted the stochastic programming model to solve the problem of supply chain network interruption [6]. Lee, H. L. et al. studied the Bullwhip Effect in the supply chain [7]. Wolsey, L. A. et al. published the application of integer programming and combinatorial operations [8].

Since this year, in the face of various problems in the supply of medical resources under the situation of COVID-19, the research on the supply chain of medical resources has gradually increased. Siqian Shen outlined the operational research and industrial engineering tools against COVID-19[9]. In China, Guidong Li et al. conducted researches on vegetable supply chain under epidemic conditions [10]. Hua Song et al. summarized the construction methods of supply chain system under the condition of epidemic [11]. Feng Xiang et al. put forward suggestions on the construction of emergency supply chain system under the situation of COVID-19 [12].

2.2. Contribution and Innovation

In this paper, mathematical programming is adopted to provide a method to tackle the problem of medical resources deployment in the context of COVID-19. The main contributions and innovations are as follows:

- A simplified supply chain model was established. Under the given initial data and judgment criteria, an optimal scheme for medical resources dispatch under the epidemic situation was proposed.
- At the present stage, this model can consider simplified medical resources dispatch decisions, storage decisions and production plan decisions among multiple subregions.
- By introducing some primary data for case analysis, this model has been able to provide an effective real-time optimization scheme for medical resources dispatch.

3. Formatting the text

Based on the following assumptions, this model studies the deployment of medical resources of a region that is in a coronavirus pandemic context:
• The geographical territory of the region is known and the region is currently affected by COVID-19.
• The quantity of existing medical resources in all hospitals in the region, the stock of various resources in the warehouse, the production capacity and reserves of different medical resources in each sub-region are known.
• The region is undergoing an outbreak, which indicates that COVID-19 cases is expected to increase rapidly.

This model cannot provide effective forecast of the probability of outbreak yet. Therefore, model calculation can only be done by inputting the given epidemic statistics, and it is assumed that the data has been predicted by establishing a prediction model based on time series, such as ARIMA (Auto-regressive Integrated Moving Average) model.

3.1. Model Hypothesis

The simplified model, as illustrated in Figure 3.1, simplifies the process of medical resources from production to use into three stages: production, storage and use, which respectively correspond to the three facilities, factory, warehouse and hospital. Medical resources can be transported either from the factory to the warehouse and hospital, or from warehouse to the hospital. Thus, the following assumptions are made:

• It is assumed that the factories, warehouses and hospitals in each province have been clustered, which means that each province has only one factory, one warehouse and one hospital. Additionally, they are assumed to be geographically located in the provincial capital.
• The demand of medical resources is positively relative to confirmed cases.
• Deployment decisions will be measured in days.
• Various transportation methods are considered, such as air shipment, railway shipment and freight automobiles, while the traffic capacity is not taken into consideration.
• Time needed for facility expansion and traffic transportation will be measured in days.

3.2. Decision Model

Based on information available, the following decisions will be made:

• Daily transportation decision:
  ① Shipment amount of medical resources from any factory to any warehouse;
  ② Shipment amount of medical resources from any warehouse to any hospital;
  ③ Shipment amount of medical resources from any factory to any hospital.
• Daily expansion decision
  Expansion of factories, warehouses and hospitals.
4. Research Method
Mixed integer linear programming is adopted in the model to solve the problem. Mixed integer linear Programming is a special subtype of Mathematical Programming, which is composed of known parameters, decision variables, model constraints and objective functions. For example, known parameters in this model are the time span, initial factory productivity, initial warehouse storage capacity, and the expansion cost of the three types of facilities. Decision variables are expansion decisions of factories and warehouses, and transportation decisions while model constraints include constraints related to productivity and storage capacity. Finally, the objective function aims at minimizing the total cost, that is, to calculate the minimum value of objective function.

4.1. Linear Planning
Based on information available, the following decisions will be made:

Linear programming means that the objective function and all the constraints are linear. Therefore, the decision variable can be any real number. A general linear programming problem can be expressed by the following formula, where \( x \) represents the decision variables in the real number field, matrix \( A \) and vector \( B \) represent the constraint parameters, vector \( C \) represents the coefficients of each variable in the objective function, and \( \mathbb{R}^n \) represents the variable \( x \) defined in the n-dimensional real numbers.

\[
\begin{align*}
\text{min } & cx \\
\text{s.t. } & Ax \leq b \\
& x \in \mathbb{R}^n
\end{align*}
\]  
(1)

On the basis of linear programming, mixed integer linear programming is adopted in this model. Mixed integer programming requires some of the variable to be integer by definition. Generally, the programming is adopted when it requires extensive use of integer variables defined in \( \{0, 1\} \), which are usually associated with “true” and “false” logic in the problems. Therefore, integer programming is often represented as zero-one integer programming. In this model, 1 represents “true” while 0 represents “false”. For example, in this model, a zero-one variable should be introduced to indicate whether the capacity of the factory, warehouse, and hospital should be expanded at each moment in the time span before determining capacity expansion.

4.2. Programming and Software
The model is programmed in Python using a commercial solver, CPLEX, to solve the problem.

5. Mathematical Model
5.1. Constraints
5.1.1. Constraints on Factory Capacity Expansion
\( \text{CAP}_{gd} \) represents the constraint of initial factory capacity while variable \( \text{CUP}_{gdt} \) represents production capacity of the factory at time \( t \). At the initiative point, the production capacity is determined by known parameter \( \text{CAP}_{gd} \).

\[
\text{CUP}_{gdt} = \text{CAP}_{gd} \quad \forall g, d, t; \ t = 1
\]  
(2)

At time \( t \), the production capacity \( \text{CUP}_{gdt} \) is the sum of the capacity of previous moment \( \text{CUP}_{gdt-1} \) and incremental production capacity at moment \( t \). And the incremental production capacity is determined by expansion decision \( \text{CEP}_{gdt-1t_p} \) made \( lp_g \) before, where \( lp_g \) stands for time required for expansion.

\[
\text{CUP}_{gdt} = \text{CUP}_{gdt-1} + \text{CEP}_{gdt-1t_p} \quad \forall g, d, t; \ t \geq lp_g + 1
\]  
(3)
For each expansion decision, the value of zero-one variable $y_{gdt}$ will be considered first. If the value is 0, it indicates that no expansion will take place. Otherwise, if the value equals 1, the $CEP_{gdt}$ value will fall in between the upper and lower boundary of $UBP$ and $LBP$.

$$LBP \cdot y_{gdt} \leq CEP_{gdt} \leq UBP \cdot y_{gdt} \quad \forall g,d,t$$  

(4)

5.1.2. Constraints on Warehouse Capacity Expansion

The main structure of constraints on warehouse capacity expansion is similar to that of constraints on factory capacity expansion.

$CAS_g$ represents the constraint of initial warehouse capacity, while variable $CUS_{gt}$ represents storage capacity of the warehouse at time $t$. $CUS_{gt-1}$ represents the capacity of previous moment while the expansion decision $CES_{gt-ls_g}$ is made $ls_g$ before, where $ls_g$ stands for time required for expansion. The upper and lower boundary are respectively $UBS$ and $LBS$.

$$CUS_{gt} = CAS_g \quad \forall g,t; t = 1$$

(5)

$$CUS_{gt} = CUS_{gt-1} + CES_{gt-ls_g} \quad \forall g,t, t \geq ls_g + 1$$

(6)

$$LBS \cdot z_{gt} \leq CES_{gt} \leq UBS \cdot z_{gt} \quad \forall g,t$$

(7)

5.1.3. Constraints on Hospital Capacity Expansion/downsizing

The main structure of constraints on hospital capacity expansion/downsizing is similar to that of constraints on factory capacity expansion. For hospital, this model has taken downsizing strategy into consideration since the maintenance of hospital facilities can be costly. In this model, the downsizing of the hospital is assumed to be accomplished instantly. The downsizing decision is represented as $CMH_{gt}$.

$CAH_g$ represents the constraint of initial hospital capacity, while variable $CUH_{gt}$ represents capacity of the hospital at time $t$. $CUH_{gt-1}$ represents the capacity of previous moment while the expansion decision $CEH_{gt-lh_g}$ is made $lh_g$ before, where $lh_g$ stands for time required for expansion. The upper and lower boundary are respectively $UBH$ and $LBH$.

$$CUH_{gt} = CAH_g \quad \forall g,t; t = 1$$

(8)

$$CUH_{gt} = CUH_{gt-1} + CEH_{gt-lh_g} - CMH_{gt} \quad \forall g,t, t \geq lh_g + 1$$

(9)

$$LBH \cdot w_{gt} \leq CEH_{gt} \leq UBH \cdot w_{gt} \quad \forall g,t$$

(10)

5.1.4. Constraints on factory transportation capacity

Factory in this model is assumed to have no storage function, which means that the medical resources will be transported to warehouses or hospitals once they are produced. In the following equation, $PUP_{gdt}$ stands for the factory production of the day while $TPS_{ggrdmt}$ and $TPH_{ggrdmt}$ represent the quantity of medical resource shipment to warehouse and hospital of the day respectively.

$$PUP_{gdt} = \sum_{m \in M} \sum_{g \in G} (TPS_{ggrdmt} + TPH_{ggrdmt}) \quad \forall g,d,t$$

(11)

$$PUP_{gdt} \leq CUP_{gdt} \quad \forall g,d,t$$

(12)
5.1.5. Calculation of Various Medical Resources in Warehouse
The reserve of medical resources at time $t$ is the sum of reserve at previous moment and shipment from warehouse and factory. In the following equation, $\text{Inv}_{gdt}$ represents the reserve in warehouse at time $t$.

$$\text{Inv}_{gdt} = \text{Inv}_{gdt-1} + \sum_{m \in M, g' \in G} \left( TPS_{g'g} + \text{t}_{m} - \text{t}_{mg} \right) \quad \forall g, d, t$$  \hspace{1cm} (13)

5.1.6. Establish Feedback on Insufficient Medical Resources
To make every individual have access to adequate medical resources, the model has established punishment mechanism. The following equation shows that demand of medical resources equals the sum of the supply and shortfall, where $\text{Slack}_{dgr}$ represents shortfall and $\text{Demand}_{dgr}$ represents demand for medical resources.

$$\sum_{g \in G} \sum_{d \in D} \left( TSH_{gg} + \text{t}_{m} - \text{t}_{mg} \right) \quad \forall g', d, t$$  \hspace{1cm} (15)

5.2. Programming and Software
In the objective function, the model aims to optimize the total cost, and thus make more efficient deployment of medical resources. The cost items in objective function include the followings:

$$\sum_{g \in G} \sum_{d \in D} \sum_{t \in T} \left( \alpha_{gd} \text{y}_{dt} + \beta_{gd} \text{CEP}_{gdt} \right)$$  \hspace{1cm} (17)

Equation (17) stands for the expansion cost of factory. It is assumed that regardless the expansion scale, a fixed cost will incur. The fixed cost of factory expansion is represented by $\alpha_{gd}$, while the expansion decision is represented by $\text{y}_{dt}$. Meanwhile, depending on the expansion scale, a variable cost will incur. $\beta_{gd}$ stands for the variable cost per unit of expansion while $\text{CEP}_{gdt}$ stands for the factory expansion scale in units.

$$\sum_{g \in G} \sum_{t \in T} \left( \lambda_{g} \text{z}_{gt} + \gamma_{gt} \text{CES}_{gt} \right)$$  \hspace{1cm} (18)

Equation (18) stands for the expansion cost of warehouse. The fixed cost of warehouse expansion is represented by $\lambda_{g}$, while the expansion decision and the warehouse expansion scale in units are represented by $\text{z}_{gt}$ and $\text{CES}_{gt}$ respectively.

$$\sum_{g \in G} \sum_{t \in T} \left( \zeta_{g} \text{w}_{gt} + \eta_{gt} \text{CEH}_{gt} \right)$$  \hspace{1cm} (19)

Equation (19) stands for the expansion cost of hospital. The fixed cost of hospital expansion is represented by $\zeta_{g}$, while the expansion decision and the hospital expansion scale in units are represented by $\text{w}_{gt}$ and $\eta_{gt}$ respectively.

$$\sum_{g \in G} \sum_{d \in D} \sum_{t \in T} \text{Cost}_{gd} \text{PUP}_{gdt}$$  \hspace{1cm} (20)

Equation (20) stands for the manufacturing cost of medical resources. The cost incurred per unit is represented by $\text{Cost}_{gd}$, while actual production is represented by $\text{PUP}_{gdt}$.

$$\sum_{g \in G} \sum_{d \in D} \sum_{t \in T} \sum_{m \in M, d \in D} \sum_{t \in T} \text{TS}_{gg}' \text{TPS}_{gcd} + \text{TPH}_{g} + \text{TSH}_{g}$$  \hspace{1cm} (21)
Equation (21) stands for the transportation cost of medical resources. The cost incurred per unit is represented by $T_s g_{g'} m$, while actual transportation amount from factory to warehouse, from factory to hospital and from warehouse to hospital are represented by $T P_S g' d_{m} t$, $T P_H g_{g'} d_{m} t$, and $T S H g_{g'} d_{m} t$ respectively.

\[ \sum_{g \in G} \sum_{d \in D} \sum_{t \in T} h_g I_{n v_g d t} \]  

Equation (22) stands for the storage cost of medical resources. The cost incurred per unit is represented by $h_g$, while actual reserve in the warehouse is represented by $I_{n v_g d t}$.

\[ \sum_{d \in D} \sum_{g \in G} \sum_{t \in T} p e n_d S_{l a c k_d g t} \]  

The punishment mechanism was introduced in hope that every individual will have access to adequate medical resources. Equation (5.22) stands for the punishment caused by medical resources where $p e n_d$ represents the punishment caused by each unit of insufficient medical resources and $S_{l a c k_d g t}$ represents the shortage of medical resources.

\[
\begin{align*}
\min & \left( \sum_{g \in G} \sum_{t \in T} \sum_{d \in D} (\alpha_{g d} y_{g d t} + \beta_{g d} C_{E P_{g d t}}) + \sum_{g \in G} \sum_{t \in T} (\lambda_{g z_{g t}} + \gamma_{g} C_{E S_{g d t}}) \\
& + \sum_{g \in G} \sum_{t \in T} \sum_{d \in D} (\zeta_{g w_{g t}} + \eta_{g} C_{E H_{g d t}}) + \sum_{g \in G} \sum_{d \in D} \sum_{t \in T} C_{o s t_{g d} P U_{P g d t}} \\
& + \sum_{g \in G} \sum_{g' \in G} \sum_{m \in M} \sum_{d \in D} \sum_{t \in T} T_{s g_{g'} m}(T P_{S g' d_{m} t} + T P_{H g_{g'} d_{m} t} + T S H g_{g'} d_{m} t) + T S H g_{g'} d_{m} t) + \sum_{g \in G} \sum_{d \in D} \sum_{t \in T} h_g I_{n v_g d t} + \sum_{d \in D} \sum_{g \in G} \sum_{t \in T} p e n_d S_{l a c k_d g t} \right)
\end{align*}
\]  

6. Case Analysis
After programmed in Python, the model is divided into two cases, slow development and sudden outbreak of epidemic situation. Data of two region is input respectively to run the program.

6.1. Case One
In Case One, two regions, A and B; five moments in time span, from Day 1 to Day 5; one type of medical resource; and two transportation methods, method one and method two are introduced. Meanwhile, the model provides primary numerical values, including transportation costs and expansion cost. (cost variable symbols see Appendix 1)

Since the model is unable to estimate the number of subsequent daily confirmed cases based on a given initial number of confirmed cases, the daily number of confirmed cases is given in advance, namely the daily demand for medical resources, as illustrated in Figure 4.
In Case One, the development of epidemic situation is assumed to be slow. Region A has a demand of 14, 34, 34, 47, 32 units of medical resources from Day 1 to Day 5 respectively while Region B has a demand of 45, 57, 64, 75, 86 units of medical resources respectively. It is hoped that the model can generate a production and transportation solution which meets as much demand for medical resources as possible with a minimum cost.

6.1.1. Case Solution
The promo package of Python language is used to formulate a mixed integer linear programming model. There are 249 variables in this case, with 30 zero-one variables, 219 continuous variables, and 141 constraints. It takes 0.09 second to generate solution with CPLEX solver.

6.1.2. Result Analysis
In the optimal scheme given by the model, it mainly includes the following elements, medical resources productivity, storage and transportation in each region at each moment.

Figure 5 illustrates the actual production of the factory in two regions at moment in the five-day time span. In this case, both factories made expansion decisions at different moments.
Figure 6. Medical resources transportation between regions in slow epidemic development situation

Figure 6 illustrates the transportation of medical resources between two regions at moment in the five-day time span. The data only considers the departure region, departure time and destination. Data in Figure 6 is consisted of two transportation methods.

It is worth noting that the amount of cross-region transportation is extremely small, with only 1 unit of medical resources transported from region B to region A on Day 2. The reason was that cross-region transportation has a high cost and the local factory is capable of meeting the local demand for medical resources.

Meanwhile, in Case One, warehouse in region A was only used on Day 3, storing six units of medical resources. These resources were produced on the same day and later transported to and used in hospital. Similarly, warehouse in region B was only used on Day 3 and Day 4, storing one and six units of medical resources respectively. These resources were produced on the same day and later transported to and used in hospital on Day 5. It was found that by storing the production surplus, the unnecessary expansion of factory can be avoided, thus reducing the total cost.

6.2. Case Two
For case two, in a sudden outbreak epidemic situation, the model will generate a production and transportation solution which meets as much demand for medical resources as possible with a minimum cost.
In Case Two, it is assumed that Region A has a demand of 14, 34, 34, 47, 32 units of medical resources from Day 1 to Day 5 respectively while Region B has a demand of 45, 57, 64, 150, 86 units of medical resources respectively. Compared with Case One, Case Two doubled the confirmed case on Day 4, namely a sudden outbreak took place on Day 4.

6.2.1. Case Solution
There are 249 variables in this case, with 30 zero-one variables, 219 continuous variables, and 141 constraints. It takes 0.06 second to generate solution with CPLEX solver.

6.2.2. Result Analysis
In the optimal scheme given by the model, it mainly includes the following elements, medical resources productivity, storage and transportation in each region at each moment.

As illustrated in Figure 8, at some moments, the production equals to the sum of production at previous moment and 20. This is because in this model, there is a upper boundary for factory production expansion of 20 units. Another reason is that the expansion, in this case, has reached the saturation point.

Figure 9. Medical resources transportation between regions in slow epidemic development situation
Figure 9 illustrates the transportation of medical resources between two regions at moment in the five-day time span. The data only considers the departure region, departure time and destination. Data in Figure 9 is consisted of two transportation methods.

Figure 10 illustrates the actual delivery condition of the fourth day in case two.

Figure 10 illustrates the actual transportation on Day 4. As illustrated in Figure 10, it is assumed that an outbreak took place on Day 4. Region A made preparation in advance and transport medical resources to Region B. Meanwhile, reserves in Region B kept in warehouse were transported to and used in hospital.

In the optimal scheme for the case, the warehouse in Region B was only used on Day 2 and Day 3. On Day 2, the warehouse stored 3 units of medical resources, which was produced on the same day from the factory in Region B. On Day three, 25 units of medical resources were kept at the warehouse in Region B, which included 3 units from the day before; 6 units transported from Region A using transport method two on Day 1; and 16 units produced on the same day from the factory in Region B.

From this case, a conclusion can be drawn as followed. Due to the upper boundary of factory production expansion, the production of medical resources on the same day will not be able to meet the demand when a outbreak occurs. In this case, two strategies can be adopted. The first strategy is to transport medical resources from other regions; the second strategy is to store the production surplus into local warehouse. However, even though the two strategies were adopted, 5 patients will not have access to medical resources due to insufficient production capacity this case.

7. Conclusion and future prospects

In this paper, a mixed integer linear programming model was applied to complete the planning of the optimal production and dispatch scheme for medical resources in the context of COVID-19 under simplified conditions. The three stages of production and dispatch of medical resources including production, storage and use were taken into consideration in this model. Based on given information on epidemic development, the model is able to make medical resources production and dispatch scheme for several regions that uses different modes of transportation over multiple moments in the time span.

Based on the two cases in this paper, the following conclusions related to the model are drawn.
- In the case of slow epidemic development when local factory is able to meet local demand for medical resources by expanding production capacity, it was found that by moderately storing the production surplus and using them later, the unnecessary expansion of factory can be avoided, thus reducing the total cost.
- In the case of sudden outbreak when local production capacity is unable to meet local demand for medical resources, cross-region transportation and local reserve of production surplus should be combined to meet as much demand as possible.
At present, the model, which relies on the assumption of knowing information on epidemic situation development, is idealistic and has room for further improvements. Improvements may include the following:

- In order to make the model more realistic and practical, other models or methods like ARIMA (Auto-regressive Integrated Moving Average) can be applied to make reasonable prediction of epidemic situation;
- Methods like Stochastic Programming can be applied to get the expected value of the minimum cost and the corresponding medical resources supply chain;
- Longer expansion times can be introduced, considering that expansion decisions are not made on a daily basis;
- Special circumstances, including sudden outbreaks and recurring outbreaks across different regions, can be taken into consideration.
- The time span of the model can be further lengthened, adding more different regions, introducing factors based on regional conditions, including infrastructure, population, and production capacity and demand for medical resources.

The ultimate goal of the model is to produce accurate optimal production and dispatch planning for medical resources in the context of COVID-19 based on real-time epidemic statistics.

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