Optimizing The Number of Hospital's Emergency Department in Petaling Jaya Using Set Covering Problem Analysis

AUTHORS

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INTRODUCTION

The emergency department (ED) has become a crucial frontline service for unscheduled patients who arrive at the hospital and need urgent attention. However, the emergency departments is struggling to provide the service and ensure all potential demand are efficiently covered. This is proved by the previous research that, if the demand too far from the emergency department, the mortality rate will increase. Therefore, the main goal of this project is to find the least number of emergency departments needed to cover all potential demand within a certain distance.

OBJECTIVE

1. Optimal Emergency Departments: Determine the **optimal number of emergency departments** in Petaling Jaya and its vicinity, formulating coverage for all potential demands within duration limitations.
2. Identification of Uncovered Areas: **Identify areas of potential demand** lacking coverage by any emergency department.
3. To analyze the behavior of the set of optimum solutions based on the **Maximal Covering Location Problem** (MCLP) model and **Maximum Expectation Covering Location Problem** (MEXCLP) model.

METHODOLOGY

MCLP Model

$$Max\ F = \sum_{j=1}^{470} d_j D_j$$

$$\sum_{i=1}^{14} t_{j,i} H_i \geq D_j\ , \forall j = 1, \dots, 470$$

$$\sum_{i=1}^{14} H_i = m$$

MEXCLP Model

$$Max\ G = \sum_{j=1}^{470} \sum_{i=1}^{14} (1-p) p^{i-1} d_j D_{ij}$$

$$\sum_{i=1}^{14} t_{j,i} H_i \geq \sum_{i=1}^{14} D_{ij}\ , \forall j = 1, \dots, 470$$

$$\sum_{i=1}^{14} H_i = m$$

p - **The probability of EDs not Working**

d_j - The associated population demand value at D_j.

m - The number of emergency department to be located.

l - The associated travel duration

$T_{j,i}$ - Duration taken from D_j node to H_i node.

$$t_{j,i} = \begin{cases} 1, & T_{j,i} \leq l \\ 0, & otherwise \end{cases}$$

$$D_j = \begin{cases} 1, if\ atleast\ one\ emergency\ can\ cover\ demand\ j \\ 0, otherwise \end{cases}$$

$$H_i = \begin{cases} 1, if\ the\ emergency\ department\ i\ is\ chose\ as\ demand\ coverage \\ 0, otherwise \end{cases}$$

$$D_{ij} = \begin{cases} 1, if\ atleast\ i\ emergency\ department\ cover\ demand\ at\ node\ j \\ 0, if\ less\ i\ emergency\ department\ cover\ demand\ at\ node\ j \end{cases}$$

RESULTS AND ANALYSIS

MCLP RESULT

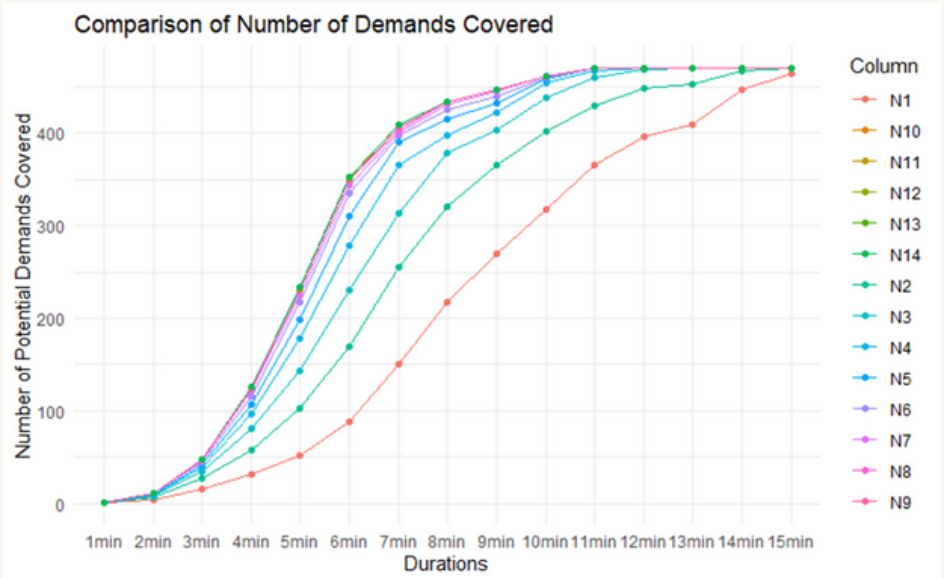


Figure above shows result of the objective value of MCLP model for each limited number of EDs for different travelling durations from EDs to potential demand points All demand points can be covered within 11 minutes by 5 emergency departments and above.

MEXCLP RESULT

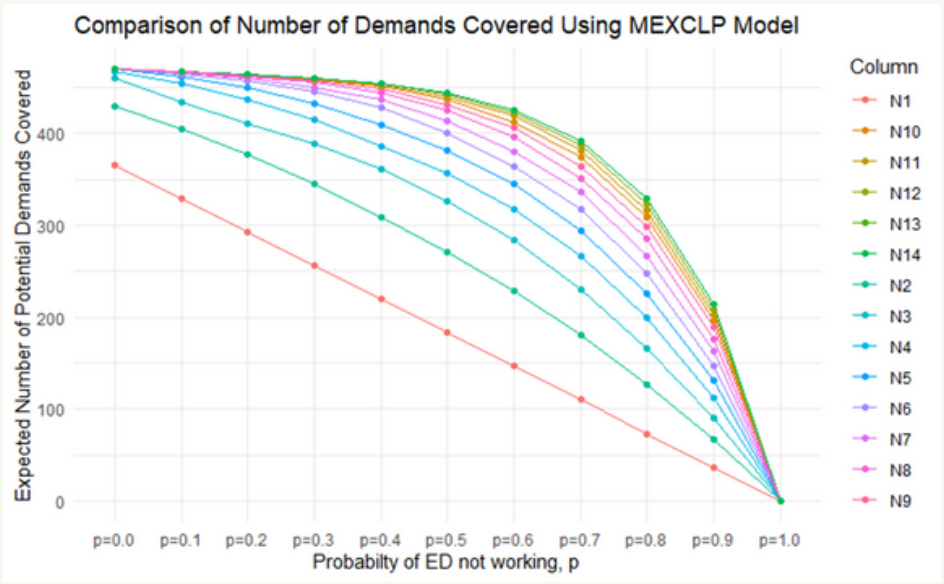
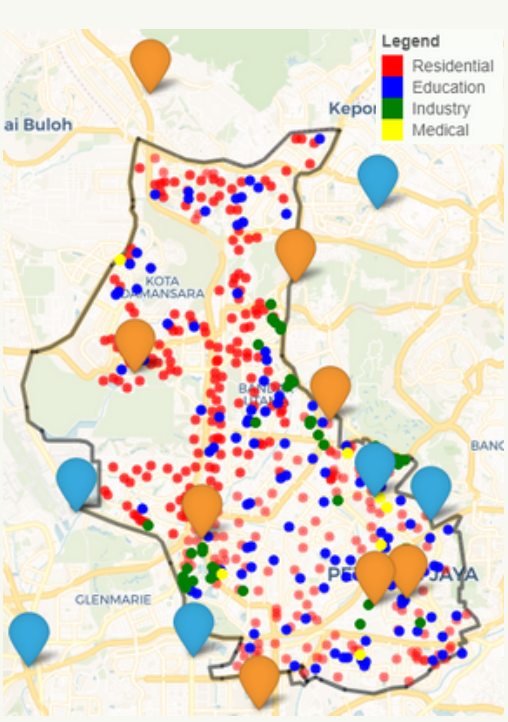


Figure above shows result of the objective value of MEXCLP model for each limited number of EDs for 11 minutes travelling durations from EDs to potential demand points.



Based on the analysis of set of optimum solution from the MCLP and MEXCLP model, all demands in Petaling Jaya can be covered by 8 Emergency Department :

1. Assunta Hospital
2. KPJ Damansara Specialist Hospital
3. Thomson Hospital
4. Beacon Hospital
5. KMI Kelana Jaya Medical Centre
6. KPJ Damansara Specialist Hospital 2
7. Sunway Medical Centre
8. Sungai Buloh Hospital

CONCLUSION

Mathematical programming offers a systematic approach to address location problems, aiming to determine optimal facility placements within specified constraints to meet demands effectively.

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