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Impact of Capacity of Mobile Units on Blood Supply Chain Performance: Results From a Robust Analysis

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Abstract

Background and Objectives: A sudden jump in blood demand during natural disasters may have strong negative impact on the performance of blood supply chain. Appropriate response to emergency situations requires predictive approach to determining the optimal allocation of blood supply chain resources for various disaster scenarios. The present study, thus, presents an optimization model aimed at decreasing blood shortage, blood wastage, and blood supply cost in emergency situations.

Methods: This work is an extension of our previously introduced stochastic blood supply chain model, which was developed based on the robust optimization concept. The aim of this model is to determine the optimal number and service areas of the blood facilities under different disaster scenarios using mixed integer linear programming. While in our previous model, the capacity of blood facility center was assumed to be constant, in the present work, it is considered as an integer variable varying within a defined interval. The present model, hence, allows exploring the influence of capacity of temporary facilities on the total costs of blood supply chain.

Findings: Changing the capacity of mobile units from 80 to 120 resulted in roughly 10% reduction in the costs, 20% reduction in the optimal number of fixed blood facilities, and 25% reduction in the optimal number of the required mobile blood facilities.

Conclusions: While the results of model analysis predict a marginal impact of the capacity of mobile units on the total cost, the capacity of these units is anticipated to considerably influence the optimal number of both permanent and temporary facilities.

Keywords: Blood supply chain, Robust optimization, Stochastic modeling, Disaster, Emergency situations

Background and Objectives

The availability blood supply often becomes limited in emergency situations due to a sudden jump in blood demand betides. Governments may face extreme difficulties in managing blood supply during and after disaster. For instance, during the Bam earthquake in 2003 in the east of Iran, only 23% of the nationally donated blood was used for the plagued people.[1] After the 2004 tsunami, the National Blood Transfusion Service of Sri Lanka encountered an influx of blood donors, which increased the difficulty of coordination of blood supply chain.[1] In the 2008 deadly earthquake of China, the quality and wastage of Chinese blood management system became the matter of high concern.[3] During the 2011 Japan (Tohoku) earthquake the blood collection process in the plagued areas was disrupted despite that blood supply increased outside Tohoku.[4] These examples suggest that effective management of blood supply chain is crucial to the security of blood supply and distribution during and after emergency situations.[5-8]

To address this requirement, Jabbarzadeh et al[9] developed a robust stochastic optimization model aimed at reducing the blood shortage, wastage and cost under various scenarios. The model was formulated so as to determine the optimal location and number of blood facilities (permanent and temporary facilities),

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assign service areas to these facilities, and determine the amount of required blood that should be collected in each facility, while the optimal solution will be robust to major scenarios. There are two kinds of blood facilities in the proposed supply chain: (*i*) permanent facilities with large capacity, which has fixed location in all periods, and (*ii*) temporary facilities with smaller capacity, which can be located in different positions. For complete description of the model, we refer the readers to reference 9. Jabbarzadeh et al, however, assumed the capacity of blood facilities to be a fixed value. In the present work, we provide an extension to the model of Jabbarzadeh et al by considering the capacity of blood facilities to be variable. Our aim is to explore the impact of capacity on the costs and the number of blood supply facilities during disaster.

Methods

Robust Model

Robust optimization model is an effective tool for decision-making under uncertainty, which was first introduced by John et al.[10] Consider the following linear optimization model:

$$Min\ Z = C^T x + d^T y \quad (1)$$

Subject to:

$$Ax = b \quad (2)$$

$$Bx + Cy = e \quad (3)$$

$$x, y \geq 0$$

Where, x and y are design and control variables, respectively. Equation (2) defines the structural constraints. The coefficients of this constraint are fixed and free of noise. Equation (3) defines the control constraints whose coefficients may be subject to noise. To define the robust optimization, a set of scenarios is defined as: Ω = {1, 2,…,S}. With each scenario (s∈Ω) we associate the subset Ω = {d_s, B_s, C_s, e_s} for the coefficients of control constraints. Let p_s be the probability of each scenario, $\sum_{1}^{S} p_s = 1$.

We first introduce control variable for each scenario, and then define error vector, which measures the infeasibility allowed in the control constraints under each scenario. The associated robust optimization model can be formulated as follows:

$$Min\ Z = \sigma(x, y_1, \ldots, y_s) + \omega\rho(\xi_1, \ldots, \xi_s) \quad (4)$$

Subject to:

$$Ax = b \quad (5)$$

$$\begin{aligned} &B_s x + C_s y + \xi_s = e_s \ \forall s \in \Omega \\ &x, y_s \geq 0 \ \forall s \in \Omega \end{aligned} \quad (6)$$

The first term in the objective function is a measure of solution robustness that indicates the closeness of a solution to optimality for each scenario s. The second term indicates the model robustness that is used to penalize violations of the control constraint for each scenario. Weighting penalty denotes the tradeoff between the solution robustness and the model robustness.

Results and Discussion

All data for model analysis was adopted from reference 9. As mentioned above, we considered the capacity of temporary facilities (b) as a variable. This variable was assumed to take five different values (b(i) = [80, 90,100,110,120]).

Table 1 presents the optimal number of permanent and temporary facilities for different capacities of the mobile unit.

Figure 1 shows the relationship between the capacity of temporary facilities and costs. As seen, with the increase of the capacity of mobile units, the associated costs decrease.

The variation of the total costs with the capacity of mobile units is illustrated in Figure 2. As can be seen, by increasing the capacity, the costs decrease constantly but in a nonlinear fashion.

Figure 3 presents the optimal number of permanent blood units that should be established before a disaster. Again the decrease of the number of required blood units with increase in capacity is observable.

The change in the optimal number of permanent blood units at each b(i) that should be established before a disaster with the capacity is presented in Figure 4. As seen, the required number of permanent blood units shows a monotonic nonlinear reverse relationship with the capacity.

Conclusions

While the results of model analysis predicts a limited

Table 1. Optimal Number of Permanent and Temporary Facilities

i	b(i)	Permanent Units	Temporary Units
1	80	10	50
2	90	9	49
3	10	9	42
4	110	8	39
5	120	8	37

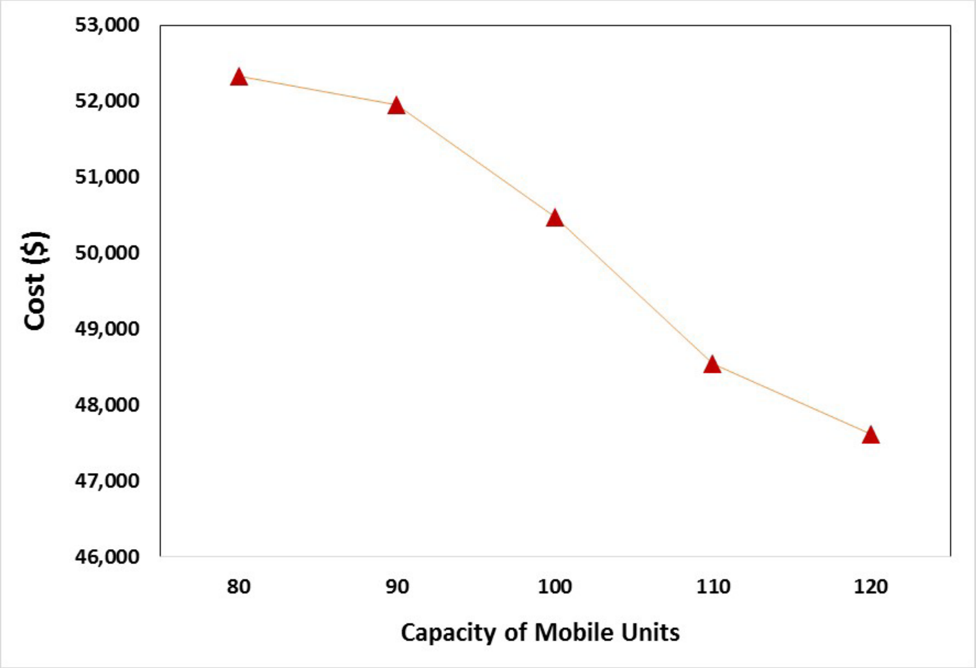

Figure 1. Capacity of Temporary Facilities vs. Costs.

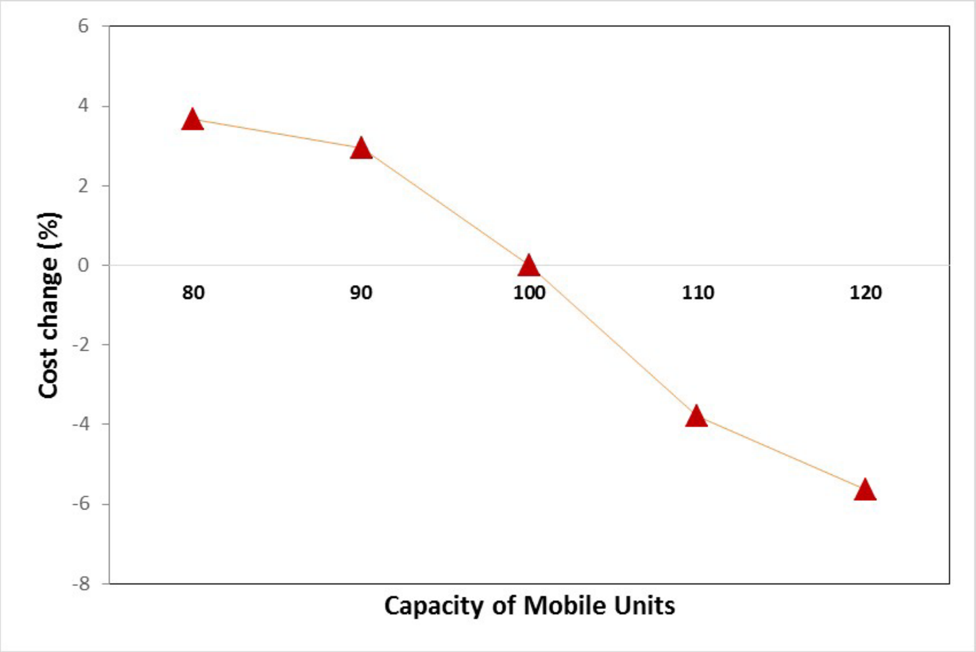

Figure 2. Variation of the Total Costs With the Capacity of Mobile Units

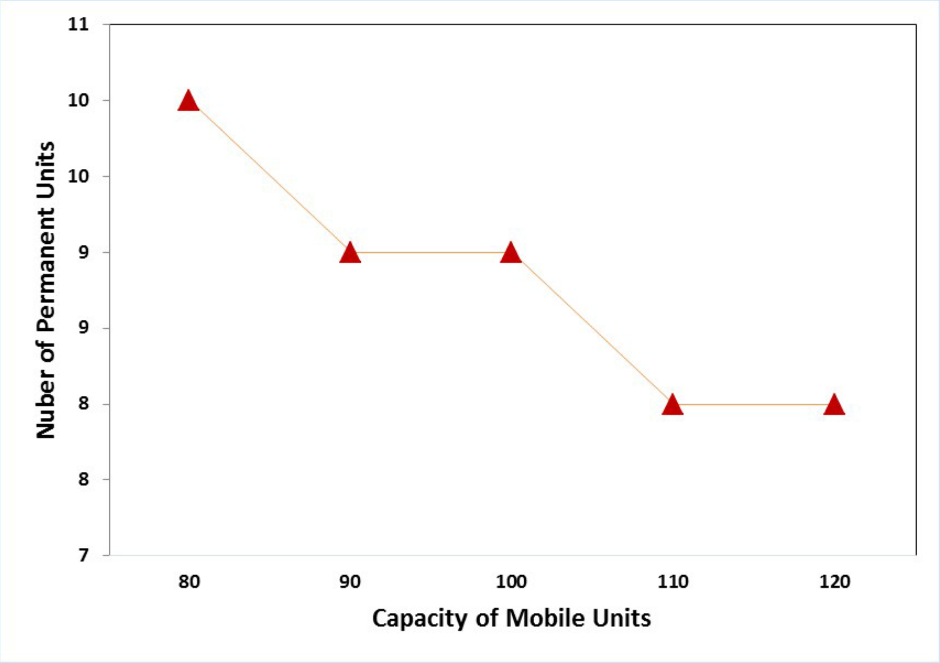

Figure 3. Optimal Number of Permanent Blood Units That Should be Established Before a Disaster.

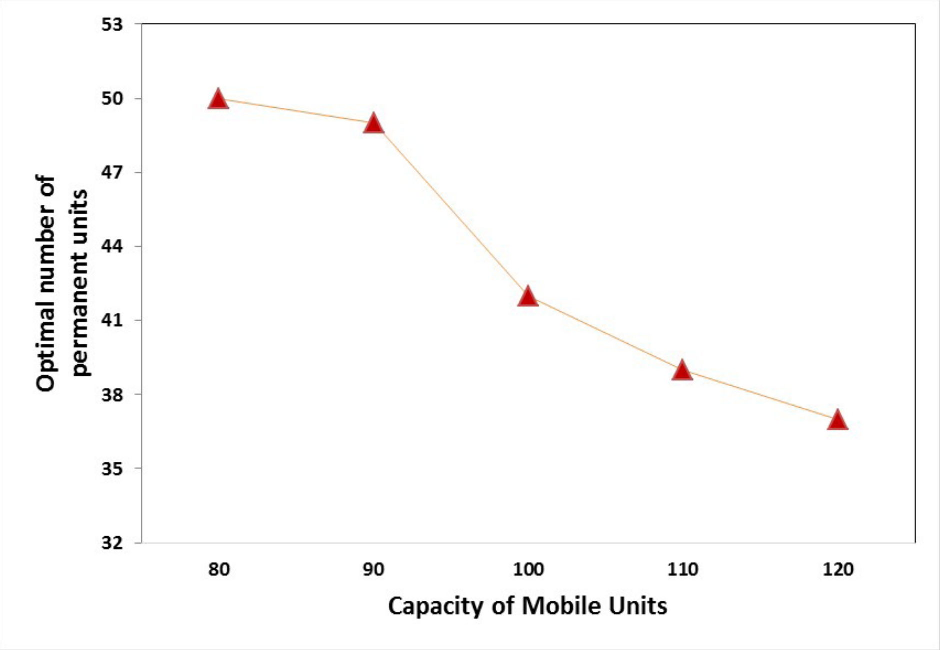

Figure 4. Variation of the Optimal Number of Permanent Blood Units That Should be Established Before a Disaster vs. the Capacity of Mobile Units.

impact of the capacity of mobile units on the total cost, the capacity of these units is anticipated to significantly influence the optimal number of both permanent and temporary facilities.

Competing Interests

The authors declare no competing interest.

Authors' Contributions

AJ developed and adapted the research tools and made the major contribution to the preparation of the manuscript. SMHM conceived the original concept, designed the study, participated in analysis and interpretation of the data, and contributed to the drafting and revising of the manuscript.

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References

1. Abolghasemi H, Radfar MH, Tabatabaee M, Hosseini-Divkolayee NS, Burkle FM. Revisiting blood transfusion preparedness: experience from the bam earthquake response. Prehosp Disaster Med. 2008;23(5):391-394.
2. Kumudu KK. Management of blood system in disasters. Biologicals. 2010;38(1):87-90.
3. Yue S, Jun H. The multi-period location-allocation problem of engineering emergency blood supply systems. Syst Eng Procedia. 2012;5(3):21-28.
4. Kenneth EN, Hitoshi O, Hiroyasu Y, Arifumi H. The Great East Japan earthquake of march 11, 2011, from the vantage point of blood banking and transfusion medicine. Transfus Med Rev. 2013;27(1):29-35.
5. Nagurney A, Masoumi AH. Supply chain network design of a sustainable blood banking system. In: Sustainable Supply Chains. New York: Springer; 2012:49-72.
6. Pierskalla WP. Supply chain management of blood banks. In: Brandeau ML, Sainfort F, Pierskalla WP, eds. Operations Research and Health Care: A Handbook of Methods and Applications. New York: Springer Science & Business Media; 2004:45–103.
7. Jiuh-Biing S. An emergency logistics distribution approach for quick response to urgent relief demand in disasters. Transport Res E-Log. 2007;43(6):687-709.
8. Jeroen B, Hein F. Supply chain management of blood products: a literature review. Eur J Oper Res. 2012;217(1):1-16.
9. Jabbarzadeh A, Fahimnia B, Seuring S. Dynamic supply chain network design for the supply of blood in disasters: a robust model with real world application. Transport Res E-Log. 2014;70(13):244-55.
10. Mulvey JM, Robert JV, Zenios SA. Robust optimization of large-scale systems. Oper Res. 1995;43(2):264-281.
11. Azimi S, Sepehri MM, Etemadian M. A nurse scheduling model under real life constraints. Int J Hosp Res. 2015;4(1):1-8.
12. Khasha R, Sepehri MM, Khatibi T. A fuzzy FMEA approach to prioritizing surgical cancellation factors. Int J Hosp Res. 2013;2(1):17-24.
13. Rastegar-Panah MM, Hosseini-Motlagh SM, Babaei E, Noughani F. Use and usefulness of social network analysis in the primary health context. Int J Hosp Res. 2013;2(4):177-186.

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