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Optimal logistics scheduling with dynamic information in emergency response: Case studies for humanitarian objectives

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ABSTRACT

The mathematical model of infectious disease is a typical problem in mathematical modeling, and the common infectious disease models include the susceptible-infected (SI) model, the susceptible-infected-recovered model (SIR), the susceptible-infected-recovered-susceptible model (SIRS) and the susceptible-exposed-infected-recovered (SEIR) model. These models can be used to predict the impact of regional return to work after the epidemic. In this paper, we use the SEIR model to solve the dynamic medicine demand information in humanitarian relief phase. A multistage mixed integer programming model for the humanitarian logistics and transport resource is proposed. The objective functions of the model include delay cost and minimum running time in the time-space network. The model describes that how to distribute and deliver medicine resources from supply locations to demand locations with an efficient and lower-cost way through a transportation network. The linear programming problem is solved by the proposed Benders decomposition algorithm. Finally, we use two cases to calculate model and algorithm. The results of the case prove the validity of the model and algorithm.

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References

[1] Wang, H., Wang, X., Zeng, A.Z. (2009). Optimal material distribution decisions based on epidemic diffusion rule and stochastic latent period for emergency rescue, *International Journal of Mathematics in Operational Research*, Vol. 1, No. 1-2, 76-96, doi: 10.1504/IJMOR.2009.022876.

[2] Huang, K., Jiang, Y., Yuan, Y., Zhao, L. (2015). Modeling multiple humanitarian objectives in emergency response to large-scale disasters, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 75, 1-17, doi: 10.1016/j.tre.2014.11.007.

[3] Cao, J., Han, H., Jiang, Y.-P., Wang, Y.-J. (2018). Emergency rescue vehicle dispatch planning using a hybrid algorithm, *International Journal of Information Technology & Decision Making*, Vol. 17, No. 6, 1865-1890, doi: 10.1142/S0219622018500414.

[4] Holguín-Veras, J., Pérez, N., Jaller, M., Van Wassenhove, L.N., Aros-Vera, F. (2013). On the appropriate objective function for post-disaster humanitarian logistics models, *Journal of Operations Management*, Vol. 31, No. 5, 262-280, doi: 10.1016/j.jom.2013.06.002.
[5] Zhang, J., Ma, Z. (2003). Global dynamics of an SEIR epidemic model with saturating contact rate, *Mathematical Biosciences*, Vol. 185, No. 1, 15-32, doi: 10.1016/S0025-5564(03)00087-7.
[6] Li, D., Liu, S., Cui, J. (2017). Threshold dynamics and ergodicity of an SIRS epidemic model with Markovian switching, *Journal of Differential Equations,* Vol. 263, No. 12, 8873-8915, doi: 10.1016/j.jde.2017.08.066.
[7] Fan, K., Zhang, Y., Gao, S., Wei, X. (2017). A class of stochastic delayed SIR epidemic models with generalized nonlinear incidence rate and temporary immunity, *Physica A: Statistical Mechanics and its Applications*, Vol. 481, 198-208, doi: 10.1016/j.physa.2017.04.055.
[8] Song, P., Lou, Y., Xiao, Y. (2019). A spatial SEIRS reaction-diffusion model in heterogeneous environment, *Journal of Differential Equations,* Vol. 267, No. 9, 5084-5114, doi: 10.1016/j.jde.2019.05.022.
[9] Yang, P., Wang, Y. (2019). Dynamics for an SEIRS epidemic model with time delay on a scale-free network, *Physica A: Statistical Mechanics and its Applications,* Vol. 527, Article No. 121290, doi: 10.1016/j.physa.2019.121290.
[10] Bolzoni, L., Bonacini, E., Soresina, C., Groppi, M. (2017). Time-optimal control strategies in SIR epidemic models, *Mathematical Biosciences*, Vol. 292, 86-96, doi: 10.1016/j.mbs.2017.07.011.
[11] Guo, W., Zhang, Q., Li, X., Wang, W. (2018). Dynamic behavior of a stochastic SIRS epidemic model with media coverage, *Mathematical Methods in the Applied Sciences*, Vol. 41, No. 14, 5506-5525, doi: 10.1002/mma.5094.
[12] Britton, T., Ouédraogo, D. (2018). SEIRS epidemics with disease fatalities in growing populations, *Mathematical Biosciences*, Vol. 296, 45-59, doi: 10.1016/j.mbs.2017.11.006.
[13] Anparasan, A., Lejeune, M. (2019). Resource deployment and donation allocation for epidemic outbreaks, *Annals of Operations Research*, Vol. 283, 9-32, doi: 10.1007/S10479-016-2392-0.
[14] Yee, W.S., Ng, H., Yap, T.T.V., Goh, V.T., Ng, K.H., Cher, D.T. (2022). An evaluation study on the predictive models of breast cancer risk factor classification, *Journal of Logistics, Informatics and Service Science,* Vol. 9, No. 3, 129-145, doi: 10.33168/LISS.2022.0310.
[15] Choi, J.-W., Jeong, E.-R. (2022). Multi-output convolutional neural network based distance and velocity estimation technique for orthogonal frequency division multiplexing radar systems, *Webology,* Vol. 19, No. 1, 4555-4570, doi: 10.14704/WEB/V19I1/WEB19302.
[16] Farahani, R.Z., Lotfi, M.M., Baghaian, A., Ruiz, R., Rezapour, S. (2020). Mass casualty management in disaster scene: A systematic review of OR&MS research in humanitarian operations, *European Journal of Operational Research,* Vol. 287, No. 3, 787-819, doi: 10.1016/j.ejor.2020.03.005.
[17] Kwapong Baffoe, B.O., Luo, W. (2020). Humanitarian relief sustainability: A framework of humanitarian logistics digital business ecosystem, *Transportation Research Procedia,* Vol. 48, 363-387, doi: 10.1016/j.trpro.2020.08.032.
[18] Wang, Y.D., Lu, X.C., Song, Y.M., Feng, Y., Shen, J.R. (2022). Monte Carlo Tree Search improved Genetic Algorithm for unmanned vehicle routing problem with path flexibility, *Advances in Production Engineering & Management*, Vol. 17, No. 4, 425-438, doi: 10.14743/apem2022.4.446.
[19] Zaldívar-Colado, A., Tripp-Barba, C., Brito-Rojas, J.A., Aguilar-Calderón, J.A., García-Sánchez, O.V., Ramírez-Zambada, L., Zatarain-Montalvo, J.N. (2017). Management of traffic lights for emergency service, *Tehnički Vjesnik – Technical Gazette,* Vol. 24, No. 2, 643-648, doi: 10.17559/TV-20140910051747.
[20] Wang, L., Chen, X.Y., Zhang, H. (2021). Joint distribution models in fast-moving consumer goods wholesale enterprise: Comparative analysis and a case study, *Advances in Production Engineering & Management*, Vol. 16, No. 2, 212-222, doi: 10.14743/apem2021.2.395.
[21] Zhou, Y., Liu, J., Zhang, Y., Gan, X. (2017). A multi-objective evolutionary algorithm for multi-period dynamic emergency resource scheduling problems, *Transportation Research Part E: Logistics and Transportation Review,* Vol. 99, 77-95, doi: 10.1016/j.tre.2016.12.011.
[22] Othman, S.B., Zgaya, H., Dotoli, M., Hammadi, S. (2017). An agent-based decision support system for resources' scheduling in emergency supply chains, *Control Engineering Practice*, Vol. 59, 27-43, doi: 10.1016/j.conengprac.2016.11.014.
[23] Ferrer, J.M., Martín-Campo, F.J., Ortuño, M.T., Pedraza-Martínez, A.J., Tirado, G., Vitoriano, B. (2018). Multi-criteria optimization for last mile distribution of disaster relief aid: Test cases and applications, *European Journal of Operational Research*, Vol. 269, No. 2, 501-515, doi: 10.1016/j.ejor.2018.02.043.
[24] Garrido, R.A., Aguirre, I. (2020). Emergency logistics for disaster management under spatio-temporal demand correlation: The earthquakes case, *Journal of Industrial and Management Optimization*, Vol. 16, No. 5, 2369-2387, doi: 10.3934/jimo.2019058.
[25] Lam, E., Van Hentenryck, P., Kilby, P. (2020). Joint vehicle and crew routing and scheduling, *Transportation Science*, Vol. 54, No. 2, 488-511, doi: 10.1287/trsc.2019.0907.
[26] Rajak, S., Parthiban, P., Dhanalakshmi, R. (2019). A hybrid metaheuristics approach for a multi-depot vehicle routing problem with simultaneous deliveries and pickups, *International Journal of Mathematics in Operational Research*, Vol. 15, No. 2, 197-210, doi: 10.1504/IJMOR.2019.101619.
[27] Sedehzadeh, S., Seifbarghy, M., (2021). Redesigning a closed loop food supply chain network considering sustainability and food banks with different returns, *Economic Computation And Economic Cybernetics Studies and Research*, Vol. 55, No. 4, 85-100, doi: 10.24818/18423264/55.4.21.06.
[28] Gutjahr, W.J., Nolz, P.C. (2016). Multicriteria optimization in humanitarian aid, *European Journal of Operational Research*, Vol. 252, No. 2, 351-366, doi: 10.1016/j.ejor.2015.12.035.
[29] Liu, M., Xiao, Y. (2015). Optimal scheduling of logistical support for medical resource with demand information updating, *Mathematical Problems in Engineering*, Vol. 2015, Article ID 765098, doi: 10.1155/2015/765098.

[30] Liu, M., Zhang, Z., Zhang, D. (2015). A dynamic allocation model for medical resources in the control of influenza diffusion, *Journal of Systems Science and Systems Engineering,* Vol. 24, No. 3, 276-292, doi: 10.1007/s11518-015-5276-y.
[31] Buschiazzo, M., Mula, J., Campuzano-Bolarin, F. (2020). Simulation optimization for the inventory management of healthcare supplies, *International Journal of Simulation Modelling*, Vol. 19, No. 2, 255-266, doi: 10.2507/IJSIMM19-2-514.
[32] Fischetti, M., Ljubić, I., Sinnl, M. (2017). Redesigning benders decomposition for large-scale facility location, *Management Science*, Vol. 63, No. 7, 2146-2162, doi: 10.1287/MNSC.2016.2461.
[33] Alkaabneh, F., Diabat, A., Gao, H.O. (2020). Benders decomposition for the inventory vehicle routing problem with perishable products and environmental costs, *Computers & Operations Research,* Vol. 113, Article No. 104751, doi: 10.1016/j.cor.2019.07.009.
[34] Fachini, R.F., Armentano, V.A. (2020). Logic-based Benders decomposition for the heterogeneous fixed fleet vehicle routing problem with time windows, *Computers & Industrial Engineering*, Vol. 148, Article No. 106641, doi: 10.1016/j.cie.2020.106641.
[35] Cordeau, J.-F., Furini, F., Ljubić, I. (2019). Benders decomposition for very large scale partial set covering and maximal covering location problems, *European Journal of Operational Research*, Vol. 275, No. 3, 882-896, doi: 10.1016/j.ejor.2018.12.021.
[36] Behmanesh, R., Rahimi, I. (2021). Improved ant colony optimization for multi-resource job shop scheduling: A special case of transportation, *Economic Computation And Economic Cybernetics Studies And Research,* Vol. 55, No. 4, 277-294, doi: 10.24818/18423264/55.4.21.18.
[37] Tang, F. (2021) An improved intelligent bionic optimization algorithm based on the growth characteristics of tree branches, *Journal of Intelligent & Fuzzy Systems*, Vol. 40, No. 3, 3821-3829, doi: 10.3233/JIFS-190487.
[38] Liu, M., Liang, J. (2013). Dynamic optimization model for allocating medical resources in epidemic controlling, , *Journal of Industrial Engineering and Management,* Vol. 6, No. 1, 73-88, doi: 10.3926/jiem.663.
[39] Han, H., Cao, J., Wang, Y.-J. (2023). A hybrid algorithm of ant colony and benders decomposition for large-scale mix-integer linear programming, *International Journal of Information Technology & Decision Making*, Vol. 22, 1-23, doi: 10.1142/S0219622023500335.
[40] Benders, J.F. (1962). Partitioning procedures for solving mixed-variables programming problems, *Numerische Mathematik,* Vol. 4, 238-252, doi: 10.1007/BF01386316.