

Improving Earthquake Preparedness: A GIS-Based Decision Support System for Emergency Treatment Site Placement

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Abstract

While temporary medical facilities play a critical role in earthquake preparedness and immediate response, they remain underexplored in research on facility location problems. Addressing this gap, we present a decision support system (DSS) designed to assist local municipalities in positioning emergency treatment sites (ETS), which are temporary medical facilities set up near destruction zones to provide immediate care for minor injuries. These temporary sites aim to manage minor injuries (accounting for over 80% of casualties) and alleviate the burden on hospitals immediately after an earthquake. The proposed DSS integrates a location network characterization with a hybrid simulation/optimization model to determine the number and optimal locations of ETSSs. It delivers recommendations within seconds, making it suitable as both an emergency response and a preparedness planning tool. Key components of the DSS include a GIS-based database, a decision engine, and a user-friendly interface. A preliminary feasibility study conducted with a local municipality demonstrated encouraging results. The mathematical model identified optimal locations for emergency treatment sites, while simulations validated these choices across various destruction scenarios. This collaboration not only strengthens the DSS's practicality but also lays the groundwork for broader implementation as a scalable solution for improving earthquake response.

Keywords

Decision support system (DSS), Earthquake preparedness, Temporary medical facility, Facility location, health care application.

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Biographies

Sagit Kedem-Yemini (Ph.D.) is an industrial engineer proficient in information systems and currently holds two lecturing positions: a tenured lecturer position at Sapir Academic College (Logistics Department) and an adjunct lecturer at Ben-Gurion University (both in IE&M and the Faculty of Business and Management). In 2023-2024 she was a visiting professor at California Polytechnic State University (Cal Poly) at IME department. Her teaching portfolio is broad, focusing on enterprise systems implementation (SAP and Oracle Applications) and derivatives of ERP data collection, ranging from business analytics to process mining. Additionally, she has extensive experience in academic curriculum development, serving as the head of her department's teaching committee and acting as a liaison to the graduation projects unit. Her research interests include process mining and its practical applications, ERP-related issues, and DSS development. Since 2015, she has served as a member of the JITCAR Editorial Review Board. Prior to her academic career, Dr. Kedem-Yemini worked at a global clean-room fab build-up construction management company with major clients such as Intel, Tower Semiconductors, and Teva Pharmaceuticals. During her tenure there, she held various positions, including logistics manager, scheduling manager, and CIO (Chief Information Officer).

Simona Cohen Kadosh (Ph.D.) is a mechanical and industrial engineer proficient in operations research and currently holds two lecturing positions: a tenured lecturer position at Sapir Academic College (Logistics Department) and an adjunct lecturer at Ben-Gurion University (in Industrial Engineering & Management Faculty and Health Systems Management at the Faculty of Business and Management). Her teaching portfolio includes Supply Chain Management, logistics management, location problems in disaster cases, and various problems in operational systems. Her research interests include measuring efficiency in different cases using the DEA method and improving preparedness for natural disasters. Additionally, she served as the Acting Head of the Logistics Department during most of the last year. Before that, she took part as a research assistant in research conducted by the Dead Sea & Arava Science Center (DSASC) about preparation for earthquakes of small and medium businesses (SMB) sectors in peripheral country areas. Nowadays, she is the head of a research team on "Locating Emergency Treatment Sites (ETS) with Decision Support System (DSS) for Preparedness and Response to Earthquake Events for Local Municipalities".

Yuval Bitan (Ph.D.) is a human-factors engineer and research scientist who studies cognitive systems engineering at Ben-Gurion University of the Negev. His research focuses on the cognitive strategies human operators apply to handle incomplete and conflicting interactions with information, and the impact this has on decision making. Implementing the knowledge acquired in such research into the design of systems and processes throughout the healthcare system will make them easier and more efficient to operate and will improve patient safety. Yuval is an Associate Professor in the Department of Health Policy and Management, at Ben-Gurion University of the Negev, Beer Sheva, Israel, and serves as the director of SimReC, the Research Center for Simulation in Healthcare. Prior to his tenured position, he was an Assistant Professor (status only) in the Department of Mechanical and Industrial Engineering at the University of Toronto, and a Research Associate at the Cognitive Technologies Laboratory (University of Chicago, Illinois) and at HumanEra (University Health Network, Toronto, Canada). Yuval received a Ph.D. in Industrial Engineering and Management in 2003 from Ben-Gurion University of the Negev, Beer-Sheva, Israel.

Zilla Sinuany-Stern is Professor Emerita of Operations Research (OR), in the Department of Industrial Engineering & Management (IEM), at Ben Gurion University (BGU) of the Negev, in Beer Sheva, Israel. She Headed the Department of IEM at BGU and held the Chair of "*Sir John and Lady Cohen of Business and Industrial Management*". She was Vice President for Academic Affairs (Rector) of Ariel University (loaned from BGU for 8 years). On the national level she was: a Member of the Israeli Council for Higher Education (CHE), chaired the Quality Assurance Committee of CHE; and was the President of the Israeli Society of OR (ORSIS). On the international level, she was elected twice as Vice President of the European Association of OR. Her Ph.D. is from Case Western Reserve University (CWRU) in OR. Her BA and MA are in Economics and Statistics from Tel Aviv University. Zilla is best known for developing efficiency rank-scales for measuring organizational units' performance, combining DEA (Data Envelopment Analysis) with multivariate statistics. She developed models for: transportation, evacuation, facility location, water planning, and other public sector applications, while consulting in Israel and USA; utilizing methods

such as: analytical hierarchical process (AHP), discrete multiattribute utility function, simulation and multi-objective. She published over 100 papers in main OR, IE and logistics journals. Since 1995 to date, she is a member of the International Advisory Board of the Journal of the Operational Research Society (British). She was a visiting professor in many universities in various countries.