

# **Posters and Abstracts**

## **Humanitarian Logistics Conference**

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## **A Pandemic Influenza**

**\*Ozgur M. Araz<sup>1,2</sup>, Tim Lant<sup>2,4,5</sup>, John Fowler<sup>1</sup>, Megan Jehn<sup>3</sup>**

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Pandemic influenza continues to be an area of great interest in emergency preparedness planning with increasing concerns about the potential social and economical disruptions that a pandemic may cause. Simulation models are increasingly being used to develop better policies to mitigate the effects of emerging disease outbreaks such as pandemic influenza. Simulation modeling allows policy makers to gain better clarity of the issues, a better understanding of how to impact the outcomes and ultimately how to build a better plan.

We present a geospatial-temporal disease spread simulation model for pandemic influenza affecting multiple communities. School closure, a social distancing policy listed in the federal guidelines for community mitigation during pandemic influenza, is investigated in this research with several questions such as a) at what level should schools be closed (state-wide, county-wide or etc.), b) for how long should they be closed and c) how should the re-opening decisions be made. These questions will be considered in terms of minimizing: a) the total infection cases b) total mortalities, and c) the impact on food delivery to the school children.

Besides the mathematical modeling of the disease spread and response policies, we also investigate how to efficiently use simulation models in conjunction with the support of other visualization tools and techniques in real time in order to develop better mitigation policies during the influenza pandemic.

**Keywords:** Disaster Response- Modeling, Simulation and Training, Pandemic Influenza

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## **Design of a Centrally Managed Stockpiling System to Support Refugees and IDPs**

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Our Senior Design Project consisted in the design of a centrally managed stockpiling system that will be managed by the United Nations High Commissioner for Refugees (UNHCR), the UN agency that helps and protects refugees and IDPs, to supply non-food items to refugees and internally displaced persons (IDPs) around the world.

UNHCR needs to react for both regular and emergency refugee demand. The service within UNHCR that is responsible for acquiring and delivering the goods that are requested by the different field offices around the world is the Supply Management Service (SMS).

Currently, each field operation decides on how to distribute their resources based on the funds available and current demand. This makes demand unpredictable for the procurement done by UNHCR, often resulting in expensive air-lifts and inefficient procurement scenarios to meet last minute demands. The lack of predictability in demand eventually causes long service lead times and accumulation of unutilized goods in field/regional warehouses that could be better used by other entities.

The project consisted of the design of a buffer stockpiling system that will be managed by SMS. It proposes a set of warehouse locations (Accra, Ghana; Dubai, UAE; Kampala, Uganda) and inventory levels to preposition non-food items around the world, offsetting the unpredictability of refugee and IDP demand. The warehouses will sustain both regular and emergency demand.

The methodology included a two-phase model. The first phase of the model consisted of a strategic location model that selects the optimal configuration of warehouses based on a list of nine proposed locations. This location model was tested for robustness and its value was measured in terms of costs, lead-time, and stock-outs. The second phase consisted of a tactical inventory model (Beamon & Kotleba, 2006), which is able to account and serve both regular and emergency demand. This inventory policy determines the reorder points and quantities of each item in each warehouse. The policy was implemented in a tool that SMS can update based on changes in demand and other parameters such as costs and the willing risk of a stock-out.

With the conclusion of both models, we determined that having a centralized system was the best option for SMS by comparing the current process with our proposed process. With a centralized process SMS could potentially have cost savings up to 75% (\$356 million per year), a reduction in lead times of 76% (8 weeks), and a reduction in stock-outs of 52%. Most importantly, the system will increase the amount and the quality of aid given to refugees and IDP's around the world. For more information please contact: Patricio Bichara [pbichara@gatech.edu](mailto:pbichara@gatech.edu)

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## **Logistic Capabilities Improvement Project of CARE**

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The collaborative efforts between CARE, UPS and GA Tech, embodies several tasks designed to enhance and strengthen CARE's ability to rapidly respond to global challenges by focusing on the improvement of CARE's logistical capabilities.

The project will prove to have a global reach far beyond CARE USA's current foot print. This collaboration is intended to positively impact CARE's emergency humanitarian response work, while also enhancing CARE's on-going development programs world wide. The application of a global commodity tracking system, together with the pre-positioning of emergency relief supplies in identified locations, and the further development of standard procedures and tools will play a key role in CARE's emergency preparedness capabilities.

Standing as the corner-stone accomplishment of these collaborative efforts we have the establishment of a Global Logistics Center within CARE USA headquarters. In this approach, we will seek to improve the inventory management and accountability by enhancing monitoring and oversight; warehouse operations, layout and design; and having a global tracking software supported and funded through strategic partnerships.

While slowly, some results are just beginning to show. Initial work has started on the development of the commodity tracking system, and on the adoption of global standards. CARE is answering the challenge to over haul, modernize, and reengineer their supply chain processes to position itself as the premier humanitarian organization in the World.

*This poster was originally presented at the CARE "Fight Against Global Poverty" conference that took place in Johannesburg South Africa, in early November of 08'.*

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**Estimating Material Convergence: Flow of Donations for Hurricane Katrina**

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In the case of an extreme event such as Hurricane Katrina, the delivery of critical supplies (e.g., food, water) to the disaster site often becomes a difficult task because such events originate a convergence process. This process is characterized by the movement of personnel, information and materials towards the disaster site. From the emergency logistics standpoint material convergence is an important issue because donations particularly of non-priority items can severely hamper the flow of critical supplies by distracting resources from critical tasks. The main problem is that the logistic system has a limited capacity and there is a high volume of low priority goods and a low volume of high priority supplies trying to use the system simultaneously, therefore the efficiency of the flow of critical supplies depends on the flow of low priority supplies. In the case of the Katrina response one of the main issues was the lack of planning for handling and distributing donations. This research focuses on the quantification of the material convergence. A database of Katrina donations has been assembled based on post-processing of newspaper articles and web publications to be used for spatial econometric modeling to quantify convergence. These data are used to investigate the donations' patterns taking Hurricane Katrina as a case study, with the objective of trying to figure out if donations can be explained in terms of the magnitude of the disaster, or the socioeconomic characteristics of the geographical locations of the event and the donors. Developing such models is important because it might improve the efficiency of humanitarian relief agencies, giving them an idea of what to expect in the event of a disaster and thus helping the agencies to be ready for the management of donations in the response process.

## Community Based Approach for Natural Disaster Management in Sri Lanka

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Sri Lanka is a natural and human induced disaster prone developing country, and a small island, thus, it needs to pay a special attention to disaster risk reduction in view of its higher vulnerability and risk levels. Most of the ongoing disaster mitigation/ preparedness programs are not based on local knowledge and are not community driven. Thus, the present study aimed at developing community based disaster risk reduction (DRR) models to recommend strategies to be adopted in future DRR interventions.

The study was conducted during the year 2008 in five districts of Sri Lanka namely Kaluthara, Galle, Hambantota, Ratnapura and Ampara to study five disaster situations; flood, tsunami/ tidal waves, drought, landslides and cyclones respectively. Sri Lanka Foundation Institute in collaboration with Institute of Human Development and Training implemented the program with the financial support of Oxfam-America. Participatory Rural Appraisal (PRA) exercises were carried out and secondary information gathered to obtain an in-depth knowledge on the above natural disasters to develop disaster risk reduction (DRR) models for each disaster situation. Tools used in PRA were: social mapping; historical profile; seasonal calendar; impact diagram; Venn diagram; SWOT (strengths, weaknesses, opportunities and threats) Analysis, Wealth ranking and Case studies.

Five community based DRR models were developed for five disaster situations in the considered districts. In these models the family is considered as the nucleus of the model structure. The community is organized comprising family units and knitted by interactions of various factors under different categories such as physical, economic, social, institutional, environmental, livelihoods etc. Influence of these factors can vary due to any external shock such as natural disasters. There can be strengths or weaknesses of these factors in a community. As a result the community would be strong enough or fail to respond the disaster event. Empowerment of a community is determined on how the institutional framework is strongly structured. There can be threats or opportunities affecting this community mostly through this institutional setup. In implementing the model six steps were recommended by the study. They are: problem analysis, need identification, need assessment, action plan, implementation and monitoring and evaluation. The paper discusses recommendations made by the study to support the policy, programming and learning improvements in building the capacity of the community in disaster mitigation and preparedness and reduce the risk due to disasters.

**KEYWORDS:** Disaster risk reduction, community participation, DRR modeling, SWOT analysis, community empowerment

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## **Cyclone Nargis Storm Surge Flooding in Myanmar's Ayeyarwady River delta**

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Tropical cyclone Nargis (Cat. 4) made landfall on May 2, 2008, causing the worst natural disaster in Myanmar's recorded history. Cyclone Nargis struck low-lying coastal plains particularly vulnerable to storm surge flooding. The first independent reconnaissance team surveyed maximum high water marks, inland inundation, coastal erosion, fatality rates and damage to infrastructure and vegetation by boat and helicopter. The importance of cyclone awareness, education and evacuation plans is highlighted for an area where a successful evacuation is only possible hours before cyclone landfall. The multi-hazard aspect is analyzed by comparing observations from Cyclone Nargis with the 2004 Indian Ocean Tsunami.



## Heuristics for Emergency Response Supply Chains

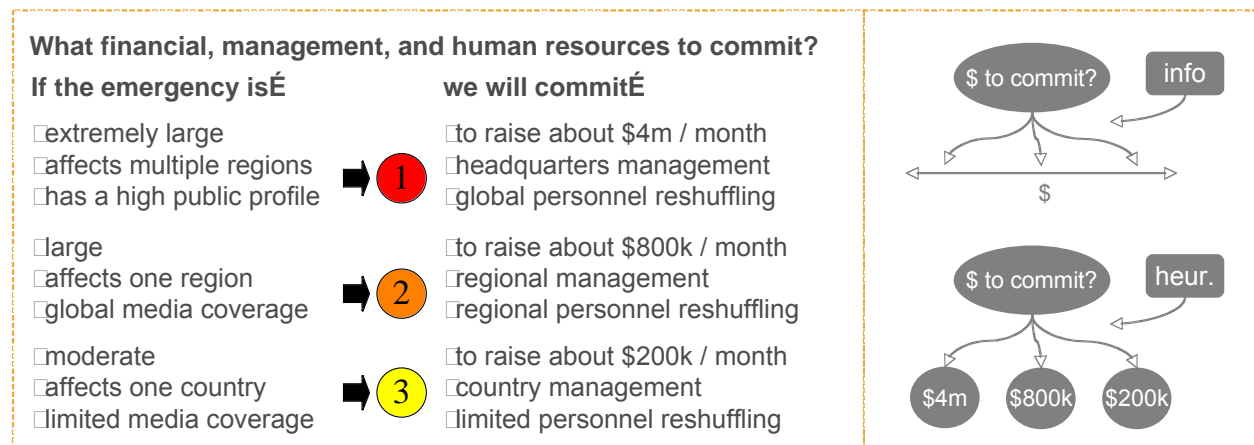
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Humanitarian supply chains are particularly challenging to design and manage because of the speed with which they must be built, and the uncertainty of where they will be needed. Essentially, humanitarian supply chains must be designed and built ‘overnight’. In the immediate aftermath of a disaster, there is not enough time or information for traditional supply chain design methods of modeling and optimization. In the preparation phase before a disaster, the range of possible problems is huge, so modeling cannot be completed ahead of time. This research suggests, as an alternative to these traditional methods, the notion of ‘heuristics’ for rapid supply chain design.

The idea was suggested by the way in which expert humanitarian logisticians think about emergency supply chain design. Through a series of interviews, it was discovered that humanitarian

### Example: Resource Allocation Heuristic



logisticians begin designing a supply chain quickly, based on very little knowledge of an emergency. They appear to utilize various heuristics: sets of decision rules that are useful, yet approximate, for guiding emergency response. Such operational heuristics allow quick decisions based on little information, and appear to provide a reasonable (if suboptimal) response. The figure below shows an example heuristic that helps one organization simplify the problem of allocating organizational resources (human and financial) after a disaster has occurred. The heuristic guides what might otherwise be a complex decision by simplifying the response space into three discrete alternatives, and specifying the information needed to choose among the alternatives. In this ongoing research, we continue to look for heuristics used by expert humanitarian logisticians. One example is the standard item kits stored by the International Federation of Red Cross and Red Crescent societies. When a disaster occurs anywhere, they can deliver a set of standard relief items quickly from their global warehouses, based on very little information about the specific emergency. The next step is to model and evaluate some of these existing heuristics, and suggest improvements to them.

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**Extending Global Field-Based Specimen Survey Data to Humanitarian Logistics Applications—Exploring the Potential.**

Julian Buckmaster is the project lead and system architect for the Lymphatic Filariasis Field Data System project. He is the chief architect of ASTRO 21C™, CDC's enterprise specimen management system.

\*Frederic Grant, PhD, is the Chief Scientist for Northrop Grumman Corporation's Public Health Division, Atlanta, GA.

A Northrop Grumman team developed, tested, and deployed a low cost global field data collection and management system to support The Task Force for Child Survival and Development research into Lymphatic Filariasis (LF, Elephantiasis). The project has required an electronic data collection and management system to provide accurate and timely data, from field data entry to analysis, across an eight country study.

Beyond the expertise gained in developing CDC's specimen management system, ASTRO 21C™, creating a field survey PDA-based system, and managing CDC labs, repositories, and specimen collection activities—these experiences have provided the Northrop Grumman team with unique insights into the potential for utilizing these data for future humanitarian logistics applications including public health preparedness as well as disaster relief.

This poster illustrates how pseudonymized data collected for specimen management may be geocoded and used to represent important reference point information for general humanitarian logistics responses as well as application modeling.

Informational by products from field-based data collection can prevent redundant and time consuming independent data collection efforts. Additionally, these types of data when available can be transformed within hours or days for review and analysis.

The implications for this are that certain types of field work can be generalized to assist the analysis of other diseases such as malaria or Neglected Tropical Diseases (NTD's), thus enabling public health teams to have a preunderstanding of population status and requirements. This work suggests that there may be untapped sources of planning information which might enable more efficient public health response.

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## **Logistics of Deworming Drug Distribution in Zambia**

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Since 2005, an NGO has supplied millions of tablets of mebendazole, albendazole, and capsules of vitamin A to control soil-transmitted helminthes (commonly known as “worms”) and supplement children’s nutrition in 27 countries. While, the drugs are donated, there are still substantial costs for shipping and distribution of the products, at both the international and local levels. A study was performed to identify improvements to the efficiency and effectiveness of this distribution in Zambia. First, forecasting for the amount of medicine necessary to treat all Zambian children under the age of five was conducted. Additionally, a map of the transportation system was created. Through field observations of the delivery of mebendazole and vitamin A to young children, and interviews with key personnel at all levels of the health system, a supply chain map was developed. It was found that the current system results in duplication, excess costs, gaps in supply, and unnecessary confusion on the part of health providers who are unsure of how much product they will receive, when and from whom. Changes to the supply chain structure and distribution strategies were proposed.

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## **A Cost Sharing Mechanism for the Global Information and Communication Technology Service Network of the World Food Programme**

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The *World Food Programme* runs hundreds of projects each year, each of which requires ICT service such as computer support and telephone service. Currently, ICT services for a country project are largely fulfilled locally. In other words, the requests are taken care of by the corresponding local offices, resorting only to the local resources. Such a decentralized service model hinders efficiency and effectiveness. Some of the more apparent problems include, economies of scale are not utilized to their fullest, lack of standardization between countries makes universal support difficult, and efforts can be duplicated in each country.

In order to deal with this problem, WFP plans on building up a global network which adopts a centralized service model, providing ICT support via professional Service and Competency Centres (SCC). Each SCC is dedicated to one particular area of ICT service, for instance, Desktop Sourcing and Support and Telephone Management. When a local project needs ICT service, the corresponding local office submits a service request to the central SCC Service Desk through the first-level SCC staffs working in the local office. The service request, after being preprocessed, is then sent to the appropriate SCC(s) for resolution and informing the originator accordingly. At the same time, local offices pay a service fee according to a given price list. The money goes into a SCC fund pool which is to support the main operation of the SCC network.

Each SCC draws funding from the SCC fund pool based on its needs. Such service model can help to promote the economies of scale and the standardization of service quality. It is expected that the global ICT network will lead to at least a ten percent reduction of the total annual ICT expenditures within WFP.

Our research focuses on promoting financial fairness of the global ICT service network. In other words, we want to cleverly design a way to charge for the ICT services provided so that the SCC fund pool holds enough funding to support the operations of the SCC structure, while all countries are treated fairly. By analyzing the available cost data, we conclude that simple pricing scheme, such as to charge a flat rate per number of users, is not reasonable in this scenario. We further adopt the approach to design a mathematical program which tries to achieve the optimal fairness level based on various fairness criteria by setting prices for services offered globally and discount rates to particular countries, under the constraints that the operational costs of the global service network are fully covered. The program is then tested on an eighteen country example created based on the available WFP data. Three fairness criteria, Percentage Saving, Cost per User and a hybrid of them, have been analyzed so far. We then study on the reasonableness of the corresponding cost sharing mechanisms and the robustness of the prices computed by the math programs.

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## **An Analysis of Greater Pittsburgh Community Food Bank**

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Greater Pittsburgh Community Food Bank (GPCFB) is a non-profit organization that collects and distributes food through approximately 350 agencies in southwestern Pennsylvania. With the recent downturn in economy, GPCFB reports diminishing supply (donations) and increasing demand. GPCFB, like many other Food Banks around the U.S., faces with a higher demand as greater number of low-income people affected by the soaring food prices turn to food assistance programs. In order to cope with the current situation, GPCFB is searching for alternative ways such as trying to reduce some of their cost, and using the savings to purchase more food. In this study, we approach to GPCFB's problems in the following order: First, we perform a comprehensive data analysis to validate the common belief that due to economic slowdown, GPCFB is facing increasing difficulties to serve needy people. Second, we analyze GPCFB's inventory in terms of nutritional value of the items in stock rather than cumulative poundages. The aim here is to replace the common practice of evaluating inventories according to poundages with evaluating them according to nutritional content of the items. Third, we consider GPCFB's transportation problem with the purpose of identifying potential savings in transportation costs. The problem considered is named as One-Commodity Pick-up and Delivery Vehicle Routing Problem (PDVRP) and it is a large scale problem with many side constraints. Although Vehicle Routing Problems (VRP) has a rich literature built over the last 50 years, our problem has not been studied in the literature. Therefore, we investigate the performance of various methods to solve this difficult problem. To this end, we first aim at solving our problem to optimality by applying an exact solution method. Our first exact approach is to model the problem as a large-scale Mixed Integer Program via delayed column generation, in which also the column generating sub-problem is modeled as an Integer Program. However, despite the appropriateness of this framework to handle problems with many side constraints, it proved to be inefficient for our problem. Our second exact solution method is based on Constraint Programming, and uses ILOG Scheduler to implement the model. A variant of this approach, using ILOG Dispatcher, allows us to implement and solve our problem using various Local Search methods. Our analysis with ILOG Dispatcher shows that cost savings can be achieved already when a limited number of locations, i.e., the current daily schedule, is taken into account.

This project not only serves as an analysis of GPCFB, but it also provides a good documentation of the common operations in Food Banks. Therefore, we believe that it will serve as a good starting point for other people looking to improve their local Food Banks and other such organizations.

**Efficient Utilization of Mobile Facilities in Humanitarian Logistics**

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The management of humanitarian relief is increasingly complex. Relief requests are diverse and varied. They occur across different sectors including: educational activities, health, disaster relief, refugee assistance, poverty eradication, etc. Furthermore, relief agencies are under increasing pressure to manage their resources efficiently while maximizing the amount of services provided. In that sense it behooves international agencies to try to *maximize their efficiencies* in the process of delivering aid. Mobile facilities are often used to meet this goal. It is common in remote areas, areas where the availability of relief personnel is scarce, or areas where local infrastructure has been disabled after a disaster to use mobile facilities to provide services to a large geographical area.

In this problem we consider relief or aid that is provided via multiple mobile facilities. These mobile facilities could be mobile clinics (e.g., on immunization drives, or performing free health check-ups), mobile communication facilities (e.g. portable cellular base stations), mobile schools, or mobile warehouses. In this setting there is spatial and temporal demand. The mobile facilities can provide service while stationary, but not while traveling. The mobile facilities have a certain capacity, and can only provide aid at a specified rate. The logistics problem is then to determine the best strategies to route these mobile facilities to maximize service to the affected population. In particular, routing determines *both* the movement of these mobile relief facilities and the duration of time for which they should remain stationed at the various locations on their route. Whilst this problem is simple to state, it turns out to be extremely challenging. Our research develops algorithms for the efficient routing and utilization of these mobile facilities.

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## **Improving the Pan American Health Organization's Vaccine Supply Chain**

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The Pan American Health Organization (PAHO), serving as the regional office for the Americas of the World Health Organization, procures vaccines for 37 countries in Latin America and the Caribbean. We developed analytical tools to address three supply chain challenges at the agency: demand forecasting, transportation cost estimation, and bid award allocation. This work has assisted PAHO in achieving its goal of controlling costs while improving service to member countries. Its impact includes new insights into the benefits and challenges of bundle bidding in vaccine procurement as well as an increased focus on quantitative supply chain management at PAHO.

Forecasting vaccine demand is an important and difficult task for PAHO's supply chain. The team evaluated past demand forecasts, observing that those for some vaccines were very good but those for others were poor. After analyzing potential factors influencing forecasting quality, the team made several recommendations for improvement. These included the development of causal forecasting models, PAHO led training on forecasting techniques at the country level, and benchmarking of best practices.

Transportation costs comprise a significant portion of total vaccine procurement costs. PAHO previously estimated these costs for each supplier and vaccine based on historical data and used these estimates in their supplier selection process. However, the research team identified that the destination country also impacts the transportation cost. Omitting this factor from decision-making led to unnecessary supply chain costs. The team developed an improved approach to estimate transportation costs using data that PAHO already had available, accounting for the factors of supplier, vaccine, and country in the estimates.

Finally, the team investigated the impact that bundle bidding could have on PAHO's supply chain. Bundle bidding is a system in which suppliers submit not only prices for individual vaccines, but also prices for groups of vaccines that may be offered at a discounted price if all the vaccines in the group are purchased from that supplier. PAHO wanted to assess the impact on total cost and on supplier diversity since PAHO is committed to having multiple suppliers for each vaccine whenever possible. Choosing suppliers in the presence of bundle bidding was modeled as an integer programming problem. Computational experiments with hypothetical bundling cost parameters illustrated that bundling can lead to cost savings for PAHO, as expected. However, the results also showed that explicit supplier diversification is more costly when bundling is *not* allowed. The latter result indicated that bundle bidding can be implemented in a way that preserves fairness for both large and small suppliers and that achieves the supplier diversification PAHO seeks.

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## Country Level Supply Chain Process Review in NGO Operations

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This project was a part of which is a significant internal change initiative being undertaken by one of the leading NGOs in order to keep pace with its rapidly growing operation. One of the major initiatives under this project was to create a world-class supply chain infrastructure that will be effective at global, regional and national office levels. The project was piloted in four countries in Africa. Zambia was the first country to implement this new supply chain structure for the NGO. In order to implement the new structure successfully Zambia office wanted to review and change their business processes related to supply chain.

The main purpose of this project was to identify potential bottlenecks in the existing business processes that might holdback the effective operation of new supply chain structure.

The bottleneck identified was the existing procurement process with multiple levels of approvals. The approval limits of managers didn't change over time while the operation grew five times larger than it used to be five years ago. In order to analyze the problem we conducted a complete process mapping for planning, procurement and payment processes cutting across finance, operation and supply chain organization. We also did statistical analysis to review the manager's approval level with current situation. The findings were mostly related to inadequate planning for procurement and inflexible policy in terms of project finances which causes delay in the procurement process by adding multiple levels of scrutiny for most of the transactions. Because of the slow procurement process most of projects suffered to meet their deadline and resulted in a very high positive variance in budget at the end of the year.

In response to the findings, few changes were suggested to improve the process regarding reducing the multi-level approval by increasing the approval limit for regional/ project managers. Also we recommended an electronic approval system to avoid expensive travel/ delay in the process inside the country. Although the organization has a comparative strong IT infrastructure among its peer organization but still the information sharing system regarding supply chain issues is inadequate like most of the humanitarian organization in general. The other opportunity we found is the use of "Gifts in Kind" in the procurement process. "Gifts in Kind" comes from corporate product giving initiative from the developed world. We found that "Gifts in Kind" can have a huge impact on NGO supply chain in terms of procurement. It can be viewed as unique sourcing option for NGOs compared to for profit organization – which can lead to meaningful partnership between business world and NGOs.



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## **A Web-based System for Homeless Shelters**

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Urban homelessness continues to be a major problem in the US. Homeless individuals often have issues related to substance abuse, mental illness, physical disability, etc. To address this problem, a number of shelters provide temporary housing as well as supportive housing aimed at rehabilitation, with the ultimate goal of making tenants self-sufficient.

To realize this goal, shelters have to keep up-to-date records on the availability of beds/rooms and restrictions on them (e.g., women and children only, no addiction etc.), information about clients in housing, etc. They need an efficient means of sharing agency information (e.g., types of available accommodation) as well as the client data. Currently, for agencies in the Atlanta area, such data is maintained as paper records or as Excel files. This state of affairs has several problems and inefficiencies, including multiple versions of files and lack of up-to-date shared information leading to inappropriate referrals or the need to check many other agencies to direct clients.

We have designed and implemented a lightweight web-based system with a central database to track the availability of beds, share client information and record the occupancy history. The system can be accessed by any participating agency on a standard web browser via a simple user interface. Data input by any agency is immediately integrated into the full system providing an up-to-date search facility for all, and can be used to generate reports. The database is end-user customizable and thereby also serves as a management tool for individual agencies by allowing them to maintain agency-specific data. United Way of Atlanta, the managing organization, uses the system to generate overall reports and monitor the needs and effectiveness of participating agencies.

We have followed the LAMP (Linux, Apache, MySQL, PHP) model for this web-based application. Our database design is a hybrid one where we have our regular tables as well as meta tables storing agency specific custom fields. These meta tables have data tables that store information for a client tagged by the Field Id, Agency Id and Client Id. Thus, individual agencies have the flexibility to create their own private fields. We have minimized page reloads by leveraging AJAX technology for reloading only the changed portion of a web page. Using AJAX with jQuery we can generate graphs on the fly for specific fields over a chosen time period. We have also optimized our system for minimal re-execution of the same queries. To enable restoration of accidentally deleted data, any data marked for removal is simply flagged “deleted” and excluded for queries.

In all, this project showcases how advances in computing can be used for socially relevant projects. The ease of access and flexible design together make this a potentially sustainable system, helping homeless agencies by taking them one step closer to eradicating chronic homelessness.

## Application of Voronoi Based Heuristic for Facility Location in Disasters

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Pre-positioning of supplies is one of the preparedness activities that have recently captured the attention of non government organizations and government agencies. This activity is important because, an effective and efficient pre-positioning increases the ability to provide relief (supplies and aid) in a timely fashion. In essence, a good pre-positioning strategy minimizes the time it takes to deliver the supplies to the disaster zones.

In this paper we address the problem of locating facilities which can be used to pre-position supplies in an area affected by a disaster. Our objective is to locate facilities to minimize the response time such that all affected demand points can be reached from a given facility in the minimum time possible. We formulate the problem as a mixed-integer program which is a variation of the Uncapacitated Facility Location Problem (UFLP), where we seek to assign the demand points to a given set of facilities in such a way that the response time is minimized.

Instead of solving the non-convex optimization problem, we develop a heuristic algorithm by exploiting the geometry of the problem.

The heuristic algorithm is based on Voronoi diagrams. In this paper, our main contributions are three fold: contrary to traditional approaches for solving similar problems we provide a heuristic solution that exploits the geometry of the problem; our results show that embedding the Voronoi diagrams (traditionally used for the continuous facility location) in our heuristic for solving a hard discrete problem provides close to optimal solutions in a reasonable amount of time; and we provide an extensive evaluation of strategies for setting up the initial starting points to speed up and improve the solution of the heuristic. The development of such an algorithm can have important applications in the strategic location of warehouses for pre-positioning of critical supplies during disasters.

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**An Analysis of the Immediate Resource Requirements After  
Hurricane Katrina: Policy Implications for Disaster Response**

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This paper develops quantitative estimates of the immediate resource requirements and their temporal patterns after Hurricane Katrina. The analyses are based on a dataset put together by the authors by post-processing the Action Request Forms (ARFs) issued in the aftermath of the Hurricane. The analyses provide a fairly solid idea about the relative importance of the various commodity types, and the associated temporal patterns. The data show that a total of only about

150 different commodities were requested, which is a fraction of previous estimates that placed that number in the range of 350-500 different items. The relatively low number of commodities suggests that if emergency response agencies focus on ensuring efficient procurement and logistics of these commodities, delivery times could be cut down significantly.

The data also show that an even smaller number of commodities was the subject of a significant share of the requests (twenty commodities account for about 30% of the requests, and fifty commodities for 56%). Clearly indicating that regional prepositioning of a subset of key commodities could be an extremely cost-effective way to reduce delivery times, simply because the initial investment in a safety stock would be able to cover a large portion of the needs.

Feasibility of econometric estimation of the temporal patterns of requests was also explored. The results clearly show that it is indeed possible to estimate robust ARIMA models to predict needs.

This has important implications for both research and humanitarian logistic response because it opens the door for exciting possibilities such as the combined use of need forecasts, inventory control, and supply chain models, translating into an expedite flow of supplies to disaster areas.

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## **Environmental Sustainability at MedShare International**

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MedShare International is a nonprofit organization headquartered in Atlanta, with an environmental and humanitarian impact of international scope. MedShare collects surplus medical supplies and used equipment from U.S. hospitals, manufacturers and distributors, and processes the materials to make them available to underserved hospitals and clinics. MedShare's recovered medical product, once shipped to a recipient user, effectively offsets the production of another product needed to meet that need. This offset of the new product results in the savings of carbon pounds, waste and energy usage in the production process. In August of 2008, the Georgia Tech Pro Bono consulting team was asked to deliver a model for measuring and reporting the environmental impact, or footprint, associated with MedShare's operations. After researching industry standards for reporting environmental sustainability, the team created an Environmental Sustainability Scorecard. The Scorecard evaluates MedShare's operations using four major impact categories: carbon dioxide emitted, waste created, energy used, and water used. Using these impact categories, MedShare's value chain is evaluated across four major segments: collection, facilities, shipping, and recipient.

The 2007 Environmental Sustainability Scorecard indicates that MedShare's work added significant value to the environment. The collection and redistribution of medical supplies allows for a significant offset in the carbon, waste and energy that would otherwise be used in the production of new medical supplies, and MedShare's unique ordering system increases this usable product offset as hospitals are able to order exactly what they need.

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## **Using the internet to communicate disaster information to individuals with disabilities and chronic illness**

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**Purpose and Scope:** Hurricane Katrina demonstrated that individuals with chronic illness or disabilities face significant challenges during disasters. In Katrina's aftermath, various North American cities are using websites to provide citizens with information on how to prepare, respond, and recover from disaster. This study examined how U.S and Canadian cities are using the web to inform citizens with chronic illness or disabilities on how to manage disaster challenges.

**Methods:** Using information from health organizations in both countries, the researcher developed a checklist of information that individuals with chronic illness or disabilities need during a disaster. This checklist was used to assess how Toronto, New York, Vancouver, Los Angeles, Ottawa, Chicago, Calgary, and Houston are using the web to provide information on how individuals with chronic illness or disabilities can obtain evacuation assistance, receive post-disaster health services, and address other challenges.

**Results:** Findings revealed four problems in how cities are providing information. First, the information provided often deals with challenges that emerge immediately following a disaster but neglects challenges that arise during the longer process of disaster recovery which can last months or years.

Hence, most of the cities provide limited guidance on post-disaster challenges such as how to properly re-enter a disaster zone, obtain clean-up assistance, avoid disaster-related health hazards, access psychological assistance and file disaster claims with insurance companies or government agencies.

Second, information provided does not address the challenges arising from specific chronic illnesses or physical disabilities. For example, few of the websites provide information on how to access RxResponse and other services that aim to reduce disruptions of prescriptions and other medical services after a disaster.

Third, information providers often assume that external caregivers will be present during a disaster. Fourth, much information is inaccessible to those with hearing or sight disabilities. Several of the websites fail to comply with internationally accepted standards on accessible website design.

**Conclusions:** Findings illustrate that cities should strive to provide accessible information that focuses on long-term disaster recovery challenges, addresses the challenges of particular illnesses or disabilities, and recognizes that external caregivers may not be present during disasters.

## **Relationship Building in Humanitarian Relief Supply Chains: A Research Agenda**

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Preparing for and responding to disasters often involves collaboration across a diverse mix of organizations, involving primarily non-government organizations (NGOs) and governments, but also including corporations. While corporations are driven by economic objectives (e.g. profit-making); NGOs, governments, and other not-for-profit (NFP) organizations focus first on social, political or spiritual missions.

In the business world, strategic supply chain partnerships are developed to improve efficiency and effectiveness; to enhance customer service, reduce total logistics costs, increase return on assets, and/or to develop marketing advantages. Relationship building in business supply chains is facilitated by compatibility of corporate cultures and management philosophies, along with a keen sense of mutuality between the parties. The profit motive can be a strong incentive for cooperation across corporations.

Humanitarian relief organizations, in preparing for and responding to disasters, can also benefit from supply chain partnerships. The purpose is not to make money but to save lives. Working together could stretch the budget and reach more people in need. However, despite this unifying humanitarian purpose, these organizations compete for donor support and may have elements of incompatibility among their missions. Some humanitarian NFP organizations are faith-based, others have political agendas. Certain other NFPs are “neutral.”

The purpose of our poster session is to discuss compelling research opportunities about building relationships in humanitarian relief supply chains. Drawing on the literature and “case-based” qualitative methods we focus on issues such as: horizontal vs. vertical supply chain relationships; cooperation vs. competition among humanitarian organizations; latent (or dormant) vs. manifest relationships; formal vs. informal relationships; the role of “agendas” in relationship building; and marketing vs. operations relationships, e.g. competing for donations, but cooperating in the field. We invite academics, humanitarians, and corporate people to join us in studying how relationship building can improve the efficiency and effectiveness of disaster preparedness and response.

## **Towards a research agenda for collaborative crisis response management**

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Disaster response organizations face increasingly complex settings driven by specialization of responders, the need for international collaboration, rising expectations by the general public and mass media, and the need for more agility to deal with unexpected scenarios in ad-hoc collaborations. Better communication, flat organizational structures, more information sharing, and collaboration are prerequisite for agile approaches in crisis response management. The question is how to design IT-infrastructures for agile crisis response management taking advantage of emerging IT-infrastructure such as mobile phones and networking sites.

Take the example of end-user smartphones: With Internet connection, global positioning information and maps they are more powerful information devices than the best professional equipment of ten years ago. Their potential role in crisis response management still needs to be understood. Its maps and navigation system influence how people move in and out of an affected area; the messaging, mailing or telephone services determine how information as well as rumours spread. Smartphones and social networking services like Youtube, Twitter, LinkedIn, or News Sites establish a relatively flat, peer-to-peer network-like structure. We suggest that this offers the basis for subsidiarity, more participation and transparency, novel collaboration systems and processes, and better performance in crisis response management.

We aim at systematically exploring design options for crisis response management and its information and communication technology. Our seminal model is the NATO Network-enabled capability Command and Control Maturity Model (N2C2M2) for inter-organizational collaboration that has been developed by NATO Research Study Group SAS-065. Among others, this model supports the assessment, evaluation and empirical analysis of disaster response endeavours involving a variety of organizations. Our research approach includes:

- case studies of collaboration in crisis response management
- simulation games for demonstrating, analyzing and training virtual inter-organizational collaboration
- empirical analysis of virtual team collaboration
- methods and research designs for life experiments (concept development and experimentation campaigns) and
- development of an architectural framework for crisis response including models of motivation, capabilities, services and collaboration processes.

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## Supply Chain Optimization for World Food Programme

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An undergraduate student team from Georgia Tech worked with the World Food Programme's (WFP) logistics development unit to address the issue of variability in supply chain operations resulting from variability in the timing and quantity of donations. Recognizing the unique scope and needs of this supply chain, the group developed two models: an operational inventory management tool based on a quantity-reorder (Q, R) model, and a mathematical optimization model of the supply chain.

Unlike in many global supply chains, WFP's supply chain operations are dependent on donations. The variability in these donations has presented a serious challenge to the planning of supply chain activities and resulted in several areas of opportunity. Simultaneously, inventory management decisions at the point of demand are made by non-technical country officers. The variance in size and timing of orders creates additional difficulties for supply chain planning.

A (Q, R) tool was thus designed to support in ordering decisions at the country level. This tool evaluates an optimal order quantity for each commodity based on price, fixed cost of ordering, holding cost, lead time, lead time variability, demand, shortage cost and minimum service level. This tool can be used to significantly reduce the costs of inventory management at each country.

The optimization model can serve several purposes. As a network model of the WFP supply chain, it optimizes supply chain decisions such as when and where to source and transport food. The model was also designed to evaluate the possibility of using an advanced fund to borrow against future donations and allow food purchases based on forecasted donations. Finally, the network model can be used to study the impact of pre-positioning depots on operating costs and service levels. This optimization allows the World Food Programme to more closely analyze potential initiatives to improve supply chain activities.



## Three Central Stockpiles for 33 Million Beneficiaries: UNHCR's Inventory Challenge

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The United Nations High Commissioner for Refugees (UNHCR) by mandate is called to “lead and coordinate international action to protect refugees and resolve refugee problems worldwide.”<sup>1</sup> UNHCR operations are massive even on a global scale; they currently employ more than 6,000 staff members in 110 countries to meet the needs of 32.9 million persons affected by disaster or war. UNHCR coordinates with other agencies to provide shelter and basic subsistence items to refugees and are largely known for their work in establishing and maintaining refugee camps. UNHCR seeks improvement in their operations' supply chain functions in order to improve the timeliness and quality of disaster response. Improved response reduces morbidity and mortality among the beneficiary population and helps UNHCR achieve their mandate more efficiently.

UNHCR maintains three central stockpiles which supply refugee operations around the world. Refugee camps experience two primary types of demand: “replenishment demand” from normal operations, and “emergency demand” from natural disasters or spikes in conflict. To meet demand, UNHCR can transport supplies from the stockpiles to the camps via normal means (e.g., cargo ships) or via expedited means (e.g., airlifting). UNHCR seeks to maximize the amount of relief that they can provide subject to budget constraints.

We develop an inventory model to represent the interaction between a stockpile and a downstream refugee camp. The optimization investigates two key tradeoffs: 1) airlifting relief items can satisfy demand quickly, but is expensive and may consume an operation's budget during a fiscal cycle; and 2) a larger stockpile is costly to procure and maintain, but contributes directly to UNHCR's ability to respond quickly to refugee camp demands.

Our goal is to develop insights about shipment strategies and stockpile size that can help UNHCR improve their logistical operations, leading to improved response to refugees. UNHCR must use their financial resources wisely to carry out their mandate, and a model of this type can help them make the best use of their limited response resources.

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<sup>1</sup> [www.unhcr.org](http://www.unhcr.org)

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## **V2V: Design of a Blood Flow System**

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Blood is a precious resource needed to save lives during surgeries and other major operations at a hospital. In many developed countries, there are systems and protocols in place to ensure that the blood is collected safely and only safe and healthy blood is transfused to a patient. In developing countries, past research has shown that transfusion of unsafe blood units has led to the spread of Transfusion-Transmitted Infections (TTI) such as HIV, HBV, HCV and Syphilis. This knowledge has led to the development of protocols in developing countries to ensure that only safe blood is being transfused. In addition to this challenge, many developing countries do not have enough safe blood to meet the needs of the country hence the need for appropriate methods for collection, testing and allocation of a limited blood supply.

To understand and improve the blood supply chain in such developing countries, we conducted a series of interviews at the Zambia National Blood Transfusion Service which indicated that blood allocation is currently being done in an ad hoc manner in which a blood safety officer uses past and current internal knowledge about the amount of blood available and possible needs to determine how much blood should be distributed to a hospital. To ensure fair and efficient distribution of blood, it is necessary to monitor and understand the patterns of blood collection and requests and to have up-to-date data on available blood.

With this in mind, our work focuses on the design of a blood flow system that tracks blood supply from vein to vein (V2V) that is from collection to utilization in order to maximize the availability of safe blood in developing countries. The major components of this system include monitoring the collection and usage pattern of blood units, predicting the collection and usage for upcoming time periods and finding a flow assignment for blood distribution that is fair and efficient. The system serves as a method for visualization and analysis of blood data and as a decision-informing tool.

## Reliable and Low-cost Mobile Ad Hoc Wireless Networks

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Mobile ad hoc networks are, in principle, an ideal solution for communication in many scenarios, including disaster and crisis management. Multi-hop routing uses little power, does not require physical infrastructure such as antenna towers and allows mobility. Every device can become a part of the network, and help in relaying signals from one point to another. These features together could lead to a network that can be set up quickly at any location, whether this be in response to disasters or emergencies, or to provide coverage in regions where economic/infrastructure conditions are not amenable to fiber-based networks, or broadband is available but prohibitively expensive.

In spite of these compelling benefits, such networks are not a practical reality. There seem to be two reasons for this. First, in most developed countries, the wireless connection needs only to be a single hop --- broadband is ubiquitous and affordable. Second, the technical challenge of a reliable routing protocol for wireless networks has not been satisfactorily solved. While a plethora of multi-hop wireless protocols are known in the literature, there are hardly any real implementations or comparisons. Part of the reason for this is that wireless networks are highly transient, links go up and down routinely, and mobility only complicates this further. Thus, solutions that are essentially adapted from wired protocols, requiring a faithful representation of the topology, are unsuitable as the effective topology changes too quickly due to obstacles and interference of wireless signals.

This project aims to make such multi-hop wireless ad hoc networks extremely sustainable, scalable and cost-effective in developing regions. To achieve sustainability, we keep changes to the existing end-point devices (e. g., Wifi enabled Laptops) to a minimum, use the existing 802.11 framework for low-level media access and management, and introduce minimal modifications to the open-source, traditional Linux network stack. We have developed a wireless decision layer inserted in the network stack to control routing decisions and to monitor traffic and link conditions. Kernel space implementation of the core routing logic, including packet forwarding, ensures minimal overhead. We currently have a loadable kernel module that can be dynamically inserted whenever multi-hop routing capability is desired by the network device.

The second phase of this project is the implementation of a recent protocol called “Manifold Routing” that differs from earlier ones in using a highly compact representation of the signal traversal space. Manifold Routing is also more efficient compared to geographic routing, as measured by success rate, routing load and failure tolerance. We hope that such a reliable and low-cost multi-hop wireless network leveraging existing wireless mobile devices; can help in coordinating emergency response operations and providing greater access.

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## **Emergency Logistics Issues Impacting the Response to Katrina: A Synthesis and Preliminary Suggestions for Improvement**

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Extreme events pose serious logistical challenges to emergency and aid organizations active in preparation, response and recovery operations, as the disturbances they bring about have the potential to suddenly turn normal conditions into chaos. Under these conditions, delivering the critical supplies (e.g., food, water, medical supplies) urgently required becomes an extremely difficult task because of the severe damages to the physical and virtual infrastructures and the very limited, or non-existent, transportation capacity. In this context, the recovery process is made more difficult by the prevailing lack of knowledge about the nature and challenges of emergency supply chains. As a result, the design of reliable emergency logistic systems is hampered by the lack of: knowledge about the particulars of how formal and informal (emergent) supply chains operate and interact; methods to properly analyze and coordinate the flows of both priority and non-priority goods; and, in general, scientific methods to analyze logistic systems under extreme conditions.

This research, funded by the National Science Foundation, attempts to contribute to the study of this important problem by providing a succinct description of the key logistical issues during the response to Hurricane Katrina, a disaster that provide a prime example of the need to significantly improve the efficiency of the supply chains to the site of an extreme event. On the basis of public records and interviews with individuals directly involved in the logistical response at all levels (local, state, federal, and volunteer organizations) the authors identified three broad categories of issues: (1) Initial Impact on the System (i.e., Magnitude of the requirements, and Impacts on the Communication System); (2) Institutional (i.e., Understaffing and Lack of Training, and Lack of integration Between Federal and State Logistic Systems); and (3) Logistical (i.e., Inefficiencies in Pre-positioning Resources, Lack of Planning for the Handling and Distribution of Donations, Procurement, and Limited Asset Visibility). The authors also suggest a basic set of recommendations to avoid a repeat of this logistical disaster.

**Keywords:** *supply chain, humanitarian relief, logistics, disaster*

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**National VOAD Virtual Field Coordination Center (VFCC)**

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In the US, voluntary organizations (VOs) participate in every aspect of disaster response, from planning to long-term recovery. VO activities and resources are crucial to both the near- and long-term success of an overall response effort- not supplemental to government activities.

Studies of 2005's Gulf Coast Storms noted two shortfalls in the response: underutilization of VOs and miscommunication in the transition from immediate response to long-term recovery efforts. In February 2008, US Government Accountability Office reported, "[FEMA Should Take Action to Improve Capacity and Coordination between Government and Voluntary Sectors](#)". By then, the role of VOs was already officially expanded in FEMA's [National Response Framework](#). [National Voluntary Organizations Active in Disasters](#) (VOAD), representing 49 organizations, was tasked to create a communication protocol and meet increased accountability, reporting, and performance standards. National VOAD's position as an umbrella group for organizations addressing all stages of disaster response and recovery makes the need for intergroup communication especially acute. As of December 2008, no funds had been made available. The result: a communication structure often out-of-touch with the operating situation in the field, and human needs go unaddressed.

So development forges ahead on a communications portal: the Virtual Field Coordination Center (VFCC). The VFCC will be a web-based incident management tool that will provide real-time information to users. It will provide center for local activities, National VOAD headquarters, national offices of VOAD member organizations, and FEMA, and would include global information system (GIS) data.

Stakeholders at the national level identified a need for a coordination portal such as VFCC, and the federal mandate has been issued. The purpose of this poster would be to solicit feedback on previous similar projects, and determine the possibility of a proof of concept project on a smaller, local scale.

### **Providing Technical Assistance to Mungoa-go, Cameroon: Site Assessment Trip**

Engineers Without Borders at the Georgia Institute of Technology, Student Chapter

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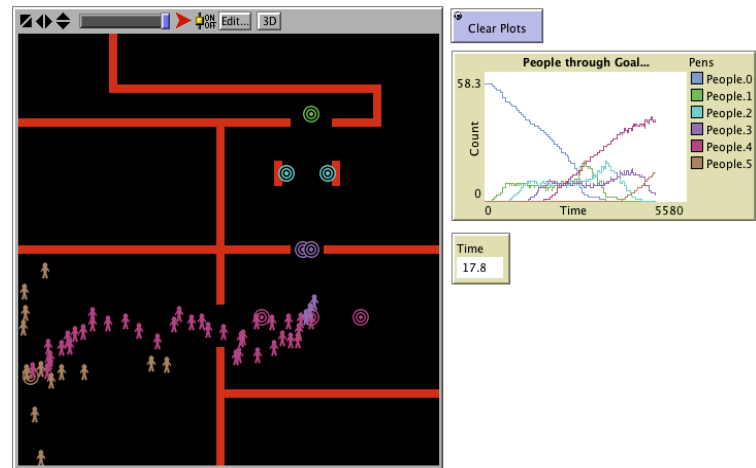
The community of Mungoa-go, approximately 1500 people, sought help from Engineers Without Borders (EWB), as the upper portion of their village has limited access to water and the entire village suffers from water shortages in the dry season. EWB-GT received the project for providing assistance to Mungoa-go in May of 2008, and accordingly began to plan a site assessment trip. From December 27, 2008 to January 7, 2009, four students and a senior research scientist from the Georgia Tech Research Institute traveled to the community of Mungoa-go, Cameroon, with the assistance of the Life and Water Development Group Cameroon, a local NGO. The purpose of the trip was to conduct a water and sanitation survey and a health assessment, to learn the community's culture, and to determine the general needs of the community. In addition, the group was to meet with community leaders to learn their expectations and objectives.

While in the community, the group conducted a thorough assessment of the current water distribution system, which included measuring flow rates, GPS mapping of stand taps and catchment tanks, and collection of water samples. The water quality samples focused on the presence of coliforms, specifically fecal coliforms. In addition, the group investigated the upper region of the village, mapping each of the homesteads and determining the number of people. The data collected will provide means of designing quantity specific solutions for the community as well as quality specific solutions. The design must take into account the possibility for growth as people in the community value large families, and they stated that if affordable water was provided, population would increase dramatically. The water quality results will provide visual information that can be used to educate the surrounding communities about the danger of surface water.

Apart from data collection, the most important path to success in the development of an undeveloped community is to involve the people and understand the culture. To achieve this, the Georgia Tech group held multiple meetings with the community, leaders, and other volunteers in the area. The group also met with the mayor and assistant mayor of the region of Njinikom. A Peace Corps volunteer in the area assisted in providing health and hygiene information on the people. Local NGOs, Medicine for Humanity and Project Hope, are able to provide information on water quality in the surrounding areas as well as other health aspects of the region. The community was trained by the students to better manage the system that they currently have through collection of flow rate data and rainfall data, as well as water usage data at individual households. Meetings were held with the entire community to communicate what needed to be accomplished and the methods to be used in the process. During daily meetings with the community development committee, the group discussed solutions to the problems facing the community in addition to water, such as open fire kitchens, the burning of plastics, no form of waste management, and loss of traditions.

The data gathered on this trip, the continuous data being gathered currently, and the relationships formed on the trip will be used to develop a number of alternative solutions and educational programs to discuss with the community and their leadership. Solutions will focus on the quantity and quality of water for every member of the community. Additional trips will be taken in the following months for more data collection and for implementation of developed solutions to the discussed issues.

## Decision-Support For Mass Vaccination During a Pandemic Influenza Using Agent-Based Modeling.



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**Project Purpose:** The purpose of this project is to develop an agent-based modeling environment and tool that will allow real-time decision support and resource allocation for managers and staff of point-of-distribution (POD) locations conducting mass vaccination for pandemic influenza. Managers can use this agent-based model to help address problems and emergencies that may arise.

**Problem and Scope:** The threat of pandemic influenza could wreak havoc on the United States public health and healthcare system as they try to marshal resources and conduct rapid, mass vaccination or drug prophylaxis interventions. One important strategy during such a pandemic is the rapid setup and use of point-of-distribution (POD) sites established in a variety of clinical, commercial, school and community settings. However, POD design and deployment factors remain largely unexplored because mass vaccination cannot be easily practiced in real-world settings at such a large scale.

**Method:** This project uses an agent-based modeling development environment to create a tool that allows POD managers to alter the design and layout of the POD they currently run. The simulation testing environment allows depicting the physical POD environment, staffing location and behaviors, and patient flow. Various POD optimizations were analyzed and discussed in light of recent public health recommended layouts and resource deployment.

**Results & Conclusions:** Agent-based modeling is a useful tool to examine the physical arrangements and queuing behaviors of patients at PODs. The development of real-time tools for supporting POD implementation and ongoing logistics is a means to make adjustments to resource restrictions (i.e., layout of rooms and vaccination stations, lack of staff, etc.) in the midst of emergency deployment. Agent-based modeling continues to grow as a valuable tool for public health planning, implementation, and evaluation activities.

### **Investigating the Effects of Partnerships on Local Health Departments Preparedness**

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**RESEARCH OBJECTIVES:** The Institute of Medicine (IOM), “The Future of the Public’s Health in the 21st Century,” promotes partnerships as an important way to improve public health preparedness through better coordination of preparedness activities and information sharing. However, the evidence of the positive effects of partnerships on preparedness is scarce. This study intends to provide quantitative evaluation of the effects of partnerships of local health departments on the preparedness of local health departments (LHDs).

**STUDY DESIGN:** There are expectations that local health departments that have developed a network of partners will be better prepared to respond to public health emergencies. However, uncovering effects of these partnerships on preparedness pose some methodological difficulties. The gold standard of study design for quantification of the effects of interventions is randomized control trial (RCT). However, RCT is not feasible in the case of partnerships because partnering is a matter of choice, and, thus, random assignment of LHD into partner and non-partner groups is not possible. Partnership effects estimated without accounting for non-random selection will be biased. We use propensity-scores-matching methodology to conduct quasi-experimental assignment of LHDs into comparable pairs of cases and controls. Pscore routine in STATA9 is used to estimate a Probit model of partners’ choice as a function of observable characteristics (LHD expenditures, number of customers in jurisdiction, number of employees, the size of the jurisdiction). Predicted probabilities of having a partner are used to match LHDs with and without particular partner by nearest-neighbor-matching method. The effects of LHD partnerships are estimated by calculating the difference in outcome variables for each pair. The outcomes are dichotomous variables indicating if LHD is engaged in implementation of five emergency preparedness activities.

**POPULATION STUDIED:** The main sources of data on LHD characteristics, partnerships, and types emergency preparedness activities is the 2005 NACCHO survey of 440 LHD. The five preparedness activities included in the survey are the following: 1) develop or update a written emergency plan, 2) review relevant legal authorities 3) participate in drills or exercises, 4) assess emergency preparedness competencies of staff, 5) provide emergency preparedness training to staff.

**PRINCIPAL FINDINGS:** LHDs are more likely develop or update a written emergency plan if they partner with emergency responders (30% point difference,  $t=3.30$ ), community organizations (20%,  $t=2.68$ ), doctors (15%,  $t=2.98$ ), businesses (14%,  $t=2.97$ ) and schools (16%,  $t=1.79$ ). Partnerships with businesses seemed to induce LHDs to review legal authorities (20% point difference,  $t=2.70$ ). LHD participation in drills was more likely if they partners with emergency responders (25% point difference,  $t=2.60$ ), community organizations (19%,  $t=2.51$ ), doctors (9%,  $t=1.84$ ). LHDs more frequently assessed emergency competencies of staff if they partner with hospitals (31% difference,  $t=2.97$ ), emergency responders (30%,  $t=2.61$ , doctors (23%,  $t=3.21$ ), businesses (15,  $t=2.11$ ). LHDs tend to provided more training if they partner with hospitals (21%,  $t=2.27$ ), emergency responders (19%,  $t=2.01$ ), community organizations (17%,  $t= 1.95$ ).

**CONCLUSIONS:** This study suggests that LHD partnerships with emergency responders, doctors, community organizations, hospitals and businesses may have beneficial effects on preparedness activities. No statistically significant effects of partnerships with community health centers, insurers, economic development agencies, faith based organizations and universities on LHD preparedness activities were observed.

**IMPLICATIONS FOR POLICY, DELIVERY AND PRACTICE:** Promoting LHD partnerships may have heterogeneous effects on preparedness. Some partnerships may improve preparedness more than others.

**PRIMARY FUNDING SOURCES:** CDC



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## **The Impact of Gender on Humanitarian Logistics**

*“The tyranny of the urgent makes gender issues appear a luxury”  
(BRIDGE Project at the UK Institute of Development Studies)*

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Against the background of a clear increase in the frequency, severity and effects of natural and man-made disasters, many UN agencies and Non-Government Organisations are actively engaged in programmes to improve the effectiveness and efficiency of their logistic response to such disasters. In this regard, it is clear that not only do the skills and attributes of the logistician have an impact on performance, but so too does his/her gender.

Taking the latter aspect first, there is overwhelming evidence of a gender-related difference in the way in which disasters affect a population with, in most cases, females being affected more severely. This, in turn, requires a differentiated response from the humanitarian logistician. On the one hand, the logistician must understand the needs of the beneficiaries. However those affected by the disaster may, for example through adherence to local customs or traditions, be unable or unwilling to articulate them to a member of the opposite sex. On the other hand, through their role as a proxy for the customer, the logistician must help to ensure that the “last mile” deliveries reach the beneficiaries according to their needs and deliver appropriate, gender and culturally sensitive goods and services.

Secondly, the gender of the logistician affects the attributes and skills sets that an individual possesses and this, in turn, leads to consideration of the linkage between the desired and actual skills/attributes of a logistician and their performance. Whilst there is a broad range of prior research that attempts to identify such skills/attributes in the “for profit” sector, there would appear to be no empirical studies that link logistic skills to performance, and certainly none that relate to the area of disaster relief. However, in general terms, the existing studies into the desired skill sets emphasise the “softer” aspects and, in parallel, there are clear indications that these are areas in which females are more effective.

Given that there is a paucity of female humanitarian logisticians – even in organisations where the gender balance is 50:50 – the aim of this research is to understand what makes a ‘good’ humanitarian logistician, particularly in relation to the interface between logistics skills/attributes and gender.

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## **A Mathematical Approach to Triage in the Context of Emergency Response Planning**

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We study characteristics of “good” triage practices in the wake of a major emergency event (such as a natural disaster or a terrorist bombing) after which resources are overwhelmed by a large number of casualties. We specifically consider a scenario where all patients are available for treatment right after the event and there are no further arrivals of patients. The resources are limited and hence patients may wait for long periods of time for service. Those who have to wait longer than their “lifetime” will not survive. We assume that patients are characterized by their lifetime and service time distributions as well as their survival probabilities after treatment. The service is performed in a non-preemptive manner, so once started, it cannot be interrupted. Our objective is to identify properties of effective dynamic triage rules that determine the order the patients should be served so as to maximize the total number of survivals. We model the problem as a stochastic scheduling problem with multiple parallel servers and then apply methods such as sample path analysis and dynamic programming to gain insights into this challenging problem.

Our first observation was that contrary to the intuition, a patient with a better chance of survival and a shorter lifetime and service time does not necessarily receive the highest priority under the optimal policy. However, if service times are stochastically identical, then the patient with a better chance of survival and shorter remaining lifetime (in the sense of hazard rate orders) should be prioritized irrespective of the number of other patients. We also identified sufficient conditions on the mean service times, lifetimes and survival probabilities under which state-independent triage rules are optimal for the case with exponential service times and lifetimes. (State-independent triage rules are those rules that do not take into account the number of patients involved in the event.) For example, when injuries are very severe (so that patients die at a very fast rate), there are cases where it is optimal to prioritize patients with less critical injuries, shorter service times, and better chances of survival. However, in general, we observed that a good triage policy should take into account the number of resources and patients from different classes. For this purpose, we developed two easy-to-implement state-dependent heuristic policies, one of which uses information on the number of patients from different classes of criticality levels and the other requiring information only on the total number of patients in the system. Our numerical experiments demonstrated that these heuristics perform well (especially when patients have serious injuries) and are robust to changes in the number of servers and patient classes.

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## **Sociocultural Considerations for Resource Allocation Models of HIV Prevention Methods**

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Although HIV/AIDS is most prevalent in regions of Africa and Asia, no part of the world has been left untouched. Consequently, the disease is present in numerous sociocultural contexts. Even within the United States, over two-thirds of individuals affected with HIV are members of a minority population. Resource allocation models for HIV prevention methods typically include intervention factors (e.g. efficacy of the intervention, the intervention cost function, and budget constraints) and epidemiological factors (the incidence rate, prevalence, size, and risk factors associated with a given population); however, little attention has been given to how sociocultural factors may be included in these models.

By conducting this study, we sought to 1) determine aspects of the sociocultural context that may influence a population's adoption of HIV prevention methods and to 2) provide preliminary insight as to how sociocultural factors may be accounted for in resource allocation models of HIV prevention methods. A content analysis was conducted of all HIV/AIDS case study reports published by Human Rights Watch between 2002 and 2007 and of eight discussion groups conducted in the spring of 2007. Members of each discussion group were recruited from multicultural student organizations on the University of Wisconsin-Madison campus; these organizations represented Turkey, Israel, Mexico, India, Thailand, Vietnam, Cambodia, and the Philippines. Four discussion groups were of mixed gender, three were all-male, and one was all-female.

Content analysis of the Human Rights Watch case study reports and the eight discussion groups highlighted six sociocultural factors relevant to the adoption of HIV prevention methods: Awareness and perception, sex, education, drugs and drug users, religion, and gender roles. Such sociocultural considerations may be integrated into resource allocation models indirectly through modification of intervention or epidemiological factors, or directly through decision rules. For example, knowledge of the sociocultural context may constrain the type or alter the cost functions of interventions considered for a given population. Similarly, this knowledge may alter the epidemiological risk factors of a given population. Finally, knowledge of the sociocultural context may also be directly embedded into resource allocation models of HIV prevention methods through the formulation of decision rules (e.g. what subpopulations are prioritized over others).

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## **Analysis of MSF-Spain Stock Levels for Ongoing Projects and the Option of Creating a New Distribution Center in East Africa**

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Medicos Sin Fronteras (MSF, also known as Medecins Sans Frontiers; or, Doctors Without Borders) is an international humanitarian organization with more than thirty years of experience in providing medical services to victims of disasters, either natural or man-made, as well as victims of armed conflict areas. It serves more than 60 countries, with about 500 missions worldwide. MSF distributes food, non-food, medical and logistics items to each of the missions on the field. The strong desire to help, which awarded them the Nobel Peace Prize in 1999, was initially focused on serving the missions and not on the distribution system. The organization has grown operations considerably during the last few years. With an increase in operations also came the need to improve its distribution systems in order to be able to help as many people as possible.

The project analyses Medicos Sin Fronteras (MSF) Spain's real needs of medical and non-food items as well as what the best distribution option is. MSF-Spain increasing operations during the last two years resulted in a higher volume of goods shipped to the African missions. It has been observed that the share of air-shipments within all shipments (air + sea) has increased considerably during this period. The absence of a formal forecasting process and a full understanding of demand uncertainty are potential causes of this situation. In order to address this problem, a simple mechanism has been developed. It contributes to fine tune the forecasting process and to educate decision makers about the trade-offs when facing demand uncertainty. It uses a standard statics approach (maximizing likelihood) to improve the forecast and the News-Boy problem as an approximation to make inventory decisions. Zimbabwe was chosen as a standard mission and its product flows have been analyzed. A number of items were selected for a pilot study in order to assess the project impact. Since this is an on-going project, we are unable to determine conclusions. However we found possible evidence of three advantages of using the mentioned methodology. First, the implementation of a new forecasting process could immediately reduce total supply chain costs. Second, the data analysis will allow for a better-informed decision-making-process, such as an assessment of the impact of installing a distribution center in East Africa. Last, a recommended new process could allow for continuous improvement of operations.

([http://www.msf.es/conocenos/msf\\_1/index.asp](http://www.msf.es/conocenos/msf_1/index.asp))

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## Debris Management Operations

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### Objectives:

To understand how and what type of analytical methods could be used to make better decisions when managing debris, somewhat focused on the collection and disposal activities during the response and recovery stages of a disaster.

### Results:

Debris collection is a complex logistics problem, and a debris management plan should be developed in advance in order to be better prepared to recover from a disaster. Such debris collection management plan should address each disaster stage: pre-disaster (mitigation and preparedness), response and recovery. We first identified the main activities to perform on each of the elements of a debris management plan: debris forecasting, outsourcing strategy, debris management sites planning and operation, debris collection operations during the response and recovery phases, and debris reduce, recycle and final disposal activities. Then, we discussed how analytical techniques and models could be used to improve the execution of such components of a debris management plan. Since this project is fairly focused on the collection and disposal activities during the response and recovery stages of a disaster, we proposed more detailed mathematical formulations for such activities.

We implemented the proposed model for the debris collection during the response phase using OPL 4.1. During the response stage, roads and streets that are essential for the emergency operations have to be identified and obstructing debris must be removed. Our model seeks to determine which roads should be cleared first, taking into account the priority of the facilities or areas to be connected, as well as the available debris removal capacity. First, we validated the model's results using a small size network. Next, we generated an instance based on a real network in order to test the model with a real size problem. The scenarios that we have run so far were designed primarily to validate the output of such model, to understand its behavior under different parameters settings, and to evaluate its applicability to a real life problem. The results also gave us an insight of the impact of different policies that could be implemented, for instance different priorities for connecting different elements on the network.

We need to set a more realistic instance, in order to analyze the applicability of the model's results. We are also exploring the MIP version of the model.

## Private Industry Case Studies in Humanitarian Logistics

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### Objectives:

- Research Home Depot's humanitarian relief supply chain, logistics, merchandising, regional management and crisis management functional areas.
- Research Waffle House's quick response to hurricanes and natural disasters with a focus on operations, marketing, purchasing, construction and human resources.
- Simulate decision making during disaster planning and response

### Results:

These companies execute specific activities during the pre-storm, prior-storm, and post-season hurricane stages.

#### Home Depot:

- Pre-storm season preparation: extensive planning and preparatory work, manage vendor relationships, prepare and train associates, ensure infrastructure and structural preparedness, etc.
- Prior-to-storm preparation: ensure associate safety, watch where the storm hits, ready trailers to be sent to aid in post-storm, ready hotel rooms, determine store closures, etc.
- Post-storm: send teams to affected areas, dynamic routing and transportation decisions, communicate specific damage types and needed supplies, evaluate damage to stores and identify repair needs, etc.

#### Waffle House:

- Pre-storm season preparation: review of previous season, secure needed equipment (generators, vehicles and communication devices), review response preparation with vendors, train associates, etc.
- Prior-to-storm preparation: storm monitoring, ensure equipment readiness, encourage associate evacuation, coordinate store closings, meet and discuss further response needs beyond basic preparation, etc.
- Post-storm: assess expected impact to stores, set up command center, organize response teams, arrive in market as soon as possible, assess damage and store readiness, reestablish supply chain, deploy equipment, rebuild and repair stores.

#### Decision making simulation: Big Depot Game

- The game simulates the decision making process during disaster planning and response
- First decision consists in deciding how much to reserve from vendors for different types of supplies required after a disaster strikes. Then, the player has to decide where to allocate these reserved quantities.
- The game is developed in two phases: the first one without any decision support tool and the second one with an Excel-based decision support tool that estimates the expected cost of the selected strategy.