Gaps Between Research and Practice in Humanitarian Logistics

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This paper, which compares humanitarian logistics research with needs in practice, has two key objectives. The first is to provide an overview of recent humanitarian operations and logistics research in the OR/MS field in order to set a foundation of academic contributions. The second builds upon the first by outlining the gaps between research and needs in practice in order to offer insights and motivate areas that could benefit from additional analysis and collaboration.

INTRODUCTION

Recent global disasters have given impetus to a growing body of research in humanitarian logistics (often abbreviated as "humlog"). One of the newest growing research areas in the Operations Research / Management Science (OR/MS) field, humanitarian logistics is focused on enabling the mitigation, preparation, response, and recovery for natural and man-made disasters. Due to a disaster's immense impact on life, infrastructure, and economies, the optimal delivery of aid and the efficient management of resources are of paramount importance.

In this paper, we take a holistic approach to discuss existing OR/MS research in this area and compare it with the existing areas of focus for practitioners. Our goal is to establish prior and align future research directions. Such an alignment between research and practice has long been sought after in all manners of business practice. There is, however, a dichotomy between the research needs of corporate logistics and those of humanitarian logistics. Humanitarian logistics research is, in comparison, not as mature of a field and has many opportunities for development.

The specific humanitarian needs involved have given rise to two distinct areas of study in the field: disaster management and long-term development, both of which hold promise for research contributions. Therefore, these two areas help guide our paper in the discussion of historical progress, examples in practice, and potential areas of future research.

WHAT IS HUMANITARIAN LOGISTICS?

Common Definitions

We define humanitarian logistics by defining its two parts: humanitarian work and the logistics contributions to help achieve it. Humanitarian work is driven by individuals and organizations with the principal goal of improving the conditions of target populations (known as beneficiaries). Humanitarian

aid, the general umbrella that our discussion usually falls under, has a presence that is felt by populations around the world because of its criticality and involvement with many stakeholders. These stakeholders may include the populations receiving aid, organizations involved with its distribution, manufacturers that produce it, militaries, shipping companies, donors who sponsor the activities, governments that play many roles (financial, regional, or political), and many more. Logistics is concerned with the movement of information, goods and services between entities.

Humanitarian logistics is therefore considered to be the set of actions taken by organizations in an attempt to move information, goods, and services for the specific goal of aiding target beneficiaries, environments, and societies. This has an overlap with what is commonly referred to as humanitarian operations, which may include the entirety of processes within an aid program. We acknowledge this overlap and focus herein on the logistics aspect (as defined above) of humanitarian operations.

Areas of Focus in Humanitarian Logistics

The actions taken by organizations practicing humanitarian logistics can be considered in two distinct ways:

1) Actions regarding potential and actual disasters may warrant humanitarian response, which we will call *disaster management* and which has been the major focus of past literature.
2) Actions with the goals of structural and sustainable development for an area/population, what we will call *long-term development*, which we go into more detail in the potential research directions section.

In this paper, we use the word disaster to represent the various forms of man-made or naturally occurring events referred to as hazards, catastrophes, etc. These types of events have the potential to negatively impact lives, communities, environments, and economies. Disaster management is therefore known to represent the set of activities performed before, during, and after a disaster in order to diminish its impact (Altay and Green, 2006). Interestingly, within disaster management, it is estimated that 97% of disasters are man-made and only 3% occur as a result of natural phenomena (van Wassenhove, 2006). **Recap and Key Takeaways** Humanitarian logistics is a growing research area in OR/MS that attempts to support two functions: disaster management and long-term development.

EXISTING HUMANITARIAN OR/MS RESEARCH AND MODELS

A quick Google Scholar® search for "Humanitarian Logistics", at the time of this paper's finalization, returns approximately 45,000 results. The conundrum for introducing ourselves to this array of publications becomes: how do we cull through these results to find themes and true contributions from academia and practitioners? Although the field is relatively new, several researchers from various branches of academia have attempted to collate the library of knowledge on the topic, allowing us to use those indexes as a starting point to understand prior research.

Historically, research in disaster management has taken place mostly outside of the OR/MS field. We find that the social sciences have invested a great deal of time and effort in studying the effects of disasters on human populations. OR/MS papers began to grow in number around the year 2000 and have grown steadily since then, partly due to a growing need for expertise and recognition of the role researchers can continue to play.

The Humanitarian Life Cycle

Much of the research in disaster management can be separated into four parts of what is referred to as the humanitarian life cycle: Mitigation, Preparedness, Response and Recovery, with the majority of prior research being done in the Mitigation phase (Altay and Green, 2006). OR/MS humanitarian research has used many of the same tools as were used in classical research; therefore, existing models and methods were easily adapted and applied to the Mitigation phase for problems foreseen by humanitarian organizations. As breadth in this field grows, we are now witnessing more research into the Preparedness

and Recovery phases. There is a strong correlation in growth to the field of Emergency Response, which witnessed many contributions in the 1970's and has recently been revived (Green and Kolesar, 2006).

In order to provide a comprehensive understanding of the entire system, we briefly discuss each part of the life cycle using review information aggregated from Altay and Green (2006), Galindo and Batta (2013), and Ortuño et al. (2013). For each part, we include the areas of focus by academics, the type of research methods commonly used, and contributions made through analysis.

Mitigation

Until 2005, Mitigation constituted the majority of active work in humanitarian research. Mitigation, in practice, attempts to pre-plan for disaster relief by performing a risk analysis of potential threats and then focusing on gaps to ensure the proper planning and dampening of disaster effects. We consider the Mitigation phase as long-term planning. For example, setting up facilities that hold relief supplies are of paramount importance during Mitigation and this can directly impact the stages that follow it. This exemplifies the idea that no single phase exists in isolation; they are inter-connected and flow into one another. Another Mitigation example is early warning systems, which are implemented to alert first responders, agencies, and the general population of eminent disasters in order to assist with potential evacuations. Mitigation may also include the installation of protection systems such as police patrols and infrastructure strengthening.

Academic contributions to the Mitigation phase have included planning mechanisms for natural disasters (floods, earthquakes, hurricanes, etc.) and preventing industrial accidents (chemical spills, computer network vulnerabilities, hazmat transportation, etc.). The methods used in this research include (but are not limited to) simulations for vulnerability assessments, linear programming for facility locations, and set analysis for supply chain design and efficient distribution. Actionable insights obtained include decision support tools that use an integrated approach to measure disruption scenarios (Fiorucci et al., 2005 and Snediker et al., 2008) complemented by recommendations to coordinate with micro-retailers to distribute aid after predictable disasters occur (Sodhi and Tang, 2013).

Preparedness

Following the Mitigation phase comes the Preparedness phase, which is principally concerned with action planning, protocols, and guidance to adhere to before a potentially imminent disaster. The idea is that by actively discussing steps and taking preventative actions before a disaster strikes, a community can put response plans in place that can be readily executed if necessary. In addition to human preparation, this phase also involves pre-positioning inventory and creating supply contracts with vendors.

Academic focus areas in this part of the cycle have been similar to those of Mitigation (e.g. floods, hurricanes, accidents) and also include other types of disasters such as warfare, wildfires and nuclear response. Methods used include evolving multi-variable algorithms, modeling of network flows for evacuation, inventory modeling for strategic stock-pile placement, and spreadsheet-based modeling tools for on-site decision making. This part of the cycle has seen growth in recent years, representing 28% of academic contributions made from 2005 to 2010, up 7% from 1980 to 2004 (Galindo and Batta, 2013). Sample insights offered from this stage include the cost-benefit trade-off of pre-positioning inventory and the resulting response times (Duran et al., 2011), as well as an actionable framework with decision modeling tools for warehouse locations, capacities, and stock levels (Rawls and Turnquist, 2011).

Response

Response entails the required movement of aid after a disaster strikes. In this third part of the life cycle, the protocols that were developed in the Preparedness phase are used to mobilize resources to areas of need. Such resources are primarily concerned with protecting human life and stabilizing the economic and physical infrastructure of the affected location. In addition, this phase requires the cooperation of multiple agencies and governments to deliver aid in an efficient manner, thereby minimizing response time and duplication of effort.

Research focus areas in this stage are similar to those in the previous stages yet also include papers on responses to terrorism. Theory used in this type of work mostly relies upon multi-period linear and dynamic programming, game theory, and routing problems (e.g. traveling salesman, vehicle routing, heuristics development). Similar to Preparedness, Response research has seen growth in recent years, making up approximately 34% of contributions made between 2005 and 2010 (Galindo and Batta, 2013). Sample insights gained from Response research includes the optimal assignment of resources to minimize the time of tasks such as rescue activities (Yan et al., 2009), and modeling solutions for rapid deployment in multi-priority response situations (Chiu and Zheng, 2007).

Recovery

The last phase in the field, Recovery, involves cleanup of debris, rebuilding of infrastructure, restoration of services, and planning for long-term housing and aid. This phase is both: the area where practitioners could have the longest time invested and the stage with the least amount of research volume, accounting for only 11% of contributions made between 1980 and 2004 and only 3% of contributions made between 2005 and 2010 (Galindo and Batta, 2013). Reasons for this dearth of contributions are numerous but include less availability of data, more complexity in models that depend on significantly more variables or assumptions, unique situations which are harder to generalize, and longer, more variable time horizons.

Academic focus areas in this stage are similar to those mentioned in the previous parts of the life cycle but also include infrastructure recovery (e.g. of road networks, health, financial systems). Modeling techniques used include linear and dynamic programming, spreadsheet-based tools, and simulations for infrastructure analysis and restoration considerations. One interesting example is simulating rebuilding frameworks based on how the human body and ant hills recover from damage. Insights gained in this phase include disaster waste management considerations with implications for local environments and economies (Brown et al., 2011) alongside heuristics for real-time restoration of infrastructure over finite horizons (Nurre et al., 2012).

Summary of Disaster Management Research

Altay and Green (2006) performed an exhaustive analysis of 109 humanitarian operations articles published in the literature related to humanitarian logistics between 1980 and 2004. We have taken their analysis by life cycle stage and created Table 1, which includes a summary of the preceding paragraphs as well as the volume of academic contributions (by total percentage) to each stage of the life cycle. We see that the majority of research performed took place in the early phases of the humanitarian life cycle, and a deeper analysis confirmed that much of it employed mathematical models, more than half of such research occurring after the year 2000. Subsequent to Altay and Green's analysis, Galindo and Batta (2013) published a follow up review of 155 papers, which showed strong shifts between 2005 and 2010, also depicted by percentage in Table 1.

TABLE 1
OMMS PAPER CONTRIBUTIONS

Altay and Green: 1980-2004

Mitigation 44%	Preparedness 21%	Response 24%	Recovery 11%
• Risk Analysis • Early warning • Facility locations • Protection systems	• Pre-Position • Infrastructure	• Dist. Of supply • Air Transport • Inv. Mgmt. • Evacuation	• Waste Mgmt. • Network Restoration • Relief distribution

Galindo and Batta: 2005-2010

Mitigation 24%	Preparedness 28%	Response 33%	Recovery 3%	Multi-Stage: 11%

The changing proportions of research focus indicates a more recent shift towards the middle of the life cycle, potentially in response to many natural disasters that have engaged the public eye and called for deeper analysis. We believe it is fair to say that our academic efforts in assisting with humanitarian organizations have been successful, yet we can continue to learn from the needs of fast-moving practitioners. Therefore, as we dive deeper into humanitarian research, we must continue to do so while paying attention to shifts in this dynamic field.

Lastly, past literature reviews have separated research into three main contribution areas: Theory, Modeling, and Application. An increasing majority of the research produced in humanitarian operations focuses on Modeling. Over time, Theory has declined as a focus area and Application has received the least amount of work, constituting only 5% of research contributions from 2005 to 2010. This lack of attention to Application makes us question if research is being performed in collaboration with or in response to practitioners, or if the research extends existing models. Throughout this paper, we return to this question and offer recommendations to bridge the growing chasm.

Recap and Key Takeaways The four parts of the humanitarian life cycle are categorized as Mitigation, Preparedness, Response, and Recovery. For each part, we have discussed the main focus areas and techniques through which previous contributions were made. We show that Modeling has been a tool and contribution of focus in OR/MS humanitarian logistics research, while contributions to Applied research are significantly less in volume than those toward Modeling or Theoretical areas.

HUMANITARIAN LOGISTICS IN PRACTICE

To explore the directions research can go, we look to humanitarian operations occurring across the globe for insights into the needs of practitioners. In the sections that follow we review work being done by several organizations and discuss opportunities that are available for impactful research.

Disaster Management

Although each of the four phases of the life cycle are critical, it is important to note that international humanitarian organizations do not usually respond to a disaster until the affected country or local government declares a state of emergency and invites international aid (Van Wassenhove, 2006). When this happens, these organizations face many challenges (Kovács and Spens, 2007) depending on the:

- type of disaster (natural vs. man-made, warning time, probability),
- location (regional presence, topography, phase of relief), and
- stakeholders (internal, external, other relevant organizations) involved.

It is the combination of compounding variables, short lead times, multiple players, heterogeneity of disasters, and the relative recency of interest in this field that makes humanitarian logistics ripe with opportunity for discovery. While academics use empirical and analytical tools to understand and improve research, multi-national and global organizations are actively attempting to maximize humanitarian logistics capability, coordination, and efficiency.

Long-Term Development

Similar to the commercial industry, the coordination of multiple operating units in various regions is difficult to plan and manage. We begin to see the depth of difficulty faced by humanitarian organizations when we add the complexity of random shocks, stochastic inventory requirements, limited data or infrastructure, and other hurdles. This raises the question: how does the world navigate in this uncertainty, and are there protocols in place which make it easier? To help answer this questions, we discuss the United Nations (UN) cluster system, the Millennium Development Goals (MDGs), and provide examples of organizations performing work in long-term development through health and education programs.

United Nations Cluster System

Humanitarian crises can be overwhelming for the populations impacted by, and organizations responding to, an event. Coordination amongst these organizations is critical to capitalize on synergies and thereby reduce the duplication of services. Along the same vein, a lack of coordination can lead to confusion, bottlenecks, and inefficiency.

In 2005, the UN cluster system was created as a standardized approach to the way in which humanitarian agencies would work in unison when responding to a crisis. The cluster system is organized into eleven thematic areas: Nutrition, Health, Water/Sanitation, Education, Shelter, Camp Coordination/Management, Protection, Early Recovery, Logistics, Food Security, and Emergency Telecommunications. Each area is led by a focal UN organization tasked with coordinating the required activities within the purview of its assigned theme. A graphical representation of the humanitarian life cycle (as detailed by the UN), the clustered themes, and their respective lead organizations can be seen in Figure 1.

FIGURE 1
UNITED NATIONS CLUSTER APPROACH TO HUMANITARIAN EMERGENCIES
(UN Clusters, 2015)
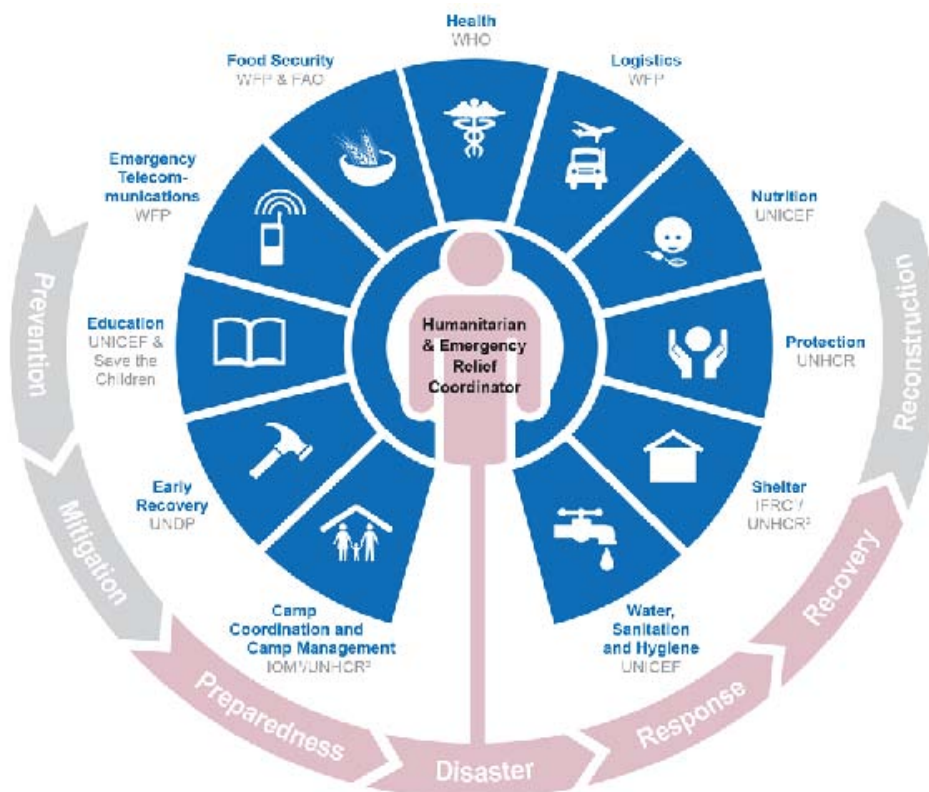
Envisioned in 1991, implemented in 2005, and updated in 2007 and 2010, the cluster system recently celebrated a decade of being in operation and is currently being used in over 30 countries. We note that the cluster system has come under scrutiny for, what critics say is, its inability to fully engage local government and citizens. According to these critiques, which have been acted upon, past cluster meetings failed to solicit participation from all relevant stakeholders and thereby unintendedly sacrificed buy-in from local groups. Taking a step back, we can see that the successes and limitations of the cluster system also provide opportunities for research. Analysis can be considered in stakeholder collaboration, communication, game theoretic models with multiple agents, facility capacity sharing, inventory management, information flows, joint purchasing and more.

We now provide brief examples of academic research towards collaboration. Balcik et al. (2010) discuss coordination challenges and offer potential applications of corporate coordination mechanisms to the humanitarian sphere. Christopher and Tatham (2011) take this thought further by analyzing and commenting on the multi-agency approach led by the UN cluster system. Related research outside of the humanitarian field includes Gui et al. (2012), who identify theoretical properties of fair cost sharing mechanisms, and Meca and Sošić (2013), who provide a game theoretic model showing equilibrium of cooperation under certain conditions of shared costs.

It is important to recall that humanitarian logistics does not only involve disaster management, but also long-term development of regions in which populations receive assistance from organizations to improve their quality of life. This includes building sustainable infrastructure for the future such as programs involved with disease prevention, infant mortality rate reduction, permanent refugee camps, and food programs to eradicate hunger.

Millennium Development Goals

The Millennium Development Goals in Figure 2 (UN-MDGs, 2015) encompass a spectrum of eight long-term development goals through an incredible global push in development aid coordinated by the United Nations. The MDGs involve agencies from all parts of the globe and interface with academia on a multitude of projects. Similar to the UN cluster system, we believe that field work geared towards the MDGs can benefit from additional OR/MS expertise. There are many organizations with varying size levels making positive impact and progress towards these goals and it is within our capacity to learn from and contribute to their work.

FIGURE 2
MILLENNIUM DEVELOPMENT GOALS
(UN-MDGs, 2015)

Case Studies

This section contains case briefs that outline ongoing projects in Health and Education as part of long-term development. The purpose of each case brief is to engender thought regarding potential areas that OR/MS can contribute to.

Health: Maternal Health Outreach

The Clinton Health Access Initiative (CHAI), a global health organization founded in 2002, began with a focus on HIV/AIDS care and treatment. Today, it is involved with multiple MDG-oriented

programs similar to those of more tenured organizations (e.g. IFRC, UNICEF). Despite its relative youth and size, CHAI is open to new directions, broad-spectrum engagement, and opportunities for rapid change.

One example of a program that CHAI is currently attempting to tackle within the 5th MDG (improvement of maternal health) is a maternal health outreach program in Kenya. The program supplies expecting mothers with tools (in the form of medical kits) and awareness (through discussion, documentation and point of contacts) regarding potential newborn issues. The program has engaged representatives with local clinics, making door-to-door trips to spread knowledge on the availability of life-saving resources available to the community. An important question of interest is how programs, similar to CHAI's maternal health outreach program, are measured, optimized, and ultimately deemed as successful. In measuring success, we do not limit our scope to this one organization, as CHAI is not alone in this type of work and all organizations are in some way accountable for fulfilling their mission. For examples of a similar program, see CARE Maternal Health (2015) in References.

Health: Anemia Response

We now provide an example of Nutrition as part of delivering long-term development aid. It is known that a significant portion of the world's population (approximately 2 billion people) suffer from iron deficiency anemia (IDA). Many international and grass-roots programs have collectively taken action to improve iron supplement access (LBWR, 2015) and continuing research shows the negative economic and societal impacts from such nutritional deficiencies (Duncan et al., 2006). While there is access to data for many of these programs, organizations on both sides (supplement distribution and its analysis) do not always employ OR/MS expertise or approach their program from an optimization (modeling, simulation, etc.) perspective. This creates a gap, and therefore provides opportunities for our field to contribute, collaborate, and ultimately improve such projects.

Health: Summary

Despite their goals and promise, programs such as those mentioned above can benefit from improved measurement policies. Without operations best practices, last mile program delivery may be inefficient and could ultimately fall through. Part of the reason for a potential fall through may be due to the misalignment of goals with operational structure, a common issue faced in corporate and humanitarian sectors. Issues may also occur if well-intentioned resource allocations prove to be sub-optimal from Theoretic, Modeling, or Applied perspectives.

The health briefs discussed are examples of how academia can contribute to the long-term development of impactful health care: to build additional partnerships with organizations such as CHAI, CARE, and LBWR in order to understand where their pressure points are and how we can tailor our research to address their needs. Collaboration is common in all realms of academia; however, we believe that additional applied work in humanitarian logistics can create substantial opportunities for understanding the supply chain and having a greater impact. We encourage readers to consider extending their thoughts beyond these examples to other areas related to health such as immunization delivery, blood banks, food banks, and communicable disease prevention.

Education: Delivery of World-Class Primary Schooling in Africa

We now provide examples of education as a long-term development goal in Africa, a continent that is expected to have a burgeoning workforce of 924 million people, where the principle concern is robust education delivery to an expanding population.

The African Leadership Academy (ALA, 2015) is a school that aims to develop and connect the next generation of leaders in Africa. In October of 2014, Fred Swaniker, the founder and executive chairman of the ALA, announced to the world via his TED talk that their academies would expand their impact by increasing their training capacity from 700 students to 250,000 students at a time by opening 25 new university campuses (which will train 10,000 each). Adding up the math, this means that the ALA intends to train three million new students over the next 50 years.

The ALA is not alone in their mission, as there are many other organizations working on the efficient dissemination of robust education. One such organization is the Aga Khan Academies, part of a network of agencies called the Aga Khan Development Network (AKDN, 2015), which works to create opportunities for people in the developing world. The Aga Khan Academies are delivering an international standard of excellence in education to targeted populations in Africa and Asia who previously lacked access. By creating cooperation agreements with a variety of international educational systems, the Aga Khan Academies are building institutions that can empower youth from multiple continents to lead and enact positive change in the communities they inhabit (Aga Khan Academies, 2015).

Potential Research Implications The related questions we may pose to ourselves as a research community are: how can we help with health and education delivery? More specifically, can delivery be analyzed, modeled, and improved? Furthermore, can this only be applied to a single continent, or can it be scaled up to be distributable across the globe, or scaled down to a small town in India (see case learnings in Vachani and Smith, 2007), or near where we live? Our careful consideration of these questions is important, and their answers have the ability to impact the opportunities and quality of health and education available to future generations.

OPPORTUNITIES: THE GAP BETWEEN RESEARCH AND PRACTICE

We see from the above examples that there is ample opportunity for engagement between academia and the humanitarian field. Below, we discuss a few potential directions this collaboration can take to help spark the research imagination.

Opportunities for Future Research

Our review of current literature and challenges faced by practitioners indicated many areas where OR/MS can assist. A significant portion of these potential areas fall under two categories: disaster response (the third part of the humanitarian life cycle), and capacity building (part of the long-term development process). We have simplified our findings of these research opportunities into Table 2.

TABLE 2
OPPORTUNITY AREAS IN HUMANITARIAN LOGISTICS

Disaster response	Capacity Building
• Decision support tools • Connection between transparency, inter-agency performance and data collection • Implementation of best practices from industry	• Food and aid collection • Long-term distribution of aid • Infrastructure development • Local resource development • Alignment with goals of MDGs

We are reminded that capacity building is not only an important structural building block for society. As part of the recovery phase, it is also one of the most ignored parts of disaster management research and a critical opportunity area for future contributions within long-term development.

In addition to Table 2, we highlight two streams of potential research which can have important impacts on communities: policy evaluation and education.

Opportunity: Policy Evaluation

We first consider the series of agency policies that maximize the delivery of aid. A sweeping problem in humanitarian logistics is whether aid is actually delivered to its intended receipts, or if it is lost,

spoiled, or misdirected in the process. Ultimately, the efficiency measures of any organization focus on delivery to its customers, yet a common complaint from practitioners is that much of the aid sent never makes it to its destination or arrives in an unusable form. This has tenants analogous to those of the corporate world, which may include backordering, shrinkage, spoilage, etc. In our context, organizations can benefit from a customization of performance metrics to humanitarian systems such as policy evaluation (e.g. using simulations, dynamic programming), last-mile delivery (e.g. linear and dynamic programming), and large scale distribution problems. It may also involve combining methods from other fields to create externally valid solutions.

Opportunity: Education

Generalizing the earlier introductions of school systems in Africa, we seek to explore how we can optimize the global delivery of quality education for the upcoming generation. Delivery of primary education ranks highly for the UN cluster system and the MDGs; however, how do we efficiently educate the world in a standardized, measureable, and robust way?

Over the summer of 2014, one of the authors of this paper spent two months in East Africa working with a global organization that engages social enterprises, primary schools, orphanages and special care homes to understand their needs and develop unique solutions to help meet them. It became clear that working with one organization at a time resulted in greater local benefits (improved operations, sustainability, and efficiency metrics); however, scaling the education delivery problem could enable us to reap additional benefits, insights, and standardization, which should be further studied to discover optimal delivery mechanisms.

Re-Think: Humanitarian Logistics

In relation to the opportunities mentioned above, many individuals outside the field believe that infrastructure and distance are debilitating issues in humanitarian work. We must, however, challenge this notion and see that organizations are trying to maximize operations just as any major corporation, by utilizing existing infrastructure despite the distance. The quintessential difference, of course, between corporations and humanitarian organizations is, in OR/MS terminology, an objective function prioritized on life in the latter.

Re-Think: Existing Infrastructure

It is easy to think that locations that require aid are located in remote regions and that existing infrastructure does not allow us to efficiently access them. This thought process discounts the ingenuity and resourcefulness of local people to move knowledge, materials, and aid where infrastructure may be considered substandard or unavailable. Consider this: If Coca-Cola can make its way into relatively small remote villages, why can't the medications and aid that humanitarian organizations are trying to provide to their beneficiaries make it to the same villages? More importantly, can OR/MS help? We emphatically believe the answer is yes. We may consider the study of existing delivery systems (private or otherwise) in order to understand, replicate, or optimize them in areas of need. Interested readers are recommended to read Vachani and Smith (2007), who discuss methods of physically reaching populations without developed infrastructure, as well as Sodhi and Tang (2013), who explain the use of micro-retailers for the delivery of post-flood aid.

Re-Think: International vs. Local

We somehow presume that the problems of humanitarian logistics/aid are in far-away countries and thus, even we as your authors, travel to find them. Despite the fact that humanitarian crises occur globally, it is important to realize that similar problems are faced within our own regions, cities, and neighborhoods.

For example, the authors of this paper currently reside in the state of North Carolina, which ranks amongst the bottom of the states in the U.S. in standings of primary education and average income levels. In some counties (districts) of our state, 1 in 4 adults and 1 in 3 children live below the poverty line, and

may not regularly have access to the nutrition necessary to work or learn. How do we reach, feed, and teach students who are impoverished, do not have enough food to sustain themselves, or are missing the basic disposition to be able to learn? Taking this further, how would this impact society at large, as those children grow and attempt to enter an ever-demanding work force?

The purpose of the example above that we would like to (quite literally) drive home is that the problems we aim to solve, such as lack of quality education, are not far away in distant lands; they exist locally and should also be carefully considered. The underlying truth is that because of the global (and local) nature of need, opportunity is closer than we think. A local understanding and community engagement can help us stumble onto organizations near us who are trying to tackle some of society's most debilitating problems and could use the prowess of optimization and analytical methodology to help them along their paths.

The New Agenda

It should be noted that because there is renewed effort on all fronts (from the UN, MDGs, etc.) to improve operational efficiency, this in turn opens up the landscape for even more research because there is now additional attention on, funding for, and availability of data that was previously inaccessible. Understanding the context of problems (i.e. beneficiaries, stakeholders, environments, goals, infrastructure) is central to building models and assumptions that can be robust enough for use in practice (Starr and Van Wassenhove, 2011). Although we should rely heavily on our core OR/MS strengths of Theory and Modeling, we believe there must be a renewed effort towards fully understanding the problems at hand and developing solutions that can be applied in settings beyond those envisioned by the heritage tools that we are accustomed to.

The new agenda therefore requires us to further engage with organizations in the field and to work side-by-side to develop new tools and research that fit the needs in practice. This new face of research may appear daunting and difficult to surmount because of its complex nature; however, it also welcomes support and brings with it the satisfaction of improving living conditions for those around the globe.

By pursuing this agenda, we continue to carry the analytical spirit of previous OR/MS developments and further expand our boundaries to become more applicable along our path. This boundary spanning, we believe, is a completely natural extension of our research and would provide considerable insights, expertise, and needed analysis to the humanitarian sector. Table 3 provides a summary of potential research directions discussed in this paper.

Recap and Key Takeaways There are many local and global organizations working to improve humanitarian logistics in a variety of ways. Academic collaboration requires us to re-think our focus areas, holds the promise of greater efficiency for organizations, and allows for a natural expansion of OR/MS research.

CONCLUSIONS AND A PATH FORWARD

In this paper, we have detailed the streams of research in the four areas of the humanitarian life cycle and discussed some key focus areas that practitioners are currently engaged in. Overall, we believe that the OR/MS field has made significant strides in building a foundation of analytical knowledge in the area of humanitarian logistics. It is our hope to not only help align future research with practice, but also to inspire applied collaboration between humanitarian researchers and practitioners. Successfully improving the efficiency of humanitarian logistics is crucial because it directly impacts human lives.
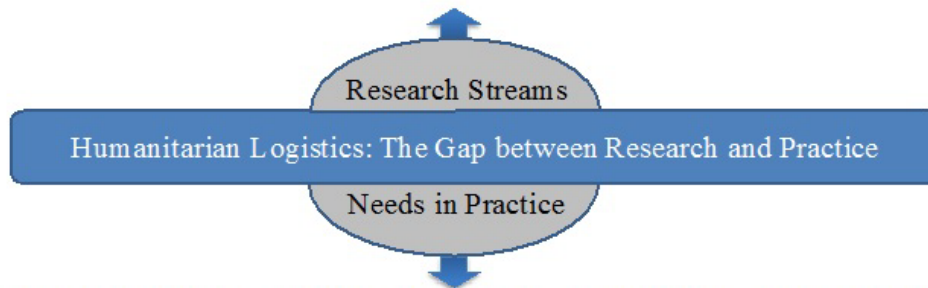
Two key areas we have pointed out in Table 3 for the alignment of humanitarian logistics research are in disaster response and capacity building. Examples of research opportunities in disaster response include data-driven decision support tools, efficiency metrics, and coordination mechanisms. Examples of opportunities in capacity building include the establishment of long-term camps/housing, infrastructure design, health/sanitation, building local capacity, and collaborating with organizations to reach the delivery of MDG goals. Through a discussion of current programs, such as health and education delivery, we explored a variety of exciting paths that could benefit from applied research.

We believe that the gap between research and practice can be filled with targeted analysis in tandem with deeply understanding the needs in practice. Ultimately, addressing the needs of humanitarian logistics can create substantial positive impact on beneficiary populations and the body of research in OR/MS.

TABLE 3
GRAPHICAL REPRESENTATION OF THE GAP BETWEEN RESEARCH AND PRACTICE

Mitigation	Preparedness	Response	Recovery
• Risk analysis	• Prepositioning	• Dist. of supply	• Waste mgmt.
• Early warning	• Evacuation	• Air transport	• Flow restoration
• Facility locations	• Infrastructure	• Inv. mgmt.	• Relief distribution
• Protection systems	• Response protocol	• Evacuation	• Camps / Housing

Methodologies: Mostly mathematical (deterministic) models

Research Streams

Humanitarian Logistics: The Gap between Research and Practice

Needs in Practice

Research needs: Food/blood supply, Education, Infrastructure, Healthcare delivery, Optimization (with realistic assumptions based on stat. analysis) , Inter-stage analysis

Disaster response	Capacity Building
• Decision support tools	• Food and aid collection
• Connection between transparency and interagency performance and collection	• Long-term distribution of aid
• Adaptation of best practices from industry	• Building sustainable infrastructure
• Coordination mechanisms	• Local content success
• Efficiency indicators	• Institute industry best practices
	• Aligning with goals of UN-MDGs

AUTHORS NOTES

We were fascinated by the plentiful amount of information that is publicly available on the web and have noted such resources in the References section of this paper. One resource we recommend for accessing data with regards to humanitarian logistics is the Emergency Management Database (EM-DAT). EM-DAT is an international, free to access web-site maintained by the Centre for Research on the Epidemiology of Disasters (CRED), and is an excellent source for disaster and development data. Through this web-site researchers, practitioners and the general public can obtain valuable information on historical and current natural disasters, including data sets from which to analyze and perform research.

REFERENCES

Aga Khan Academies (2015), Retrieved from http://www.agakhanacademies.org/general/introduction-aga-khan-academies

ALA, African Leadership Academy (2015), Retrieved from http://www.africanleadershipacademy.org/building-foundation/academy

AKDN, Aga Khan Development Network (2015), Retrieved from http://www.akdn.org/about.asp

Altay, N., & Green III, W. G. (2006). OR/MS research in disaster operations management. *European Journal of Operational Research*, 175(1), 475-493.

Balcik, B., Beamon, B.M., Krejci, C.C., Muramatsu, K.M., Ramirez, M., (2010). Coordination in humanitarian relief chains: practices, challenges and opportunities. *International Journal of Production Economics*, Vol.126 (1): 22–34.

Brown, C., Milke, M., & Seville, E. (2011). Disaster waste management: A review article. *Waste Management*, 31(6), 1085-1098.

CARE (2015), Care – Maternal Health, Retrieved from http://www.care.org/work/health/maternal-health

Celik, M., Ergun, O., Johnson, B., Keskinocak, P., Lorca, A., Pekgun, P., & Swann, J. (2012). Humanitarian logistics. *In Tutorials in Operations Research*: *New Directions in Informatics, Optimization, Logistics, and Production. Hanover, MD: Institute for Operations Research and the Management Sciences.*

CHAI (2015). About CHAI. Retrieved from https://www.clintonfoundation.org/about

Christopher, M., Tatham, P., (2011). *Humanitarian Logistics: Meeting the Challenge of Preparing for and Responding to Disasters*, Kogan Page, pp. 85–69.

Chiu, Y. C., & Zheng, H. (2007). Real-time mobilization decisions for multi-priority emergency response resources and evacuation groups: model formulation and solution. *Transportation Research Part E: Logistics and Transportation Review*, 43(6), 710-736.

Duncan, T., Frankenberg, E., Friedman, J., Habicht, J. P., Hakimi, M., Ingwersen, N., & Seeman, T. E. (2006). Causal effect of health on labor market outcomes: Experimental evidence. *California Center for Population Research*.

Duran, S., Gutierrez, M. A., & Keskinocak, P. (2011). Pre-positioning of emergency items for CARE international. *Interfaces*, 41(3), 223-237.

EM-DAT (2015), EM-DAT – Emergency Events Database, Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain, Louvain-La-Neuve, Retrieved from: www.emdat.be

Ergun, Ö., Keskinocak, P., & Swann, J. (2011). Introduction to the special issue on humanitarian applications: Doing good with good OR. *Interfaces*, 41(3), 215-222.

Fiorucci, P., Gaetani, F., Minciardi, R., & Trasforini, E. (2005). Natural risk assessment and decision planning for disaster mitigation. *Advances in Geosciences*, 2, 161-165.

Galindo, G., & Batta, R. (2013). Review of recent developments in OR/MS research in disaster operations management. *European Journal of Operational Research*, 230(2), 201-211.

Green, L. and Kolesar, P. (2004). "Improving Emergency Responsiveness with Management Science", *Management Science*, Vol. 50. No. 8, pp. 1001-1014.

Gui, L., Atasu A., Ergun, O., & Toktay, L. (2012). *Fair and efficient implementation of collective extended producer responsibility legislation*. (Doctoral dissertation, Georgia Institute of Technology).

Kovács, G., & Spens, K. M. (2007). Humanitarian logistics in disaster relief operations. International Journal of Physical Distribution & Logistics Management, 37(2), 99-114.

LBWR (2015). About Let's Be Well Read. Retrieved from http://www.home.letsbewellred.org/

Meca, A., & Sošić, G. (2014). Benefactors and Beneficiaries: The Effects of Giving and Receiving on Cost-Coalitional Problems. *Production and Operations Management*, 23(9), 1549-1560.

Nurre, S. G., Cavdaroglu, B., Mitchell, J. E., Sharkey, T. C., & Wallace, W. A. (2012). Restoring infrastructure systems: An integrated network design and scheduling (INDS) problem. *European*

Journal of Operational Research, 223(3), 794-806.

Ortuño, M. T., Cristóbal, P., Ferrer, J. M., Martín-Campo, F. J., Muñoz, S., Tirado, G., & Vitoriano, B. (2013). Decision Aid Models and Systems for Humanitarian Logistics. A Survey. In *Decision Aid Models for Disaster Management and Emergencies* (pp. 17-44). Atlantis Press.

Rawls, C. G., & Turnquist, M. A. (2010). Pre-positioning of emergency supplies for disaster response. *Transportation research part B: Methodological*, 44(4), 521-534.

Snediker, D. E., Murray, A. T., & Matisziw, T. C. (2008). Decision support for network disruption mitigation. *Decision Support Systems*, 44(4), 954-969.

Sodhi, M. S., & Tang, C. S. (2014). Buttressing supply chains against floods in Asia for humanitarian relief and economic recovery. *Production and Operations Management*, 23(6), 938-950.

Starr, M. K., & Van Wassenhove, L. N. (2011). Special issue of production and operations management: Humanitarian operations and crisis management. *Production and Operations Management*, 20(5), 787-788.

Tomasini, R. and Van Wassenhove, L. (2009), "From preparedness to partnerships: case study research on humanitarian logistics", *International Transactions in Operations Research*, Vol. 16, pp. 549-559.

Vitoriano, B. (2013). Decision aid models and systems for humanitarian logistics. A survey. Chapter 2 in *Decision aid models for disaster management and emergencies* (pp. 17-44). Atlantis Press.

United Nations (2015), Department of Economic and Social Affairs. Population Division. Retrieved from http://esa.un.org/wpp/Excel-Data/population.htm

United Nations (2015) Office for the Coordination of Humanitarian Affairs, Humanitarian Response. Retrieved from http://www.humanitarianresponse.info/

UN Clusters (2015), What are UN clusters? Retrieved from http://business.un.org/en/documents/249

UN-ISDR (2004), "Living with risk. A global review of disaster reduction initiatives, Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR)", Retrieved from http://www.unisdr.org/we/inform/publications/657

UN-MDGs (2015), Millennium Development Goals. Retrieved from http://www.un.org/millenniumgoals/

Vachani, S., & Smith, N. C. (2007). Socially responsible distribution: distribution strategies for reaching the bottom of the pyramid. *INSEAD Business School Research Paper*, (2008/21).

van Wassenhove, L.N. (2006), "Humanitarian aid logistics: supply chain management in high gear", *Journal of the Operational Research Society*, Vol. 57 No. 5, pp. 475-89.

Yan, L., Jinsong, B., Xiaofeng, H., & Ye, J. (2009). "A heuristic project scheduling approach for quick response to maritime disaster rescue". *International Journal of Project Management*, 27(6), 620-628.