The use of technological innovations in promoting effective humanitarian aid: a systematic review of the literature.

TICKLE, M. and HANNIBAL, C.

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The Use of Technological Innovations in Promoting Effective Humanitarian Aid:
A Systematic Review of the Literature

Matthew Tickle, University of Liverpool, UK*
Claire Hannibal, Liverpool John Moores University, UK
https://orcid.org/0000-0001-6840-9097

ABSTRACT

The number and scale of natural and man-made disasters is increasing at an unprecedented rate, leading to devastating consequences for citizens, governments, and entire economies. In response, humanitarian supply chains (HSC) are used as a means of reducing suffering and saving lives. HSCs manage and deliver aid to those in need after a disaster strikes and exist only for the period of the relief operation. With reduced budgets there is an impetus to investigate technological innovations that offer increased efficiencies and reduced costs. One such innovation is information and communications technology (ICT), which is currently under-utilized by HSCs. This paper investigates the benefits, barriers, and enablers of increased ICT adoption in HSCs and offers solutions most suited to their needs. The study develops a matrix that identifies the enablers and barriers of implementing innovative ICT and highlights associated managerial implications and suggested areas for future research.

KEYWORDS

Disasters, Humanitarian Aid, Humanitarian Supply Chains, ICT Applications, Innovative Technology

INTRODUCTION

Natural disasters cause devastating consequences for those caught in the affected area, with research suggesting that the number of magnitudes of these events are increasing at an alarming rate (Overstreet et al, 2011; Sandwell, 2011). Earthquakes, floods, and hurricanes cause widespread disruption and dislocation and often occur with no prior warning (Britton, 1998; Fritz, 1961; Palen and Liu, 2007). In addition, man-made disasters such as conflict and wars create similar levels of disruption and dysfunction and require a comparable crisis response (Beamon and Kotleba, 2006).

An organized approach to disaster management is essential (Dubey et al, 2017). One response mechanism is Humanitarian Supply Chains (HSC), which are supply chains (SC) that deliver goods and services to those in need in a timely fashion (Beamon and Balcik, 2008). Academic interest in this field has been piqued, driven by the increased number and magnitude of natural disasters and conflict crises in recent years. In additional, it is acknowledged that the majority of disaster relief projects are deemed unsuccessful due to the numerous and multi-faceted challenges these SCs face (Fawcett and Fawcett, 2013). Examples of these challenges include uncertainty over supply and demand locations after the disaster strikes, limited access to accurate information from those in the field, duplication of effort by the multiple non-governmental organizations (NGOs) operating in the same location, damage to local infrastructure in the affected area, a shortage of skilled workers on the ground, and

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the multitude of stakeholders involved in these operations (each with their own cultural and political nuances and mandates), to name just a few.

A suggested method of reducing the challenges faced by HSCs is increased use of information and communication technology (ICT), especially given the proven efficiency and effectiveness it offers commercial SCs (Beamon and Balcik, 2008). Successful ICT adoption increases agility within and between organizations, and the continued decrease in implementation costs makes adoption increasingly affordable for NGOs (Scholten et al., 2010). The potential for ICT to have a positive impact on HSCs is thus increasingly recognized (Pettit and Beresford, 2009), with some suggesting that ICT is the "*single most important factor in determining the success or failure of a disaster relief operation*" (Kovacs and Spens, 2007) and others advocating it as a "must have" tool within HSCs (Özdamar and Ertem, 2015).

In this context, the strength of ICT is its ability to store and manage vast amounts of information (Brogueira et al, 2017). The importance of information in HSCs cannot be underestimated, with managers needing to calculate the demand for all goods and services across the SC, their current location and their destination, as well as the transportation options available for distribution (Baldini et al., 2012). Understanding these requirements in commercial SCs is difficult enough, but the complexity of HSCs makes managing this information even more challenging (Schniederjans et al, 2016), further highlighting the need for strong ICT systems for storing, managing, and disseminating information.

Aside from the technical challenges, there is evidence to suggest that NGOs with crucial information can often be reluctant to share it, particularly as personal networks are usually prioritized in these environments, leading to information flowing in an ad-hoc fashion (Bharosa, Lee and Janssen, 2010). As numerous NGOs are involved in the HSC, co-ordination is crucial, yet studies show how humanitarian relief organizations tend to use a multitude of incompatible and unconnected systems that rely on manual input, thereby severely limiting the accuracy of the information they possess (Ilhan, 2011; Overstreet et al., 2011; Pettit and Beresford, 2005). Similarly, limited evidence exists of NGOs utilizing ICT to effectively manage the relief inventories, leading to suggestions that this is an obvious area for improvement (Whybark, 2007).

Studies suggest that several benefits can be achieved by increasing ICT usage in humanitarian relief operations; examples include tracking and tracing of goods from origins to beneficiaries (da Costa et al., 2012), managing relief inventories (Whybark, 2007), and coordinating communication between all parties of the HSC (Kovacs and Spens, 2007). However ICT implementation is not straightforward. Communication in HSCs must be able to function when existing communication networks have collapsed (Maroj and Baker, 2007). This is particularly pertinent to developing regions that have relatively limited ICT infrastructure to begin with (McClintock, 2009; Pettit and Beresford, 2005), and it is well known that implementing ICT solutions in such developing areas can be particularly challenging (Sanford and Bhattacherjee, 2008).

There are clearly benefits to applying ICT to HSCs and this topic therefore requires further exploration. There are also numerous challenges (often concerned with human interaction) associated with adopting ICT applications in this field; for example, HSCs require input from many stakeholders that are geographically disparate and hold several conflicting mandates, goals and objectives (Oloruntoba and Gray, 2006; Oloruntoba and Kovacs, 2015). It is widely recognized that innovative ICT applications require a large degree of collaboration between all involved (Albert and LeBrasseur, 2007) and such lack of collaboration can therefore act as a significant barrier to successful innovative ICT adoption in HSCs. Similarly, those engaged in humanitarian relief may do so because of the mission, beliefs or values of the cause or organization, and may be less concerned with the application of ICT. For this reason, many of these organizations work in isolation, resulting in some scholars calling for more research investigating how the collaborative use of ICT can increase the levels of trust and agility within HSCs (Schniederjans et al, 2016). In focusing on technology and human interaction, this is therefore a pertinent and timely topic to examine and hence the following research questions are used to frame the study:

1. How can ICT innovation benefit HSCs?
2. What are the barriers to implementing innovative ICT in HSCs?
3. Which innovative ICT applications offer the most benefits to HSCs?

The remainder of the paper is structured as follows; the authors begin by explaining the systematic literature review methodology used by this study, in particular focusing on the methods used to ensure rigor. The findings from the literature review are then discussed by addressing the three research questions posed. A matrix is developed to classify the enablers and barriers to innovative ICT adoption within HSCs from both a people and process perspective. The study concludes by highlighting areas for future research as well as the managerial implications of the study.

RESEARCH METHODOLOGY

This study adopts a systematic literature review approach; rigorous systematic reviews are characterized by their replicability and as such the authors followed the guidelines set by Denyer and Tranfield (2009). The first phase of the research involved liaising with expert scholars in the field of logistics and supply chain management to define the scope of the study and also the specific search terms that should be used to identify relevant articles in the citation databases. As only a relatively small number of previous studies have focused exclusively on innovative ICT usage within HSCs, the discussions suggested not to limit the search strings to specific terms around ICT; instead the authors were advised to review the HSC literature as a whole, before homing in on specific ICT issues. Through this exercise, the terms "Humanitarian Relief", "Logistics", "Supply Chain", "Rapid Response", "Agility", "Operations Management", "Purchasing" and "Procurement" were identified as relevant in obtaining the most suitable articles in the HSC field. As previous work in this area has been published in an array of diverse journals, the authors ensured they searched numerous citation databases, with the following being used to search for relevant articles; Scopus, Science Direct, Emerald, and Business Source Complete.

The results of the initial search produced 5,547 papers, of which 3,384 were duplicates. The abstracts of the remaining 2,163 papers were then reviewed by both authors in order to remove those that:

1. Were editorial papers,
2. Did not mention Logistics, Supply Chains, Rapid Response, Agility, Operations Management, Purchasing or Procurement in the context of Humanitarian Relief.

Based on the above criteria, 280 papers were then selected for the second phase; this involved each of these papers being read and then classified using the 'A, B, C' criteria proposed by Thorpe et al. (2005). In this criteria, 'A' papers are defined as definitely relevant, 'B' papers are defined as relevance not clear and 'C' papers are defined as less relevant or where the "*nature of the research work was unclear*" (p260). In the case of 'B' and 'C' papers, these were judged to have limited information (and therefore offer insufficient insight) into ICT within HSCs. For example, many these papers mentioned HSCs but their main focus was not the SC, rather it was on another aspect of operations management. Similarly, other papers from the search mentioned HSCs, but did not discuss issues of ICT.

Coding of the articles was conducted independently by both authors. Several meetings took place at various stages throughout this process to ensure that both authors were using the same criteria for classification, and after discussion of all papers, 41 papers were placed on the 'A' list. These 41 papers were selected based on their relevance to the topic; as a result no limitations in terms of date or journal were imposed.

Data Analysis

With the relevant papers identified, the next phase involved data analysis; thematic analysis techniques were used due to the strength of this analysis method with qualitative data (Boyatzis, 1995). The authors utilized an inductive method of thematic analysis (sometimes referred to as "grounded analysis") to analyze the data, whereby codes and themes were identified based on the content of the data rather than from previous theories or prior research (Boyatzis, 1995; Easterby-Smith et al, 2013; King, 1998 p118). This choice was made as there has been very little previous research in the area of innovative ICT in HSCs and also because the authors did not want to become biased before data analysis had begun, thereby missing some highly important aspects of the data; this issue has been highlighted by Collins and Hussey (2014: pp. 168-169) who state that "*..if you select only the words or phrases you have determined are of interest, you may ignore large amounts of data that could help you understand the phenomena under study at a deeper level*". This approach is said to create high levels of inter-rater reliability as well as greater validity of the findings from the data (Boyatzis, 1995). Working directly with the raw data allowed the authors a more complete view of all the information available, thereby allowing for both the "easily evident" and "difficult-to-discern" aspects of the data to be uncovered (Boyatzis, 1995, p30).

Both authors used the NVIVO software package, as recommended by Easterby-Smith et al (2013) who suggest that using software such as this allows for a more collaborative analysis of the data. The authors used the open coding technique highlighted by Riege (2003), Goulding (2002) and Saunders et al (2009). This technique breaks down the data into distinct units of meaning; the text is analyzed line-by-line and key words or phrases are transformed into codes. Throughout the coding process the authors met regularly to share codes and ideas so that a common code book was created and adhered to (Saldana, 2016). The codes were then collapsed into the three themes of the benefits offered by ICT, the barriers to ICT adoption, and the innovative ICT applications that are likely to offer the most benefits to HSCs.

FINDINGS

To systematically address the research questions posed this section begins by discussing how ICT innovation can benefit HSCs, before highlighting the various barriers to implementing innovative ICT in HSCs, and finally discussing the innovative ICT applications that offer the most benefits to HSCs.

How Can ICT Innovation Benefit HSCs?

Analysis of the data highlighted a number of benefits in applying ICT to HSCs. Cost savings (Baldini et al., 2012; Ergun et al., 2014), improved decision making (Chandes and Pache, 2010a), increased coordination throughout the HSC (Jaeger et al., 2007), increased donor awareness (Day et al., 2012; Fawcett and Fawcett, 2013), increased SC capacity (Rietjens et al., 2007) and increased SC agility (Scholten et al., 2010) were most prevalent.

Improved and more secure information sharing was perceived as important for all HSCs (Baldini et al., 2012). Collecting information in one central place and sharing it across all actors in the HSC increases the accuracy of the information made available (Jensen, 2012), allowing for more effective performance measurement, increased inventory savings and increased control of the entire HSC (Pettit and Beresford, 2009). The improved visibility and transparency this offers across the HSC has the added benefit of increasing accountability, thereby reducing "*theft, losses, or manipulation of aid*" (Tomasini and van Wassenhove, 2009, p556). Not only do ICT systems increase the level of information exchange across the HSC, they also increase the speed with which the information can be exchanged (Rietjens et al., 2007). Disseminating accurate information to those in the field is therefore far easier, as information related to the emergency response can be sent to mobile phones, tablets and other communication devices via text message and e-mail (Jaeger et al., 2007).

ICT also enables improvements in the data collection process; firstly, data from the field can be collected rapidly and in vast quantities using devices such as mobile phones and tablets, allowing NGOs to quickly and easily recognize patterns, thereby coordinating their response to better suit these patterns (Jaeger et al., 2007). Secondly, this information can be collated from multiple actors (emergency responders such as army and police personnel, medics, victims, civilians) and places (satellite imaging, CCTV cameras), allowing for a more accurate picture of the current situation (Jaeger et al., 2007). Having access to an increased amount of accurate information (from multiple sources and in multiple formats) allows for more informed decisions to be made in a much shorter timeframe (Yates and Paquette, 2011). Combining this information with a decision support tool allows decision makers to create a set of recommendations based on the experiences of past disasters (Chandes and Pache, 2010a), with this being particularly valuable in decisions about logistics operations (Chandes and Pache, 2010b).

Increased ICT usage also improves the efficiency of coordination across the entire HSC (Chandes and Pache, 2010b; Kabra et al., 2015; Rietjens et al., 2007) by enabling frequent and meaningful communication; the use of the Internet, mobile communication technologies and social media enhances coordination and communication between victims and responders (Holguin-Veras et al., 2012; Jaeger et al., 2007). Advancements in battery technology (particularly alternative sources of energy such as solar-power), as well as wireless and satellite technology, have also enabled increased communication opportunities in a disaster hit area, whereby communication can occur regardless of the impact the disaster has on the local infrastructure (Sandwell, 2011). As coordination between the numerous parties within HSCs is extremely difficult, the ability to have real-time communication across this large number of diverse and disparate actors is seen as a huge benefit in HSC operations (Jaeger et al., 2007; Kovacs and Spens, 2007), with some seeing it as the most important factor of effective coordination (Pettit and Beresford, 2009).

Similarly, the use of ICT tools to share information across boundaries removes the bureaucratic structures that usually prohibit knowledge sharing between organizations (Oliveira et al, 2017). Previously, information was only shared during private formal meetings, yet ICT has enabled increased visibility throughout the organization (and also across organizations) by allowing users to log on to a system to access all relevant information as well as search for the exact information that is required (Yates and Paquette, 2011). This allows all parties to have access to the same information sources, thereby permitting them to identify (and subsequently reduce) duplication of effort as well as use the same information for multiple requirements (Schniederjans et al, 2016).

Increased awareness is another benefit; the Internet (and social media in particular) has allowed us to become more aware of the impact of a disaster in real time (Day et al., 2012). The distress of those affected by disasters is showcased on TV, mobile phones, tablets and laptops / PCs, allowing us to witness the pain and suffering of the victims, as well as understand their immediate needs (Fawcett and Fawcett, 2013). Social media enables citizens to engage in the relief operation by providing and receiving information (Simon et al, 2015). Donors can also quickly respond, with ICT having the potential to increase the amount of donations whilst simultaneously allowing NGOs to quickly and easily communicate the exact requirements of victims, thereby minimizing the detrimental impact of unsolicited donations (Balcik et al., 2010).

Finally, ICT has the potential to increase the efficiency of individual NGOs as well as the entire relief operation (Ergun et al., 2014). ICT has been shown to increase agility within commercial SCs, and some believe it has even greater potential for HSCs, given that agility is such an essential requirement (Scholten et al., 2010). ICT also offers increased capacity to process information across the HSC (Rietjens et al., 2007), as well as the ability to improve the processes within HSCs; Sheppard et al (2013, p33) found that adopting a common IT system across all parties in the HSC helped to "drive commonality of logistic processes". Solutions such as tracking and tracing of goods and services also have the additional benefit of reducing the opportunities for criminals to steal the important

items (that are extremely difficult to replace due to their being in short supply) while they are being transported to their destinations (Baldini et al., 2012).

What are the Barriers to Implementing Innovative ICT in HSCs?

Despite the various benefits of ICT adoption within HSCs (and the apparent awareness and willingness to adopt these tools from those in the field (Scholten et al., 2010)), barriers exist to impede successful implementation. In fact Kabra et al (2015) found that the effective management of HSCs is most affected by the significant barriers to ICT adoption; this is perhaps why the use of ICT is still not prevalent within HSCs (Özdamar and Ertem, 2015).

Incompatibility of technologies across the HSC is one such challenge (Jaeger et al., 2007; John and Ramesh, 2012) with each party in the HSC using their own software dictated to them by their headquarters. For those in the field, having a multitude of systems is important (particularly for communication) as this increases their resilience and capacity by reducing their reliance on one particular system. However, having too many systems can lead to compatibility issues as well as "black holes" in coverage whereby some areas are well served but others are not (Pettit and Beresford, 2009).

Lack of familiarity with the system can also be cause for concern. Communication problems can easily occur if users are not sufficiently experienced in using the systems, and are reluctant to spend time learning a new piece of software rather than conducting their work activities, especially in the time-sensitive environment HSCs operate in (Wakolbinger et al., 2013). Given the stressful conditions encountered by those working in HSCs, familiarity is a must if the technology is to be used effectively and efficiently (Jaeger et al., 2007); especially as electronic communications (e-mail, text messages etc.) are misinterpreted as much as 50% of the time (Wakolbinger et al., 2013). Given what is at stake during these relief operations, these types of mistakes need to be minimized, and most staff will therefore require training on new systems (Jensen, 2012).

One of the most significant barriers to ICT adoption in HSCs is the lack of sufficient funds to invest in new technologies owing to the ways in which NGOs are funded (Ergun et al., 2014; Maon et al., 2009). While ICT systems can reduce the uncertainty associated with complex environments, they will increase costs if used only for simple activities (Rietjens et al., 2007). Training staff in new ICT systems can be prohibitively expensive for NGOs, as are the implementation costs when attempting to install new systems in an area that has just recently been hit by a disaster and cannot guarantee a sufficient electricity supply (Sandwell, 2011). The lack of electricity and subsequent Internet access in the affected area during the immediate aftermath of a disaster results in an overreliance on expensive battery-operated technology (Jaeger et al., 2007). The ensuing bandwidth restrictions can also limit the amount of information exchanged (Jaeger et al., 2007), severely impacting the coordination effort.

A further challenge is the volume of data that is created during HSC operations. Having ICT systems accessible by multiple stakeholders for the purpose of sharing information is obviously a great advantage, however Yates and Paquette (2011) suggest that when the ownership of the information is shared across multiple parties, the management of the information becomes increasingly ambiguous. For example, if all users are contributing content to the systems without formal structures or naming conventions, the systems can quickly become unwieldy, with information overload making it extremely difficult for users to find the specific information they require. Conflicting information from multiple data sources is a common occurrence. As the accuracy of the information available is of the highest importance in HSC operations, a huge task ensues to check and validate all the information present in the ICT system which leads to questions about its "manageability, usability and perceived value" (Yates and Paquette, 2011).

A final implementation barrier is the security of the information stored, particularly given that the vast majority of NGOs utilize standalone software that runs on laptops and makeshift networks with limited security settings (Scholten et al., 2010; Whiting and Ayala-Öström, 2009). Some fear that criminals could easily hack into these systems to steal identities or even take advantage of at risk

populations, or that government agencies could abuse their power by invading the privacy of those involved in the disaster response (Yates and Paquette, 2011).

Which Innovative ICT Applications Offer the Most Benefits to HSCs?

The literature suggests a number of areas of ICT that are particularly suited to increase the efficiency and effectiveness of HSCs. One such opportunity involves the use of ICT for increased tracking and tracing of both goods and services (da Costa et al., 2012; De la Torre et al., 2012). Pettit and Beresford (2009) believe that utilizing ICT for tracking and tracing has the potential to increase the efficiencies of the HSC as well as minimize the level of waste within the SC; they cite the example of the World Food Programme (WFP) gaining benefits of improved network, warehouse, vehicle and spare part management simply by adopting the ICT systems utilized in the commercial sector. Some authors have suggested the use of Radio Frequency Identification (RFID) for this task due to the opportunities it offers (Baldini et al., 2012). RFID is beneficial for increased data security when compared to more traditional technologies, such as barcode, and has also been proven to improve the operational efficiency of commercial SCs (Baldini et al., 2012). It appears that such tracking and tracing software is available to those in HSCs and is being used by some NGOs but its use is not widespread. Some NGOs have actually begun developing their own specialized software for tracking and tracing (as well as fleet management) and have begun offering this software to other parties in order to improve HSC efficiency (Kovacs and Spens, 2011). One such example is SUMA, a simple piece of software that can be used on laptop computers in order to track and trace donations from point of origin to point of consumption, allowing those in the field to be more organized in terms of knowing what they currently have and where it is needed (Chandes and Pache, 2010b). Inventory tracking systems such as this allow NGOs an overall picture of all the purchases (and donations) that enter the HSC, and can also automatically produce reports highlighting goods received and dispatched, the outstanding requirements for the beneficiaries per area as well as detailing the parties responsible for the delivery of the aid (Tomasini and Van Wassenhove, 2009).

John and Ramesh (2012) suggest another opportunity; a central database holding details of previous disaster relief activities. Information contained in such a database could include the type of disaster, the NGOs involved, the suppliers used (and their associated reliability, quality, and lead time ratings), the volunteer organizations involved, and the locations and associated capacities of warehouses. The authors suggest that attaching such a database to a decision support system (DSS) would allow for more rapid and accurate decisions, thus empowering those in the field. Such a database could also be used to match the needs of victims with individual donors in order to facilitate more rapid donation income as well as reducing the amount of unsolicited donations received (Tomasini and Van Wassenhove, 2009).

The use of satellite technology is another frequently suggested opportunity. VSAT (very small aperture terminal) services seems appropriate, particularly where local communication infrastructure is damaged or destroyed (Ergun et al., 2010; Tapia et al., 2012). These small satellites are highly portable (some can be transported in a small suitcase) and can be used to enable Internet access in remote areas. Although relatively expensive, Tapia et al (2012) suggest that NGOs could come together to jointly purchase and maintain such a solution. A similar opportunity is the ability to develop bespoke applications (or "apps") for smart devices such as mobile phones and tablets that can lead to increased resilience and scalability in the HSC (Wakolbinger et al., 2013). The use of satellites is not only restricted to communication; satellite imaging gives those in the field an accurate picture as to the state of the transportation network as well as allowing them to identify the locations of beneficiaries and the optimum routes (Holguin-Veras et al., 2012). Having access to information that is both current and highly accurate is incredibly helpful to those in the field (Crooks and Wise, 2013).

An opportunity that has gained significant interest is the use of Web 2.0 / social media for HSC operations. The importance of social media (in particular social networks) in disaster relief has gained traction in the literature (Yates and Paquette, 2011), particularly as some have already found that

social media usage can improve HSC coordination (Holguin-Veras et al., 2012). The proliferation of social networking sites allows NGOs to track victims' activities before, during and after a disaster hits, whilst also allowing victims to report incidents that are occurring in real-time; victims are also able to receive up-to-date emergency information from government agencies and NGOs, allowing for a more coordinated response (Pateman et al., 2013). In this regard, established social media platforms such as Facebook and Twitter allow NGOs to gain a highly accurate understanding of the situation in the affected area in a short space of time. This allows them to assess the damage to the infrastructure for transportation purposes as well as the relative security situation in the area and the number (and associated needs) of those affected by the disaster (Crooks and Wise, 2013).

Other applications for social media include searching for missing relatives, fundraising for NGOs, and matching donations with demand (Kovacs and Spens, 2011). The use of social media fundamentally changes the nature of donations; rather than asking for donations, NGOs can now ask for people's time through crowdsourcing initiatives whereby individuals assist in the HSC operation by tagging photos, marking areas of interest on satellite images, and also offering vital information on local cultural norms and other background information (Yates and Paquette, 2011). The first recorded use of social networks and crowdsourcing occurred during the Haiti earthquake in 2010, whereby citizens, NGOs, the armed forces, technical experts and government organizations utilized these tools extensively to help coordinate the HSC operations in real time, with these tools now being used regularly in HSC operations to fill the information gap (Crooks and Wise, 2013). Both NGO and military personnel took hundreds of photographs that were then uploaded on to wikis so that everyone involved in the operation could understand the current situation on the ground; all users were then able to comment on the usefulness of these photographs (Yates and Paquette, 2011). Crooks and Wise (2013) suggest that this increased use of Web 2.0 tools has facilitated a move from Disaster Relief 1.0 to Disaster Relief 2.0; Web 2.0 is characterized as the use of tools that allow for user-generated content, therefore Disaster Relief 2.0 can be characterized as the numerous parties involved in the HSC utilizing such tools to help fill the gaps in information almost instantaneously.

Yates and Paquette (2011) believe that the HSC environment is the perfect testing ground for social media applications as knowledge management platforms. Firstly, social media encourages frequent small contributions of information that can be acquired, shared and used easily; disaster response information is sent via images, text messages, blog / wiki posts, web links and short videos. Secondly, social media applications allow for users with different expertise and backgrounds to be brought together through a common interest. HSCs are a perfect application for this, as they require coordination among participants from a multitude of cultural and professional backgrounds. Finally, social media has the ability to "create order from chaos" by organizing knowledge into clusters through use of comments on wikis and blog posts or tagging on images; given the chaotic nature of HSC operations, decision makers are in desperate need of information that is contextualized in such a way, thereby minimizing misunderstandings and allowing for more accurate decisions to be made.

A final opportunity for increased ICT usage in HSCs is cloud computing. Schniederjans et al (2016) found that some NGOs are already using cloud computing to enable on demand access to data storage and services such as joint writing of proposals, transferring data to suppliers and government agencies, geo-tagging images for those in the field, and appealing for donations from corporations. The ability to scale-up computing capacity on demand is extremely helpful given that the remote location of humanitarian disasters (and their associated uncertain environment in terms of aftershocks etc.) often results in limited availability for powerful servers in the local area (Schniederjans et al., 2016). Cloud computing also offers NGOs the ability to back up data over the Internet, ensuring information security as well as increasing information transparency and availability by allowing large amounts of data to be shared globally and instantaneously (Schniederjans et al., 2016). Finally, cloud computing offers opportunities for NGOs to obtain internal efficiencies. Not only does outsourcing IT solutions offer the advantages of cost and effort reduction over managing and maintaining their own data centers and servers, it also allows NGOs to focus more on the quality of the data being collected,

processed and transferred, thereby facilitating increased collaboration efficiencies throughout the HSC (Schniederjans et al., 2016).

To synthesize the literature that has been examined, Table 1 below provides a summary of the barriers and enablers to ICT adoption in HSCs. As the focus of the study is technology and human interaction, the barriers and enablers have been categorized as relating to either 'process' or 'people'. Adopting this approach permits a clear interpretation as to whether the barrier or enabler is due to either technological factors or human interaction factors.

CONCLUSION AND IMPLICATIONS

It is predicted that the number of humanitarian crises will increase dramatically over the next few years, while funding for aid relief is likely to diminish (Sandwell, 2011; Schulz and Blecken, 2010). In consequence, HSCs need to increase their efficiency and agility in order to make themselves more cost-effective. ICT offers the opportunities to achieve these goals. This study offers important strategic and practical recommendations concerning the benefits and opportunities of particular ICT adoption within HSCs.

Based on the analysis of the findings, the study suggests a number of ICT tools that can be implemented by NGOs in order to increase the efficiency and effectiveness of their operations as well as that of the entire HSC. This is particularly relevant following suggestions from scholars who believe that adopting tools and techniques from the commercial sector could give significant benefits to HSCs (Chandes and Pache, 2010a; Jahre et al., 2009). From the summary in Table 1, it is worth noting how the barriers to implementation outweigh the enablers; this is an important finding and demonstrates a requirement for scholars and managers to champion the use of ICT in HSCs in order to raise awareness of both their usefulness and the positive impact they can have. It also offers an interesting research agenda for further work on this critical topic. For example, the study identifies a number of new ICT solutions that could be investigated in future research; the use of social media, RFID and cloud computing solutions in particular could be examined to see if they hold any advantages for NGOs operating within HSCs. Similarly, barriers to the adoption of these particular ICT tools could be investigated from the perspective of those in the field through use of semi-structured interviews, focus groups and/or questionnaire surveys.

The study identifies opportunities for future ICT development in the area of HSCs and is of particular relevance to supply chain managers. Due to the comparative infancy of the topic when compared to research on commercial supply chain ICT implementation, the study provides a synthesis of usable technologies for HSC managers and clearly sets out the barriers and enablers to adoption. Those working in NGOs or with other organizations in the field can draw on this research in developing fundraising strategies, understanding training requirements and considering collaboration approaches with other actors in the HSC. The study makes a practical contribution to the field by providing a rationale for adopting specific ICT tools and techniques as well as by identifying a clear focus for areas of ICT that can or should be implemented in HSCs in the near term; both of which will be of interest to HSC managers and those researching this emerging topic.

Table 1. Process and People Barriers and Enablers to ICT adoption in HSCs

	Barriers to innovative ICT adoption in HSCs	Enablers to innovative ICT adoption in HSCs
Process	• Lack of accurate information on the ground after a disaster hits (Kovacs and Spens, 2007) • Insufficient ICT infrastructure in the affected area (either there is an insufficient infrastructure in the first place and / or the disaster destroys communication towers and electricity / gas supplies) (Jaeger et al, 2007) • Sporadic, short-term and front line delivery-specific nature of funding detracts from ability to invest in ICT (Maon et al, 2009) • Donors reluctant to give funding for "back office" operations such as ICT (Sheppard et al, 2013) • Concerns over security of ICT networks limits usage (Scholten et al, 2010) • Privacy concerns; highly sensitive information about beneficiaries is often unsecurely stored and is susceptible to hackers (Whiting and Ayala- Öström, 2009)	• New technologies (e.g. cloud computing, VSAT etc.) are cheaper and therefore constitute a reduced investment risk while offering potentially improved results compared to more traditional ICT solutions (Ergun et al, 2014) • Satellite technologies (such as VSAT) can operate without the need for any physical infrastructure (that may or may not be present to begin with, or may be destroyed as a result of the disaster) (Sandwell, 2011) • NGO reporting requirements (i.e. reporting to donors how their donations have been spent) may require innovative ICT solution to accurately track and trace donations (Baldini et al, 2012)
People	• Lack of motivation to share information between NGOs (due to different mandates, goals etc. and also competition between NGOs leading to them not wanting to share information) (Oloruntoba and Kovacs, 2015) • Large number of stakeholders, each with their own goals, objectives and mandates as well as size, structure and processes results in ICT integration across the HSC becoming an incredibly difficult task (Oloruntoba and Gray, 2006) • Competition between NGOs for funding and / or limited resources in the affected area results in a lack of trust, thereby limiting motivation for information exchange (Chandes and Pache, 2010a, 2010b) • Currently a lack of skilled workers within the HSC, with ICT being a particularly difficult skill to obtain (Wakolbinger et al, 2013) • Threat of criminal activity (e.g. hackers); there have been examples of criminals attempting to relocate / redirect aid-carrying vehicles from those that need it most to those that will pay for the aid (Kovacs and Spens, 2011) • High staff turnover (can be as high as 80% annually (Sheppard et al, 2013)) poses challenges for knowledge management	• Individuals' willingness and capability to adopt ICT in HSCs (Scholten et al., 2010) may prove a significant enabler to adoption • Previous working relationships between staff of different NGOs increases trust and therefore promotes increased information exchange (Petit and Beresford, 2009) • Increased popularity of crowdsourcing to obtain additional funding via social media (Fawcett and Fawcett, 2013)may increase NGO awareness of (and eagerness to adopt) new technologies • The large number of volunteers active within the HSC (De la Torre et al, 2012) may suggest new ICT solutions they have seen in other environments (or even previous disasters they have worked in) • Increased public awareness of disasters (via the Internet and social media) increases the amount of donations received (Balcik et al, 2010); this may motivate NGOs to utilize more innovative ICT solutions to "tap in" to these potential resources

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Matthew Tickle is a Lecturer in Operations and Supply Chain Management at the University of Liverpool. He holds a BSc and a PhD in Operations Management, both from the University of Liverpool. Matthew's research interests include Operations and Supply Chain Management, in particular Humanitarian Supply Chains, Quality management, and e-business tools and technologies. Prior to his Academic appointment, Matthew worked as a project manager in the software development industry and managed projects in excess of 50,000 US dollars.

Claire Hannibal (née Moxham) is Professor of Operations Management at Wolverhampton Business School. She has held Faculty positions at the University of Liverpool Management School, Bradford University Management School and Manchester Business School. Her research focuses on performance measurement in the context of social sustainability and non-profit/voluntary sector organisations and her work has been published in peer review journals including the International Journal of Operations and Production Management, Supply Chain Management: An International Journal, Production Planning and Control and the Journal of Business Ethics. In 2014 she guest edited a special issue of the International Journal of Productivity and Performance Management on the theme of Third Sector and Performance.