



A Review of Lean and Agile Management in Humanitarian Supply Chains: Analysing the Pre-Disaster and Post-Disaster Phases, and Future Directions

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4 **A Review of Lean and Agile Management in Humanitarian Supply Chains:**
5 **Analysing the Pre-Disaster and Post-Disaster Phases, and Future**
6 **Directions**
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Abstract

Disasters have quadrupled over the last two decades leading to unprecedented loss of life. The objective of disaster-focused humanitarian supply chains (HSCs) is to ensure saving maximum lives with limited resources; despite severe uncertainties. Therefore, significant research has investigated lean and agile in HSCs; to effectively source and speedily deploy resources, with minimum wastage; in each disaster life-cycle phase. However, the literature and research findings are currently highly disjointed regarding how lean and agile principles may be aligned with different HSC activities in the disaster management lifecycle; and do not provide a collective understanding for practitioners and researchers. This paper reviews and organises the literature on HSCs in relation to lean and agile paradigms, focusing on the pre-disaster (mitigation and preparedness) and post-disaster (response and recovery) phases. Findings reveal, all phases benefit from both lean and agile, with agile benefitting the response phase most. The phases are inter-dependent and identifying optimum decoupling points for lean and agile principles are crucial. Majority research has focused on individual or a couple of phases. Therefore, authors recommend research on integrating the functions of the different phases by employing lean and agile principles, to generate rapid response, economies of scale and cost minimisation.

Keywords: Lean, agile, disaster phases, disaster lifecycle, humanitarian supply chains, review

Introduction

“The International Federation of Red Cross and Red Crescent Societies’ (IFRC) World Disaster Report (2015) reports that between 2005 and 2014, approximately 6311 disasters resulted in 0.8 million casualties, affected 1.9 billion people, and caused \$1.62 trillion in damages” (Ransikarbum & Mason; 2016a: 324). These circumstances are neither atypical nor rare in the humanitarian aid (HA) context. Significant injury and loss of life triggered by disasters; make it imperative to study humanitarian supply chains (HSCs) and how they can effectively contribute to the different stages of the disaster/humanitarian mission management cycle, prior and post disaster occurrence. “A natural or man-made disaster means managing ephemeral supply chains in a great hurry while trying to adhere to performance objectives” (Chandes & Pache’, 2010: 321). HA organisations are under perpetually increasing pressure to strategically use resources (Scholten, Scott and Fynes, 2010; Pettit & Beresford, 2009), while providing high quality service to the end-user within realistic timeframes and constrained budgets. A crucial way to achieve these efficiencies while delivering high quality and value, is through effective supply chain processes, as supply chain management (SCM) accounts for 80% of HA activities (Van Wassenhove, 2006).

HA is essentially funded by donors (Kovacs & Spens, 2007). The deliverers of HA thereby cater to dual clients: the recipient of aid and donors. Sufficient donor availability can help make HSCs agile and resilient (Dubey et al., 2014). While HA recipients seek high quality and prompt aid to save lives and restore normalcy; donors seek transparency, high value for money and measurable outputs (Scholten, Scott & Fynes; 2010). Lack of efficiencies may result in loss of life and resultantly loss of crucial donor funds (Oloruntoba & Gray, 2009). This challenging situation requiring trade-offs amongst speed, cost, and quality has generated research interest in principles and processes which can enhance speed,

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3 efficiencies, and effectiveness while reducing cost and waste in HSCs. Therefore, to enhance
4 HSC performance (notwithstanding time and budgetary constraints) and reduce wastage; the
5 principles of lean and agile have been found to be highly beneficial (Cozzolino, Rossi &
6 Conforti, 2012; Oloruntoba & Kovacs, 2015).
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12 Lean management is defined as the elimination or reduction of waste (or *muda*) in any
13 form (Christopher & Towill, 2001; Goldsby et al., 2006). This entails, any action, which
14 exhausts and expends resource or energy, without yielding required outcomes for the
15 customer (Womack & Jones, 1996; Goldsby et al., 2006) or end-user. Lean principles help
16 address emergent demands within short time-spans with process efficiency (Goldsby et al.,
17 2006). This is a key focus of HA organisations as HSCs are characterised by intensive
18 timelines, addressing specific disasters at a point in time (Chandes & Pache', 2010). Most
19 HA is funded by appealing to the altruistic nature of donors. Lean principles in SCM focuses
20 on enhancing efficiencies and saving costs (Cozzolino et al., 2012). Taylor and Pettit (2009)
21 advocate the application of lean principles like value chain analysis to enhance efficiencies of
22 HSCs. Techniques like horizontal and vertical collaboration (Jahre & Jensen, 2010) of
23 leanness can also reduce spend for HA organisations. Consequently, there has been an
24 increase in research studying lean applications in HSCs.
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42 Agility in SCM embodies a high degree of flexibility and perpetual preparedness to
43 react to incremental and radical change, including changes in market and customer
44 requirements (Goldman et al., 1995; Jain et al., 2008). Agility can also; support risk
45 management in supply chains (Faisal et al., 2007) and enhance responsiveness (Christopher
46 & Towill, 2000) to unpredictable change (Oloruntoba & Gray, 2006). HSCs are
47 characteristically involved in large-scale operations, addressing high magnitude risks to life;
48 and need to coordinate speedy delivery of rescue and relief goods and services to disaster
49 zones (Jabbour et al., 2017; Balcik et al., 2010; Kovacs & Spens, 2009). HSCs are often
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3 emergent, with short lives; responding to specific disasters, uncertainty and mostly
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5 unforeseen situations (Day et al., 2012). HSCs need to assess and evaluate end-user needs in
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7 disaster zones and respond with speed and flexibility, to the diverse, unique and specific
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9 needs of the affected populations (Heaslip, 2018) while balancing standardisation and
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11 adaptation (Chandes & Pache', 2010). Achieving these extensive and varied humanitarian
12
13 targets swiftly, requires a high level of flexibility or agility (Heaslip, 2018). Hence, the
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15 principles of agile SCM have gained attention in relation to HSCs (Chandes & Pache', 2010;
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17 Cozzolino, Rossi & Conforti, 2012; Heaslip, 2018; Oloruntoba & Gray, 2006; Oloruntoba &
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19 Kovacs, 2015).

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24 Authors indicate that lean and agile principles are often complementary and need
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26 integrating within the same supply chain at different points (Cozzolino et al., 2012; Goldsby
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28 et al., 2006; Narsimhan et al., 2006; Scholten et al., 2010) including HSCs (Scholten et al.,
29
30 2010). In their seminal study, Naylor et al. (1999) strongly argue that lean and agility are
31
32 complementary processes, which provide synergistic value in combination, compared to
33
34 applying these paradigms in isolation. Applying the lean and agile principles to HSCs can
35
36 help make them effective, efficient and eliminate waste simultaneously (Cozzolino et al.,
37
38 2012). Lean can be instrumental in facilitating efficiencies, cost reduction and waste
39
40 elimination; while agility is arguably crucial in facilitating effectiveness and speed in HSCs
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42 (Cozzolino et al., 2012). Hence, the focus of this review is on both lean and agile applications
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44 in HSCs; aimed at minimising resource waste, and enhancing flexibility, speed and delivery
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46 efficiencies, leading to ultimately saving lives.

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51 HSC activities linked to disasters are classified into four key phases. Prior to the
52
53 disaster, the focus is on 'mitigation' and 'preparedness'. Post-disaster, the focus is on
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55 'response' and 'recovery' (McLoughlin, 1985). The entire disaster HSC lifecycle focuses on
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57 saving life, preserving life, and building and maintaining standard life quality in disaster
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3 zones. While studies in the last two decades have been focusing on lean and agile
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5 management in relation to HSCs – there is a need to clearly articulate how lean and agile
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7 principles are aligned with different HSC activities in the disaster management lifecycle;
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9 particularly, evaluating their effectiveness in the different pre-disaster and post-disaster
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11 phases.
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15 In this review paper, the different ways in which lean and agile principles have been
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17 facilitated and implemented in HSCs, is examined. Most of the research has focused on an
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19 individual, or a couple of phases of the humanitarian SCM lifecycle. The literature is
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21 currently highly disjointed in terms of how lean and agile principles may be aligned with
22
23 different HSC activities in the disaster management lifecycle. This review organises the
24
25 literature by investigating the alignment of the HSCs with lean and agile principles and their
26
27 effectiveness, in the different phases of a disaster: mitigation, preparedness, response and
28
29 recovery. There is a gap between research and practical applications. This review will
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31 provide clarity to humanitarian organisations focusing on different disaster stages, aid them
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33 in prioritising their tasks and investments; and highlight crucial areas requiring further
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35 research.
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41 **Research Methodology**

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44 This study employs a literature review as recommended and adopted by Tranfield et al.
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46 (2003) and Wong et al. (2012). Hereby, the evidence-informed five-step approach advocated
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48 by Denyer & Tranfield (2009), is adopted. This involves framing the aim; detecting and
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50 identifying relevant studies; selecting and appraising studies; examining and synthesising the
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52 studies; finally reporting and using the results.
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56 **Review Research Aim**

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59 A database of the relevant articles was generated by identifying and appraising each article in
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3 relation to the review aim of this study. This aim is as follows:
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- 6 • Evaluating the paradigms of lean and agile aligned with humanitarian supply chains,
7 while differentiating between the four-phases of the disaster life cycle; and identifying
8 future research directions.
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15 *Detecting/Identifying Studies*

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17 In order to identify the relevant studies, a 3-step approach was adopted: conducting a generic
18 search in academic search engines including ABI-Inform Proquest, EBSCO Host, Scopus and
19 Web of Science; locating articles published in journals listed in the ABS journal list and
20 finally identifying pertinent articles from the citations in the articles identified in the first two
21 steps. Denyer & Tranfield (2009) advise that “the review protocol should not restrict the
22 review and the output of the search should result in a comprehensive list of core contributions
23 which will help address the research questions”. This 3-step approach provided the widest
24 coverage of relevant articles.
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36 As the context of the study is HSCs, the above search engines were deemed
37 appropriate as databases with the widest exposure in this field. In order to capture the
38 maximum possible related articles, a few search strings were employed, which yielded 93
39 papers. These search strings are presented in Table 1 below.
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53 The search for this study, concentrated on peer-reviewed articles between 1985 and
54 2019. This review focused on the time period from 1985, as this is when the seminal article
55 by McLoughlin (1985) was published, classifying the humanitarian aid life cycle into the four
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3 phases of mitigation, preparedness, response and recovery stages. Furthermore, in the last two
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5 decades work on linking lean and agile principles to HA has gained traction. Hence, the
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7 period from 1985 to the present was included in this review, to ensure the fullest coverage of
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9 relevant articles.
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15 ***Selecting and Appraising Studies***

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18 The relevance of the articles were established, based on whether the search terms were
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20 present in the title and abstract of all the articles in the supply chain and logistics journals on
21
22 the ABS list. The selection criteria we adopted, include the following:
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- 25 • Humanitarian – the articles needed to align with humanitarian operations
- 26 • Supply Chain – the papers needed to focus on lean and/or agility in supply chain
- 27 • Disaster Phase – the article could be located in at least one of the four disaster phases
- 28 • Language – paper needed to be in English
- 29 • Journal Type – double blind, peer reviewed journals ideally included on the ABS list

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32 In addition to the 93 articles above, 10 more articles were extracted through searches
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34 in supply chain journals on the ABS list. A further 23 articles were identified via
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36 investigating citations within the articles identified in the above process. Thereby bringing
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38 the total number of articles collated initially to 126. In the next step, duplicate journal articles
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40 from the various search engines, were removed. Articles were filtered by ensuring that the
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42 articles either made (1) a theoretical or conceptual contribution or (2) an empirical
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44 contribution. The articles were also screened based on whether they contributed to at least
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46 one of the disaster life-cycle phases. This resulted in a final number of 57 articles, which we
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48 reviewed for this study. In addition, some articles were included for supporting information.
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3 The articles, which formed part of the core review, are indicated with an asterisk in the
4 reference list.
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9 ***Examining and synthesising studies***

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11 Each paper was evaluated in terms of descriptive information and thematic content. The
12 descriptive analysis adopted a more deductive style and the articles were classified based on
13 which disaster life cycle phase the article aligned with, the year and country of author
14 location.
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21 Thereafter the articles were thematically analysed and classified into one or more of
22 the four disaster life cycle phases of HSCs: mitigation and preparedness (pre-disaster stage)
23 and response and recovery (post-disaster stage). Here a more inductive style was employed.
24
25 The purpose here was to identify the different ways in which lean and agile principles could
26 enhance effectiveness and efficiencies in each of these stages. The literature on this is
27 disparate and disjointed, and the aim was to re-organise the literature, analyse the various
28 approaches through which lean and agility can be achieved in these phases, and finally
29 identify the gaps and argue future research needs, which can contribute to enhancing HSC
30 outcomes and saving lives.
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43 ***Disseminating and utilising the outcomes/results***

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45 This article is the first and primary route of disseminating these results to academia and
46 practitioners. The following sections of this article provide the findings of this study
47 including the descriptive analyses, thematic analyses and finally an overall analysis of the
48 application of lean and agile paradigms to HSCs, in relation to the disaster life-cycle phases.
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Descriptive Analysis: Characterising the Literature on Supply Chain in Humanitarian Operations

The 57 articles identified for this review, was analysed in terms of the disaster lifecycle phases, year and country; to comprehend the key trends visible in the research field of lean and agile in HSCs.

The relevant articles for this review were classified into the different HSC disaster life cycle phases they pertained to. Some of the articles aligned with more than one phase (table 2). Based on this classification, it can be seen that the response phase, which is the phase directly engaged in saving lives, has received the most attention, while considering lean and agile principles.

Insert table 2 about here

The papers relevant to this review were published between 1985 and 2019. Figure 1 illustrates the number of publications each year. Publications on lean and agile management in HSCs has gained visible traction since 2006. This is attributable to the unprecedented loss of life and disruption in the aftermath of the Aceh Tsunami in 2004 and hurricane Katrina in 2005. The highest number of relevant publications are in 2010. This is consistent with the time taken in conducting and thereafter publishing academic research, which would have commenced right after the aforementioned large-scale disasters. Furthermore, a surge in HSC publications on lean and agile applications is noticeable in 2016. This may be attributed to the large-scale disasters of the Haiti earthquake in 2010 and the Japan Earthquake-Tsunami-Nuclear Emergency in 2011, coupled with a substantial increase in international funding for

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3 humanitarian and disaster relief activities around 2013 (GHA¹ Report, 2016). This would
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5 have provided an impetus for research on applying lean and agile principles in HA, aimed at
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7 understanding how resources can be optimised, in developing waste-free and flexible HSCs.
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14 Insert Figure 1 about here

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22 Based on the location of the authors' affiliated institution, the following country map
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24 was developed (fig 2). In the country mapping, shades of deep blue highlight the countries
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26 where most publications have originated. With the highest number of authors from the USA
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28 at 28 %, a high level of interest is visible from USA, in lean and agile applications in HSCs.
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30 Notably, 53% of authors publishing in this field were from Europe (including UK), also
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32 demonstrating a significantly high level of interest in lean and agile HSCs in Europe. Other
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34 countries from where academics have conducted studies on lean and agile HSCs include
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36 Australia, India, Pakistan, Thailand, Brazil and Canada.
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43 Insert Figure 2 about here

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49 **Thematic Results**

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51 This literature review classified the content of the review articles into four major phases
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53 based on whether the focus was on the pre-disaster stage or the post-disaster stage. As
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59 ¹ GHA – Global Humanitarian Assistance
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3 indicated in the introduction, the pre-disaster phases are referred to as ‘mitigation’ and
4
5 ‘preparedness’, while the post-disaster phases are known as ‘response’ and ‘recovery’
6
7 (McLoughlin, 1985). While this review distinguishes the literature based on the four stages of
8
9 the disaster SCM life cycle, some studies address more than one stage simultaneously. The
10
11 various aspects of the different studies is drawn upon in separate thematic discussions below.
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15 This paper focuses on large-scale disasters, which are rare but of a high magnitude
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17 with the potential for long-lasting consequences, as opposed to routine emergencies. This
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19 includes: ‘sudden-onset natural disasters’ like earthquakes, tornadoes and hurricanes; ‘slow-
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21 onset natural disasters’ like famine, drought and poverty; ‘sudden-onset man-made’ disasters
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23 like terrorist attacks, coup d’etat and chemical leaks; and ‘slow-onset man-made’ disasters
24
25 like economic collapse, political crises and refugee crises (Van Wassenhove, 2006).
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29 In the following sections, first each phase is defined, followed by the identification
30
31 and evaluation of the core HSC research pertaining to each of these phases. Herein, this paper
32
33 reviews, organises, argues and analyses how lean and agile principles have been implemented
34
35 in these phases and the resultant benefits.
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38 39 ***Pre-disaster: ‘Mitigation’ in the Humanitarian Disaster Supply Chains***

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42 Mitigation focuses on reducing the long-term impact of disasters, thereby attempting to
43
44 reduce the extent or magnitude of loss and damage to human lives, land and property; caused
45
46 by natural and man-made disasters (McLoughlin, 1985). Examples include “building codes,
47
48 disaster insurance, land-use management, risk mapping, safety-codes, and tax incentives and
49
50 disincentives” (McLoughlin, 1985: 166). This stage also focuses on preventing disasters
51
52 (Ransikarbum & Mason, 2016) which includes land-use controls so that high risk areas are
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54 not occupied, building barriers to swerve disaster forces, reducing the impact of
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56 ongoing/impending disasters, designing codes to enhance resistance of buildings/structures,
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3 negotiating tax incentives/disincentives with governments, and so on (Altay & Green III,
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5 2006).
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8 With the plethora of activities crucial for disaster prevention, funding needs are high.
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10 Unfortunately, prevention activities are under-funded (Kovacs & Tatham, 2009), and donors
11
12 prefer their funds to directly benefit victims (Kovacs & Spens, 2007; Tatham & Pettit, 2010),
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14 thereby further constraining already constrained budgets for this phase. Hence, building in
15
16 flexibility and collaboration using agile principles and eliminating any possible waste through
17
18 lean principles will be extremely beneficial in this stage and ultimately save and preserve
19
20 lives.
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24 Dubey and Gunasekaran (2016) highlighted that dynamic sensing models can
25
26 significantly mitigate loss of life by anticipating impending disasters beforehand, and
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28 enhancing response action, thereby incorporating agility. Bhattacharya et al. (2014)
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30 advocated investing in building infrastructure to facilitate efficient transfer mechanisms
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32 through robust networks, harnessing lean and agility. As part of studying HSC dynamic
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34 capabilities, Altay et al. (2018) investigated SC agility in the pre and post disaster phases of
35
36 the HSC, and interestingly, they reported that SC agility had significant impact on pre-
37
38 disaster performance (including mitigation). Through structural equation modelling, Dubey et
39
40 al. (2015) studied the relationship between supply chain agility, adaptability and alignment on
41
42 human performance and logistics performance; which they empirically tested on data
43
44 collected from senior officials in the police, transport and HA organisations associated with
45
46 Allahabad Kumbh, an extensively large scale religious pilgrimage festival, entailing high
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48 levels of mitigating actions against potential disasters. Based on this, Dubey et al. (2015)
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50 advocated the impact of agility and adaptability on HA performance.
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56 L'Hermitte et al. (2015) also proposed a model by integrating various agility drivers
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58 (i.e. risks, complexities and new opportunities), agility enablers (i.e. people, processes and
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3 technology), speedily reactive and adaptable operations, and strategic level agility capabilities
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5 (i.e. being purposeful, action-driven, collaborative and learning-focused). They empirically
6
7 tested this model on a case study of the World Food Programme (L'Hermitte et al., 2016a).
8
9
10 Dubey and Gunasekaran (2016) advocate long-term capacity building by HSCs to be
11
12 successful; including integrating information/knowledge exchange, training, speedy response
13
14 and adjustability. This should help build in agility and achieve lean targets of waste
15
16 reduction. Applying such models to practice, needs to commence in the pre-disaster stage to
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18 mitigate the impact on potential disasters.
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21
22 Tofghi et al. (2016), focused on mitigating logistical challenges in pre- and post-
23
24 disaster stages by generating a two-stage scenario-based possibilistic stochastic programming
25
26 (SBPSP) system. Through this, they attempt to overcome network design issues to integrate
27
28 and coordinate more efficiently between central warehouses and local distribution centres, to
29
30 enhance flexibility and reduce waste. They created a differential evolution algorithm to
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32 estimate practicable solutions, within realistic time-spans; which they tested on authentic data
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34 from extant relief networks in Tehran, with favourable outcomes. Arguably, this model
35
36 harnessed both agile principles for flexibility and lean principles for economisation.
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40
41 Blecken (2010) adopted a modelling approach to increase the effectiveness of HSCs.
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43 Through a survey, he found, a key obstacle in HA is the lack of documentation and
44
45 standardisation. Availability of this data can enhance the effectiveness of the mitigation
46
47 phase. Information technology (IT) can be crucial to the humanitarian efforts (Ergun et al.,
48
49 2014; Kovacs & Spens, 2007). Blecken (2010) suggested IT infrastructure and its
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51 applications have significant potential to aid standardisation; which can lead to lean and agile
52
53 outcomes of cost minimisation, transparency, and fruitful interaction between HA and end-
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55 point users in the HSC.
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3 Herein, it can be seen that both agile and lean management emerge as crucial and
4
5 complementary contributors to the mitigating stage in the humanitarian disaster life cycle. A
6
7 strong overlap and follow-through is also visible between lean and agile activities in the
8
9 mitigation and preparedness stages.
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12 13 14 15 ***Pre-disaster: 'Preparedness' in Humanitarian Disaster Supply Chains***

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17 Preparedness entails nurturing and perfecting operational skills and resources to respond to
18
19 emergencies and disasters (McLoughlin, 1985). These include, “emergency operations plans,
20
21 warning systems, emergency operating centers, emergency communications, emergency
22
23 public information, mutual aid agreements, resource management plans, and training and
24
25 exercises” (McLoughlin, 1985: 166; Altay & Green III, 2006). The key purpose of this stage
26
27 is to minimise or escape the “gravest possible consequences of a disaster” (Cozzolino et al.,
28
29 2012). Preparedness also needs to focus on network design to reduce response lag, decision-
30
31 making models identifying locations of critical emergency supplies and developing tools to
32
33 efficiently collaborate between physical and IT systems when disaster strikes (Cozzolino et
34
35 al., 2012; Kovacs & Spens, 2007). Hence, lean and agile principles are crucial to this phase.
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41 Day et al., (2012) reported a need for ‘preparedness templates’ to help pre-plan for
42
43 different disasters. These templates can facilitate lean, and minimise resource and cost
44
45 wastage while incorporating agility. Estimations are needed to decipher the optimum level of
46
47 preparedness planning; so that the pre-planning is ‘forward-facing’ (Day et al., 2012). This
48
49 will help reduce risk, waste of time and investment costs of HA organisations. Tomasini and
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51 Van Wassenhove (2009) assert that preparing in terms of collating resources, reordering
52
53 supply chains, repositioning relief goods and postponement; is crucial for HA success.
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55 These initiatives help reap the benefits of lean and agile principles simultaneously. Gatignon
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57 et al. (2010) highlighted that preparatory actions, also help achieve lean objectives of saving
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3 expenses caused through ‘mission creep’, an occurrence whereby certain HA organisations
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5 slip into being involved with activities beyond their remit, i.e. development rather than
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7 immediate relief, leading to resource waste.
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10 Identification of optimum location of central warehouses in the preparedness phase
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12 can help minimise waste and facilitate speed. Interestingly, nonetheless, Bhattacharya et al.
13
14 (2014) found no outcome differentiation for HSC supply chains, where the aid program was
15
16 entirely centralised; and those where a combination of centralised resource transfer and
17
18 localised infrastructural investments were made by aid programs. This raises decision-making
19
20 challenges for the agile HSC agenda. However, Tofighi et al. (2016) successfully designed a
21
22 scenario-based possibilistic stochastic programme, to identify the most beneficial locations
23
24 for central warehouses and local distribution centres, in anticipation of disasters (like
25
26 earthquakes). In contrast to Bhattacharya et al. (2014), Tofighi et al.’s (2016) model promised
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28 to be beneficial, while also making provisions to account for ambiguous information on
29
30 supply and demand, and access to transportation networks; in the aftermath of a disaster
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32 (Tofighi et al., 2016). This is arguably crucial in developing agility in the HSC and can help
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34 local authorities in decision-making and building resilience to recurring disasters like
35
36 earthquakes. Similarly, Gatignon et al. (2010) also advocate decentralised HSCs based on a
37
38 10-year retrospective of the International Federation of Red Cross (IFRC) developing a
39
40 decentralisation model and successfully implementing it during the Yogyakarta earthquake in
41
42 2006. Through decentralisation, these models arguably focus on reducing wastage and
43
44 promoting lean in tandem with enhancing agility.
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51 Chandes and Pache’ (2010) also endorse the agile concept of ‘pre-positioning’
52
53 resources in anticipation and preparation for disasters, rather than passively awaiting an
54
55 emergency. They propose implementing the agile ‘decoupling point technique’ to HSCs.
56
57 They advise pre-positioning human resources and products prior to the decoupling point, in
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3 appropriately placed ‘hubs’ focusing on: “gathering and diffusion of information, ...
4
5 coordinated use of logistical resources, ... training of personnel” (Chandes & Pache’, 2010:
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7 332). Another pre-decoupling aim is to develop standardised products, which can be
8
9 subsequently tailored to specific needs of affected recipients, post the HSC decoupling point
10
11 (Cozzolino et al., 2012; Shafiq & Soratana, 2019). Van Wassenhove and Martinez (2012)
12
13 also advocates the agile principle of manufacturing ‘postponement’ while accounting for
14
15 internal and external factors, and applying operation research methodology for effective
16
17 vehicle fleet management in HA. Similarly, Jahre and Fabbe-Costes (2015) showed that
18
19 applying the agile engineering technique of modularity of products and survival kits,
20
21 incorporating ‘loose coupling’ in the HSC; enhances speedy response and reduces time and
22
23 finance wastage, facilitating lean outcomes. Herein the crucial complementarity of lean and
24
25 agility is emphasised.
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31 During disasters, different HA stakeholders work in parallel to deliver aid, effectively
32
33 and efficiently. However, lack of coordination and collaboration can waste efforts, resources,
34
35 finances and time. Successfully delivering HA, requires effective coordination amongst
36
37 various stakeholders, like manufacturers, service providers, government agencies,
38
39 international NGOs and different stakeholders’ modus operandi (Day et al., 2012). The
40
41 preparedness phase can ease coordination by building relationships, agreements and
42
43 memorandums of understanding, amongst different stakeholders (Kovacs & Spens, 2007). IT
44
45 programmes and software are crucial to supporting HA coordination (Gatignon et al., 2010;
46
47 Tomasini & Van Wassenhove, 2004). All these initiatives facilitating coordination foster lean
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49 outcomes (Pettit & Taylor, 2007) of waste elimination and agility in tandem.
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3 Van Wassenhove (2006) conducted case studies on the South African food crisis in
4
5 2002, IFRC in Gujarat, UNJLC²'s role in the Mozambique floods, winterisation campaign in
6
7 Afghanistan; Nokia versus Ericsson; TNT³ with the World Food Programme. He found that
8
9 cross-learning between HA organisations and the private sector can significantly help
10
11 develop better response strategies in the preparedness phase of the disaster HSC, fostering
12
13 agility. Closer collaboration between the humanitarian organisations, businesses and
14
15 academia can help to address the logistical complexities in delivering aid to populations
16
17 affected by disasters, thereby harnessing both agile and lean outcomes.
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21 Applying critical success factors to HA (Pettit & Beresford, 2009), in particular, the
22
23 preparedness and response phases (Yadav & Barve, 2015); enhances coordination and
24
25 responsiveness of HSCs. Yadav and Barve (2015) analyse the mutual relationship and power
26
27 of the critical success factors, using interpretive structural modelling and cross-impact matrix
28
29 multiplication. Critical success factors include: humanitarian logistics (Vitoriano et al., 2011),
30
31 risk and need assessment, procurement and donation management, working with other relief
32
33 agencies, capacity building of institutions and people (Pettit & Beresford, 2009; Yadav &
34
35 Barve, 2016). This also includes robust ICT, disaster resilient infrastructure and transport
36
37 facilities, strategic planning for emergency relief, government policies and organisational
38
39 structure, improved forecasting, early warning systems, inventory management and
40
41 continuous improvement in preparedness and response practices (Pettit & Beresford, 2009;
42
43 Yadav & Barve, 2016). Focusing on these critical success factors in the preparedness phase,
44
45 can enhance both the leanness and agility of HSCs; ultimately contributing towards waste
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47 elimination, cost effectiveness and quick response to disasters.
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58 ² United Nations Joint Logistics Centre

59 ³ Formerly known as TPG is a large logistics organisation spread across 60 countries
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Post-disaster: 'Response' in Humanitarian Disaster Supply Chains

Response pertains to all activities undertaken immediately prior to, during and in the immediate aftermath of a disaster or emergency; to save human lives, reduce damage to property and enhance the post-disaster recovery process (McLoughlin, 1985). These include, “emergency plan activation, activation of emergency systems, emergency instructions to the public, emergency medical assistance, manning emergency operation centres, reception and care, shelter and evacuation, and search and rescue” (McLoughlin, 1985: 166). These also include firefighting, establishing and protecting emergency infrastructure, lifeline services recovery, managing and reducing fatalities (Altay & Green III, 2006). Lean or avoidance of waste and agile principles or flexibility are crucial to the response phase (Cozzolino et al., 2012). The response phase in HA, benefits profusely through cost efficiencies and timely aid, while maintaining high quality. Time saved equates lives saved (Cozzolino et al., 2012) during response.

Vitoriano et al. (2011), designed a multi-criteria optimisation model for aid distribution. Barahona et al. (2013) developed a simulation and optimisation model to support relief supply distribution to affected zones, employing a multi-tier supply network. Similarly Balcik et al. (2008) brought together preparedness and response phases, and created an integrated model focusing on the final leg of the distribution chain. These models take into account; optimisation of stock, uncertainty of demand, and the rapidly changing nature of disaster response activities during an ongoing disaster; thereby exploiting both lean and agile principles.

Kovacs and Spens (2007) highlighted that sometimes the overwhelming receipt of unsolicited donated supplies cause bottlenecks at airports and warehouses, leading to waste of time, space and supplies. These include expired drugs and food, inappropriate clothing, digital goods which need electricity where infrastructures have been damaged, and incorrect

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3 or foreign labelling of donations. Efficiencies of lean are therefore, being achieved through;
4 colour coding, employing local suppliers and retailers as the first port of call, joining forces
5 in logistics, to reduce duplication and waste.
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10 Disaster response facilities storing emergency facilities need strategic locations
11 (Balcik & Beamon, 2008; Jahre et al., 2016; Verma & Gaukler; 2015) to be lean and agile.
12 This also ties in with preparedness. Researchers encourage decision-making tools over
13 individual knowledge (Jahre et al., 2016; Verma & Gaukler; 2015). Identifying suitable
14 strategic locations are challenging, as response facilities are susceptible to the same disasters,
15 as the affected regions (Verma & Gaukler, 2015). Simultaneously, proximity of the disaster
16 centre, helps achieve lean. Verma and Gaukler (2015) evaluated two location modelling
17 approaches, a deterministic accounting model for distance-dependent damages to facility and
18 population areas, and a stochastic model built on the deterministic model, adding damage
19 intensity as the random variable. They applied these to a case study of a large-scale
20 earthquake in California to assess performance. Findings demonstrated that the stochastic
21 model significantly reduced supplies costs, especially when many facilities cannot be
22 established; manifesting lean. Charles et al. (2010) also developed a model improving agility
23 and capabilities of HSCs. Furthermore, Tofighi et al.'s (2016) two-stage scenario-based
24 possibilistic stochastic model, focused on generating a relief distribution plan for the response
25 phase, drawing upon different disaster circumstances to reduce delivery times of crucial items
26 to disaster zones, wastage, costs of unused stock and costs of outstanding demands. Hence,
27 these models promised the desired outcomes of lean and agile management.
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51 Humanitarian organisations usually have separate supply chains and warehouse
52 locations for emergency response and ongoing long-term operations. Jahre et al. (2016)
53 advocated speed and cost reduction through jointly pre-positioning warehouse locations.
54 While Verma and Gaukler (2015), factored in damage to emergency facilities only; Jahre et
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2
3 al. (2016) integrated emergency response and post-emergency recovery facilities; factoring in
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5 difficulties of merging two supply chains, budget constraints, demand risks, infrastructure
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7 limitations, security, pilferage (due to political instability/ military operations/ civil war), co-
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9 location, relation of humanitarian organisation with governments, and accessibility. Thereby,
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11 like Verma and Gaukler (2015), Jahre et al. (2016) also developed a stochastic model. They
12
13 tested it through a UNHCR⁴ case study coordinating two supply chains. The crucial
14
15 difference in the two supply chains is that emergency response is characterised by ‘high
16
17 uncertainty’ and sudden demand, unlike recovery. Therefore, response aim is to speedily
18
19 purchase ‘unconsigned’ stock from central facilities, for transport to the affected region. The
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21 central emergency stock is pre-funded by big donors like the DFID⁵. In contrast, ongoing
22
23 recovery operations, benefit from low ‘uncertainty’ and continuous demand. Hence, here
24
25 consigned stock is purchased and held in country/region specific warehouses, directly from
26
27 suppliers. Jahre et al.’s (2016) stochastic modelling revealed a reduction in costs and lead
28
29 times, by expanding the international network design. One centre could be closed, with a
30
31 slight budget increase to a different centre (e.g. closing Dubai centre and increasing Karachi
32
33 centre’s budget). Furthermore and crucially, Jahre et al. (2016) found synergistic benefits in
34
35 combining the pre-positioning of stock for emergency response and recovery. The stochastic
36
37 model showed that combining global warehouses as emergency response and recovery
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39 centres, added demand stability, justified establishing additional warehouses; while reducing
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41 lead times and the overall cost (Jahre et al., 2016). All these aspects channelled lean and agile
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43 principles in the HSCs.
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51 Effective and speedy response also requires effective coordination (Day et al., 2012).

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53 This in turn requires agility. HA organisations have different expertise and aims (Kovacs &
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58 ⁴ United Nations High Commissioner for Refugees

59 ⁵ Department for International Development
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3 Tatham, 2009). Jahre and Jensen (2010) theoretically investigated humanitarian logistics
4 coordination in relation to the cluster system. Clusters are based on the areas of separate
5
6 functional activities for humanitarian relief. The Inter-Agency Standing Committee (IASC)
7
8 (2006), a key body in coordinating humanitarian aid adopted 11 clusters: agriculture, camp
9
10 coordination and management, early recovery, education, emergency shelter, emergency
11
12 telecommunications, health, logistics, nutrition, protection and water/sanitation and hygiene.
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14 However, co-operation between these clusters need improvement (Hollingworth, 2009;
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16 Stoddard et al., 2007). Cluster cooperation can lead to cost-reduction and waste-reduction,
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18 thereby achieving lean outcomes.
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24 Jahre and Jensen (2010) developed a theoretical framework presenting the trade-offs
25
26 between horizontal and vertical coordination amongst clusters. Horizontal coordination
27
28 entails cooperation between clusters and service providers at the same stage in the aid process
29
30 or experts in similar functions. Horizontal coordination is more prevalent in HSCs and
31
32 provides better access to information and tangible resources. Vertical coordination entails
33
34 cooperation between service providers and clusters at different stages and points of HSCs,
35
36 while focusing on the same end-user. This helps reduce overall supply chain costs and
37
38 improves customer service via smoother movement along the HSC (Jahre & Jensen, 2010).
39
40 Jahre and Jensen (2010) advocated increased vertical and cross-functional coordination
41
42 amongst the clusters in HSCs. Thereby they implicitly advocate flexibility and synergistic
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44 values through vertical integration. Cozzolino et al. (2012) also showed that collaboration
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46 with suppliers who can respond fastest is a preferred choice of HA organisations. These
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48 ultimately emphasise lean and agile outcomes.
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54 Scholten et al., (2010) identify NGOs lack of investment in IT as the primary
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56 roadblock to lean and agility in HSCs. The financial dilemma is in the need to divert
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58 resources currently engaged in response, towards developing IT systems and virtual
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3 organisations. Yet, Scholten et al.'s (2010) findings showed that IT investment would aid
4
5 effective coordination of resources and supply chains. This review argues that this would help
6
7 achieve successful vertical integration recommended by Jahre and Jensen (2010). Scholten et
8
9 al. (2010) also report that while achieving lean and agility, investing in sophisticated IT
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11 systems increases transparency. Donors are sceptical and demand transparency. This would
12
13 help HA organisations win the limited donor funding available (Heaslip et al., 2018; Scholten
14
15 et al., 2010).

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19 Another agile phenomenon, which facilitates rapid response, is emergent temporary
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21 supply chains (TSCs) which borrow shared logistical resources (Merminod, Nollet & Pache',
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23 2014). TSCs respond to lack of stability and time, catering to ad-hoc projects. TSCs are
24
25 disbanded on project completion and may last only a few weeks. Merminod et al. (2014)
26
27 report that "TSCs require an advanced level of time and organisational stability for the human
28
29 and material resources involved" (Merminod et al., 2014: 16). Humanitarian TSCs need
30
31 immense agility to save maximum lives and speedily resume normalcy (Merminod et al.'s,
32
33 2014). TSCs operate based on 'anticipated responsiveness'; however the oxymoron is that for
34
35 optimal effectiveness, they need to be 'prepared' for sudden-onset disasters (Merminod et al.,
36
37 2014); achievable by pre-positioning resources for months or even years (Scholten et al.,
38
39 2010; Verma & Gaukler, 2015; Jahre et al., 2016; Meminod et al., 2016).

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45 The response phase can also benefit from the decoupling point technique in HSCs
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47 (Chandes & Pache', 2010). Pre decoupling, the HSC can focus on preparedness (discussed
48
49 under *preparedness*) and, post decoupling, on tailoring products (like survival kits) based on
50
51 specific recipient needs (depending on the nature of the disaster, religious beliefs, culture,
52
53 gender etc.). Thereby the HSCs can combine lean and agile benefits. Shafiq and Soratana
54
55 (2019a) also developed the lean-agile decoupling point (LADP) model based on humanitarian
56
57 logistics and supply chains. Chandes and Pache' (2010) draw upon Astley & Fombrun's
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(1983) work, recommending two distinct collective partnerships to best serve recipient needs through effective coordination and collaboration among different HSC actors. The two partnership types are direct “*symbiotic partnership*” in a vertical relationship and direct “*commensalistic partnership*” in a horizontal relationship. The former entails the emergence of a temporary chain, with organisations contributing to different parts of the chain based on their expertise; as and when required; while focusing on balancing end-recipients’ needs with available supplies (Chandes & Pache’, 2010). The latter focuses on temporarily uniting and mobilising various actors and resources in the supply chain, in the immediate aftermath of a large-scale disaster. In this horizontal collaboration system; various firms offering similar human and material resources temporarily unite with the ‘shared intent’ of building efficiencies and collectively meeting the needs of the disaster victims (Chandes & Pache’, 2010). This review argues that employing these collaborative partnerships in the response phase would facilitate lean and agile advantages enhancing productivity.

Post-disaster: ‘Recovery’ in Humanitarian Disaster Supply Chains

Recovery refers to activities undertaken in the aftermath of disasters/emergencies to restore life and living conditions to minimum standards in the short-term, and normal conditions in the long-term (McLoughlin, 1985). These activities include “debris clearance, contamination control, disaster unemployment assistance, temporary housing, and facility restoration” (McLoughlin, 1985: 166). These also include financial support to government, aid organisations and affected people; reconstructing infrastructure, roads, buildings and core facilities; restoring lifeline services; providing care for displaced people, livestock and animals; organising reburial of displaced mortal remains; providing support for mental health and religious needs of affected populations (Altay & Green III, 2006).

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3 The recovery stage focusing on longer-term rehabilitation entail a focal shift from
4 emergencies to planned, routinised, repetitive HSC functions (Holguín -Veras et al., 2012)
5 allowing opportunities to avoid waste and capitalise on lean principles of economies of scale.
6 Here, lives are not at immediate risk, and the focus shifts from purchase-to-delivery to
7 purchase-to-stock (Oloruntoba & Kovacs, 2015). However, L'Hermitte et al. (2016b)
8 demonstrates that in the short-term, the recovery stage is also fraught with uncertainties and
9 disturbances. Hence, agile principles are beneficial in facilitating operational changes over a
10 short time-span and ensuring continuance of HA delivery. Oloruntoba and Kovacs (2015)
11 also emphasises the need to build-in agility to develop HSC resilience, so that HSCs can
12 function effectively during reconstruction, in this phase.
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26 Similar to decision-making models developed to quicken response, Ransikarbum and
27 Mason (2016a) developed a goal-programming based tool to aid response and recovery
28 activities 'jointly'. They employed a major Geographical Information Systems (GIS) based
29 hazard estimation tool known as the Hazards US Multi-Hazard (HAZUS) tool (FEMA, 2014;
30 Ransikarbum & Mason, 2016a); analysing catastrophic sudden-onset natural disasters. The
31 end-goal being the integration of response systems, ultimately leading to network restoration
32 and recovery. Using this model with goal-constraints like capacity, budget and resources;
33 revealed compromised solutions, providing flexibility and trade-offs for decision-makers.
34 Post analysing a range of design factor permutations and combinations, Ransikarbum and
35 Mason (2016a) reported that decision-makers can trade-off between computation time and
36 design superiority. Barzinpour and Esmaili (2014) created an integrated multi-objective
37 model bringing together considerations of ideal locations for facilities versus relief
38 distribution. Similarly, Ransikarbum and Mason (2016b) developed the MOIRR (multiple
39 objective integrated response and recovery) model integrating supply distribution difficulties
40 during response and restoration in the recovery phase. In this multi-criteria model, they
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3 incorporated a cost-based as well as equity/fairness-based solution. Arguably, these models
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5 incorporated lean principles of budget and resource constraints, while generating alternative
6
7 agile solutions simultaneously.
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10 In addition to the risk of HSC facilities being impacted by the disasters (Verma &
11
12 Gaukler, 2015), the recovery phase can also be challenged by disasters impacting the
13
14 distribution infrastructure of roads, bridges and access routes to the affected locations
15
16 (Liberatore et al., 2014). Liberatore et al. (2014), analysed planning issues for
17
18 repair/recovery of damaged infrastructure so that recovery phase operations and distribution
19
20 activities can be continued effectively at the earliest. In order to estimate this, they apply the
21
22 RechADS model to a case study of the 2010 Haiti earthquake. Their findings emphasise the
23
24 imperative of resuming efficient coordination and distribution operations at the earliest.
25
26 Arguably Liberatore et al.'s (2014) proposals help facilitate agility in the humanitarian SC
27
28 recovery phase through optimisation of coordination and distribution activities.
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33 This phase also entails reconstruction, focusing on the long-term; however, this phase
34
35 suffers from lack of priority due to restricted funds (Cozzolini et al., 2012). Hence, it is
36
37 crucial to eliminate waste through lean principles in this phase, to reduce costs and ensure
38
39 efficiencies. Ertem et al. (2010) propose a multiple-buyer procurement auction framework for
40
41 HSC management. In this framework, they consider the announcement of construction, bid
42
43 construction and bid evaluation activities; in the aftermath of a disaster. This entailed
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45 identifying auction design parameters and their values, and investigating how these affected
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47 changes in auctioneer and supplier behaviours. This can also help identify appropriate and
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49 reliable suppliers to support agile outcomes in HSCs, while maintaining lean solutions in the
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51 recovery phase.
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Discussion and Future Directions

The core objective of disaster-focused HSCs is to ensure saving and preserving maximum lives. HSCs are essentially funded by altruistic donors (Kovacs & Spens, 2007; Tatham & Pettit, 2010), resulting in restricted funding availability (Kovacs & Tatham, 2009). Therefore, both human and product-related resources need to be sourced speedily and deployed efficiently with minimum waste, in each disaster life-cycle phase.

The specific needs of each disaster life cycle phase, varies depending on the affected populations' religion, food habits, climate etc. This is rarely predictable in advance. Taking this into account, in the past, lean and agile principles have been employed to investigate optimum decoupling points to balance the standardised supplies and customised supplies catering to the specific needs of the affected populations (Chandes and Pache', 2010; Cozzolino et al., 2012; Shafiq & Soratana, 2019). Lean and agile principles are highly beneficial in these HSCs. The technique of decoupling can also serve as a transition point between agility and lean.

Some researchers argued that HSCs benefit from greater alignment with lean in the pre-disaster phase and agility in the post-disaster phase (Cozzolino et al., 2012). While most of the literature on the response phase, embraces the need for agility, it is interesting to note that, Altay et al.'s (2018) study suggested that supply chain agility had no significant impact on performance post-disaster but had the most impact in the pre-disaster stage. Yet again, in contrast, Cozzolino et al.'s (2012) research showed that the post-disaster phase benefited most from agile principles. Notably, the response phase benefits the most from agile applications, the primary focus being speed, flexibility and adaptability of HA products and services as per the needs of affected populations and regions. However, our review shows that all phases benefit from both lean and agile applications.

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3 The entire HSC lifecycle is arguably inter-related and inter-dependent. Sporadic
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5 research has looked at developing models integrating more than one phase (e.g. Balcik et al.,
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7 2008; Barzinpour and Esmaeili, 2014; Liberatore et al., 2014; Ransikarbum and Mason,
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9 2016a; Ransikarbum and Mason 2016b). Programmes and tools which enable joint decision-
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11 making across the pre and post-disaster phases (e.g. Liberatore et al., 2014; Ransikarbum &
12
13 Mason, 2016a; Ransikarbum and Mason, 2016b) incorporate agility and lean principles
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15 helping enhance speed and cost-savings. However, most research has focused on individual
16
17 phases of the Humanitarian SCM lifecycle. In a few cases, research has combined a couple of
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19 phases, at the most. Both lean and agile principles will help, with the aim of making the HSC
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21 designs inherently flexible and reducing wastage. Integrating functions of the different phases
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23 will also generate economies of scale and cost reduction. Hence, the authors argue a need to
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25 focus research on integrating all four phases, particularly through decision-making tools and
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27 modelling.
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33 Bringing together different HSC entities can enhance humanitarian actions (Ergun et
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35 al., 2014). The literature demonstrates that in the four disaster lifecycle phases; HA
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37 organisations need to work harmoniously with the separate functional activity clusters that
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39 exist for HA. These clusters include agriculture, camp coordination and management, early
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41 recovery, education, emergency shelter, emergency telecommunications, health, logistics,
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43 nutrition, protection and water/sanitation and hygiene. Attempts have been made to
44
45 demonstrate how lean and agile principles can aid effective vertical and horizontal
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47 coordination and collaboration amongst these clusters; thereby reducing costs and enhancing
48
49 speed (Kovacs and Spens, 2007). While lean and agile outcomes can be achieved through
50
51 vertical and horizontal collaboration between different HSCs (Jahre & Jensen, 2010);
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53 partnering up and gaining the confidence of different actors can be challenging (Day et al.,
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55 2012). Lack of cohesion can negatively impact decision-making and logistical operations
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3 while responding to disasters (Rodriguez-Espindola et al., 2018). Therefore, the authors argue
4 a need to investigate how lean and agile principles can help eliminate duplication of efforts
5 and aid activities fostering harmonious networks and working relationships, between
6 different HSC actors.
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12 In addition to the above; a key challenge aligned with multiple disaster phases, is the
13 need to identify the most appropriate locations for central warehouses and the different
14 distribution centres (Barzinpour and Esmaeili, 2014; Verma & Gaukler, 2015). Our review
15 shows that stochastic models and programmes are being developed to estimate optimum
16 location points, which will reduce transport times and costs (Jahre et al., 2016; Tofighi et al.,
17 2016; Verma and Gaukler, 2015) thereby achieving lean and agile outcomes in the long-run.
18 Our review also revealed contradictory views and findings on optimisation, through
19 centralisation and decentralisation of resources and warehouses (Bhattacharya et al., 2014;
20 Gatignon et al., 2010; Tofighi et al., 2016). Lack of planning, poor decision-making and
21 unreliable structures adversely affect HSCs, causing unnecessary waste. In such cases,
22 aligning operational activities with centralised systems to enhance responsiveness, flexibility
23 and collaboration can be highly fruitful (Rodriguez-Espindola et al., 2018) in harnessing
24 lean and agility. Simultaneously, Tofighi et al., (2016) successfully implemented lean
25 philosophy showing localised decentralisation proved to be beneficial with centralised
26 support; as this reduces costs of excess storage and delivery and quickens response to
27 affected zones (Tofighi et al., 2016). On reflection, the authors surmise that an optimal
28 integration of centralisation and decentralisation is desirable for lean and agile outcomes. The
29 estimations of this integration, facilitating lean and agility, will depend on the nature and
30 magnitude of the disaster, geographical terrain, infrastructure resilience and generic vs.
31 specific needs of the affected population. Therefore, advanced modelling techniques and
32 analysis of realistic and wherever possible real time data; will be crucial to effective
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3 implementation of lean and agile principles, yielding speedy delivery of aid with minimum
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5 wastage.
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8 A core issue observed through this review of the application of lean and agile
9
10 principles in all the disaster phases; is the lack of availability of real data, which would be
11
12 useful in developing and testing lean and agile models and frameworks. Accessing and
13
14 reliably recording data from HA activities is highly challenging. Humanitarian organisations
15
16 understandably, rarely collect and record data at the time of a crisis. Even where data has
17
18 been recorded, minimal data (21%) was available and most entries were incomplete (Kunz et
19
20 al., 2017), making it challenging to employ in any meaningful analysis. Hence, generally
21
22 HSC studies on lean and agile applications, are based on hypothetical situations, which make
23
24 it challenging to extrapolate to real-life scenarios. The lack of data also makes it very
25
26 challenging to assess end-point demand during crises (Day et al., 2012). Collecting and
27
28 analysing data that are more accurate will enable estimation of more accurate models to help
29
30 facilitate lean and agile outcomes in HSCs. This will enhance further contribution to theory
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32 and practice.
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38 To conclude, this paper contributes to knowledge and practice, by analysing and
39
40 organising the extant literature on lean and agile management in HSCs, with respect to the
41
42 four phases of the disaster lifecycle. The authors evaluate similar and contradictory findings
43
44 on how lean and agile applications contribute to HSCs in each phase separately. This is
45
46 supplemented with an overall discussion of lean and agile applications across the four phases.
47
48 Based on this review, authors identify future directions of research to bridge the gap between
49
50 the current literature and practice needs. It is noted that the majority of research in this field
51
52 has been confined to an individual or a couple of phases of the HSC lifecycle, at the most;
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54 and overall further research is advocated on integrating the functions of the different phases
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56 by employing lean and agile principles in HSCs.
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Appendix A: List of acronyms

ABS – Association of Business Schools

GIS – Geographical Information Systems

HA – Humanitarian Aid

HSC – Humanitarian Supply Chain

HAZUS – Hazards US

ICT – Information and Communication Technology

IFRC – International Federation of Red Cross/ and Red Crescent

IT – Information Technology

NGO – Non-Government Organisations

SCM – Supply Chain Management

TSC – Temporary Supply Chains

UNHCR – United Nations High Commissioner for Refugees

UNJLC – United Nations Joint Logistics Centre

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Table 1: Search strings and resultant number of papers

Search	Actual search settings	No of papers
1	humanitarian* OR natural disaster * OR disaster* AND lean*	46
2	humanitarian* OR natural disaster * OR disaster* AND agile*	22
3	humanitarian* OR disaster* AND supply chain* AND lean*	16
4	humanitarian* OR disaster* AND supply chain* AND agile*	9
	Total	93

Table 2: Articles in each Phase of the Disaster Lifecycle

Articles in each Phase of the Disaster Life-Cycle (includes double counting)				
	Pre-disaster Stage		Post-disaster Stage	
Disaster Phase	Mitigation	Preparedness	Response	Recovery
Number of	20	30	46	34
Articles	*some articles aligned with multiple phases			

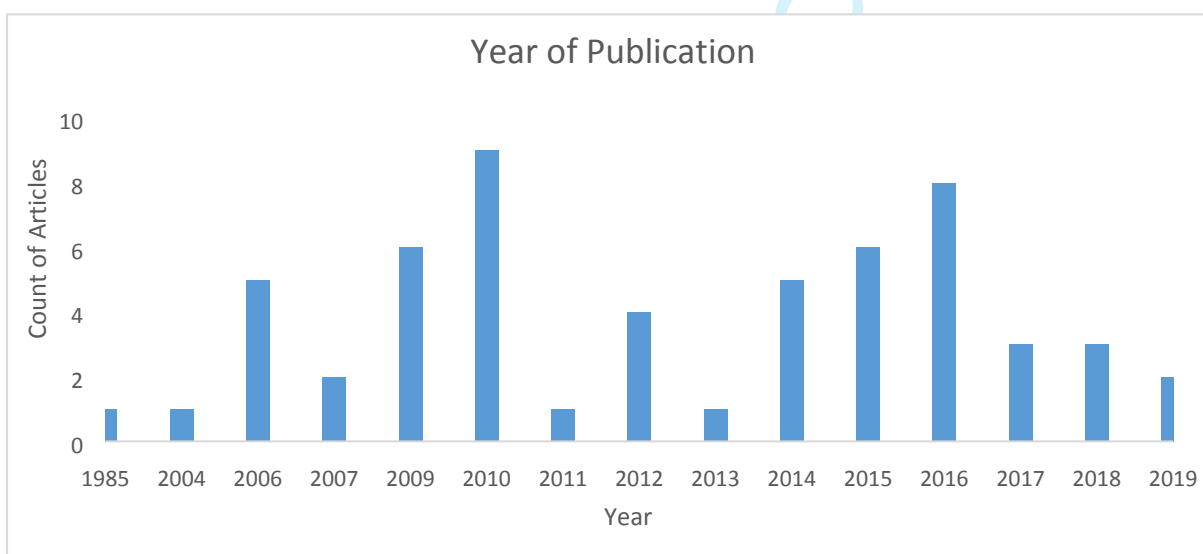


Figure 1: Number of relevant articles published each year

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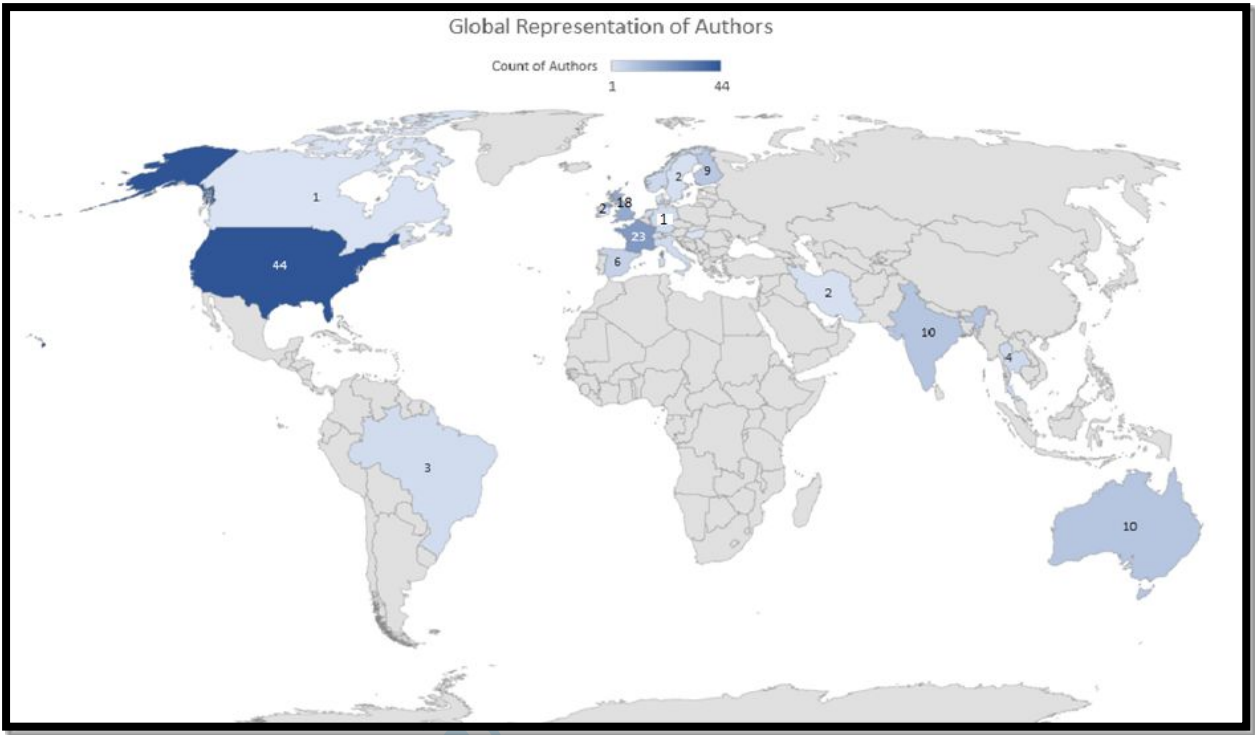


Figure 2: Location of authors publishing on lean and agile HSCs

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Response to Reviewer's comments

We would like to thank reviewer 1 for his feedback and suggestions. Please see the list of changes we have made below.

In addition, to the following we have also proofread the document and amended some typos which we spotted.

Reviewer Comments	Response
Abstract	
In the abstract, the authors stated that "the literature and research findings are currently highly disjointed and do not provide a collective understanding which practitioners and researchers can benefit from" however, what type of disjoint is not stated.	<p>Clarified this in the abstract, with the following:</p> <p>'However, the literature and research findings are currently highly disjointed regarding how lean and agile principles may be aligned with different HSC activities in the disaster management lifecycle...'</p> <p>In addition, this disjoint has also been clarified in the introduction with the following:</p> <p>'The literature is currently highly disjointed in terms of how lean and agile principles may be aligned with different HSC activities in the disaster management lifecycle.'</p>
The need for a lean and agile paradigm in the abstract is not yet justified. Please provide its link to what has already been stated in the abstract.	<p>Clarified this in the following:</p> <p>The objective of disaster-focused humanitarian supply chains (HSCs) is to ensure saving maximum lives with limited resources; despite severe uncertainties. Therefore, significant research has investigated lean and agile in HSCs; to effectively source and speedily deploy resources, with minimum wastage; in each disaster life-cycle phase.</p>
Also, highlight some of the key findings in the abstract, which is currently missing.	<p>We clarified the findings in the abstract with the following:</p> <p>'Findings reveal, all phases benefit from both lean and agile, with agile benefitting the response phase most. The phases are inter-dependent and identifying optimum decoupling points for lean and agile principles are crucial. Majority research has focused on individual or a couple of phases. Therefore, authors recommend research on integrating the functions of the different phases by employing lean and agile principles, to generate rapid response, economies of scale and cost minimisation.'</p>

Introduction:	
It is not clear from the abstract or introduction which aspect the authors are looking into for lean. Is it loss of life, cost, speed?	We clarified this by incorporating the following sentence in the introduction: 'Hence, the focus of this review is on both lean and agile applications in HSCs; aimed at minimising resource waste, and enhancing flexibility, speed and delivery efficiencies, leading to ultimately saving lives.'
Research Aim	
In the abstract you highlighted how different research take silo approach and integrated approach is required. However, aim highlights analysis of each stage so how will it cater for the integrated approach?	The need for an integrated approach is the recommendation of this study and to clarify this we have amended the abstract.
What about the research question? It was raised by Reviewer 2 in the earlier draft too.	We provided a Research Aim as most literature reviews tend to provide either a Research Question or Research Aim. This is also in keeping with Denyer & Tranfield's (2009), literature review methodology adopted in this paper. We are however happy to revisit this, if the editor requires a research question instead of the aim.
Thematic results of 4 different phases of the disaster cycle are well written. However, its link to lean and agile is not coherent. The authors could create sub-themes and structure each phase accordingly. There are other sub-themes stated too, for example, coordination. How is this linked to lean and agile should be made clear.	As advised, we considered incorporating sub-themes, but realised this would make the discussion fragmented and reduce coherence. However, we have made this explicit by incorporating clarifications to highlight the links to lean and agile in the thematic results sections.
Discussion/Future Direction:	
Is there any way you could pull all the findings into a figure? This would help readers understand how different phases are linked and how	Many thanks for this interesting suggestion. We have given a serious thought to develop a figure to show all the findings. However, we have realised that it would make the figure too complicated if we show all the findings. Hence, we appreciate the

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4 agile/lean could help during
5 humanitarian operations.
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concern shown by the reviewer but we have
chosen not to make it.
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Search	Actual search settings	No of papers
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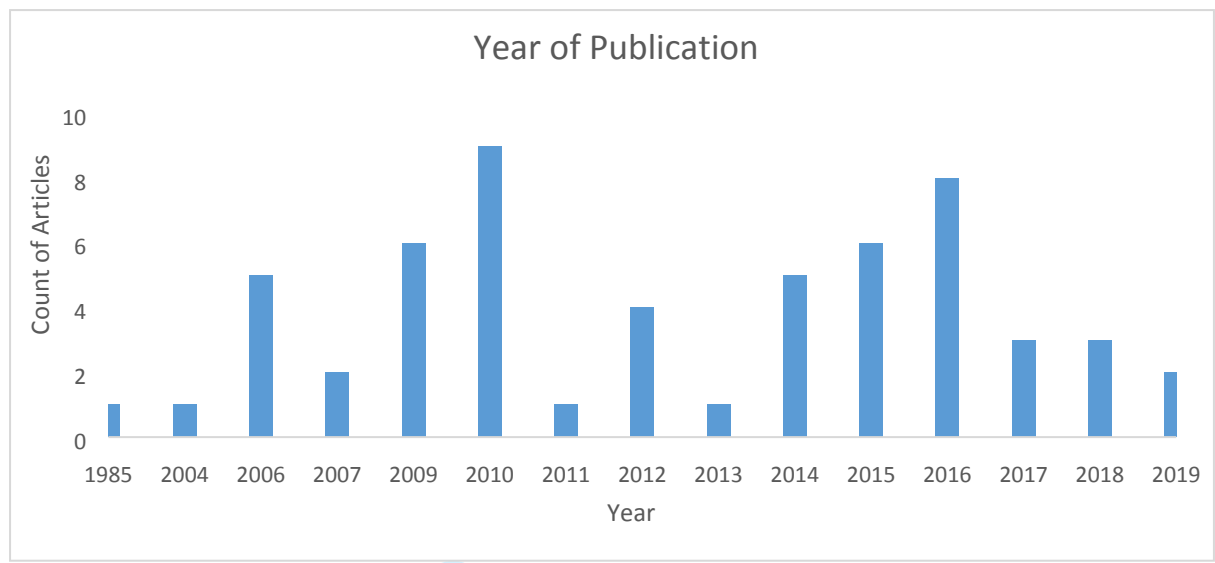
Table 1: Search strings and resultant number of papers

Articles in each Phase of the Disaster Life-Cycle (includes double counting)				
	Pre-disaster Stage		Post-disaster Stage	
Disaster Phase	Mitigation	Preparedness	Response	Recovery
Number of	20	30	46	34
Articles	*some articles aligned with multiple phases			

Table 2: Articles in each Phase of the Disaster Lifecycle

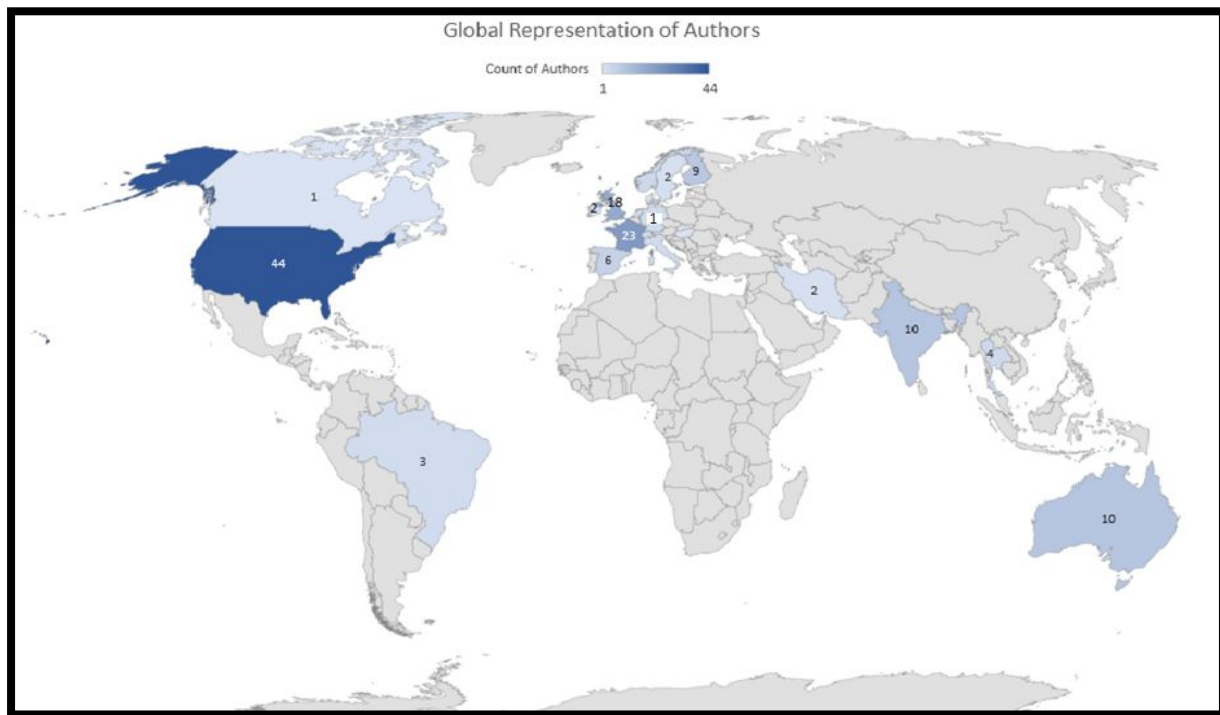
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Figure 1: Number of relevant articles published each year



Peer Review Only

Figure 2: Location of authors publishing on lean and agile HSCs



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