Supplementary Appendix

Methodology

To assess how successful ISAR teams are after an earthquake disaster, the number of people extricated from rubble alive will be used as a direct measure of success. This was chosen as it is the prime objective of SAR teams and also because it is measurable, which is important such that outcomes can be compared.[1]

Literature Search

Table 1 details the databases used and search strategy performed.

DATABASES	Web of Science + Scopus + Embase + Georef + Geobase + Google Scholar		
			"Search and Rescue"
			OR
	Earthquake		**US&R**
	OR		**OR**
	"Natural Disaster"	**AND**	**"International Response"**
	OR		**OR**
	"Natural Hazard"		**"Immediate Response"**
			OR
			Local

Table 1 Database search for SAR response to earthquake

"SAR/USAR", both commonly used acronyms for Search and Rescue/Urban Search and Rescue, were excluded as searches resulted in hundreds of irrelevant articles containing "Synthetic Aperture Radar", used in geophysical monitoring of natural hazards. Given SAR/USAR acronyms should, in theory, be described using full terminology on first usage, any relevant literature should be found by searching 'Search and Rescue'.

As saturation appeared to have been achieved after the first 200 Google Scholar search results were reviewed, results up to 200 were included for each Scholar search.

Table 2/3 present the inclusion and exclusion criteria used for search results for local SAR and ISAR. For local SAR, earthquakes from any time period were included. For ISAR, earthquakes from 1985 were chosen, as while there may have been some international input into previous disasters, the Mexico City earthquake has been described as an important event in the development and expansion of ISAR.[2,3] The Nepal earthquake in 2015 was chosen as the last major international response. There was an international response to the 2017 earthquake in Mexico, however, no relevant literature was found, perhaps as there has been insufficient time to publish. The time frame 1985–2015 was therefore chosen, providing a 30–year period of review. Published literature from any year was included, providing the earthquake itself occurred between 1985–2015.

INCLUSION	EXCLUSION
• English Language	• Non-English Language
• Full text available online	• Full text not available online
• Description of local SAR response	• No information on SAR response
• Earthquakes from any year	• Information on ISAR only

Table 2 Inclusion and exclusion criteria for local SAR search

INCLUSION	EXCLUSION
• English Language	• Non-English Language
• Earthquakes ≥ 1985	• Earthquakes <1985
• Earthquakes ≤2015	• Earthquakes >2015
• Full text available online	• Full text not available online
• Description of ISAR response/teams	• No information on ISAR response
• Live rescues by ISAR	• Local SAR response only

Table 3 Inclusion and exclusion criteria for live rescues by ISAR search

Figure 1 represents the selection of papers for the literature review. The higher number of snowballed papers reflects that papers discussing SAR issues are not usually specifically about SAR, so more specific literature was found by snowballing of references from relevant papers.

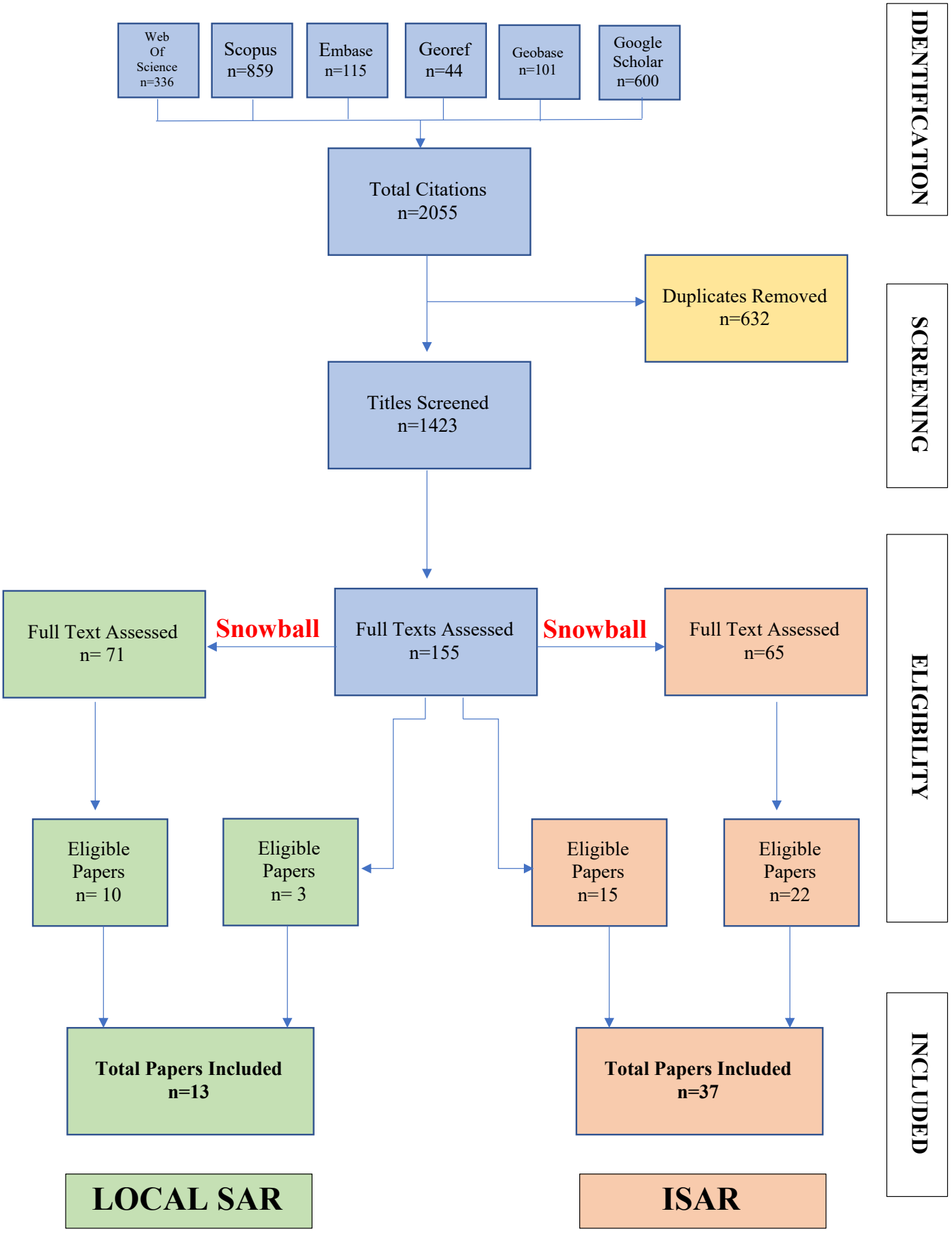

Figure 1 Flowchart of literature Methodology

Grey Literature

Google, Google Scholar and UCL Explore were used to search the grey literature. Table 4 describes the search strategy used for each earthquake identified in the literature review, or highlighted by grey literature review of other earthquakes.

Grey Literature Search Prefixes:
• OCHA – eg: "OCHA Armenia earthquake 1988"
• UNDAC
• OSOCC
• INSARAG
• USAID
• DFID
• Search and Rescue
• Reliefweb

Table 4 Grey literature search strategy

For events post-2001, the vOSOCC website archived discussions were reviewed.[4]

The literature search generated 13 earthquakes of interest. One additional event was added following grey literature review, resulting in 14 earthquakes in total. A table was used to collate general details regarding each earthquake, as well as information about responding teams and number of live rescues.

To provide an idea of the financial cost of ISAR, costs of UK and US deployments were searched for in the grey literature. UK and US costs were chosen as reports are in English, United States Agency for International Development (USAID) publishes budget breakdowns with situation updates and UK government departments are subject to Freedom of Information (FOI) requests, where information is not publicly available.

Notable Omissions

The 2004 Indian Ocean Earthquake and Tsunami is an important omission, given the size of the event, with an estimated death toll of more than 283,000,[5] and extensive earthquake-related building collapse.[6] While ISAR teams would not have been able to reach those trapped before the subsequent tsunami resulted in drowning, potential for SAR input did exist, as not all building collapse was confined to the tsunami inundation zone.[7] As no specific data could be found on responding teams or live rescues, it has not been included in this review.

An ISAR response to the earthquake in Kobe, Japan 1995 did occur, for example from the UK,[8] but specific details relating to teams attending and outcomes could not be found, so it has not been included.

Presentation of the Data

All stated earthquake magnitudes and depths are taken from United States Geological Survey (USGS) data available online. Magnitudes measure the energy released by an earthquake,[9] and have been given in Moment Magnitude (Mw), as this scale provides an estimate of earthquake size which is reliable over the full range of magnitudes.[10] The depth of the earthquake has been included, as its distance from the earth's surface affects the amount of shaking at the surface, thus the deeper the earthquake the lower the strength of surface shaking.[11]

Estimating deaths and injuries following disasters is controversial,[12,13] and in-depth analysis of how these figures are estimated is beyond the scope of this review. The figures used are best estimates from the numbers reported in the literature, combined with review of figures provided by the USGS. Deaths have been rounded to the nearest hundred (apart from New Zealand, 2011), as given their estimated nature, estimating to the nearest one or even ten would make the estimates appear more precise than they are.

Haiti's death toll remains controversial, with figures ranging from government estimates of 300,000,[13] a USAID study suggesting 65,575,[14] and a study by University of Michigan quoting 149,095.[15] 200,000 deaths has been used here as this figure lies between these estimates and is commonly internationally quoted. [16–18]

It is unclear how injury estimations are made, and there is no definition of what constitutes an earthquake-related injury in the literature.[19–21] Injury estimations should therefore be treated with caution, but have been included to give an overall impression of impact, and as they are frequently quoted in the literature despite these limitations.

Timing of arrival of first International team in-country, represents the timings when the teams were reported to be in-country, but may not reflect when they became operationally active, which in some cases was noted to be delayed due factors such as arriving at night, without all team members,[22] or due to logistic issues such as lack of transport. These timings are still included to give an overall understanding of how long it may take even the first ISAR team to arrive in-country following an earthquake.

There are several reasons why statistical testing has not been applied to these results. Firstly, this is a literature review rather than a secondary data analysis. The data itself would provide only 14 data points, which is too few to legitimately apply statistical testing. While the best efforts have been taken to extract the most accurate data from the sources reviewed, there are challenges, as has been described for death and injury rates. There are no relevant correlations evident, for example size of teams and rescues. Given previous studies have confirmed no correlation between magnitude of earthquake and death toll,[23] correlation with number of live rescues is also unlikely. Due to the small sample size, regression analysis cannot legitimately be applied to prove any associations or lack thereof.[24]

References

1. Gargon E, Gurung B, Medley N, et al. Choosing important health outcomes for comparative effectiveness research: a systematic review. *PloS one* 2014; **9**(6): e99111.
2. Bookmiller K. The International Law of 96 Hours: Urban Search and Rescue Teams and the Current State of International Disaster Response Law. In: D. Caron MK, & A. Telesetsky ed. The International Law of Disaster Relief Cambridge: Cambridge University Press; 2014: pp. 111-36.
3. El-Tawil S, Aguirre B. Search and rescue in collapsed structures: engineering and social science aspects. *Disasters* 2010; **34**(4): 1084-101.
4. vOSOCC. Virtual On Site Operations Coordination Centre. https://vosocc.unocha.org/VOOverview.aspx#_top (accessed 29 December 2019).
5. USGS. M 9.1 - 2004 Sumatra - Andaman Islands Earthquake - Impact. https://earthquake.usgs.gov/earthquakes/eventpage/official20041226005853450_30/impact (accessed 29 December 2019).
6. Ghobarah A, Saatcioglu M, Nistor I. The impact of the 26 December 2004 earthquake and tsunami on structures and infrastructure. *Engineering structures* 2006; **28**(2): 312-26.
7. Rai DC, Murty C, Jain SK, et al. The effect of the December 2004 Great Sumatra earthquake and Indian Ocean tsunami on transportation systems in India's Andaman and Nicobar Islands. *Earthquake Spectra* 2006; **22**(S3): 561-79.
8. IRC. Japan Earthquake - January 1995. http://www.intrescue.info/hub/index.php/missions/japan-earthquake-january-1995/ (accessed 29 December 2019).
9. Doocy S, Daniels A, Packer C, Dick A, Kirsch TD. The human impact of earthquakes: a historical review of events 1980-2009 and systematic literature review. *PLoS currents* 2013; **5**.
10. USGS. Moment magnitude, Richter scale - what are the different magnitude scales, and why are there so many? https://www.usgs.gov/faqs/moment-magnitude-richter-scale-what-are-different-magnitude-scales-and-why-are-there-so-many?qt-news_science_products=0#qt-news_science_products (accessed 29 December 2019).
11. USGS. At what depth do earthquakes occur? What is the significance of the depth? https://www.usgs.gov/faqs/what-depth-do-earthquakes-occur-what-significance-depth?qt-news_science_products=0#qt-news_science_products (accessed 29 December 2019).
12. Morton M, Levy JL. Challenges in disaster data collection during recent disasters. *Prehospital and disaster medicine* 2011; **26**(3): 196-201.
13. de Goyet CdV, Grünewald F, Sarmiento JP. Health responses to the earthquake in Haiti January 2010: Lessons to be learned for the next massive sudden-onset disaster. http://new.paho.org/disasters/dmdocuments/HealthResponseHaitiEarthq.pdf (accessed 29 December 2019).
14. Schwartz T, Pierre Y-F, Calpas E. Building assessments and rubble removal in quake-affected neighborhoods in Haiti. BARR survey final report. https://canada-haiti.ca/sites/default/files/Earthquake%20BARR%20Survey%20March%202011_0.pdf (accessed 29 December 2019).

15. Kolbe AR, Hutson RA, Shannon H, et al. Mortality, crime and access to basic needs before and after the Haiti earthquake: a random survey of Port-au-Prince households. *Medicine, conflict and survival* 2010; **26**(4): 281-97.
16. Rencoret N, Stoddard A, Haver K, Taylor G, Harvey P. Haiti Earthquake response context analysis. https://www.alnap.org/system/files/content/resource/files/main/haiti-context-analysis-final.pdf (accessed 29 December 2019).
17. INSARAG. Haiti Earthquake Response 2010 - An After-Action Review of Response. https://www.insarag.org/images/stories/Documents/Haiti_AAR_Meeting/Printed_Haiti_Book_Low_Definition_Version.pdf (accessed 29 December 2019).
18. Peleg K, Kellermann A. Medical relief after earthquakes: it's time for a new paradigm. *Annals of emergency medicine* 2012; **59**(3): 188-90.
19. Alexander D. Death and injury in earthquakes. *Disasters* 1985; **9**(1): 57-60.
20. Seaman J. Disaster epidemiology: or why most international disaster relief is ineffective. *Injury* 1990; **21**(1): 5-8.
21. Alexander D. The health effects of earthquakes in the mid-1990s. *Disasters* 1996; **20**(3): 231-47.
22. Movahedi H. Search, Rescue, and Care of the Injured Following the 2003 Bam, Iran, Earthquake. *Earthquake Spectra* 2005; **21**: S475-S85.
23. Shapira S, Aharonson-Daniel L, Shohet IM, Peek-Asa C, Bar-Dayan Y. Integrating epidemiological and engineering approaches in the assessment of human casualties in earthquakes. *Natural Hazards* 2015; **78**(2): 1447-62.
24. Green SB. How many subjects does it take to do a regression analysis. *Multivariate behavioral research* 1991; **26**(3): 499-510.