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Investigating Construction Workers Health and Safety Risks in Sustainable Building Projects

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Abstract

This research aims to explore workers' health and safety risks in sustainable building projects. This research systematically reviews literature on workers' health and safety risks in sustainable building projects and its non-sustainable counterparts to identify the specific safety risks posed to building projects' workers. Using the key journals in the construction industry, this research has reviewed and tabulated important safety risks. The data collected has been categorised and statistically analysed to find differences between the different types of risks posed in sustainable versus non-sustainable building projects. Also, safety risks specific to sustainable building projects has been reviewed, identified and summarised. The results indicate that while some risks such as fall hazards are common to both sustainable and non-sustainable building projects risks such as overexertion and electrocution are more likely to occur in sustainable as opposed to non-sustainable building projects. In addition, the findings show that there are some safety risks that are specific to sustainable building projects and these risks increase occupational safety on sites over and above traditional risk levels. This study's findings can be used by researchers and construction participants to better understand workers' health and safety risks in sustainable building projects and to be prepared to manage them.

Keywords: Systematic review, sustainability, worker health and safety risks, building projects

1. Introduction

Construction workers are responsible for doing all the hard and risky work to build the houses and work places we occupy every day. However, the construction industry has high levels of injuries and fatalities. As such, the Australian Cooperative Research Centre recently identified key visions for Australian construction to focus on by the year 2020. i) Improving sustainable construction practices and ii) improving the construction worker health and safety are two of these key visions. If a building is to be labelled as 'sustainable', sustainability should be considered across a building's entire lifecycle, including the design and construction phase (Rajendran, Gambatese and Behm, 2009). Construction worker health and safety is an overlooked, yet critical part of social sustainability. Thus, sustainable building projects should uphold higher standards towards worker health and safety (WHS) than traditional projects. However, currently there is no significant difference in WHS in green projects when compared to non-green projects. Even more alarming, evidence suggests that green buildings encounter higher recordable incident rates than non-green projects (Gambatese et al., 2009).

This research seeks to explore the different safety risks faced by construction workers in green projects over and above what they may face in non- green projects. Identification of these risks would be the first step to finding strategies to improve these risks. Since one of Australia's main visions for 2020 is to increase sustainable construction and better the health and safety of construction workers, this research is central to achieving those visions. The aim of this research is to identify the safety risks that construction workers face on sustainable building sites. Given that there is relatively little data on sustainable construction practices, this research first casts the net wide and collect data on both sustainable and non-sustainable safety risks. Then, this research subsequently narrows down this work to examine risks specific to sustainable construction.

Since sustainable construction practices are relatively new for researchers, it is anticipated that this research does not gather vast amounts of data specific to sustainable construction through the systematic review. Hence, this research casts the net wide and include safety risks not specific to sustainable construction in the systematic review too. This will help us to compare between the two industries to understand the added effect sustainability practices have on worker safety.

2. Research Design

Previous research undertaken in WHS in sustainable construction has employed a diverse range of methodologies to collect and analyse information as discussed above. For this research, a systematic review or a literature review of extant work are the most feasible methods. A systematic review is a means of identifying, evaluating and interpreting all available research relevant to the topic area (Bakhshi et al., 2016). All the individual studies contributing to the systematic review are called primary studies; a systematic review is a form of secondary study. Systematic literature reviews can help summarise the existing evidence and create a framework in order to position new research activity (Kitchenham et al., 2007). Thus, using already-established data to inform WHS practices is both feasible and well-suited to the research question at hand.

2.1. Search Strategy

According to Kitchenham et al. (2007) search terms can be derived directly from the research question and also from already known primary studies identified to be relevant to the research question. Based on the current research topic and primary studies mentioned previously, the keywords/phrases selected are as follows. Worker Health and Safety, Sustainable Construction, Safety, Risk and Sustainability. These key phrases were selected by undertaking preliminary searches in literature already available to the author. The keyword 'safety' was chosen to be included in the title of all articles searched to target papers relevant to the research topic. The keyword occupational was later added to further target research papers most relevant to the current research topic.

Since the timeline excluded the ability to search multiple databases to gather primary studies, the SR was conducted by searching eight of the leading construction management journals. These eight journals were selected by Hong et al. (2012) conclusion of the top-tier leading construction management journals. Other authors such as Aliakbarlou et al. (2017) and Izam Ibrahim et al. (2013) has also undertaken similar systematic research by reviewing these journals considered to be the best in the field of construction management. ASCE Journal of Construction Engineering and Management (CEM), ASCE Journal of Management in Engineering (JME), Automation in Construction (AIC), Building Research and Information (BRI), Construction Management and Economics (CME), Engineering, Construction, and Architectural Management (ECAM), International Journal of Project Management (IJPM) and Supply Chain Management: An International Journal (SCM) were the considered journals to carry out the search. Research published between 1994 and 2018 was included in the literature search. Literature published within the last two years was included in the search due to the increased awareness of the importance of WHS in sustainable construction being realised during this time.

Resulting primary articles were then reviewed and all safety risks were identified and tabulated. Tabulated safety risks for both sustainable and non-sustainable construction is shown on Appendix 1. Table 4 narrows down on risks specific to sustainable construction only. After conducting a search with the parameters mentioned above, the results yielded 39 research articles. A summary of the search is shown on Table 1.

Table 1: Number of articles by journal in both sustainable and non-sustainable risks

Journal Name	No. of Articles		%
	Initial results	Refinement	
ASCE Journal of Construction Engineering and Mgmt.	118	16	41%
ASCE Journal of Management in Engineering	39	1	3%
Automation in Construction	53	6	15%
Building Research and Information	81	3	8%
Construction Management and Economics	106	9	23%
Engineering, Construction, and Architectural Mgmt.	22	0	0%
International Journal of Project Management	79	4	10%

Supply Chain Management: An International Journal	17	0	0%
Total	**515**	**39**	

3. Result and Discussion

Seven of the articles mentioned safety risks related specific to sustainable construction, 18 articles mentioned safety risks not specific to sustainable construction and 14 articles failed to mention any worker health and safety risks at all, although they were captured by the search criterion. This maybe because even though these articles discussed safety, they did not mention any safety risks. A network visualisation of the search carried out is represented in Figure 1 below. Consistent with previous predictions, very little research in WHS in sustainable construction has been undertaken. Thus, to retain as many data points as possible, the author first analyses the data with both sustainable risks and risks not specific to sustainable construction.

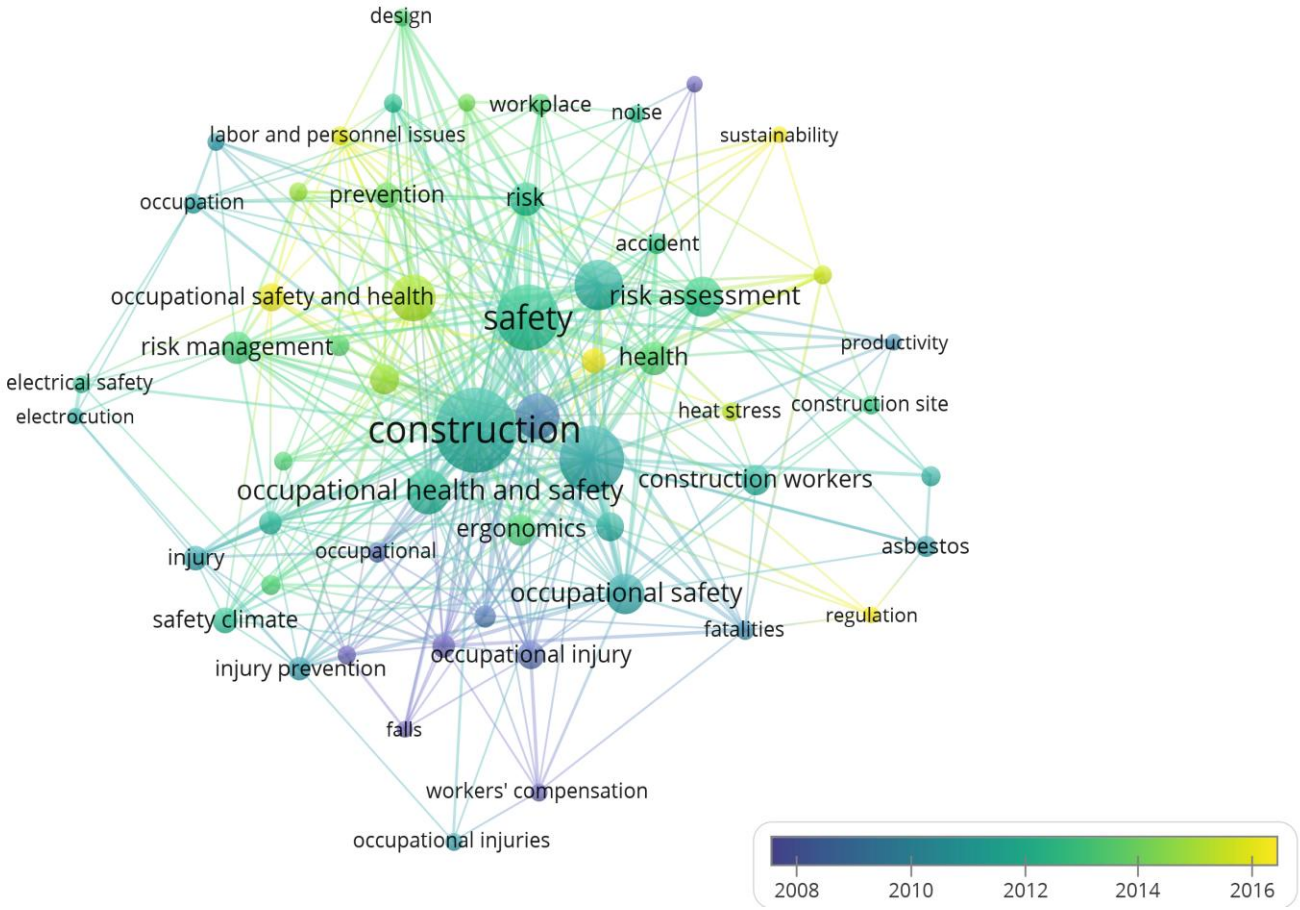

Figure 1: Keywords Network Visualisation of search carried out for systematic review

All 39 papers were carefully read, while making notes of all the safety risks mentioned in each paper. While conducting the review, risks specific to sustainable construction and other general risks in non-sustainable projects were all retained for analysis. The next two tables summarise the results found in both sustainable risks and non-sustainable risks.

Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction paper?
A	Ali A. Karakhan, and John A. Gambatese	2017	Identification, Quantification, and Classification of Potential Safety Risk for Sustainable Construction in the United States	CEM	Research Paper	Increased injuries due to recycling, increased fall and overexertion due to PV, fall hazards due to atria, musculoskeletal injuries due to permeable parking, use of greener material leading to additional hours of work causing more injuries, greener paints giving workers skin diseases, vegetated roofs requiring more physical work and maintenance causing more fall and overexertion injuries	Yes
B	Jimmie Hinze, Ray Godfrey and James Sullivan	2013	Integration of Construction Worker Safety and Health in Assessment of Sustainable Construction	CEM	Forum Paper	Re-use of cleaning water promote exposure to contaminated water for workers	Yes
C	Carol K. H. Hon, Albert P. C. Chan, and Michael C. H. Yam	2012	Empirical Study to Investigate the Difficulties of Implementing Safety Practices in the Repair and Maintenance Sector in Hong Kong	CEM	Case Study	None Mentioned	No
D	Bernard R. Fortunato, Matthew R. Hallowell, Michael Behm and Katie Dewlaney	2012	Identification of Safety Risks for High-Performance Sustainable Construction Projects	CEM	Research Paper	Vegetated roofs and PV systems cause increased fall hazards, electrocution and overexertion; Increased risk due to additional trenching, Risk due to extra recycling activities, risk due to additional energy performance works, generally falls, overexertion, caught-in and struck-by or against	Yes

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
E	Pia Perttula, Pekka Korhonen, Jouni Lehtelä, Pirkko-Liisa Rasa, Jari-Pekka Kitinoja, Simo Mäkimattila and Timo Leskinen	2006	Improving the Safety and Efficiency of Material Transfer at a Construction Site by Using an Elevator	CEM	Research Paper	Overexertion and strains due to manual handling	No
F	Luz S. Marín and Cora Roelofs	2017	Promoting Construction Supervisors' Safety-Efficacy to Improve Safety Climate: Training Intervention Trial	CEM	Research Paper	Fall Hazards	No
G	Albert P. C. Chan, Arshad Ali Javed, Sainan Lyu, Carol K. H. Hon, and Francis K. W. Wong	2016	Strategies for improving Safety and Health of Ethnic Minority Construction Workers	CEM	Case Study	Foreign worker falls hazards	No
H	Peiyao Zhang, Nan Li, Dongping Fang and Haojie Wu	2017	Supervisor-Focused Behaviour-Based Safety Method for the Construction Industry: Case Study in Hong Kong	CEM	Case Study	Lifting, Working at heights, hot working processes, pipeline installation rated as unsafe activities that increase safety risk	No
I	Nicholas Tymvios and John A. Gambatese	2016	Direction for Generating Interest for Design for Construction Worker Safety - A Delphi Study	CEM	Research Paper	None Mentioned	No
J	Mostafa Namian, Alex Albert and Jing Feng	2018	Effect of Distraction on Hazard Recognition and Safety Risk Perception	CEM	Research Paper	Struck-by accidents, trip and fall hazards, work adjacent to moving equipment	No

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
K	J. W. Garrett and Jochen Teizer	2010	Human Factors Analysis Classification System Relating to Human Error Awareness Taxonomy in Construction Safety	CEM	Research Paper	None Mentioned	No
L	Ali A. Karakhan, Sathyanarayanan Rajendran, John Gambatese and Chukwuma Nnaji	2018	Measuring and Evaluating Safety Maturity of Construction Contractors: Multicriteria Decision-Making Approach	CEM	Research Paper	None Mentioned	No
M	Marta Gangolells, Miquel Casals, Nuria Forcada, Alba Fuertes and Xavier Roca	2013	Model for Enhancing Integrated Identification, Assessment, and Operational Control of On-Site Environmental Impacts and Health and Safety Risks in Construction Firms	CEM	Research Paper	Injuries from hitting moving parts of machinery during earthworks	No
N	Qian Chen, Ruoyu Jin and Alfred Soboyejo	2013	Understanding a Contractor's Regional Variations in Safety Performance	CEM	Research Paper	None Mentioned	No
O	Ali A. Karakhan and John A. Gambatese	2017	Integrating Worker Health and Safety into Sustainable Design and Construction: Designer and Constructor Perspective	CEM	Research Paper	Heat island effect prevention and recycling methods to manage waste increase safety risk	Yes

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
P	Katherine S. Dewlaney, Matthew R. Hallowell and Bernard R. Fortunato	2012	Safety Risk Quantification for High Performance Sustainable Building Construction	CEM	Research Paper	PV systems cause increased fall hazards, electrocution and overexertion; Increased risk due to additional trenching, Risk due to extra recycling activities, risk due to additional energy performance works, generally falls, overexertion, caught-in and struck-by or against	Yes
Q	Carol. K. H. Hon and Albert P. C. Chan	2014	Safety Management in Repair, Maintenance, Minor Alteration, and Addition Works: Knowledge Management Perspective	JME	Research Paper	Fall Hazards	No
R	Riad Kanan, Obaidallah Elhassan and Rofaida Bensalem	2018	An IoT- based autonomous system for workers safety in construction sites with real time alarming, monitoring, and positioning strategies	AIC	Research Paper	Risk of injury due to collision with site vehicles, falling from heights and operating equipment run overs.	No
S	Ruta Simanaviciene, Rita Liaudanskiene and Leonas Ustinovichius	2014	Assessing reliability of design, construction, and safety related decisions	AIC	Research Paper	Fall Hazards	No
T	Antoine J.-P. Tixier, Matthew R. Hallowell, Balaji Rajagopalan and Dean Bowman	2016	Automated content analysis for construction safety: A natural language processing system to extract precursors and outcomes from unstructured injury reports	AIC	Research Paper	None Mentioned	No

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
U	Wei Zhou, Jennifer Whyte and Rafael Sacks	2012	Construction Safety and digital design: A review	AIC	Research Paper	Falls from height, being struck by a moving vehicle, being struck by a moving/falling object, or becoming trapped by something overturning/collapsing	No
V	Antoine J.-P. Tixier, Matthew R. Hallowell, Balaji Rajagopalan and Dean Bowman	2017	Construction Safety Clash Detection: Identifying safety incompatibilities among Fundamental Attributes using Data Mining	AIC	Research Paper	Trip over objects on floors, Falls and struck by accidents, Caught-in or compressed, overexertion, exposure to harmful substances, Accidents due to confined spaces, Vision related fatalities/injuries-failure to see hazards	No
W	Zainab Riaz, M. Arslan, Adnan K. Kiani and Salman Azhar	2014	CosMos: A BIM and wireless sensor based integrated solution for worker safety in confined spaces	AIC	Research Paper	Exposure to hazardous environment and injuries caused by fire and explosions, Deficiency in oxygen in confined spaces	No
X	Adnan Enshassi	2010	Construction Safety issues in Gaza Strip	BRI	Research Paper	Falling, Equipment and plant, Material dropped from a height, misuse of manual equipment, nails, steel work cause accidents in construction	No
Y	M. G. O'Reilly, P. O. Olomolaiye, A. H. Tyler and T. Orr	1994	Issues of health and safety in the Irish construction industry	BRI	Research Paper	Falling from places of work such as ladders, scaffolding, roofs. Also, contact with overhead power lines, Collapses in trenches and structures.	No
Z	John Rooke and Leslie Clark	2006	Learning, knowledge and authority on site: a case study of safety practice	BRI	Research Paper	None Mentioned	No

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
AA	Vanessa McDermott, Rita Peihua Zhang, Andrew Hopkins and Jan Hayes	2018	Constructing safety: Investigating senior executive long term incentive plans and safety objectives in the construction sector	CME	Research Paper	None Mentioned	No
AB	Matthew Hallowell	2010	Cost-effectiveness of construction safety programme elements	CME	Research Paper	None Mentioned	No
AC	Alison Furber, Sarah Duncan, Simon David Smith and Martin Crapper	2012	The health and safety implications of socio-cultural context for community construction projects in developing countries	CME	Research Paper	Trench digging with risk of collapse, Injury through sharp tools, Dehydration, sun stroke, falling from heights, Back and neck injury due to manual handling, skin irritation, eye irritation, Injury due to equipment lying on the floor	No
AD	Katie Shawn Dewlaney and Matthew Hallowell	2012	Prevention through design and construction safety management strategies for high performance sustainable building construction	CME	Research Paper	PV systems cause increased fall hazards, electrocution and overexertion; Increased risk due to additional trenching, Risk due to extra recycling activities, risk due to additional energy performance works, generally falls, overexertion, caught-in and struck-by or against	Yes
AE	Yang Miang Goh and David Chua	2013	Neural Network Analysis of Construction Safety Management Systems: A case study in Singapore	CME	Research Paper	None Mentioned	No
AF	Andrea Yunyan Jia, Steve Rowlinson, Martin Loosemore, Mengnan Xu, Baizhan Li and Alistair Gibb	2017	Institutions and institutional logics in construction safety management: the case of climatic heat stress	CME	Research Paper	Risk associated with working in hot weather that lead to heat illness or accidents	No

Continued Table 2: Detailed summaries of all 39 papers including types of risks mentioned in each

ID	Author/s	Date	Paper title	Journal name	Study type	Safety risks mentioned	Sustainable construction
AG	Helen Clare Lingard , Tracy Cooke and Nick Blismas	2012	Designing for construction workers' occupational health and safety: a case study of socio-material complexity	CME	Research Paper	Column strengthening works involve working at heights, increasing risk of fall.	No
AH	Gerard Francis Ayers, John F. Culvenor, Jim Sillitoe and Dennis Else	2013	Meaningful and effective consultation and the construction industry of Victoria, Australia	CME	Research Paper	None Mentioned	No
AI	Graeme D. Larsen and Jennifer Whyte	2013	Safe construction through design: Perspectives from the site team	CME	Research Paper	Fatalities that occurred during construction of thermal and moisture protection, doors and windows (including skylights)	Yes
AJ	Sevilay Demirkesen and David Arditi	2015	Construction safety personnel's perception of safety training practices	IJPM	Research Paper	Fatalities caused by falls and electrocutions	No
AK	Ivan W.H. Fung, C.M. Tam, Karen C.F. Tung and Ada S.K. Man	2005	Safety cultural divergences among management, supervisory and worker groups in Hong Kong construction industry	IJPM	Research Paper	None Mentioned	No
AL	Chunlin Wu, Dongping Fang and Nan Li	2015	Roles of Owners' Leadership in construction Safety: The case of high-speed railway construction projects in China	IJPM	Research Paper	None Mentioned	No
AM	Chunlin Wu, Nan Li and Dongping Fang	2017	Leadership Improvement and its impact on workplace safety in construction projects: A conceptual model and action research	IJPM	Research Paper	None Mentioned	No

3.1. Risk type by construction industry

After conducting a review of specific safety risks in the 39 papers, risks identified were categorised into broader categories to condense the data. These categories were chosen based on frequency of the specific risks being mentioned in each of the research articles, and their similarities with other specific risks. Similar categories were mentioned by Fortunato et al., (2012). Appendix 1 provides a more condensed review of the data retrieved from the selected 39 articles and highlights the frequency of risks faced in both sustainable construction and non-sustainable construction. The percentages of sustainable risks were calculated by dividing the amount of papers mentioning that specific risk category by the total amount of papers mentioning sustainable risks. Since six out of seven articles investigating sustainable risks mention fall hazards, the risk percentage for fall hazards is 86%. This percentage is closely followed by overexertion and exposure to harmful substances - both of which were mentioned 71% of the time. Electrocution and seeing and hearing injuries were mentioned in 57% of the articles.

Similarly, the percentage of risks mentioned in non-sustainable articles was also based on the number of articles mentioning risks not specific to sustainable construction. The 14 articles that didn't include any safety risks were excluded in calculating these percentages. Fall hazards were mentioned in 14 of the 18 papers, resulting in 78% of mentions in non-sustainable construction. Struck-by or against injuries were second highest with 39% of papers mentioning this type of injury. "Other" risks, which are mentioned in 29% of articles in sustainable construction and 33% in non-sustainable construction, included burns, injuries from sharp objects, injuries due to confined spaces, fires and explosions, skin irritation, dehydration, exposure to dust and heat.

3.2. Statistical analysis of risks by construction type

Given that the number of articles varied substantially between sustainable and non-sustainable construction industries, a more rigorous statistical approach was taken to draw reliable conclusions regarding a) whether there is an association between construction industry type and each of the broad categories of safety risks, and b) the odds of a particular risk being mentioned in sustainable compared to non-sustainable construction papers. To this end, IBM SPSS 22.0 software was employed to tabulate the expected and observed counts of each safety risk for both sustainable and non-sustainable construction papers. Given that the number of observations per cell frequently fell below five observations, Fisher's Exact test was used as an alternative to the traditional Chi-Square test (see Kim, 2017) to determine differences between construction industry type for each of the broad safety risks. The odds ratios reported below refer to the odds of a specified risk being mentioned in sustainable industry papers compared to non-sustainable industry papers.

Struck-by-or-against. There is no difference between construction industry type in the frequency of struck-by-or-against injuries ($p = 1.00$; odds ratio = 0.63, 95% CI: 0.10, 4.18).

Fall hazards. There is also no difference between construction industry type in the frequency of fall hazards mentioned ($p = 1.00$; odds ratio = 1.72, 95% CI: 0.16, 18.87).

Overexertion. However, there is a significant difference between construction industry type in the frequency of injuries attributed to overexertion ($p = .03$). More specifically, overexertion injuries are 8.77 times more likely to be mentioned in sustainable industry papers compared to non-sustainable industry ones [95% CI: 1.21, 62.5].

Caught-in-or-compressed. Conversely, there is no difference between construction industry type in the frequency of caught-in-or-compressed injuries mentioned (p = 1.00; odds ratio = .80, 95% CI: 0.12, 5.41).

Exposure to harmful substances. There is a significant difference between construction industry type in the frequency of injuries attributed to exposure to harmful substances (p = .007). Surprisingly, exposure to harmful substances is 20 times more likely to be mentioned in sustainable industry papers compared to non-sustainable industry papers [95% CI: 2.21, 166.67].

Seeing or hearing injuries. There is also a significant difference between construction industry type in the frequency of seeing or hearing injuries reported (p = .03). More specifically, seeing or hearing injuries are 10.64 times more likely to be mentioned in sustainable industry papers compared to non-sustainable industry papers [95% CI: 2.21, 166.67].

Electrocution. Finally, there is a significant difference between construction industry type in the frequency of injuries attributed to electrocution (p = .03). Similar to seeing or hearing injuries, electrocution injuries are 10.64 times more likely to be mentioned in the sustainable industry papers compared to the non-sustainable construction industry [95% CI: 1.31, 83.33].

To summarize, there is no difference between sustainable and non-sustainable industries in the incidence of struck-by-or-against injuries, fall hazards, and caught-in-or-compressed injuries. In contrast, there is a significantly higher incidence of injuries attributed to overexertion, exposure to harmful substances, electrocution, and seeing and hearing injuries in the sustainable industry compared to the non-sustainable construction industry.

3.3. Risks specific to sustainable construction

Since the current research places particular emphasis on risks specific to sustainable construction, as a final analysis, all safety risks posed for construction workers in the sustainable construction industry were identified and tabulated. Each of the seven articles specific to sustainable construction were carefully read and analysed to draw out all possible safety risks. A summary is provided in Table 4 below.

Table 4: Risks specific to sustainable construction identified through systematic review

No.	Risks Due to Sustainability Practices	percentage of Papers Mentioned
1	Atria/sunroof construction for better lighting increased fall hazards	13%
2	Vegetated roofs increase physical workload and increased fall hazards	13%
3	Installing photovoltaics (PV) on roofs increases risks of electrocution, increased fall hazards and overexertion due to lifting heavy material	13%
4	Fall hazards and struck-by accidents due to increased trench excavations for better quality/innovative stormwater	8%
5	Increased frequency of falls, slips, overexertion and decreased visibility due to white TPO membrane in roofs	8%
6	Heavier insulation and lighting to optimize energy performance increase overexertion, fall hazards and electrocutions	8%

7	Waste management practices such as dumpster diving increases musculoskeletal injuries, increased injuries due to struck-by and against trucks, fall hazards and exposure to harmful substances	8%
8	Longer installation times lead to higher accident rates of low volatile organic compound material due to inferior quality	5%
9	Musculoskeletal overexertion due to maintenance of permeable parking	3%
10	Green paints are associated with allergic skin reactions in maintenance workers	3%
11	Re-use of water has workers exposed to organically contaminated water and cause OHS hazards	3%
12	Additional testing and inspections increase falls hazards	3%
13	Exposure to harmful chemicals by cleaning contaminated brownfield sites. Risk of exposure to excavations cause increased risk of struck-by trucks/excavators	3%
14	Extra ductwork to achieve higher air quality increases risk of fall hazards	3%
15	Early commissioning of part of buildings have exposure to workers with who are unfamiliar of construction activity and increase falls, strains, abrasions and struck-by accidents	3%
16	Indoor chemical control increases pipe and ductwork which increases fall hazards	3%

4. Conclusion

Sustainable building construction is fast becoming a priority in modern construction. With the construction industry already being one of the most dangerous industries for workers, the added sustainable element seems to amplify this issue. The systematic review and post-hoc statistical analyses conducted reveals particular risk categories are more likely to be mentioned in sustainable construction as opposed to non-sustainable construction. Overexertion (8.77 times more likely to be mentioned), seeing and hearing injuries (10.64 times more likely to be mentioned), electrocution (10.64 times more likely to be mentioned) and exposure to harmful substances (20 times more likely to be mentioned) are the main categories. Apart from this analysis, this research has also summarised a list of risks which occur solely on sustainable building projects - injuries due to vegetated roofs, installation of PV, recycling of building material, additional piping and duct work for energy efficiency to name a few. This paper has also presented several ways that the results can be used by other parties such as future researchers, industry professionals and government agencies. This review will hopefully help worker health and safety in sustainable construction and truly make sustainable construction ‘sustainable’.

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Appendix 1: Percentages of specific risks found in sustainable vs non-sustainable construction

	Article ID	None Mentioned	Struck-By or against	Fall Hazards (slips, trips and falling from heights)	Overexertion/Musculoskeletal	Caught-In or Compressed	Exposure to harmful Substances	Seeing or Hearing injuries	Electrocution	Others
Sustainable Construction Specific	A			■	■		■	■	■	
	B						■			
	D		■	■	■	■	■	■	■	
	O			■	■					■
	P			■	■		■	■	■	
	AD		■	■	■	■	■	■	■	■
	AI			■						
	Papers Risk Mentioned		2	6	5	2	5	4	4	2
	Percentage Risk Mention		**29%**	**86%**	**71%**	**29%**	**71%**	**57%**	**57%**	**29%**
Not Specific to Sustainable Construction	C	■								
	E				■					
	F			■						
	G			■						
	H			■	■					■
	I	■								
	J		■	■		■				
	K	■								
	L	■								
	M		■			■				
	N	■								
	Q			■						
	R		■	■		■				
	S			■						
	T	■								
	U		■	■		■				
	V		■	■	■	■	■	■		■
	W						■			■
	X		■	■		■				■
	Y			■					■	
	Z	■								
	AA	■								
	AB	■								
	AC		■	■	■			■		■
	AE	■								
	AF									■
	AG			■						
	AH	■								
	AJ			■					■	
	AK	■								
	AL	■								
	AM	■								
	Papers Risk Mentioned		7	14	4	6	2	2	2	6
	Percentage Risk Mention		**39%**	**78%**	**22%**	**33%**	**11%**	**11%**	**11%**	**33%**