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Public Opinion Mining on Construction Health and Safety: Latent Dirichlet Allocation Approach

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Abstract: The construction industry has been experiencing many occupational accidents as working on construction sites is dangerous. To reduce the likelihood of accidents, construction companies share the latest construction health and safety news and information on social media. While research studies in recent years have explored the perceptions towards these companies' social media pages, there are no big data analytic studies conducted on Instagram about construction health and safety. This study aims to consolidate public perceptions of construction health and safety by analyzing Instagram posts. The study adopted a big data analytics approach involving visual, content, user, and sentiment analyses of Instagram posts (n = 17,835). The study adopted the Latent Dirichlet Allocation, a kind of machine learning approach for generative probabilistic topic extraction, and the five most mentioned topics were: (a) training service, (b) team management, (c) training organization, (d) workers' work and family, and (e) users' action. Besides, the Jaccard coefficient co-occurrence cluster analysis revealed: (a) the most mentioned collocations were 'construction safety week', 'safety first', and 'construction team', (b) the largest clusters were 'safety training', 'occupational health and safety administration', and 'health and safety environment', (c) the most active users were 'Parallel Consultancy Ltd.', 'Pike Consulting Group', and 'Global Training Canada', and (d) positive sentiment accounted for an overwhelming figure of 85%. The findings inform the industry on public perceptions that help create awareness and develop preventative measures for increased health and safety and decreased incidents.

Keywords: big data analytics; construction industry; data mining; health and safety; Instagram; opinion mining; public perceptions; sentiment analysis; social media; social media analytics

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1. Introduction

Construction workers engage in various activities that put them at risk, such as falling from roofs, being struck by heavy construction equipment, and electrocution [1]. The construction industry is one of the riskiest industries worldwide [2]. The United Nations' International Labor Organization (ILO) in 2019 recorded 2.8 million worker deaths globally, with more than 6500 people dying every day from work-related illnesses and 1000 from occupational accidents. Workers in the construction business still endure high rates of fatal and non-fatal injuries and accidents despite improvements in construction health and safety, technology, and training [3].

According to [3], despite the construction industry only accounting for 6% of the US labor force, it accounted for around 20% of work-related deaths in the country. For instance, there were 174,100 construction injuries in the US in 2020 [4]. As per the [2], 36 construction workers and 5 members of the general public were killed in the UK on average each year over the past 5 years, and 61,000 workers experienced non-fatal injuries from 2018 to 2021 [2]. In 2022, there were more than 30 casualties in China's construction sector [5].

Studies conducted in Ethiopia have shown that construction workers' injury rates ranged from 30% to 84.7% [6].

While an injury on a construction site is not entirely avoidable [7], there is an increase in the usage of the Fourth Industrial Revolution (Industry 4.0) technologies for enhancing construction site safety [8,9]. Thus far, research on construction health and safety via social media includes Sina Weibo [10], Twitter [11], and YouTube [12]. Nevertheless, to our knowledge, no research has investigated construction issues through Instagram, not to mention construction health and safety issues. Therefore, this study sheds light on public perceptions of construction health and safety by analyzing Instagram posts.

The research question is: How does the public perceive construction health and safety on Instagram? The answers to this question inform construction health and safety industry managers to share knowledge via Instagram and improve related measures on sites.

Following this introduction, Section 2 presents the literature review on construction health and safety and Instagram. Section 3 introduces the research methods. Section 4 elaborates on data and sentiment analyses. Section 5 presents the findings and discussions. Section 6 summarizes the theoretical and practical contributions, limitations, future research directions, and concludes the paper.

2. Literature Background

2.1. Construction Health and Safety

Construction works include buildings (e.g., new work, repair, additions, and alterations), civil engineering (e.g., road and railway), and specialized construction activities (e.g., demolition, electrical, plumbing, joinery, plastering, painting, and glazing) [2]. Health and safety issues are key factors affecting the sustainable development of large-scale construction projects [13].

Over the last decade, much research has been carried out on construction health and safety management. For example, the outbreak of COVID-19 has significantly impacted the construction industry. Nnaji et al. [14] surveyed construction companies and worker satisfaction in the United States. The results indicated that workers tend to use technologies such as video conferencing apps and wearable sensing devices to reduce the spread of COVID-19 on sites.

Some scholars discussed the issues in the project environment from workers' perspectives. For example, [15] took a large construction site in Iran to study site health and safety and formulate strategies to balance risks and costs to reduce health and safety risks during construction. Others researched the associations between company profiles, project characteristics, and safety practices. Gurmu [16] found that health and safety policies, health and safety plans, and hazard analysis are the three most important practices for improving construction project productivity. The level of health and safety practices increased with project costs, company experience, and size. Project delays negatively related to the level of health and safety practices [16].

Others highlighted the impact of gender and age on construction health and safety. Mariam et al. [17] conducted scientometric and meta-analyses of the health and safety of gender in construction. Women's health and safety research grew slowly. The main hazards faced by women in the construction industry were biologically related [17]. Peng and Chan [18] studied the adjusted working conditions to address the health and health deterioration of older construction workers in Hong Kong. They found that physical and mental health were key factors affecting the occupational safety of older construction workers. An organization's health and safety culture and level of maturity affect the likelihood of accidents. Williams et al. [19] identified the health and safety culture of the construction industry in developing economies. They used the construction industry in Ghana as an example to assess health and safety maturity.

2.2. Social Media and Public Perceptions

Many countries are now harnessing the power of social media to improve people's lives. Social media allows interaction with others in many ways [20]. Due to convenience, a considerable amount of information is disseminated through social media [11]. More people share and publish their ideas with increased social media, including public users, company managers, academic scholars, government officers, etc. Companies are increasingly relying on social media to analyze social media activity and professionalize their social media engagement, such as Twitter [21]. Some studies suggest that articles with more social media followers have higher visibility and citations [22].

Social media platforms have become essential for the broader dissemination of research articles. Authors, readers, and publishers host different social media campaigns for articles [22]. Social media can provide construction health and safety educational resources, especially during COVID-19. It improves the public's awareness and perception of construction health and safety. Different social groups can benefit from social media, where important news, the latest information, and updates can be quickly and efficiently disseminated.

With the help of social media, many construction health and safety companies have quickly begun to promote construction safety products. Zeng and Li [10] studied construction health and safety hazard awareness on the Web of Science and Weibo between 1991 and 2021. They explored the different foci of awareness of construction health and safety between academia and the public. Yao et al. [11] surveyed construction health and safety knowledge-sharing on Twitter and performed a social network analysis. Scholars explored how YouTube facilitates knowledge-sharing in construction health and safety [12]. Previous research found that many YouTube videos mentioned other social media such as "Facebook", "Instagram", "Twitter", and "LinkedIn". These demonstrated the information-sharing on social networking platforms [12]. However, none of these utilized Instagram data despite its popularity.

Based on the abovementioned literature background, this study identifies a research problem that is scarcely studied—the limited understanding of public opinion on construction health and safety. This research problem led us to explore how the public perceives construction health and safety on Instagram. In order to bridge this knowledge gap, this study was conducted through investigating the following three research questions: (1) What is the publics' main foci on Instagram about construction health and safety? (2) What kind of users on Instagram are active in the topic of construction health and safety? (3) What are the user sentiments on Instagram about construction health and safety?

3. Research Method

3.1. Instagram Big Data Analytics

Instagram is one of the largest and most influential social media platforms worldwide [23]. It was founded in 2010 by software engineer Michel Krieger and former Googler Kevin Systrom [23]. Since its launch in October 2010, Instagram has rapidly become one of the top four social networks in the world [24]. More than 2 billion people use Instagram every month, growing faster than other social networks such as Facebook and Snapchat [23].

Instagram is currently the fourth most popular social media network in the world by the number of users, and its parent company Facebook owns four of the six top social networks (Facebook, WhatsApp, Messenger, and Instagram) [24]. Almost a quarter of the world's active internet users visit the app monthly [24,25]. Of the 4.18 billion active mobile internet users, 23.92% visit Instagram every month, equivalent to the combined population of Europe and North America [24]. According to CNBC, Facebook had 2.91 billion monthly active users in October 2021, but its expansion is slower than Instagram's. Instagram's user base has doubled, while Facebook's has only grown by 30% [26].

Scholars have studied construction health and safety on social media. For example, [11] adopted social network analysis to examine Twitter construction health and safety knowledge-sharing. Despite Instagram being one of the main social media platforms of-

fering invaluable big data for researchers to analyze various urban and built environment phenomena [27], studies of construction health and safety on Instagram are scarce. SooHoo and SooHoo [28] examined the importance of educating teenagers on electric scooter safety equipment through content analysis of posts on social platforms such as Instagram. Couteau et al. [29] collected do-it-yourself (DIY) product recipes on social media such as Instagram and analyzed 275 eye makeup DIY recipes and their possible safety issues.

3.2. Sentiment Analysis

In recent decades, social media has become a well-known platform for expressing the feelings of ordinary people around the world. Opinion plays a vital role in uncovering some critical decisions. Sentiment analysis or opinion mining is a method used to mine the thoughts or feelings of the general population [30,31]. Studies have demonstrated and evaluated the ability of various volumetric, affective, and social network approaches to predict critical decisions from online social media platforms [30].

Sentiment analysis and applications for social media have been developed by academia to extract insights and understand public opinions on specific topics to support businesses, manufacturers, government agencies, and policymakers' decision-making and planning [32]. Social media-based sentiment analysis is generally more representative because it is based on many participants' opinions, which can enhance reliability [32]. However, sentiment analysis is vital for providing policymakers with adequate mechanisms for understanding customer and citizen attitudes that can be used in decision-making processes and future planning [33].

Research on sentiment analysis in construction health and safety is limited to date. Some scholars have applied sentiment analysis in construction health and safety on Twitter, and the study found that sentiment valence showed a positive correlation between favorites and retweets [11]. Others explored the role of YouTube in promoting construction health and safety knowledge and investigated how emotions affect users' viewing and commenting behaviors through semantic analysis [12]. With the rise of Weibo, sentiment analysis for short texts has also become a focus of social network analysis. Zeng and Li [10] adopted AI sentiment to analyze the Weibo users' foci and perceptions of construction health and safety hazards' awareness. Based on the researchers mentioned above, this paper adopted a sentiment analysis of construction health and safety posts on Instagram.

3.3. Research Methods

This studied used the keywords "construction safety", or "construction health", or "construction health and safety" and collected 17,835 posts, 93,707 paragraphs, and 116,975 sentences. The results showed that there had been a steady increase in content from 2015 to 2022. The year 2022 recorded the highest number of construction health and safety content on Instagram (Figure 1).

After obtaining the Instagram posts, this studied utilized KH Coder text-mining software for analysis. It has been widely used in many research fields in Japanese, such as sociology, economics, linguistics, and education [34,35]. KH Coder has functions such as word frequency statistics, part-of-speech analysis, clustering, correlation analysis, and visualization (such as histograms and clustering maps) [36]. This study used KH Coder to perform word frequency statistics, part-of-speech analysis, and clustering analysis of keywords and authors and to obtain the visualization results. It can support text data mining in Japanese, Chinese, English, French, German, Spanish, Portuguese, Italian, Russian, etc. The language on Instagram on this topic was mainly English, and the posts were imported into KH Coder for word selection and pre-processing to ensure the accuracy of the extracted data. The software extracts high-frequency words. Then, through the keyword search function, we observed the context information where the high-frequency keywords were located. Finally, the software generated a keyword co-occurrence relationship diagram, etc., and analyzed the distribution and connection of the main elements.

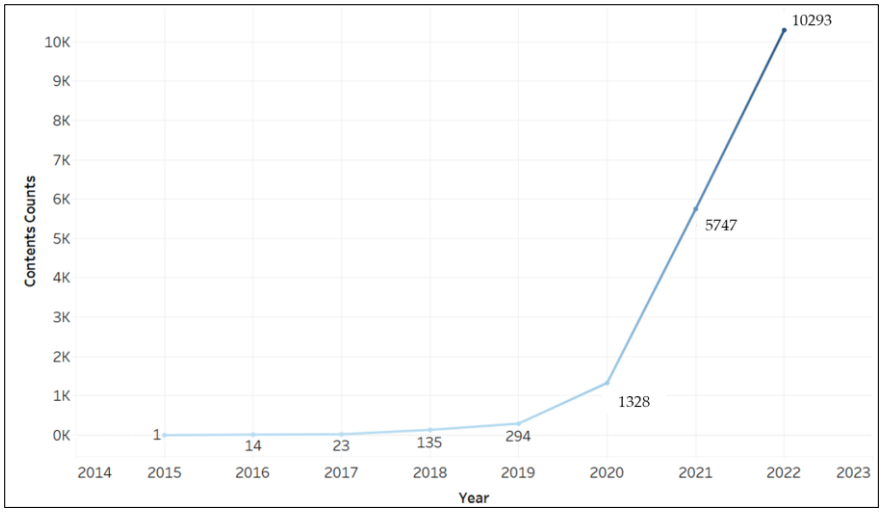


Figure 1. Instagram posts on construction health and safety by year.

We used the function of the KH Coder 3 Folder to remove stop words which were not related to our research, such as "W", and "PRP" in "Parts of Speech", etc., and some general items were removed, i.e., constructions, construction, health, health and safety, healthy, safe, safer, safest, construction health, and safely. Some other keywords with the same semantic meanings, such as "people, person", "awareness, Awareness", "builder, builders, BUILDERS", "building, buildings, Buildings", "construction site, Construction Site, construction sites", "construction worker, Construction Worker, Construction Workers, construction workers", "fall, falls", "service, services", "general contractor, General Contractor, general contractors", "COVID, COVID-19", "info, information", etc., were combined in the second-round keyword analysis.

Tableau is a business intelligence presentation tool positioned for agile development and implementation of data visualization. It provides interactive visual analytics and dashboard applications. When working with large-scale, multidimensional data, it can instantly show the patterns of data presentation from different angles. In this study, keywords and authors' word frequency data from KH Coder were imported to Tableau, attributes such as shape, color, size, and labels were defined according to the "dimension" and "measure" settings, and the visual analysis results were obtained. The larger the area of the circle, the higher the frequency of the word in the source text [34], then the hot spots and popular authors were obtained.

This study used Simply Sentiment (CX Data Science) to perform sentiment analysis. It transformed unstructured texts into digital data and identified positive and negative sentiments in the text and generated a set of numerical scores based on this analysis. In addition, Simply Sentiment could generate a dashboard with a graphical representation of the overall data processed. For each text item analyzed, Simply Sentiment's results included a score of total positive sentiment, total negative sentiment, the overall sentiment in the text (positive–negative), and a text label (positive, negative, or neutral) that represents the overall polarity of the text [37].

4. Results

4.1. Instagram Popular Contents and KOL on Construction Health and Safety

The study showed that the first content about construction health and safety appeared in 2015. Salmaraz posted the first content about construction health and safety, "Finally came in the mail! #ConstructionHealth&SafetyTechnician by #BCSP #CHST". This might be because Instagram users focused on entertainment, celebrities, etc., in the early years.

Since then, there was an increase in Instagram promotion for events such as Construction Safety Week. Based on [38], the organization was initially launched in 2014, when more than 40 national and global construction companies, comprising the Construction

Industry Safety Initiative (CISI) Group and the Incident and Injury-Free (IIF) CEO Forum, joined forces with a common goal: to inspire everyone in the industry to become a leader in safety. Through analysis of contents in 2016, they were mainly found with the hashtag of "construction safety week", which was initially started in 2014, and became a fully integrated annual campaign with a growing number of members and sponsors in 2016 [38]. Especially in 2016, the Construction Industry Federation (CIF) called on construction companies of all sizes to participate in Construction Safety Week [39], and companies started to use Instagram to share knowledge about construction health and safety. Thus, the content about construction health and safety on Instagram increased to 14 in 2016 and has kept increasing. Besides, construction workers were five times more likely to contract COVID-19 than the public from 2019 to 2022 [3]. Thus, the posts on Instagram about construction health and safety increased in 2019. More than 70 national and global construction companies are now coming together to host Safety Week [38]. Construction Safety Week is Instagram's most influential word in construction health and safety. It was an impressive and popular topic in the construction industry via Instagram.

4.2. Keyword Analysis Results

The foci on Instagram were mainly divided into two perspectives: (a) construction workers, such as team, site, work, job, etc., and (b) construction health and safety training, such as training, construction safety week, occupational health and safety administration (OSHA), courses, etc. We analyzed the word frequencies via Tableau 2021.3. The influential keywords were calculated and are visualized in Figure 2. The keywords ranked with the top ten highest frequencies were: construction safety week (n = 5666), safety first (n = 3806), team (n = 3473), site (n = 3339), work (n = 3102), project (n = 2853), training (n = 2388), construction workers (n = 2372), job (n = 2320), and industry (n = 2129) (Table 1).

Table 1. The top 20 keywords with higher term frequencies in construction health and safety on Instagram.

No.	Words	TF (Term Frequencies)
1	Construction safety week	5666
2	Safety first	3806
3	Team	3473
4	Site	3339
5	Work	3102
6	Project	2853
7	Training	2388
8	Construction workers	2372
9	Job	2320
10	Industry	2129
11	Construction sites	2103
12	Construction life	2094
13	OSHA	2052
14	Courses	2003
15	Worker	1827
16	Construction industry	1714
17	Link	1710
18	Contractors	1652
19	New	1609
20	Employee	1530

Figure 2. The influential keywords with high frequencies in construction health and safety on Instagram.

The most influential collocation was "Construction Safety Week" (Figure 2 and Table 1). Construction Safety Week is an influential organization in the construction industry worldwide. The organizer used social media and encouraged relative companies to strengthen the construction industry's safety culture and performance by sharing the best practices, tools, and resources [38]. Thus, the word can obtain the highest frequency on Instagram.

"Safety first" ranked among Instagram's top two influential words about construction health and safety. Putting safety first is key to helping reduce the high injury rate in the construction industry, and companies that put safety first will save money over time. Everyone benefits from fostering a safety culture on construction sites [3]. Thus, safety first played a vital role in construction health and safety.

"Team" ranked as the third most influential keyword. Construction workers need to pay special attention to teamwork to ensure that the entire operation is smooth, efficient, and most importantly, safe for all involved. Industrial construction projects often consist of numerous professionals. A team can include engineers, managers, architects, investors, and contractors for various applications. Each professional must deal with a specific aspect of the overall project. The team here mainly involves two concepts, teamwork and team building, which are crucial to success. Team building focuses on team formation, and teamwork focuses on aspects of teamwork ability. Understanding this critical difference can help managers play the team leader or field team member more effectively.

4.3. Jaccard Coefficient Co-Occurrence Cluster Analysis

This study utilized the Jaccard coefficient to calculate the strength of co-occurrence, and the strongest co-occurrences are drawn as network edges in Equation (1) below:

$$JC\ (M_1,\ M_2) = \frac{|M_1 \cap M_2|}{|M_1 \cup M_2|} = \frac{|M_1 \cap M_2|}{|M_1|+|M_2|-|M_1 \cap M_2|} \quad (1)$$

The intersection $M_1 \cap M_2$ is a multiset which is composed by all elements in M_1 and M_2 and repeated many times in the lower cardinality multiset. $M_1 \cup M_2$ is a multiset which is composed of all M_1 and M_2 elements and is repeated many times in the higher cardinality multiset. Assume f_M is the multiplicity function (f) of a multiset M in domain {0,1, n−1}, where $0 \leq i \leq n-1$, and $f_M(i)$ shows the frequency that the element i occurs in M.

The minimum term frequency (min. TF) was set as 475, and the number of selected words was 141 when specifying the type of edges to words. Here, 22 clusters were divided by different colors (Figure 3). The largest cluster, with an orange color, included:

"safety training", "OSHA", "HSE", "safety tips", "safety professionals", "business", "pike consulting", "training", "safety work", "workplace safety", and "safety consulting". It focused on construction health and safety training. This cluster aims to share health and safety training knowledge and education information via Instagram.

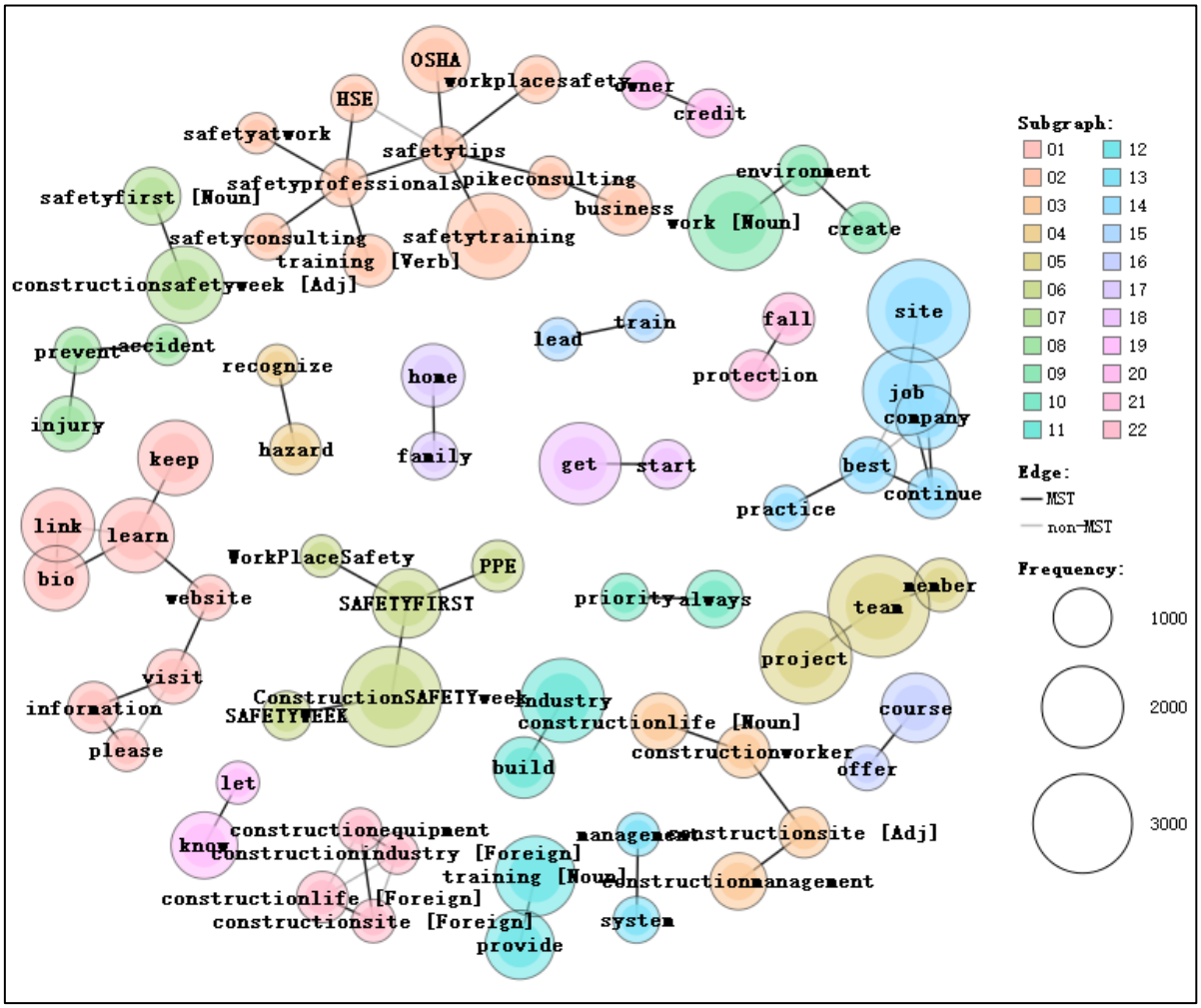


Figure 3. Co-occurrence network of words on construction health and safety on Instagram.

The words "learn", "keep", "link", "bio", "website", "visit", "information", and "please" were in the second cluster, with a pink color. It mainly described the users' actions to learn the training courses or knowledge. The blue cluster, including: "site", "job", "company", "best", "practice", and "continue", ranked third. It emphasized the site's safety and management in the construction industry. Apart from these three clusters, the light green cluster, including: "construction safety week", "safety first", "safety week", "workplace safety", and "PPE", and the dark green cluster, including: "team", "project", and "member", were also influential, as shown in Figure 3. This refers to the fact that many construction/site safety week organizers share the news of these campaigns via Instagram. On the other hand, another blue cluster contained "site", "job", "company", "best", "practice", and "continue", indicating that some companies might also use Instagram to promote safety internally and share the best practice with their employees.

4.4. Popular Construction Health and Safety Content Analysis

As shown in Table 2, the most and the secondary influential content was with the hashtag #Construction Safety Week, which obtained 4099 and 3399 publish-like counts, respectively. The first one was mainly focused on the training courses live on LinkedIn and

posted by user A in 2020. The content was about construction health and safety training in life and encouraged users to join them. The results had some agreement with the results of word frequencies. Successful event hosting became a vital motivation for people to share related information on Instagram.

Table 2. Influential content with more likes in IG construction health and safety posts.

Publish User	Account Type	Publish Time	Publish Content	Publish-Like Counts
A	safety training companies/safety product service company	15 September 2020 04:21:16	It's #ConstructionSafetyWeek, and we're getting tough on safety. Join us LIVE on LinkedIn this Wednesday, 9/16 at 12:30 pm ET for a training session.	4099
B		4 May 2022 06:00:17	Safer Handheld Coring. Learn More About How AUTOSTOP™ Technology Helps Protect Workers Core So They Can Core with More Confidence with The MX FUEL™ Handheld Core Drill. Link in Bio. #ConstructionSafetyWeek #MilwaukeeTool #NothingButHeavyDuty	3399
C	safety training companies/safety product service company	5 May 2022 06:00:12	Trips And Falls Are the Leading Cause of Fatal Workplace Injuries. Learn More About How MX FUEL™ Jobsite Lighting Helps Prevent Trips and Falls by Eliminating Cords. Photo Credit: @completelycordless #ConstructionSafetyWeek #MilwaukeeTool #NothingButHeavyDuty #LightTheSite	2719
D	safety training companies/safety product service company	4 May 2022 03:18:46	The 60V MAX* Cordless Dust Extractor keeps the Jobsite safe, easy and efficient so you can set your mind at ease and focus on the task.	2417
E		6 May 2022 06:00:07	Milwaukee Tool Provides Universal Cordless Dust Management Solutions That Deliver The Simplest Way To Be OSHA Compliant. Learn More, Link in Bio. #ConstructionSafetyWeek #MilwaukeeTool #NothingButHeavyDuty	2130
F	safety training companies/safety product service company	3 May 2022 06:00:09	Hand Injuries Are The Most Common On The Jobsite. Read About How To Help Prevent Them In Occupational Health & Safety. #ConstructionSafetyWeek #MilwaukeeTool #NothingButHeavyDuty	2005
G	safety training companies/safety product service company	7 May 2022 06:00:08	Proper Head Protection could help prevent common yet serious injuries when workers slip, trip, or fall. Read More About the Importance and Types of Proper Head Protection in Occupational Health & Safety. #ConstructionSafetyWeek #MilwaukeeTool #NothingButHeavyDuty	1974
H	safety training companies/safety product service company	16 September 2020 08:26:44	#constructionsafetyweek Are you up to date with technology? One thing I like about DeWalt is they designed a line of power tools to provide a high level of dust containment control and low vibration without sacrificing performance. In return, keeping us safe. #safteyweek #preformprotect	1816
I	General Contractor	30 January 2022 12:18:21	👷📄🏠 #construcaocivil #construction #follow #likecommentshare #engineeringstudents #engineeringproblems #fibrereinforcement #viralpost #constructions #constructionequipment #civil_engineeringmemes #archidaily #civilengineeringdaily #indianarchitects #engineeringmarvel #civilengineeringlife #civilwork #civilengineerblog #reinforcedconcrete #civilengineeringdiscoveries #constructionsafety #constructionindustry #civilequipment #steelarchitecture #civilengineeringwork #indianconstruction #civilengineeringquestions #civilogy #civilpracticalknowledge #civilstructure	1810

The secondary content with 3399 publish-like counts was "AUTOSTOP™ Technology Helps Protect Workers". It was posted by user B in 2022 and developed innovative tools and worksite solutions. The contents of "Learn More About How MX FUEL™ Jobsite Lighting Helps Prevent Trips and Falls by Eliminating Cords" ranked third and had 2719 published numbers. It was also published by the user of C in 2022. These two contents were about some companies' recommendations for new technology for users. It indicated

that users on Instagram liked companies publishing practical and innovative productions or technologies.

As shown in Table 2, these popular contents mainly focused on occupational training courses, new and innovative technologies and products, and health and safety knowledge that benefited workers. Thus, a content analysis may help managers find users' and market demands, which showed safety in first place rather than commercial profiles.

4.5. User Analysis

As presented in Figure 4 and Table 3, the most influential user was a consultancy company (user count = 282) with over 30 years of residential and commercial building surveying experience (Parallel Consultancy Ltd., London, UK, 2022, https://www.instagram.com/parallelconsultancyltd/ accessed on 29 August 2022). Its official website shows that it is a London-based building surveying firm with the capability and experience to cover London, Surrey, Essex, and surrounding areas (Parallel Consultancy 2022, https://www.parallelconsultancy.co.uk/about-us/ accessed on 29 August 2022). On Instagram, it has 351 followers. The second most active user was a leading provider of safety solutions for those working in hazardous industries, including construction safety, industrial safety, public works, and municipal safety (Pike Consulting Group, Fayetteville, GA, USA, 2022, https://pikegroup.net/ accessed on 29 August 2022). It is a company of licensed security professionals specializing in security management systems. From Pike Consulting Group (2022), Mitchell Smith and Gary DeGeorge Sr., founders of Pike Consulting Group, designed their clients' security management systems to be OSHA-compliant solutions. Then, Global training Canada (user count = 197) ranked third. It is an internationally recognized company providing technical training courses to various industries for thousands of workers annually on-site, operator safety, and industry-specific certification requirements (Global Group of Companies, Aston Manor, South Africa, 2022, https://globaltrainingcentre.com/serve_content.cfm?Page=Why%20Choose%20Us accessed on 29 August 2022).

Table 3. Influential users on construction health and safety on Instagram.

Users	Users' Counts
Parallel Consultancy Ltd.	282
Pike_Consulting_Group	261
Global Training Canada	197
Civil Techno Engineer	193
Work Zone Coffee	165
Canadian Safety Institute	163
Inspiresafety1	123
Ecoshield_Roofingnc	105
Kenara.Multi Services	98
Construction Safety Council	97
Construcedllc	94
Final Fit Safety	91
Paintlynyc	90
Core_Safety_Group	90
Preferred_Safety_Products_Inc	89
Fhconstruction	89
Anvil_Builders	85
Roland Construction_	84
Ng Companies	81
Vpg_Construction	79

Figure 4. Influential users who mentioned construction health and safety on Instagram.

All in all, the influential users were mainly companies, but not individuals. Instagram is a platform for companies to advertise their products and services. These companies can benefit workers and the construction industry, and they can also get fame by sharing construction health and safety training courses, ideas, successful projects, knowledge, etc., on Instagram. More details are shown in Table 4.

Table 4. Top 3 influential users on construction health and safety on Instagram.

Users	Followers	The Most Liked Content	Like Number Counts
Parallel Consultancy Ltd.	351	A party wall agreement is needed if you plan on carrying out any building work near or on a party wall. You must tell your neighbours, provide them with a Party Wall Notice, and come up with a Party Wall Agreement in writing.	25
Pike_Consulting_Group	115	Many hazards can go unseen or looked over; simply double-checking can keep hazards from hurting people! #constructionsafety . . .	7
Global Training Canada	218	Ouch. Knowing the hazards around you. #constructionsafety . . .	7

4.6. Sentiment Analysis

Most public users on social media are emotional. Sentiment analysis plays a vital role in social media. The study adopted CX Data Science to calculate the sentiment scores about construction health and safety on Instagram posts. There were three top scores, including a +'ve score (positive score), -'ve score (negative score), and a neutral score. As shown in Figure 5a, the +'ve score accounted for 70%, the -'ve scored only 8%, and the neutral score accounted for 4%. Among all the kinds of sentiment, positive, negative, and neutral sentiments were 85.4%, 4.7%, and 9.8%, respectively (Figures 5b and 6, Table 5).

Table 5. Source data.

	+'ve Score	-'ve Score	Neutral	No Sent	No Data	Overall	Net Sentiment =	75.6%
Total Items Processed	3493	402	194	911	0	5000	% Pos	85.4%
Total Items Processed	70%	8%	4%	18%	0%	100%	% Neu	4.7%
							% Neg	9.8%
Average Number of Words per Item	76	83	85	37		70	Total #	100%
No. Containing a URL or Email Address	392	45	23	63		523		
Percentage	11%	11%	12%	7%		10%		

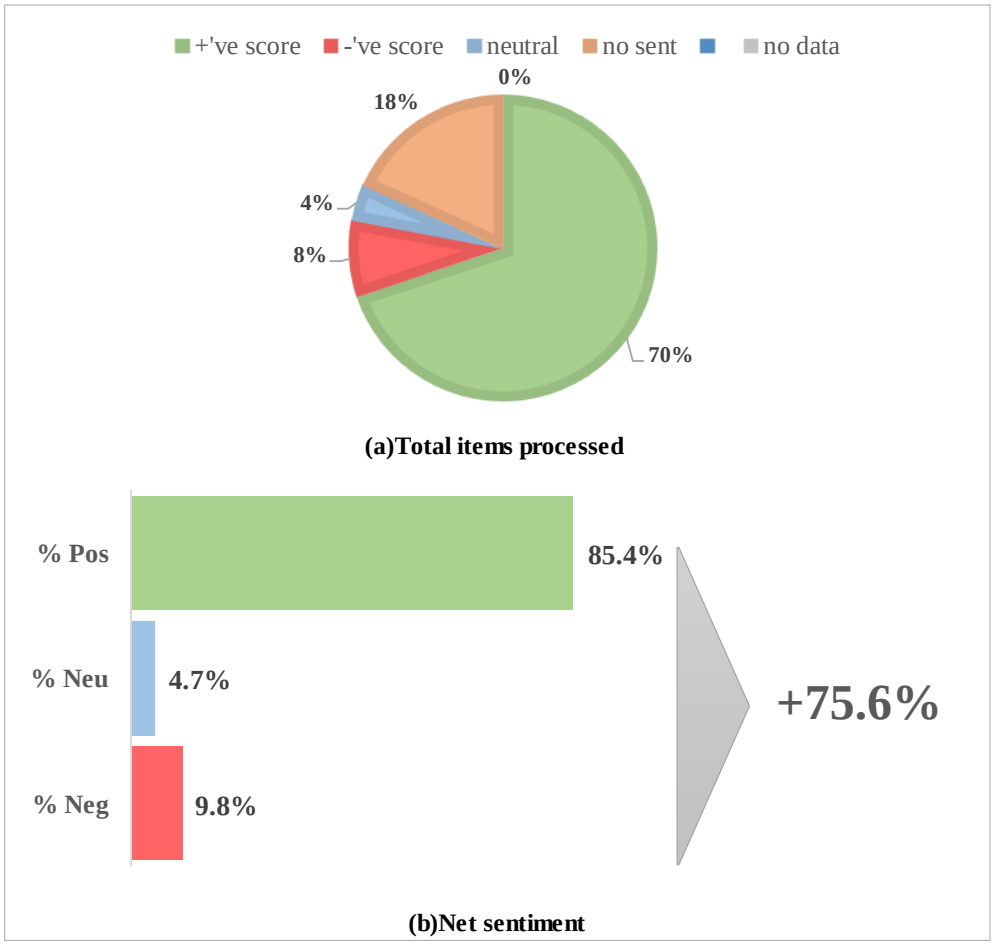
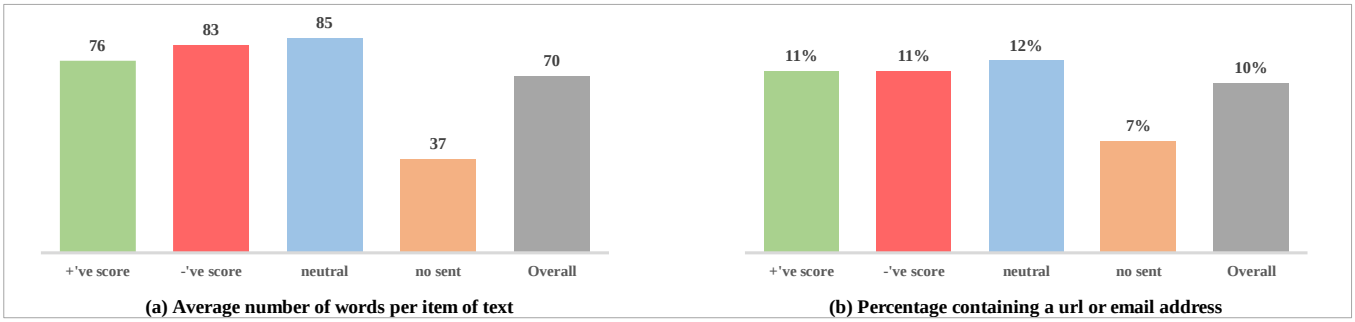


Figure 5. Total items processed and net sentiment. Note: Pos means positive, Neu means neutral, and Neg means negative.



(a) Average number of words per item of text

(b) Percentage containing a url or email address

Figure 6. Average number of words per item of text and percentage containing a URL or email address.

In Figure 7, the posted information from Instagram about construction health and safety showed a higher positive sentiment trend, such as "safe", "working", "thank you", "help", "great", "support", "proud", "thanks", and "respective", as shown in the first column of Figure 7a. While from Figure 7c, "injuries", "injury", "hard", "accidents", "stress", "issues", "suicide", and "effort" were all negative sentiments, but accounted for less than positive sentiments. This indicated that the public's perception of construction health and safety on Instagram was positive, although construction is one of the most dangerous industries. On the other hand, most users are organizations or companies that share construction health and safety training or products for the public that are beneficial for workers. Some scholars indicated that sentiment analysis on social media understands broader public opinion behind specific topics to support decision-making by businesses, manufacturers, government agencies, and policymakers and planning [32]. Thus, this result can be beneficial for companies to decide how to share the construction health and safety knowledge products, etc., on social media, especially on Instagram.

(a) Tag clouds - all sentiment

(b) Positive sentiment

(c) Negative sentiment

Figure 7. Tag clouds: (**a**) all sentiment, (**b**) positive sentiment, and (**c**) negative sentiment.

As for Figure 8, the most frequently mentioned verbs and adjectives were positive, as shown in AI sentiment analyses. The most mentioned positive adjectives included

"proper", "right", "proud", "professional", "available", "happy", "free", "important", "new", etc. The highest-frequency adjective—"new"—refers to new construction health and safety coming to new heights. It mainly includes four aspects: (a) new materials and structures, i.e., new mortar, lightweight and comfortable fall protection, steels, (b) new health and safety initiatives and measures, i.e., new health and safety protocols, procedures, standards, policies, and calibration, (c) new techniques and innovations, i.e., new 4D health and safety tools, fabrication, multi-disciplinary facility replacement project, and (d) new industrial facilities and environment, i.e., new workwear, bannisters and flooring, hard-hat, safety equipment, and tools. The second highest-frequency adjective is "important". It mainly expresses essential policies and protocols, environments, and tools for individuals and teams, i.e., safety on site is essential, the right tools for construction safety jobs are important, PPE and RRB are necessary, companies' foci on workers' wellbeing is important, safety is vital in construction because the people on the team are more important than any project, and it is crucial for construction crews to wear the right gear.

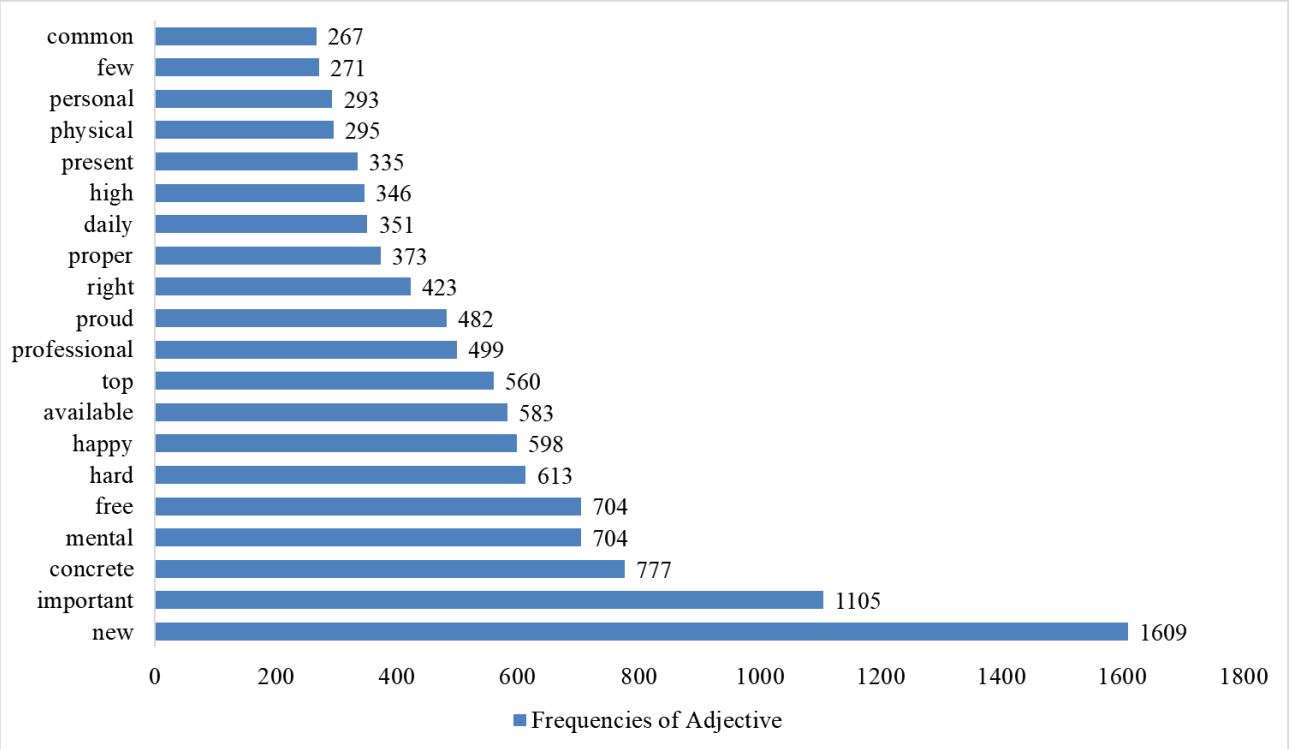


Figure 8. Frequencies of adjectives about the sentiment analysis on construction health and safety.

As for Figure 9, these words ranked in the top 20 among the higher frequencies of adjectives. For verbs, "work", "follow", "get", "keep", "learn", "help", "provide", "ensure", "thank", "check", etc., ranked in the top 20 among higher frequencies of verbs and belonged to positive sentiment. The highest-frequency verb was "work", and work safely, work with a team, work with a positive attitude, flexible work, working professionals, work together, work in conjunction with the finest state-of-the-art equipment, etc., were mainly work-related phrases on Instagram in the context of construction health and safety. Then, the secondary verb was "follow", which mainly referred to following the construction health and safety training courses, pieces of knowledge, etc.

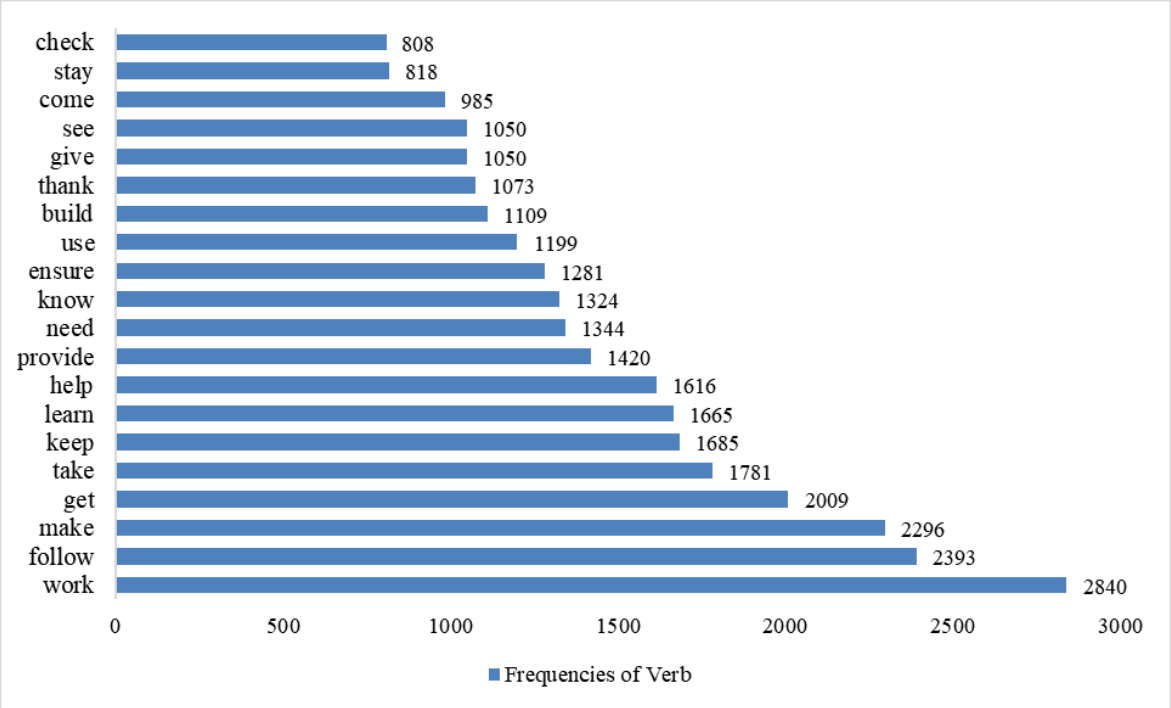


Figure 9. Frequencies of verbs about the sentiment analysis in construction health and safety.

4.7. Latent Dirichlet Allocation Topic Model

Topic models are mainly used for semantic analysis and text-mining problems in natural language processing. For example, they are utilized to collect, categorize, and reduce the dimensionality of text by topic. The Latent Dirichlet Allocation (LDA) is one of the topic model approaches that can be used to analyze the topic distribution of documents [40,41]. It reveals the topic of each document set in the form of a probability distribution so that after analyzing some documents to extract their topic distribution, it can be subject-clustered or use text classification according to the topic distribution [41]. Each topic is represented with a word distribution. Documents are shown in LDA as random mixtures of latent subjects. It computes a corpus' probability using the formula:

$$p(C|x,b) = \prod_{d=1}^{m} \int P(\Phi_d|x)\left(\prod_{n=1}^{n_d} \sum_{T_a} p(T_a|\Phi_d)p(W_{dn}|T_a,b)\right)d\Phi_d$$

where C is the corpus of the documents (D), x is each document topic distribution's Dirichlet previous concentration parameter, while b refers to the corpus-level parameter, Φ_d represents the document-level variable, n is the number of words in the document, T_a is the topic assignment, W_{dn} refers to the nth word in the dth document, and m represents the documents that needed to be analyzed [42]. The LDA topic model was analyzed from the KH Coder via the Fit a Topic Model. We set the number of topics as ten via the function of topic model (LDA) options. The 10 LDA topic models about construction health and safety on Instagram are shown in Figure 10. The 10 topic models from #1 to #10 can be relatively summarized as training service (#1, 0.726), team management (#2, 0.979), training organization (#3, 0,75), workers' work and family (#4, 0.858), users' action (#5, 0.978), site management (#6, 0.897), industry activities (#7, 0.818), industry development (#8, 0.815), training method (#9, 0.764), and responsibility (#10, 0.768). Among them, the topic of team management (#2, 0.979) had the highest score, which includes team (0.250), project (0.204), keep (0.132), jobsite (0.067), member (0.066), part (0.058), support (0.054), crew (0.054), work (0.050), and priority (0.044).

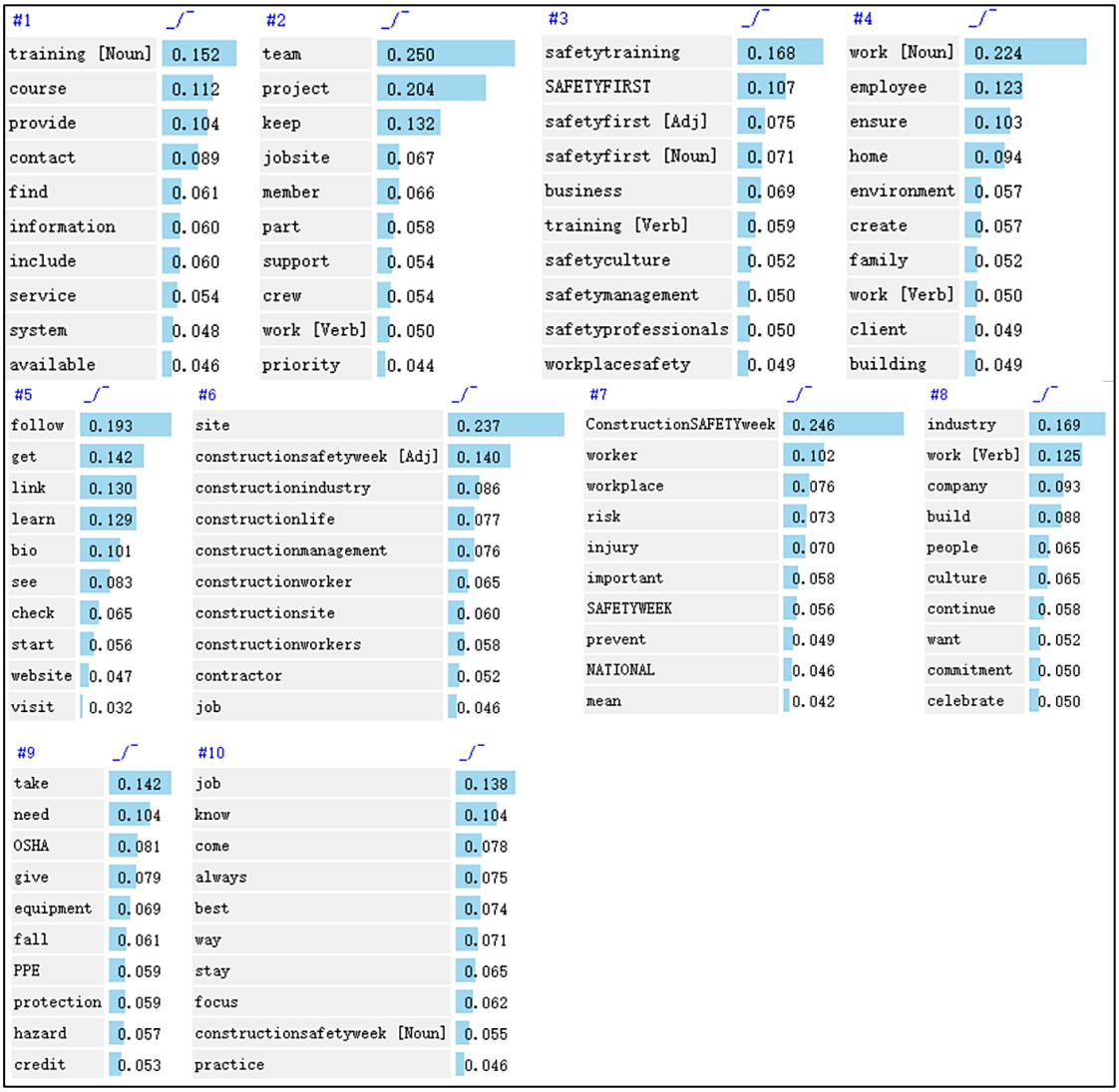


Figure 10. LDA topic model about construction health and safety on Instagram.

5. Findings and Discussion

Previous research evidenced the effectiveness and importance of social media analytics to capture public opinions and institutional capabilities [43,44]. Based on this capability in this study, the analysis of Instagram posts through the Latent Dirichlet Allocation topic model helped consolidate public opinion on construction health and safety. The analysis of public perceptions on construction health and safety generated insights and helped in addressing the three research questions of this study: (1) What is the publics' main foci on Instagram about construction health and safety? (2) What kind of users on Instagram are active in the topic of construction health and safety? (3) What are the user sentiments on Instagram about construction health and safety? The key findings are presented and discussed below.

5.1. The Most Popular Topic and Hashtag

There were 5666 "Construction Safety Week" posts which were about construction health and safety on Instagram. It was an essential annual activity in the construction industry. The result showed that successful construction safety event hosting became an essential motivation for people to share related information on Instagram. Applying hashtags about construction health and safety could be beneficial and quickly spread among relevant stakeholders. The other popular topics and/or hashtags were "Safety First"

and "Construction Team". Team management is an important topic, as per LDA topic model analysis.

At the same time, on Instagram, the public preferred to use a hashtag to record their published topics about construction health and safety. The result was different from the former studies in construction health and safety. Some scholars may not focus on other social media, such as research on construction safety and hazard awareness on Sina Weibo [10]. Besides, as social media platforms need to classify and effectively distribute online content, hashtags are essential to classify content and promote the contents to others. Adding hashtags could increase the exposure and discoverability of the social media content and raise the interaction among users who may not even know the content writers. This study found that "Construction Safety Week", "Safety First", and "Construction Team" as event tags and construction industry labels attracted many public users. It is recommended that industry companies use these tags on social media to post content on Instagram, to promote the positive dissemination of construction health and safety knowledge. It also has a positive impact on the development of the construction industry.

5.2. The Largest Cluster and the Most Liked Content

The largest cluster mainly included the keywords: "safety training", "OSHA", "HSE", "safety tips", "safety professionals", "business", "pike consulting", "training", "safety work", "workplace safety", and "safety consulting". Thus, construction health and safety training was popular among Instagram users. Previous research demonstrated the relationship between information-sharing and social networking platforms, such as "Facebook", "Instagram", "Twitter", and "LinkedIn" [12], however this research did not reveal a direct relationship in the results. The keywords indirectly revealed that similar contents were shared through Instagram. Instagram users share practical construction health and safety training courses or projects, mainly focusing on teamwork or team building and innovative AI technologies, which could be beneficial to construction workers.

5.3. The Most Active Users

The top 3 active users were Parallel Consultancy Ltd. (followers = 351), Pike Consulting Group (followers = 115), and Global Training Canada (followers = 218). They are surveying or safety training companies. Unlike other social media, for example, Sina Weibo, the most popular users are governments in the context of construction safety [10]. To promote the brand, companies adopted social media to share content related to construction safety. Nevertheless, active users may receive little focus on their posts. That is to say, active users' sharing contents may be less popular. For example, the most liked content (like number = 4099) among all the research samples was from user A (followers = 1.02 million). The safety training, especially on LIVE, is more exciting and valuable for users. Thus, active users may change their strategies to share more construction safety training courses or innovative technologies to benefit them. To enhance post-sharing effectiveness, Instagram writers might focus more on the construction team, site and environment, workers, etc.

5.4. Positive and Negative Sentiments

All in all, the number of positive sentiments was 18 times that of negative sentiments from users' posts on Instagram about construction health and safety. Although construction is a hazardous industry, people posted more positive information on Instagram. This was especially true among construction or safety training companies, who preferred sharing positive information to help workers to decrease accidents. By adopting training courses and knowledge and promoting and popularizing new tools, materials, structures, facilities, rules, and products on social media, the workers' perception of construction health and safety will increase. For example, the active user Parallel Consultancy Ltd. (2021) posted: "Funding for the new 4D health and safety tool was provided through a Small Business Research Initiative—LRB-SBRI-RRB—innovation competition funded by HS2 and managed by Innovate UK. The competition aims to deliver innovation that will drive project effi-

ciencies and processes for use during the design and construction phase of HS2." Chauhan et al. [30] have verified the ability of various sentiments to predict critical decisions from online social media platforms. These companies and organizations can share more positive posts, such as new materials and structures, new health and safety initiatives and measures, new techniques and innovations, and new industrial facilities and environments, to offer information to the public users and workers to avoid injuries.

6. Conclusions

6.1. Theoretical Implications

The construction industry is one of the most critical industries in the country. However, professionals in this industry often face multiple health and safety risks. These include slips and trips, falls, exposure to hazardous products, etc. Construction health and safety are worldwide issues that can be shared on social media such as Instagram. In total, 30.94% of the world's 4.48 billion active social media users regularly access Instagram [25]. With the increasing number of people on Instagram, we can research the public's foci and increase companies' and workers' perceptions about construction health and safety via big data analysis. This study analyzed the posts about construction health and safety on Instagram Via Python, Tableau, KH Coder, and AI sentiment. The influential and popular foci, active users, and sentiment were analyzed. The results can benefit more companies' managers and workers in the construction industry. Despite Instagram being one of the main social media platforms offering invaluable big data opportunities for researchers to analyze various urban and built environment phenomena [27], studies of construction health and safety on Instagram are scarce. The research filled the research gap by studying Instagram posts' content that shared construction health and safety knowledge. Furthermore, the study generated a consolidated understanding on public opinion on construction health and safety.

Social media's "construction safety"-related big data analysis can improve the public's perception of building health and safety awareness, improve risk prediction for construction health and safety management, and promote the sustainable development of projects. The first content about construction health and safety appeared in 2015 on Instagram. The most popular phrase about construction health and safety on Instagram is Construction Safety Week, a frequent hashtag. The foci on Instagram were primarily divided into two perspectives: (a) construction workers, such as team, site, work, job, etc., and (b) construction safety training, such as Construction Safety Week, training, OSHA, courses, etc. The active users of Instagram were mainly construction companies, and the top three were Parallel Consultancy Ltd., Pike Consulting Group, and Global Training Canada. They primarily provide consulting services and training courses in construction safety. We may speculate that an increase in profit drives online construction health and safety marketing and promotion activities via Instagram.

6.2. Practical Implications

Analyzing topics in construction health and safety through social media contributes to the decision-making of company managers and the development of safety in the construction field. Hashtags of successful event hosting, such as "Construction Safety Week", have become an important motivation that motivates people to share and focus on related information on Instagram. It indicated that users on Instagram liked companies' publishing of practical and innovative productions or technologies. Through the big data analysis, "team" should be taken into consideration by companies to promote the construction safety training. The population from Instagram analyzed here is different from that from social media analyzed by previous scholars, which is conducive to exploring views on construction safety from different dimensions and enriching the portraits of the population from social media.

The sentiment analysis on construction health and safety on Instagram was mainly positive, accounting for 85.4%. Based on previous studies, sentiment analysis is a method

used to mine the feelings of the general population [30,44]. It can be concluded that through the dissemination of social media, the field of construction safety is developing in a positive direction, and users' awareness is also more positive. Therefore, construction companies can reduce the public's negative perception of construction health and safety awareness through construction safety training. Sentiment analysis and applications for social media can support businesses, manufacturers, government agencies, and policymakers' decision-making and planning [32]. Thus, companies have adopted Instagram to share some construction health and safety knowledge, products, etc. It would give workers positive public sentiment and benefit their occupational health and safety.

6.3. Research Limitations and Research Directions

While interpreting the study findings, the following limitations should be noted: (a) There is more than one language used on Instagram. According to [24], Instagram is the most popular in India, with 180 million users, followed by the US (170 million), Brazil (110 million), Indonesia (93 million), and Russia (61 million). Still, we only chose English as the primary language to collect data. (b) Some construction workers and managers, such as older workers, may not use social media. Thus, the results might reflect younger generations' knowledge-sharing activities. (c) According to the Ghost Data report, 9.5%, or 95 million Instagram users, may be fake bots [24], impacting the data collection and analysis. We may further study the same topic based on different countries or economic situations, for example, developed countries compared with developing countries, in the context of construction health and safety on Instagram. Besides, in the future, it would be worth analyzing the share of occupational health and safety applications and tracking the extent to which they are used by various participants in the investment process.

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