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Title page

Antecedents of safety behavior in construction: A literature review and an integrated conceptual framework

Nini Xia [a], Qiuhao Xie [b], Mark A. Griffin [c], Gui Ye[d], Jingfeng Yuan [a, *]

[a] *Department of Construction and Real Estate, School of Civil Engineering, Southeast University, China*

E-mail address: ninixia@seu.edu.cn

[b] *College of Management and Economics, Tianjin University, China*

E-mail address: xieqiuhao@hhu.edu.cn

[c] *Future of Work Institute, Curtin University, Australia*

E-mail address: mark.griffin@curtin.edu.au

[d] *School of Management Science and Real Estate, Chongqing University, China*

E-mail address: yegui760404@cqu.edu.cn

[*] (**Corresponding author**)

Postal address: Department of Construction and Real Estate, School of Civil Engineering, Southeast University, No. 2 Southeast University Road, Jiangning District, Nanjing 211189, China

E-mail address: jingfeng-yuan@outlook.com

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Antecedents of safety behavior in construction: A literature review and an integrated conceptual framework

Abstract: There has been no scarcity in the literature of suggested antecedents of employee safety behavior, and this paper brings together the disaggregated antecedents of safety behavior in the construction field. In total, 101 eligible empirical articles are obtained. Bibliometric and context analyses are combined to identify the influential journals, scholars, keywords, use of theory, research methods, and countries or regions of the empirical samples. The 83 factors that are identified are divided into five groups, namely (a) individual characteristics, (b) workgroup interactions, (c) work and workplace design, (d) project management and organization, and (e) family, industry, and society. This indicates that the causes of safety behavior are manifold. Various factors from different systems likely work in concert to create situations in which an individual chooses to comply with safety rules and participate voluntarily in safety activities. Given this, we propose that safety behavior is only an ostensible symptom of more complex "The Self–Work–Home–Industry/Society" systems and establish a safety behavior antecedent analysis and classification model. Based on this model, we develop a resource flow model, illustrating why, how, and when the flow of resources between the five systems—namely the self system, work system, home system, work–home interface system, and industry/society system—either promotes or inhibits safety behavior. The safety behavior antecedent analysis and classification model and resource flow model are based mainly on bioecological system theory and resources theories. Avenues for future theoretical development and method designs are suggested based on the reviewed findings and the two conceptual models. The intention with this systematic review together with the two integrated conceptual models is to advance theoretical thinking on how safety behavior can be promoted, or instead, inhibited.

Keywords: Construction safety; Safety behavior; Antecedent factor; Conceptual model; Literature review; Bibliometric analysis

1. Introduction

Safety remains a major challenge for the construction industry worldwide (Gao et al., 2020; Lee et al., 2020). Reductions in workplace accidents and injuries have plateaued following first from improvements in legal frameworks (e.g., rules and enforcement) and then from improved engineering controls (e.g., designing out safety risks as early as possible). Pybus (1996) and Hudson (2007) identified a third stage for workplace safety improvement that focused on people and their actions. The importance of safety behavior is underscored by meta-analyses that find a generalizable association between safety behavior and accidents and injuries (Christian et al., 2009; Clarke, 2006). In the construction field, academics have also paid increasing attention to safety behavior, resulting in a body of research that is growing exponentially (Fig. 1). However, despite this large and burgeoning research interest in construction safety behavior, there are limited reviews of this research domain.

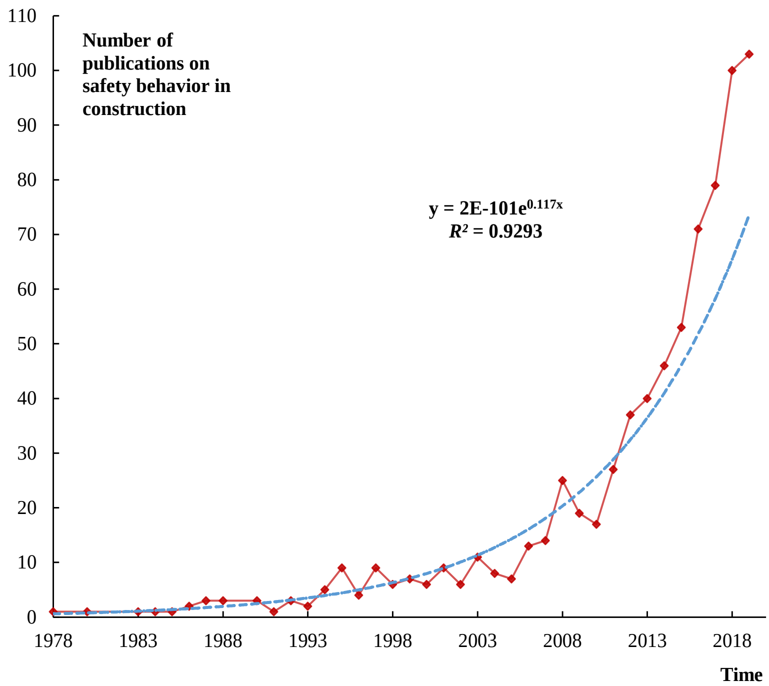

Fig. 1. Growth of literature on employee safety behavior in construction by year of publication from 1978 to 2019.

Notes: 1) This figure plots the accumulation of 753 articles that were identified as relating to safety behavior in the construction industry (see details in Section 3). 2) The first equation ($y = 2E\text{-}101e^{0.117x}$) is that of the exponential trend line fitting the data series, namely the number of articles on employee safety behavior in construction by year of publication from 1978 to 2019. The second equation (R^2 = 0.9293) gives the goodness of fit of the fitting model.

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Dodoo and Al-Samarraie (2019) reviewed 70 empirical studies to identify factors contributing to workplace unsafe behavior. Their review covered eight work domains including the construction industry, but only 14 construction-specific papers published from 2007 to 2018 were included. Focusing on construction sites, Khosravi et al. (2014) and Mohammadi et al. (2018) reviewed the literature to identify factors influencing unsafe and safety behavior, but also accidents and injuries. However, these two outcomes might have different antecedents (Christian et al., 2009). Thus, we still lack a thorough and specific understanding of the antecedents that contribute to safety behavior of construction employees. Research addressing this will help organizations and managers to design systematic and beneficial interventions aimed at increasing the likelihood of safety behavior and subsequently reducing costly accidents and injuries in the future.

To address this gap, the present study has five goals: (a) to conceptualize safety behavior; (b) to analyze the influential journals, scholars, keywords, use of theory, research methods, and countries or regions of the empirical samples in the current literature; (c) to identify and group antecedents of construction safety behavior; and (d) to propose an integrated framework comprising one conceptual model integrating different groups of antecedents of employee safety behavior, and another conceptual model illustrating the underlying theoretical mechanisms relating safety behavior and its antecedents in a unified theoretical perspective; and (e) to suggest theoretical development and method designs for future research on consideration of the previous four parts of endeavors.

This study complements existing construction safety literature by providing a systematic review specifically of the antecedents of the safety behavior of construction employees. Zhou et al. (2015) conducted a wide-ranging review of various aspects of safety in construction. In their study, however, antecedents of behavior and accidents were mixed, and future directions were not specific to behavior and its antecedents. Other reviews have targeted particular aspects of construction safety research, such as that by Alruqi et al. (2018) of safety climate dimensions and their relations to construction safety performance, that by Jin et al. (2019) of construction safety research within the scope of human-centered safety management, and that by Swuste et al. (2012) of the possibility of influencing safety in the building sector. However, despite these reviews, our review is unique in focusing on the antecedents of safety behavior. Specifically, the present study intends to make contributions in the following ways.

First, the present study clarifies the definition of safety behavior. Much of the research on construction safety is plagued by a lack of clear conceptualizations of constructs, thereby hindering the accumulation of knowledge (Osigweh, 1989). The present study provides concept foundation for the theoretical development and empirical investigations of safety behavior.

Second, the present study introduces a bibliometric approach into the domain of construction safety behavior, further combined with traditional content analysis. Previous construction safety reviews have used only a bibliometric (Jin et al., 2019) or a content (Mohammadi et al., 2018) analysis approach, and their combination of them remains limited. Bibliometric analysis can discover masses of hidden quantitative information in a cluster of studies, such as the most productive scholar (Bamel et al., 2020; Jin et al., 2019). Content analysis employs both qualitative and quantitative techniques and can provide in-depth information (Fellows and Liu, 2008) that bibliometric analysis cannot, such as the use of research methods. Thus, a combination of both approaches can produce rich information about the literature on safety behavior of construction employees.

Third, the present study synthesizes what is currently known about the causes of safety behavior in construction to further establish a safety behavior antecedent analysis and classification model comprising “The Self–Work–Home–Industry/Society” systems. Based on this model, a resource flow model is developed to elucidate the underlying mechanisms through which safety behavior occurs. Safety behavior is only an ostensible symptom of a more complex system (Hon et al., 2014), and these two models would advance a broader and deeper understanding of what causes it and how it is promoted or prevented. Potential directions for future research—based on the reviewed findings and the two models—would provide guides for scholars interested in safety behavior antecedents.

These contributions can also shed lights on safety behavior research in the generic workplace and other specific sectors, given that the construction industry ranks among one of the most dangerous sectors worldwide and research on safety behavior in construction seems to be in the majority (Dodoo and Al-Samarraie, 2019), and that our two conceptual models are based mainly on general theories, namely bioecological system theory (Bronfenbrenner, 1994) and resources theories (Demerouti et al., 2001; Hobfoll, 1989; ten Brummelhuis and Bakker, 2012).

2. Conceptualizing safety behavior in generic occupations and in construction

Clear delineation of concepts is a critical step to facilitate not only the organization of accumulated knowledge, but also the development of theory. The absence of a clear conceptualization of safety behavior in much of the safety literature necessitates a unified definition (Beus et al., 2016; Christian et al., 2009). Consequently, we begin by conceptualizing safety behavior both in generic occupational safety literature and in the construction safety field.

In generic occupational safety literature, Beus et al. (2015) defined safety-related behavior as “workplace behaviors that affect the extent to which individuals or the workplace in general are free from physical threat or harm. This includes behaviors that (a) mitigate physical threat or harm (i.e., safe behavior), whether rule prescribed or discretionary …, and also behaviors that (b) subject individuals or the workplace to greater physical threat or harm (i.e., unsafe behavior), whether intentional or unintentional” (p. 482). Safe behavior, which was often termed as safety behavior (Burke et al., 2002; Griffin and Neal, 2000), refers to “actions or behaviors that individuals exhibit in almost all jobs to promote the health and safety of workers, clients, the public, and the environment” (Burke et al., 2002, p. 432). Based on work performance theory (Borman and Motowidlo, 1993), Griffin and Neal (2000) further made distinctions between two types of safety behavior: compliance and participation. Safety compliance is rule prescribed and corresponds to task performance, defined as “the core activities that individuals need to carry out to maintain workplace safety" (Neal et al., 2000, p. 349). One sample indicator for measuring safety compliance is "I use all necessary safety equipment to do my job." On the other hand, safety participation is discretionary and corresponds to contextual performance, defined as "behaviors that do not directly contribute to an individual's personal safety but that do help to develop an environment that supports safety" (Neal et al., 2000, p. 349). One sample indicator for measuring safety participation is "I put in extra effort to improve the safety of workplace." As such, safety behavior is a type of individual work performance and often termed as "safety performance" (Burke et al., 2002; Griffin and Neal, 2000). Individual work performance is about observable behaviors rather than cognitive, motivational, or other psychological states (Schmitt et al., 2003) such as intention to behave safely or the outcomes of behavior (Campbell and Wiernik, 2015) such as safety outcomes (e.g., accidents and injuries). Both safety compliance and safety participation behaviors can be measured at the individual level by assessing the frequency with which an individual engages in those behaviors (Burke et al., 2002). The behaviors can also be aggregated from the individual to the group level (Neal and Griffin, 2006) on the basis of an acceptable measure of agreement (e.g., $r_{wg} \geq .70$; Glick, 1985).

Table 1 shows that safety behavior research in the construction field has mainly conceptualized and distinguished safety behavior into safety participation and safety compliance (Griffin and Neal, 2000; Neal et al., 2000) (see details in the supplementary material titled "Definition, measure, and theory"). To measure safety behavior on the part of construction employees, the scales of safety compliance and safety participation proposed by Griffin and colleagues have also been used the most. The practice of conceptualizing and measuring safety behavior as two dimensions of compliance and participation is consistent with that in generic occupational safety research (Neal and Griffin, 2006; Beus et al., 2016). Compared to injuries and accidents, which are lagging indicators of workplace safety, researchers in either generic occupational safety or construction safety have acknowledged safety-related behavior as a leading indicator of workplace safety (Beus et al., 2016; Guo et al., 2016; Hon et al., 2014).

To summarize, for construction safety behavior, we suggest following the definitions and measures of safety behavior proposed by Burke et al. (2002) or safety participation and safety compliance proposed by Griffin and Neal (2000). Please note that our review includes studies that focused on both safety and unsafe behavior; this decision was made because studies assessed unsafe behavior as opposed to safety behavior (Beus et al., 2015).

Table 1

Definition and measure of safety behavior in the reviewed construction research.

Category	**Number (percentage)**
Definition	
Unspecified	57 (55.88%)
Safety compliance and safety participation: Griffin and colleagues e.g., (Griffin and Neal, 2000; Neal et al., 2000)	25 (24.51%)
Safety behavior: Burke et al. (2002)	10 (9.80%)
Unsafe behavior	6 (5.88%)
Other	3 (2.94%)
Safety citizenship behavior: Hofmann and Morgeson (1999)	1 (.98%)
Total	**102**
Measure	
Griffin and colleagues/Griffin and colleagues combined with other questionnaires	27 (26.73%)
Other	20 (19.80%)
Unspecified	21 (20.79%)
Self-developed questionnaire	13 (12.87%)
Specific behavior(s)	15 (14.85%)
Burke and Hofmann/ Burke/ Hofmann questionnaire	5 (4.95%)
Total	**101**

Notes: 1) A total of 101 articles were included in the review; see details in Section 3. 2) One article (i.e., Nadhim et al., 2018) used the definitions of both Burke et al. and Griffin and colleagues, which is why the total number of the definition is 102. 3) "Specific behavior(s)" refers to the occurrence of specific acts such as protecting employee themselves against particulate matter in Stege et al. (2019).

3. Methods

A systematic review was conducted of the empirical studies of safety behavior in the construction context. Systematic literature review is an important research method capable of synthesizing the existing body of knowledge, based on which new agendas for future research can be identified and specific questions toward theory development can be addressed (Denyer et al., 2008; Fisch and Block, 2018). As cited in Zniva and Weitzl (2016), a literature review consists of a systematic, explicit, and reproducible procedure to identify, evaluate, and synthesize the existing body of knowledge. Following the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol guidelines (Moher et al., 2010) and current practices (Ayodele et al., 2020; Xia et al., 2018a), our review was conducted in three phases as shown in Fig. 2.

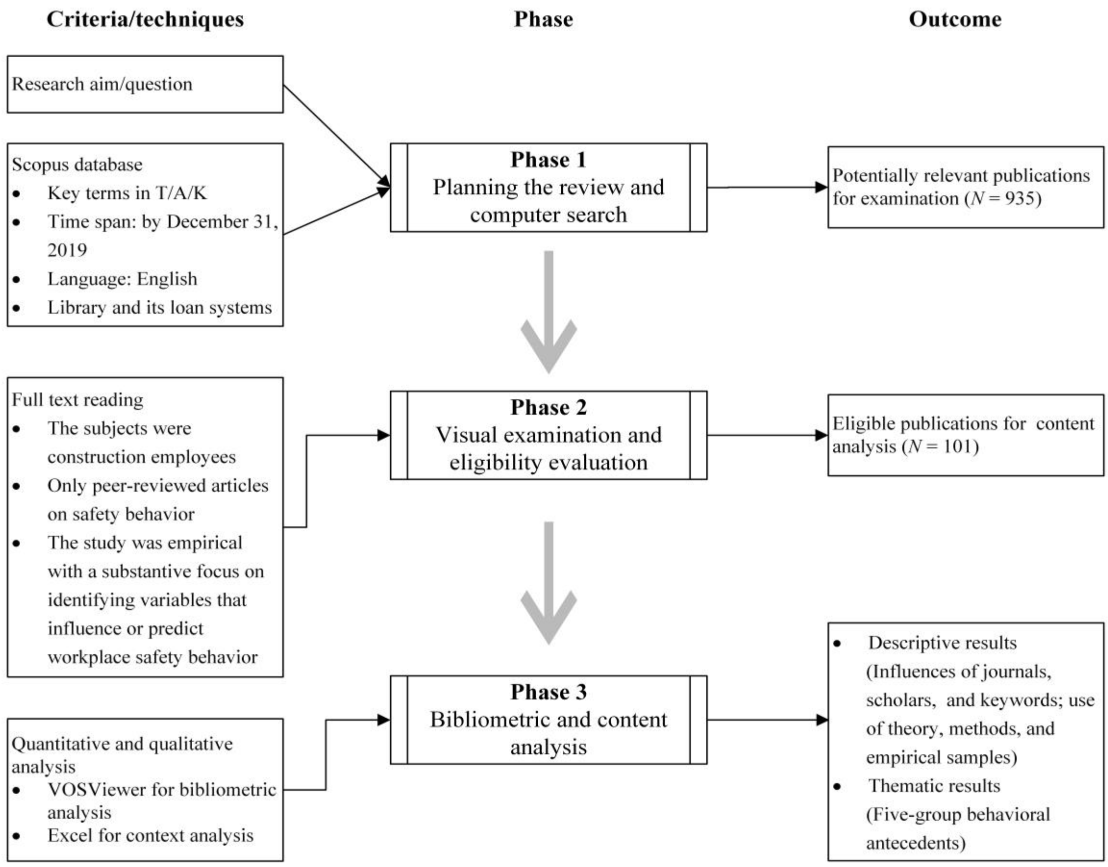

Fig. 2. Research design.

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3.1. Planning the review and computer search

We aimed to search in the three databases—namely Scopus, Web of Science, and Science Direct—for all peer-reviewed papers related to construction safety behavior. These three databases are the most widespread online academic sources on different scientific fields, which are frequently used for literature searches (Aghaei Chadegani et al., 2013; Guz and Rushchitsky, 2009) and are commonly used by construction researchers to conduct systematic literature reviews in the construction field (Gao et al., 2019; Zhou et al., 2015).

The search rule employed in the Title/Abstract/Keywords (T/A/K) field of the selected databases was "*construction*" AND ("*safety behavior*" OR "*safety behaviour*" OR "*safe behavior*" OR "*safe behaviour*"OR "*safety compliance*" OR "*safety participation*" OR "*safety citizenship behavior*" OR "*safety citizenship behaviour*" OR "*safety performance*" OR "*unsafe behavior*" OR "*unsafe behaviour*" OR "*safety violation*"). In addition, the research included only those papers written in English, published by December 31, 2019, and that were available either online or through the library of Southeast University and its interlibrary loan system. This computer search yielded 935 papers.

3.2. Visual examination and eligibility evaluation

The 935 papers were read in their entirety to scrutinize those focusing on the antecedents of safety behavior in construction. The inclusion criteria were: (a) the subjects were construction employees, (b) only peer-reviewed articles, and (c) the study was empirical with a substantive focus on identifying variables that influence or predict workplace safety behavior of employees. The following are specific examples of not meeting these three inclusion criteria:

- The subjects were not construction employees. For example, Amponsah-Tawaih and Adu (2016) examined how safety climate affected the safety behavior of health workers. In total, 160 articles were excluded for this reason.
- Systematic review papers, meta-analysis studies, conference publications, and non-peer-reviewed research reports were excluded from this review. For example, Dodoo and Al-Samarraie (2019) reviewed 70 empirical studies in different work domains to identify the factors contributing to workers' unsafe behaviors. In total, 22 articles were excluded for this reason.
- The article did not report empirical findings on causes of safety behavior directed to work. For example, Fang et al. (2016) identified cognitive failures as a factor contributing to unsafe behavior, but the identification was based on cognitive and social psychology theories and existing accident causation models, without empirical

data. In total, 652 articles were excluded for this reason.

In summary, 753 empirical articles were related to safety behavior of construction employees, of which 101 were determined as pertaining to antecedents of safety behavior directed to work and thus eligible for the final bibliometric and content analyses. Fig. 2 shows the number of these papers according to their publication year. It can be seen that since 2012, the literature on safety behavior antecedents has constituted a stable and considerable portion of the total safety behavior research.

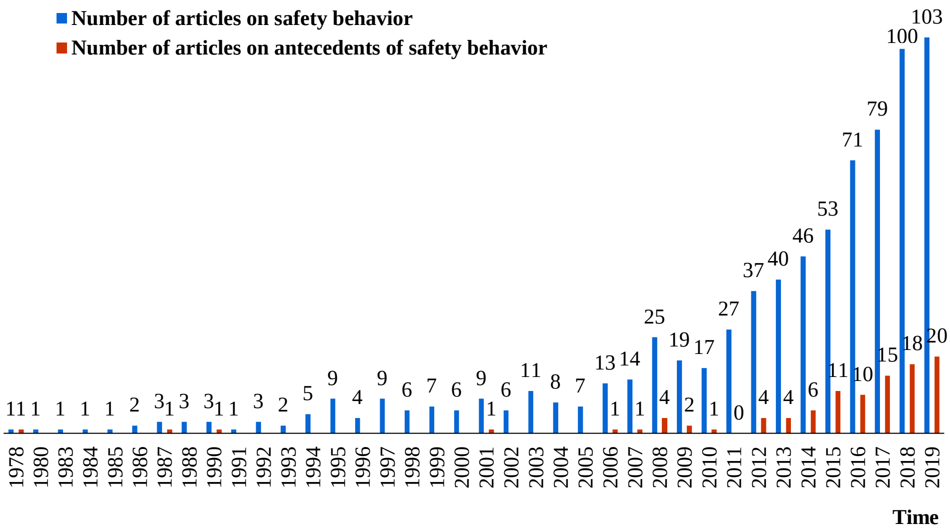

Fig. 3. Annual distribution of safety-behavior articles in construction from 1978 to 2019.
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3.3. Bibliometric and content analyses

To obtain descriptive and thematic information from the final 101 articles, we combined the techniques of bibliometric analysis and content analysis. For the descriptive analysis, we first used the VOSviewer text-mining tool for bibliometric analysis, generating results related to the influences of journals, scholars, and keywords. To detect deeper information about the reviewed articles, we also implemented content analysis for identifying the use of theory, research methods, and the country or region of the selected samples.

For the thematic analysis, through content analysis, we (a) identified specific factors influencing construction employees' safety behavior in each article (the criterion was that the factor should have a statistically positive, negative, or other empirical evidence-based influence on safety behavior) and (b) classified these factors into different groups, which were obtained inductively, namely during rather than before the process of thematic analysis.

During the content analysis, we used the Excel software to aid the qualitative and quantitative coding. The present first and second authors conducted the coding process. First, both authors coded five articles as a training exercise to establish a common frame of reference for coding. Once sufficient agreement was obtained with these five articles, the remaining articles were coded independently by the two coders. After initial coding, one checked the codes of the other. Discrepancies were resolved by discussion and by reviewing the relevant articles until complete consensus was reached between the two authors.

4. Descriptive results

4.1. Journal sources

Citation analysis of the journal sources was conducted using VOSviewer. Setting the minimum number of articles and citations as three and five, respectively, eight out of a total of 39 journals met the thresholds. In Fig. 4, the size of each node is a visual representation of the number of publications from a given journal, with a larger node indicating more publications. Accordingly, *Safety Science* (*SS*) published the most related articles (*N* = 20), followed by *International Journal of Environmental Research and Public Health* (*IJERPH*) (*N* = 11), *Journal of Construction Engineering and Management* (*JCEM*) (*N* = 9), *Journal of Management in Engineering* (*JME*) (*N* = 6), *International Journal of Occupational Safety and Ergonomics (IJOSE)* (*N* = 5), *Accident Analysis and Prevention* (*AAP*) (*N* = 4), *Journal of Safety Research* (*JSR*) (*N* = 4), and *Journal of Occupational Health Psychology* (*JOHP*) (*N* = 3). The thickness of the connecting lines indicates the relatedness among journals in terms of mutual citations. It can be seen that *SS* is closely related to *IJERPH*, *JCEM*, and *JME.* The journals in Table 2 are ranked according to their “Avg. norm. citation”; based on this index, *SS, JME*, *IJERPH*, and *AAP* are the most influential in the literature of antecedents of construction safety behavior.

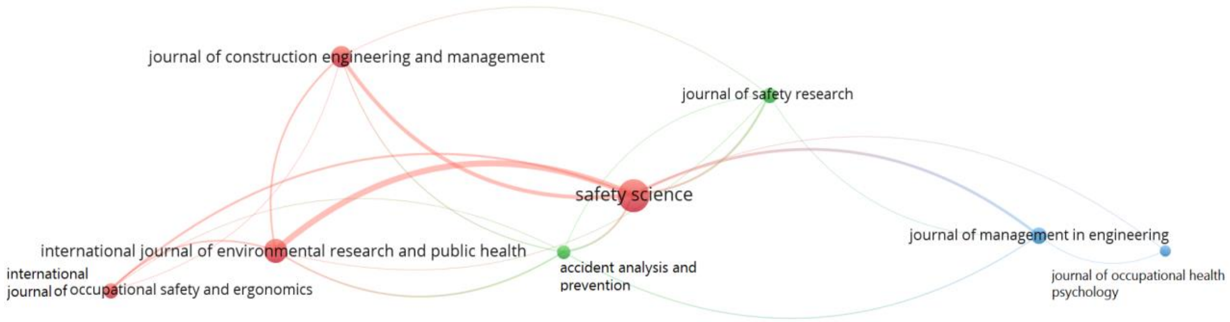

Fig. 4. Visualization of journal sources of the reviewed literature.

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Table 2

Quantitative measurement of journals' influence.

Journal	Number of publications	Total citation	Avg. citation	Norm. citation	Avg. norm. citation
Safety Science	20	1085	54.25	31.02	1.55
Journal of Management in Engineering	6	184	30.67	8.58	1.43
International Journal of Environmental Research and Public Health	11	67	6.09	15.46	1.41
Accident Analysis and Prevention	4	166	41.50	5.04	1.26
International Journal of Occupational Safety and Ergonomics	5	34	6.80	5.01	1.00
Journal of Construction Engineering and Management	9	260	28.89	8.78	0.98
Journal of Occupational Health Psychology	3	112	37.33	2.80	0.93
Journal of Safety Research	4	99	24.75	3.37	0.84

Notes: 1) This table includes the eight journals in Fig. 4. 2) When working with citation analysis, "Total citation" indicates the number of citations received by all documents published by a journal or an author, or the number of citations received by a document. "Avg. citation" indicates the average number of citations received by the documents published by a journal or an author, or the average number of citations received by the documents in which a keyword or a term occurs; it is calculated by dividing "Total citation" by the number of articles. "Norm. citation" indicates the total normalized number of citations received by all documents published by a journal or an author, or the normalized number of citations received by a document. For example, the normalized number of citations of a document equals the number of citations of the document divided by the average number of citations of all documents published in the same year and included in the data provided to VOSviewer. "Avg. norm. citation" indicates the average normalized number of citations received by the documents published by a journal or an author, or the average normalized number of citations received by the documents in which a keyword or a term occurs. For example, in this table, “Avg. norm. citation” represents the normalized citation per article of a given journal, which is calculated by dividing “Norm. citation” by the number of articles. The normalization corrects for the fact that older documents have had more time to receive citations than more recent ones (Van Eck and Waltman, 2017).

4.2. Scholar analyses

Citation analysis of the scholars was conducted using VOSviewer. Setting the minimum number of articles and minimum citations of an author as two and 25, respectively, 41 out of a total of 254 scholars met the thresholds and are visualized in Fig. 5. Here, the size of a node gives a visual representation of the number of publications by a given author, with a larger node indicating more publications. Accordingly, Fang D. (N = 11) and Chan A.P.C. (N = 5) were the most productive researchers. The thickness of the connecting lines indicates the relatedness among scholars in terms of mutual citations. It seems that Fang D. is at the core of the network, relating closely with many other scholars.

The scholars in Table 3 are listed according to their “Avg. norm. citation”. It is found that Wang X. and Xia N., although with only two articles in total from the literature sample, have the highest influence as measured by “Avg. norm. citation”. In terms of “Total citation”, Fang D., Pousette A., and Törner M. are the scholars with the highest contribution to the academic community of safety behavior antecedents in construction.

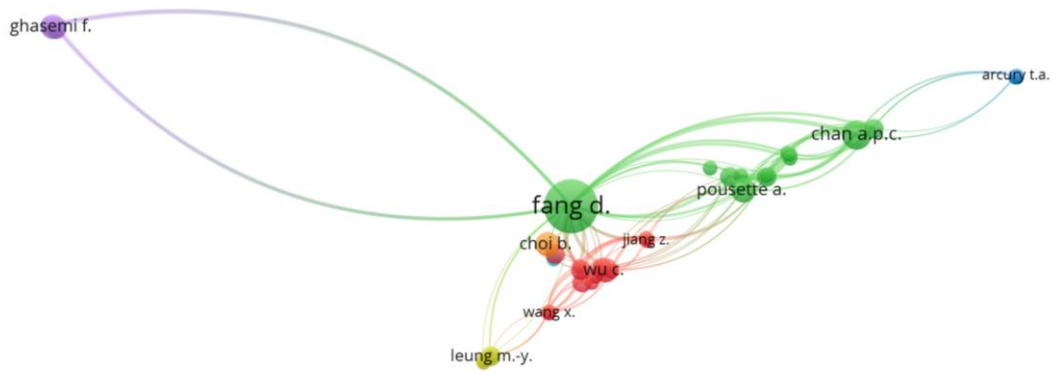

Fig. 5. Visualization of authors of the reviewed literature.

Note: Some of the 41 scholars in the network are not connected to each other; this figure displays the largest set of connected items consisting of 39 scholars.

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Table 3

Quantitative measurement of influence of scholars in the reviewed literature.

Author	Number of publications	Total citation	Avg. citation	Norm. citation	Avg. norm. citation
Wang X.	2	29	14.50	5.09	2.54
Xia N.	2	29	14.50	5.09	2.54
Guo B.H.W.	3	80	26.67	5.75	1.92
Cigularov K.P.	2	147	73.50	3.31	1.66
Wu H.	3	106	35.33	4.94	1.65
Wu C.	4	109	27.25	6.20	1.55
Rosecrance J.C.	2	71	35.50	2.94	1.47
Kalatpour O.	3	45	15.00	4.40	1.47
Moghimbeigi A.	3	45	15.00	4.40	1.47
Goh Y.M.	2	39	19.50	2.85	1.42
Chen P.Y.	3	170	56.67	4.24	1.41
Li N.	3	45	15.00	4.24	1.41
Mohammadfam I.	3	57	19.00	4.02	1.34
Hon C.K.H.	3	49	16.33	3.91	1.30
Ahn S.	2	31	15.50	2.60	1.30
Jiang Z.	2	70	35.00	2.56	1.28
Zhang M.	2	70	35.00	2.56	1.28
Ghasemi F.	4	61	15.25	4.98	1.25
Fang D.	11	740	67.27	13.40	1.22
Hoffmeister K.	2	60	30.00	2.43	1.22
Leung M.-Y.	3	100	33.33	3.29	1.10
Conchie S.M.	2	98	49.00	2.16	1.08
Chan A.P.C.	5	74	14.80	5.39	1.08
Choi B.	4	42	10.50	4.30	1.08
Lee S.H.	3	37	12.33	3.10	1.03
Hadikusumo B.H.W.	2	39	19.50	1.95	0.97
Liang Q.	2	43	21.50	1.94	0.97
Wang H.	2	36	18.00	1.72	0.86
Yu J.	2	63	31.50	1.63	0.81
Törner M.	3	212	70.67	2.22	0.74
Gao R.	2	25	12.50	1.47	0.74
Utama W.P.	2	25	12.50	1.47	0.74
Zahoor H.	2	25	12.50	1.47	0.74
Arcury T.A.	2	48	24.00	1.43	0.71

Grzywacz J.G.	2	48	24.00	1.43	0.71
Quandt S.A.	2	48	24.00	1.43	0.71
Summers P.	2	48	24.00	1.43	0.71
Pousette A.	4	217	54.25	2.63	0.66
Larsson S.	2	183	91.50	1.26	0.63

4.3. Keyword analyses

Keywords represent the core contents of existing studies and describe research topics within a given domain. Co-occurrence of keywords demonstrates the inter-closeness among them. By using “Author keywords” and “Fractional counting” in VOSviewer as recommended by Van Eck and Waltman (2017) and by setting the minimum occurrence of a keyword at two, 37 out of a total of 240 keywords were selected initially. Before this analysis, work was performed to remove general keywords such as “construction safety” and “construction industry.” By reading the articles, some keywords with similar semantic meaning were combined, such as “safety behaviour,” “safety behaviors,” “unsafe behavior,” “safety compliance,” “safety participation,” and “safety performance.”

Fig. 6 shows the final visualization of co-occurring keywords generated from VOSviewer. The size of a node gives a visual representation of the occurrence of a given keyword, with a larger node indicating higher occurrence. Obviously, the occurrence of the keyword “safety climate” was the highest, indicating high focus on this construct. The thickness of the connecting lines indicates the inter-relatedness among keywords. It can be seen that a large proportion of studies examined the relationship between safety climate and safety behavior. Since the 1990s, research on occupational safety has often treated safety climate as an antecedent of safety behavior (Guo et al., 2016; Hofmann et al., 2017). Psychological safety climate is defined as “individual perceptions of safety-related policies, practices, and procedures pertaining to safety matters that affect personal well-being at work” (Christian et al., 2009, p. 1106). When these individual perceptions are shared among individuals within a work group or an organization, a group- or organizational-level climate emerges (James et al., 1990; Zohar and Luria, 2005). The thickness of the connecting lines in Fig. 6 also shows that much attention was paid to construction workers’ safety behavior, which agrees with the review by Zhou et al. (2015). The relationship between safety behavior and leadership also attracted particular attention. Structural equation model was used frequently to analyze the relationships between safety behavior and its antecedents.

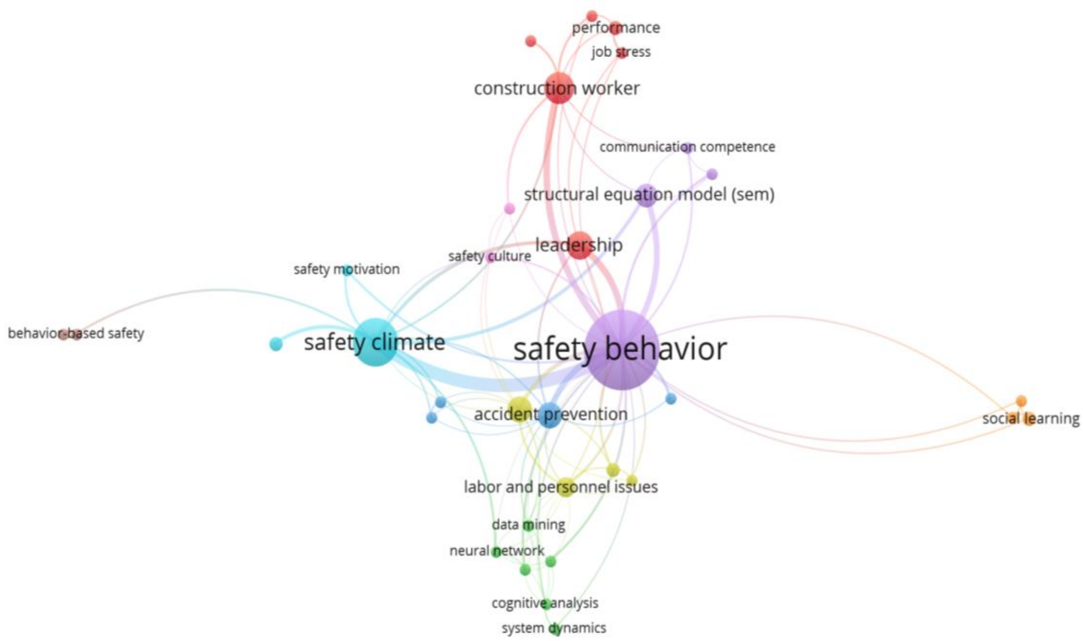

Fig. 6. Visualization of co-occurring keywords in the literature on antecedents of construction safety behavior.

Note: Some of the 37 keywords in the network are not connected to each other; this figure displays the largest set of connected items consisting of 34 keywords.

(column fitting: double)

4.4. Use of theory

Among the 101 papers, 47 lacked a theory to explain the linkages between antecedents and safety behavior (Fig. 7). Work performance theory, including social exchange theory and expectancy-valence theory on which work performance theory is based, prevailed in the current literature ($N = 13$) and were used to examine the relationships among safety climate, knowledge, skills, motivation, and safety behavior (Guo et al., 2016; Lyu et al., 2018). This dominance was consistent with the heavy focus on safety climate, knowledge, skills, and motivation (see Fig. 6 and the supplementary material titled “Antecedent”). Theory of planned behavior (Ajzen, 1991) was another frequently used theory ($N = 13$) to explain how safety behavior is related to safety attitudes, subjective norms, behavioral control, and behavioral intention (Goh et al., 2018). Theories of leadership were used by six articles, plausibly confirming the value of considering leadership as an antecedent of employee safety behavior (Clarke, 2013; Hofmann et al., 2017). For example, theories of leader–member exchange were used to explain how leader–member exchange exerted direct and indirect influences on worker safety behavior (He et al., 2019).

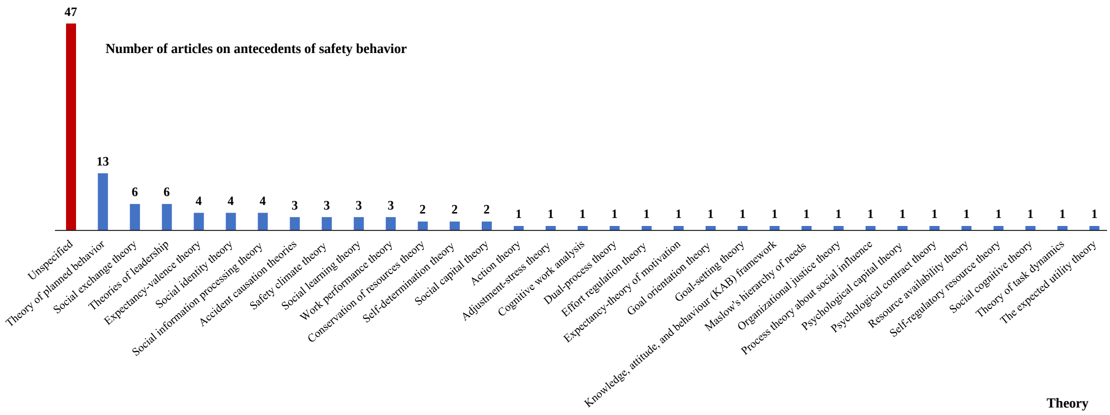

Fig. 7. Theory in the reviewed literature.

(column fitting: double)

4.5. Research methods

In terms of research methods (Table 4), questionnaire surveys dominated the reviewed literature (N = 75), two papers combined an interview and a questionnaire, nine papers used experiments, eight papers used simulation methods, and seven papers used qualitative methods (e.g., field observation, interview, and focus-group discussion). In-depth analysis was conducted to classify the 77 studies that used questionnaires, in terms of their research design, level of analysis, source of predictor, and source of safety behavior. For detailed information about research methods, see the supplementary material titled "Research method".

Among the 77 papers that used questionnaires, only two papers employed longitudinal research design (i.e., Arcury et al., 2012; Tholén et al., 2013). This indicates that most of the literature used cross-sectional data, therefore addressing only associations between antecedents and safety behavior and not causal relationships. Regarding the level of analysis, only eight papers established hierarchical linear models (e.g., Wang et al., 2018a), while the majority remained at the individual level. For example, although safety climate can be an individual-, group-, or organizational-level construct (Hofmann et al., 2017; Zohar and Luria, 2005), the majority of the reviewed studies have tested its individual-level linkage with safety behavior; few have tested for cross-level effects. This finding is consistent with that of Shen et al. (2015), who reviewed safety climate studies in construction since 2000 and found they focused primarily on the factor structure of psychological safety climate and the predictive relationships between psychological safety climate and related outcomes. For the 77 articles that used questionnaires, when measuring predictors, only two used data collected from different sources (i.e., Kao et al., 2016; Kao et al., 2019), while the other 75 articles collected data from the research subjects themselves; when measuring safety behavior, 72 articles used subjects' self-reported data, four used observation/archival data (e.g., Goh et al., 2018), and one used ratings of workers themselves and their supervisors (i.e., Conchie and Donald, 2009). A majority of the questionnaire surveys (70 of 77) used single-source self-reported data, therefore common method variance may exist.

Table 4

Research method in the reviewed research.

Research method	Total	Research design			Level of analysis		Source of predictor			Source of safety behavior		
		Concurrent	Time-lagged	Longitudinal	Individual level	Multi-level	Self	Multi-source	Manipulated	Self	Observation/ archival	Multi-source
Questionnaire	75	71	2	2	67	8	73	2	0	70	4	1
Questionnaire & Interview	2	2	0	0	2	0	2	0	0	2	0	0
Experiment	9	—										
Empirically-based simulation	8	—										
Qualitative methods	7	—										
Total	101	73	2	2	69	8	75	2	0	72	4	1

Notes: 1) The number in a cell represents the number of reviewed articles. 2) Research design, level of analysis, source of predictor, and source of safety behavior were analyzed among questionnaire and experimental papers. Individual level: both predictors and safety behavior were analyzed at the individual level. Multi-level: predictors and safety behavior were hypothesized and tested at more than one level. 3) Self: predictors or safety behaviors were rated by the research subjects of a given study. Multi-source: a single variable was measured by combining data from multiple sources, or two different variables were measured with data from two separate sources. Manipulated: predictors were manipulated through experiments. Observation/archival: safety behavior was observed or recorded by an observer (e.g., supervisor), video, report, etc.

4.6. Empirical samples

The countries or regions represent where empirical data were collected. Fig. 8 shows the distribution of these places: the size of each node is a visual representation of the number of samples from a given country or region, with a larger node indicating more samples. The number of samples from the Chinese construction industry (*N* = 28) ranked the first, followed by the United States (*N* = 19) and Hong Kong, China (*N* = 14). Only two papers used samples from different countries to test the role of culture in determining employee safety behavior (Choi and Lee, 2017; Lim et al., 2018).

Fig. 8. Number of empirical samples distributed by country or region.

(column fitting: double)

5. Thematic results

After reviewing the 101 papers, 83 factors were identified as influencing construction employees' safety behavior (see details in the supplementary material titled "Antecedent"). During the review, factors with equal meaning or implication were merged. These 83 antecedents were further condensed inductively into five categories. The largest number of articles (*N* = 64) focused on factors relating to workgroup interactions, followed by individual characteristics (*N* = 52), project management and organization (*N* = 52), work and workplace design (*N* = 26), and family, industry, and society (*N* = 10). Although workers' safety behavior can be largely influenced by stimulus at the workplace, the reviewed research also noticed possible influences from other domains such as family, as well as industry and society.

5.1. Individual characteristics

5.1.1. Physical condition

The physical condition of the labor force plays a critical role in the diminution of safety-oriented activities on the part of construction employees, this being because many construction activities are arduous and require intensive physical energy. Fatigue reduces workers' ability to concentrate and think clearly, and hence act appropriately (Mohammadi et al., 2018; Seo et al., 2015). Also, factors outside working hours (e.g., insomnia) can also decrease employees' safety behavior (Kao et al., 2016). Suffering such physical stress, they may also exhibit unsafe behavior such as taking shortcuts to get their work done as quickly as possible to alleviate their physical symptoms (Fang et al., 2015a). Furthermore, Murray et al. (1997) indicated that at a relatively low fatigue level, a worker's unsafe behavior was due mainly to the failure of hazard perception; however, as fatigue accumulated, its impact on the worker's motor control capacity became significant. Conversely, Leung et al. (2012) found that construction workers who suffer physical stress were more likely to behave safely. This may be because workers who are suffering poor physical conditions, such as back pain, will lower their work pace and thus have time to consider thoroughly each step of their tasks, thereby reducing the chance of overlooking safety behavior during construction work (Leung et al., 2012).

5.1.2. Psychological condition

The reviewed literature also recognized the role of individual psychological condition in the occurrence of safety behavior. When confronted with potential hazards on construction sites, workers' cognitive failures may occur in the five processes of obtaining information, understanding information, perceiving responses, selecting a response, and taking action, thereby resulting in unsafe behavior (Fang et al., 2016; Johnson et al., 2019). Furthermore, Kao et al. (2016) pointed out that poor physical conditions resulting from insomnia would limit employees' ability to utilize their cognitive resources for displaying safety behavior. Bad emotions and emotional exhaustion would also exert negative influences on worker safety behavior (Ju et al., 2016; Zhang et al., 2016). Furthermore, Leung et al. (2012) stated that only moderate levels of emotional stress lead to a higher level of safety behavior, while too much or too little emotional stress results in poor safety behavior. Supervisors were advised to pay attention to workers' psychological problems and maintain good relationships (Choudhry and Fang, 2008).

5.1.3. Personal traits

The determinants of performance represent the proximal causes of variability in performance. Work performance theory demonstrated the important determinants of individual work behavior to be what she/he knows, what she/he can do, and what she/he wants, namely knowledge, skills, and motivation (Campbell et al., 1993). The reviewed literature also confirmed this argument with rich empirical evidence. Construction workers' safety knowledge, safety skills, and safety motivation were all positively related to safety behavior (Lim et al., 2018; Shin et al., 2015; Zhang et al., 2016). Intention, a similar construct to motivation, is "assumed to capture the motivational factors that influence a behavior", an indication "of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1991, p. 181). The theory of planned behavior postulates that the intention of an individual is the determinant of the actual behavior. The reviewed literature confirmed it as an antecedent of safety behavior (Goh and Binte Sa'Adon, 2015; Goh et al., 2018; Jitwasinkul et al., 2016; Liao et al., 2017). The stronger an employee's intention to engage in safe behavior, the more likely should be her/his safety performance. Based on the theory of planned behavior, predictors of behavioral intention—individual attitudes, perceived behavioral control, and perceived safe or unsafe behavior norms—also had significant associations with safety behavior[1] (Jitwasinkul et al., 2016; Choi and Lee, 2017).

[1] Perceived norms are mentioned here to convey the full theory of planned behavior; this variable was grouped in the categories of workgroup interactions, project management and organization, or family, industry, and society.

Individuals' general and inherent qualities such as communication competence, self-efficacy, and learning goal orientation were substantiated to promote safety behavior (He et al., 2019; Lu et al., 2018; Wang et al., 2018b). In contrast to generic occupational safety literature where evidence substantiates the value of considering personality traits as key correlates to safety behavior (Beus et al., 2015), few studies in the construction field examined these relationships. One exception is Landeweerd et al. (1990); however, unsafe behavior of construction workers was found not to relate to their risk-taking tendency (dimension of the "sensation seeking" personality trait). Another is Seo et al. (2015), finding that personality traits (neuroticism, extraversion, openness, agreeableness, conscientiousness) did not affect safety behavior directly but did so indirectly through the mediating variables of job stress, self-perceived fatigue, safety culture, and safety climate. More studies are warranted because a small subset of accident-prone employees accounted for a large proportion of accidents (Visser et al., 2007); training of these vulnerable people is of great importance.

Other individual background variables such as age, gender, education, work experience, and work position were seldom included as the focus of study in the reviewed literature. Rather, they were usually treated as control variables (e.g., Kaufman et al., 2014; Xia et al., 2017). This finding is consistent with the review on causes of workplace safety violation (Alper and Karsh, 2009) and of safety performance in construction sites (Khosravi et al., 2014; Mohammadi et al., 2018). This scarcity in examining the effects of demographic variables on safety behavior is understandable in part because contextual causes are under the control of organizations and thus are more amenable to intervention. Nevertheless, the literature contains conflicting relationships between demographic variables and safety behavior. For example, Chen et al. (2013) found that both younger workers (below 30 years old) and older workers (above 50 years old) tended to have lower rates of safety violation.

5.2. Workgroup interactions

5.2.1. Group identity and cohesiveness

The construction industry is typically characterized by a temporary workforce, subcontracting, and varying job sites away from the contractor's office (Schwatka and Rosecrance, 2016). These characteristics lead to a workforce that is relatively disconnected from top management and interacts more within the workgroup (Choi et al., 2017). Thus, it is understandable that many studies have investigated factors associated with the workgroup. High quality leader–member exchange and a positive safety knowledge transfer environment within groups would promote worker safety behavior (He et al., 2019; Huang and Yang, 2019). The reviewed literature has substantiated the importance of group safety climate for worker safety behavior. Brondino et al. (2012) further confirmed two important dimensions of group safety climate[2], namely supervisor's safety climate and coworkers' safety climate, which reflected the priority that workers perceived their supervisor and coworkers, respectively, gave to safety issues. Similarly, if workers perceived great social pressure from their groupmates to perform safety behavior (i.e., group norms to safety behavior), they were likely to do so (Andriessen, 1978; Ju et al., 2016). Workers' group identity would strengthen the positive effect of group norms on safety behavior (Choi et al., 2017).

5.2.2. Supervisor influence

Long ago, Heinrich and Granniss (1959) pointed out that "The supervisor or foreman is the key man in industrial accident prevention. His application of the art of supervision to the control of worker performance is the factor of greatest influence in successful accident prevention." If the supervisor showed poor support for safety, then construction workers would question her/his leadership behavior (Xin et al., 2003). Even more seriously, supervisors may bend safety rules in pursuit of production (Liang and Zhang, 2019). In this scenario, the workers are likely to ignore supervisors' instructions and even flout safety rules and work in their preferred manner (Leung et al., 2016). However, supervisors can be helpful in inducing worker safety behavior when they model safe behaviors, put safety before production, raise and openly

[2] Dimensions of safety climate range from workgroup interactions to work and workplace design, and project management and organization (see details in the supplementary material titled "Antecedent"). We discuss the relevant dimensions in the respective categories of antecedents.

discuss safety issues, and encourage reporting when workers feel unsafe (Kao et al., 2016; Schwatka and Rosecrance, 2016). If supervisors demonstrated training and preventive actions, then safety climate at the group level would increase which subsequently improved safety behavior of construction workers (Fang et al., 2015b; Zhang et al., 2017).

Fig. 6 shows that leadership was studied heavily in relation to safety behavior. Further qualitative analysis showed that the focus was on supervisors' leadership, while managers' leadership received little attention (see details in the supplementary material titled "Antecedent"). Burns and Conchie (2014) showed that safety-specific transformational leadership impacted employees' safety behaviors directly or through intrinsic motivation. Furthermore, supervisors' support for safety and their general leadership can produce an interactive effect on worker safety behavior: leader justice, irrespective of context, was associated with lower safety performance when leaders were not supportive of safety (Kaufman et al., 2014). Supervisors who are considerate and open to workers' problems (i.e., open leadership) were likely to regard safety of their subordinates as important, which then increased workers' safety participation (Andriessen, 1978). Another similar finding is in Talabi et al. (2019): supervisors' respected personal qualities such as behavioral integrity would enhance workers' safety behavior. This evidenced the importance of general leadership and respected personal qualities of supervisors, consistent with Gittleman et al. (2010) suggesting that "talking the talk" and "walking the walk" may be more important than engaging in particular motivating, stimulating, coaching, or rewarding behaviors. Essentially, leadership is a complex, multi-dimensional construct, and there is reason to suspect that different facets of leadership may affect employee safety behavior in different ways. Hoffmeister et al. (2014) found that immediate supervisors' less concrete aspects of leadership (i.e., idealized attributes and behaviors; dimensions of transformational leadership) accounted for the most variance in construction workers' safety compliance and participation, whereas individualized consideration (dimension of transformational leadership) and active management-by-exception (dimension of transactional leadership) frequently accounted for the least amount of variance.

5.2.3. Coworker influence

In a meta-analysis, Chiaburu and Harrison (2008) found that coworkers influenced each other even after accounting for managerial influences. Research showed that if workers perceived that their coworkers extended support and were committed to safety (manifestations of coworker safety climate), their safety behavior would increase (Fang et al., 2006; Schwatka and Rosecrance, 2016; Zhou et al., 2008). However, safety violation by coworkers will induce worker safety violation; for example, routine safety violations by coworkers may lead to an increase in perceived production pressure and attitudinal ambivalence of workers, subsequently leading them to perform routine safety violation (Liang et al., 2018). In addition, some workers demonstrated unsafe behavior because of negative peer pressure, namely to prove that they are "tough guys" and to avoid being teased by their coworkers (Choudhry and Fang, 2008). Using an experiment with a multi-user virtual reality system, Shi et al. (2019) validated that workers' safety behavior can be influenced by their coworkers in two opposing ways: positive reinforcement by demonstrating preferred behaviors, and negative reinforcement by demonstrating negative consequences of inappropriate behaviors. Specifically, workers were encouraged to follow the demonstration and maintain normal walking in a hazardous situation when observing an avatar demonstrating appropriate walking behaviors, whereas they tended to walk faster and more irregularly and then demonstrated unsafe behavior when observing an avatar walking quickly across a plank and falling off.

5.3. Work and workplace design

5.3.1. Work and workplace physical environment

Construction work always involves various hazards (e.g., working at height), and the physical work environment (e.g., excessive noise) tends to be poor (Leung et al., 2016). Researchers have advocated physical work environment as a component of safety climate in construction sites (e.g., Mohamed et al., 2009). Workers' perceptions of risks and hazards related to their work and workplace can influence their safety behavior through cognition and/or emotional pathways (Sun et al., 2019; Xia et al., 2017). Workers may compare perceived risk and their risk acceptance levels to determine safety behavior (Choi and Lee, 2018). Considering the innate interaction among human behavior, work, and workplace conditions, ensuring the safety of the various tasks and the workplace can help improve safety behavior of workers. Design for safe work and workplace in the initial planning phase has long been underscored in generic occupational safety research (Pybus, 1996). The reviewed construction articles also give importance to this issue, such as designing comfortable personal protective equipment and designing safe working process for hazardous activities (Arcury et al., 2014), as well as designing a safe workplace to prevent workers from being tempted to implement unsafe actions (Stege et al., 2019). Sun et al. (2019) developed a system dynamics model that delineated the iterative influence between workplace design factors and human error, finding that the design factor “direct constraints on objects” had the most significant impact on worker safety behavior. For example, in the case of designing an elevator, if the bearing capacity of the lifeline was inadequate or unknown, most of the interviewed workers (over 60%) abandoned their harness or connected it to convenient but unreliable scaffolding (Wang et al., 2017).

5.3.2. Job and role characteristics

As well as engineering design for safety, appropriate social design of job and role characteristics can improve employee safety behavior. Positioned at the lowest level of an organization or project, construction workers usually have limited control over rewards and resources in their work (Leung et al., 2012). Research found that job characteristics (e.g., influence at work and possibilities for personal development) can increase safety behavior (Larsson et al., 2008), whereas role characteristics (e.g., role ambiguity, role conflict, and role overload) can reduce safety behavior (Enshassi et al., 2015; Wang et al., 2018b).

5.4. Project management and organization

5.4.1. Project management

The reviewed literature particularly stressed the role of safety-specific cues at the project level, including safety management systems, participatory programs, and management commitment to safety and production; employees' perception of these (manifestations of safety climate) would affect their safety behavior either directly (Arcury et al., 2012) or indirectly (e.g., via safety motivation and safety knowledge; Larsson et al., 2008). Safety management systems include organizing and planning, establishing safety policies, rules, and procedures, providing training and learning, providing safety resources (e.g., equipment, materials, and facilities), and establishing appropriate reward systems (Asilian-Mahabadi et al., 2018; Li et al., 2018; Seo et al., 2015; Stege et al., 2019; Wu et al., 2018). In addition to such top-down management, involving workers in safety programs—especially establishing two-way communication systems—will improve employee safety behavior by improving mutual understanding, perception, and awareness of hazards, as well as by stimulating their motivation to engage in safety behavior (Jitwasinkul et al., 2016; Stege et al., 2019). This finding is consistent with other research suggesting that it is not just management participation and involvement in safety activities that is important, but the extent to which management encourages the involvement of the workforce (Niskanen, 1994).

That said, effective safety management systems and participatory programs are not possible without management commitment. Management's lack of safety support and its prioritizing of production contributed to unsafe behavior of workers (Aksorn and Hadikusumo, 2007; Arcury et al., 2014), whereas management safety commitment was the factor of utmost importance for a satisfactory level of employee safety (Choudhry and Fang, 2008; Jitwasinkul et al., 2016). Management safety commitment was considered as one of the most fundamental safety climate factors across various high-risk occupations (Flin et al., 2000; Neal and Griffin, 2004). Neal and Griffin (2004) defined management safety commitment as "the extent to which management is perceived to place a high priority on safety and communicate and act on safety issues effectively" (p. 27).

When attitude and leadership style of the supervisor were excluded, it still held that workers would work more safely if they saw that safety definitely had a place in the policy of the higher-level management (Andriessen, 1978). This highlights the critical role of managers in the project: although the direct supervisor may show positive interest in safety, workers will still work less safely if they realize that managers have little interest in safety. Concerted efforts should be made by managers of all the key parties in construction, namely clients, general contractors, and subcontractors), because the management of the former can influence the latter (Mohammadi et al., 2018) and together they create a project-level safety climate (Asilian-Mahabadi et al., 2018; Cigularov et al., 2010). Collaboration among managers and employees from different parties may also help workers to identify with the project, which will bring about benefits for employee safety behavior. Specifically, workers' identity with the project was found to be significantly lower than that with workgroups; however, if strong project identity can be developed among workers, this would strengthen the positive effect of perceived management norms on safety behavior (Choi et al., 2017).

5.4.2. Organization factor

Organizations in the construction industry are project-based ones in which the project is the most important unit for production (Bakker, 2010). Thus, project management on safety is subject to parent organizations. Construction workers showed relatively low identity with their organizations, but if they could be motivated to commit to their organizations, then their safety participation behavior would increase (Asilian-Mahabadi et al., 2018; Shin et al., 2015). The reviewed literature showed that positive safety climate within organizations would either increase safety behavior directly, or reinforce the positive effects of individual safety awareness on safety behavior (Wang et al., 2018a). Furthermore, by demonstrating transformational leadership style, organizational managers can create positive safety organizational culture to influence employee safety behavior (Skeepers and Mbohwa, 2015).

The reviewed literature pointed out the importance of clients in the contract definition phase. Specifically, no specific resource allocation for safety, safety requirement included as contract addenda and not as main contract clauses, and a tight schedule would create constraints within which general contractors, subcontractors, and subsequently their workers have to operate unsafely (Asilian-Mahabadi et al., 2018). As another key party, if contractors had low competency (e.g., insufficient and/or improper resource allocation, high subcontracting rate, inadequate workforce, and delays in payments to workers), then unsafe behavior of workers would increase (Asilian-Mahabadi et al., 2018). The reviewed literature also indicated that workers in small construction companies tended to show low levels of safety behavior (Arcury et al., 2014). However, Guo et al. (2018) showed that although workers from large companies demonstrated significantly higher levels of safety climate dimensions (e.g., management commitment to safety and social support), workers from small and large companies understood the safety climate measure in a similar manner, and company size did not change the way by which safety climate influenced safety behavior.

5.5. Family, industry, and society

5.5.1. Family domain

Family is another salient domain that can exert cross-domain effects on employee behavior at work (Xia et al., 2018b). Pressure to support their families may cause workers to work quickly and hence ignore safety rules, or to suffer distraction and depleted resources that subsequently lead to unsafe behavior (Arcury et al., 2014; Johnson et al., 2019). On the other hand, if family members and friends who are important to workers encouraged them to work safely (i.e., family norms to safety behavior), then they would behave safely at work (Peng and Chan, 2019).

5.5.2. Industry and society

Chen et al. (2013) found that safety performance (e.g., employee safety violation) of a general contractor varied significantly across six regions, but they did not explore which factors contributed to such behavioral difference across regions. According to Andersen et al. (2015) and Choi and Lee (2017), this difference may be due to the difference in industrial employment modes and cultural context. For employment modes in the construction industry, Dedobbeleer et al. (1990) found higher safety behavior levels among union workers than nonunion workers. Because of the system of direct hiring in Saudi Arabia, workers had a salient project identity that influenced the process through which social norms affected individual safety behavior

(Choi and Lee, 2017). The individualistic culture in the United States led to significant direct effects of attitudes on safety behavior, while the collectivistic culture in Korea brought about the significant effects of perceived management and workgroup norms on safety behavior (Choi and Lee, 2017). Mohamed et al. (2009) also demonstrated the role of national culture, namely that workers with higher collectivism and higher uncertainty avoidance were more likely to have safety awareness and beliefs and thus exhibited safer on-site behavior. Although the positive effect of safety climate on safety behavior via safety motivation has been largely evidenced, the differences in national culture in terms of individualism–collectivism, power distance, and uncertainty avoidance may explain why this relationship differed in Chinese and Malaysian samples (Lim et al., 2018). For the Chinese sample, safety competence and supportive environment were strong antecedents of intrinsic and identified motivation, which then drove safety participation; for the Malaysian sample, safety commitment and safety communication predicted intrinsic motivation and then both safety compliance and safety participation. By employing a qualitative method, Asilian-Mahabadi et al. (2018) recognized economic and social conditions as factors influencing unsafe behavior. They stated that clients would possibly suffer economic, social, and political pressures in the development of a project; for example, they may have to deliver projects before the scheduled time (Asilian-Mahabadi et al., 2018). Such pressures may produce production pressure down at the project and workgroup levels, and then influence employee behavior (Mohammadi et al., 2018).

6. Integrated conceptual framework and key future avenues

Christian et al. (2009) pointed out that much of the behaviorally oriented occupational safety research is plagued by unclear conceptualizations of constructs, lack of theory, and weak methodology. Focusing on the construction field, unfortunately our review also confirmed these shortcomings. First of all, because a large proportion of studies (57 of 101) did not provide a clear definition of safety behavior, we believe that clearly conceptualizing and defining the safety behavior construct serves as a basic element in future research.

As evidenced in the previous section, the causes of safety behavior are manifold; however, there has been little research that establishes a theoretical model encompassing and systematically grouping the wide array of those antecedents. Almost half of the reviewed articles (47 of 101) lacked theoretical guidance, indicating that the literature to date has not examined adequately why, how, and when certain antecedents have a positive or negative effect on safety behavior. Therefore, above all, we suggest that future research on the formation of safety behavior would have more impact, in not only the construction field but also other risk-critical occupations, if scholars were to use theories to explain the underlying mechanisms linking antecedents with safety behavior. The studies that were based on theory used different theories, perhaps because there is no unifying theory of safety behavior at this time or perhaps because the causes of safety behavior are multi-factorial (Alper and Karsh, 2009).

As an attempt, we develop (a) a safety behavior antecedent analysis and classification model synthesizing the five groups of antecedents and then (b) a resource flow model explaining the linkages between the five-group antecedents and safety behavior. These two models were developed by combining bioecological system theory (Bronfenbrenner, 1994) and resources theories, including conservation of resources theory (Hobfoll, 1989), job demands–resources theory (Bakker and Demerouti, 2017), and work–home resources model (ten Brummelhuis and Bakker, 2012). Bioecological system theory is selected because it is able to integrate and group numerous safety behavior antecedents into different aspects of “The Self–Work–Home–Industry/Society” systems, thereby providing a holistic picture of the causes of safety behavior. Resources theories are selected because they are able to describe why, how, and when the five-system antecedents work in concert to create situations in which safety behavior is promoted or prevented, thereby illustrating the underlying theoretical mechanisms relating safety behavior and its numerous antecedents in a unified way from a resource flow perspective. Based on these two models and considering the key findings in the descriptive and thematic analyses, we point out potential theoretical avenues worthy of more investigation and also provide suggestions for rigorous research designs and methods facilitating the future theoretical development.

6.1. Integrated conceptual framework for safety behavior

6.1.1. Safety behavior antecedent analysis and classification model

Similar to the occurrence of an accident, the demonstration of safety behavior seems to be a combination of many factors (Choudhry and Fang, 2008; Mohammadi et al., 2018). However, a theoretical model that elucidates systematically the causes of safety behavior is still lacking. We propose a safety behavior antecedent analysis and classification model, arguing that safety behavior is only an ostensible symptom of a more complex system, and causes of safety behavior can be attributed to different aspects of "The Self–Work–Home–Industry/Society" systems (Fig. 9). Below, we introduce propositions within this model.

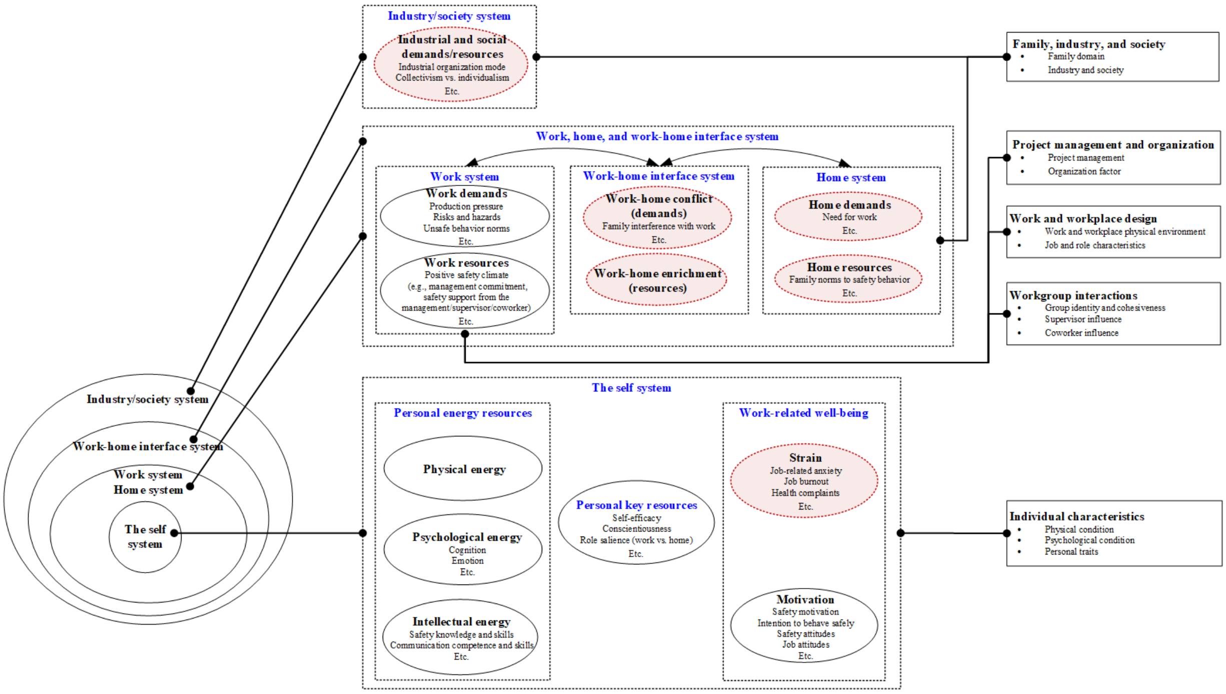

Fig. 9. Safety behavior antecedent analysis and classification model.

Note: The factors in the red ellipses received less attention than did those in the black ellipses.

(column fitting: double)

Proposition 1: Multiple systems. Biecological system theory posits that personal development can be determined by the combination of different systems, comprising the self system as the core and surrounded by several other systems (Bronfenbrenner, 1994). As shown in Fig. 9, the identified five categories of antecedents relate to different systems, namely safety behavior is an ostensible symptom of more complex "The Self–Work–Home–Industry/Society" systems. Microsystems (i.e., the work system and the home system) are used to describe interpersonal relationships and social roles that enable individuals to interact with the social context. Mesosystems (i.e., the work–home interface system) are conglomerates of two microsystems, including the linkage between those two domains. Macrosystems (i.e., the industry and society system) refer to cultural values, political environment, and economic prosperity. The work, home, work–home interface, and industry and society system is the environmental system external to the self system. Fig. 9 shows samples of safety behavior antecedents in each system.

Proposition 2: Contextual demands and resources within the environmental system. The second proposition is that antecedents relating to the environmental system can be categorized into two groups: contexctual demands and resources. Demerouti et al. (2001) categorized stimuli in the work domain into job demands and resources. By combining the concepts of hindrance and challenge job demands (Bakker and Demerouti, 2007; Cavanaugh et al., 2000), we categorize one group of antecedents to a specific environmental system as *contextual demands*. For example, *work demands* refer to those physical, psychological, social, or organizational constraints of the job that require sustained physical and/or psychological (cognitive and emotional) effort and interfere with or inhibit an individual's ability to achieve valued goals. Contextual demands are stressors specific to a context (ten Brummelhuis and Bakker, 2012). The other group is *contextual resources*. For example, *work resources* refer to "those physical, psychological, social, or organizational aspects of the job that are functional in achieving work goals, reduce job demands and the associated physiological and psychological costs, or stimulate personal growth, learning, and development" (Bakker and Demerouti, 2017, p. 274).

Proposition 3: Energies, key resources, and work-related well-being within the self system. The third proposition is that antecedents relating to the self system can be categorized into three different but related groups, namely energies, key resources, and work-related well-being. Hobfoll (1989) posited that *energies* constitute one category of personal resources and include such resources as physical energy and knowledge; these resources are typified not by their intrinsic value so much as their value in aiding the acquisition of other types of resources. We further categorize energy resources into *physical energy*, *psychological energy*, and *intellectual energy*. The first two are *volatile resources* that are either fleeting—in that once they are used, they cannot be used for other purposes (e.g., physical energy)—or temporal, such as attention and focus (which reflect psychological states that come and go) (ten Brummelhuis and Bakker, 2012). The final intellectual energy is *structural resources*, which are more durable assets because they can be used more than once and last for longer (ten Brummelhuis and Bakker, 2012). *Key resources*, such as self-efficacy and optimism, refer to personal management resources that facilitate the selection, alteration, and implementation of other resources (Thoits, 1994). Key resources are different from other personal traits such as skills and knowledge, because the latter are less inherent to a person than are key resources—for example, knowledge can be transferred more easily than can optimism. Work-related well-being includes both negative (strain such as job-related anxiety) and positive (motivation such as safety motivation) aspects (Bakker and Demerouti, 2017; Teoh et al., 2020).

6.1.2. Safety behavior resource flow model

Based on the safety behavior antecedent analysis and classification model, we further propose a resource flow model (Fig. 10). Specifically, we argue that the mechanisms through which safety behavior occurs can be illustrated by the flow of resources between the five systems, namely the self system, work system, home system, work–home interface system, and industry/society system. Bioecological system theory implies that there are many material circulations and energy flows in the interactions of the self system and the surrounding systems (Bronfenbrenner, 1994; Tansley, 1935), but it fails to describe adequately how energy flows and how that flow impacts individual attitudes, well-being, or behavior. Therefore, we further combine bioecological system theory with theories of resources to explain the mechanisms linking the five-system antecedents and safety behavior. Propositions within this model are introduced below.

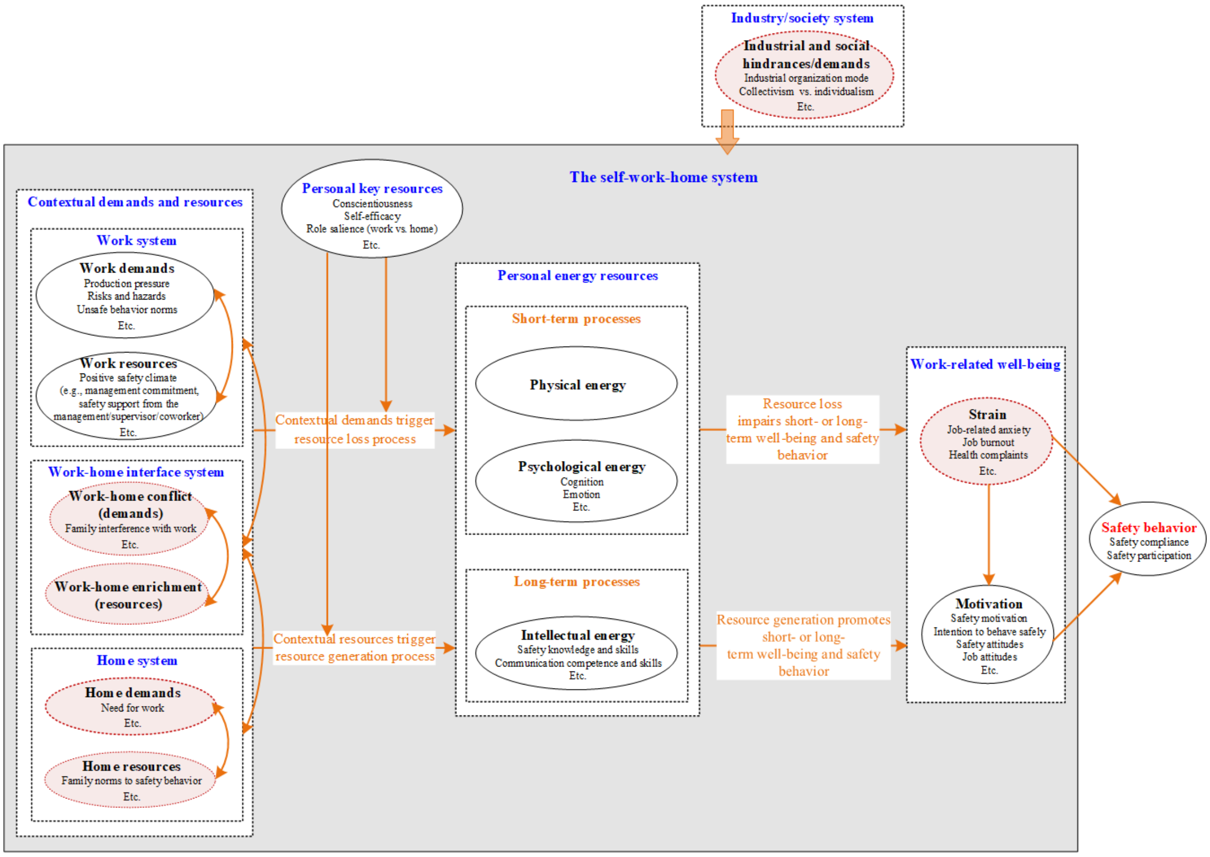

Fig. 10. Safety behavior resource flow model.

Notes: 1) Contextual demands and resources such as safety climate may also influence safety behavior directly, but for simplicity we do not illustrate such direct paths because our focus is to elucidate why, how, and when these paths unfold. 2) Industrial and societal factors such as safety legislation may also influence employee safety behavior directly, but this model is focused on how these factors influence the mechanisms through which safety behavior occurs.

(column fitting: double)

Proposition 1: Resource loss. The first proposition is that contextual demands will diminish personal energies and then impair well-being, resulting in diminished safety motivation and behavior. For example, production pressure (a contextual demand) will consume physical energies, as well as attention and cognitive psychological energies; the loss in energy resources will raise strain (Bakker and Demerouti, 2017; Hobfoll, 2002), such as anxiety. To prevent the loss of energy resources and relieve consequent strain, individuals will take measures to protect resources (Halbesleben and Bowler, 2007; Hobfoll, 2002), such as decreasing their motivation for and levels of safety behavior because demonstrating such behavior requires the investment of personal energies (Kao et al., 2016).

Proposition 2: Resource generation. The second proposition is that contextual resources will promote personal energies and then improve well-being, resulting in enhanced safety motivation and behavior. For example, positive safety climate will improve individuals' safety knowledge and skills; the gain in resources will make individuals stay healthy (Hobfoll, 2002), and then tend to adopt resource investment strategies (Halbesleben et al., 2014), such as more motivation to devote personal resources for displaying safety behavior.

Proposition 3: Cross-system effects. The third proposition is that work–home conflict—including work-to-home conflict and home-to-work conflict—as cross-system demands will also trigger resource depletion and then health impairment processes, resulting in diminished safety motivation and behavior. For example, role ambiguity at work subtracts from the finite cognitive resources available to the individual, making it difficult to meet the demands in the home domain and thereby creating work-to-home conflict (Pleck, 1977). Such conflict will deplete personal resources and impair well-being (Frone et al., 1997), subsequently damaging the motivation for and levels of safety behavior. Conversely, work resources (such as leader support) may help employees to cope with issues in the home domain, thereby creating work-to-home enrichment (Tang et al., 2014). Work–home enrichment—including work-to-home enrichment and home-to-work enrichment—as cross-system resources will in turn trigger resource accumulation and then health enhancement processes (Greenhaus et al., 2006), thereby promoting safety motivation and behavior.

Proposition 4: Demands and resources coupling. The fourth proposition concerns the interactions between demands and resources within a system and across systems, considering that resources are not independent but related to each other (resource caravans principle; Hobfoll, 2012; Hobfoll et al., 2018). Extending this view, we propose that interactions exist within resources but also demands. Specifically, we propose that "demand × demand" within a system (e.g., production pressure × workgroup unsafe behavior norms) or across systems (e.g., production pressure × work–home time conflict × home complaints) will result in more severe resource loss and subsequent detrimental effects. On the contrary, "resource × resource" within a system or across systems will generate more personal energy resources, subsequently benefiting individual well-being and then safety behavior. In addition, based on the interactions within job demands–resources theory (Bakker and Demerouti, 2017), we propose that different combinations of demands and resources (e.g., "high work demand—low home demand—low work resource—high home resource" versus "high work demand—high home demand—low work resource—high home resource") will produce either stronger or weaker resource loss and gain.

Proposition 5: Boundary of resource loss and generation. The fifth proposition concerns which conditions make resource depletion and accumulation more, or instead less, likely. Specifically, we propose that individuals with more key resources (e.g., self-efficacy, social power) will adopt a more active and efficient coping style when confronted with contextual demands (Hobfoll, 2002), thereby alleviating the resource depletion process and in turn its detrimental effects on employee well-being and then safety. These individuals can also make the use of contextual resources more efficient and effective (McCrae and Costa, 1986; Zhong et al., 2018), thereby strengthening the resource accumulation process and in turn its beneficial effects on employee well-being and then safety.

Proposition 6: Short- and long-term effects. The sixth proposition is rooted in resources dynamics (Halbesleben et al., 2014) and the dynamic processes of work–home conflict and enrichment (ten Brummelhuis and Bakker, 2012), proposing that resource depletion and accumulation will produce short- or long-term effects on well-being and safety behavior. For the short-term effect, as an example, daily coworker support will cause fluctuations in individual emotions, thereby influencing daily health status and then the motivation for and levels of safety behavior on the day. For the long-term effect, as an example, lasting positive safety climate will promote safety knowledge and allow skills to develop gradually, finally reaching high-level safety motivation and behavior over a period of time.

Proposition 7: Industry and society context. Hobfoll et al. (2018) reviewed the development of conservation of resources theory and proposed the principle of resource caravan passageways, stating that resources are context dependent. Variation exists in industry (Choi and Lee, 2017) and society settings (Hofstede, 1984). We propose that factors in the industry and society system either foster and nurture or limit and block the above resource loss and generation of safety behavior. This may work through influencing demands and/or resources in the work, home, or work–home interface system, or through strengthening, or instead alleviating, resource loss and/or generation flow. For example, subcontracting currently prevails in the Chinese construction industry; in this situation, it is plausible that construction companies pay little attention to the work designs of construction workers who are not self-employed and mobile. Compared to countries where directing hiring is dominant, this context will cause more work and home demands (e.g., job insecurity, economic pressure to support the family), thereby leading to more resource loss flow and detrimental effects on safety behavior. This context may also lead to fewer work and home resources (i.e., skill training, family support for the occupation), thereby limiting resource creation flow for conducting safety behavior. On the other hand, industry and society context is likely to influence the strength of resource loss and generation of safety behavior. For instance, the economic stage and collective culture in China made job attitudes and performance of Chinese employees less subject to the effects of work-to-home conflict and more to those of home-to-work conflict (Xia et al., 2018b). Also, the individualistic culture in the United States led to significant direct effects of attitudes on safety behavior, while the collectivistic culture in Korea brought about the significant effects of perceived management and workgroup norms on safety behavior (Choi and Lee, 2017).

6.2. Future theoretical avenues

6.2.1. Home domain and work–home interface

It is evident that the literature investigated mainly safety behavior antecedents related to the work context. Although this is understandable, we suggest that more attention should be paid to the home domain and the interface between the work and home domains. We believe this is critical for construction employees for three reasons. (a) The working environment in construction is highly demanding (e.g., long working hours, high job insecurity), while organizations lack flexible, employable, and young employees, and thus have to employ unskilled workers who would increase the prevalence of fatal and non-fatal injuries (Lee et al., 2020). The challenge to the workforce and then workplace safety may be worsened by work-to-home conflict. (b) Most construction employees have to work remotely from their home locations (Xia et al., 2018b), struggling with work–family balance. In this scenario, resources from their family seem to be more valuable to them, whereas demands from their family such as complaints may be more detrimental, for example, distracting employees from the work and hence making them unable to maintain the required level of safety behavior. This is similar to gain paradox principle (Hobfoll et al., 2018). That is, resources gain from the home increases in salience when home resources are threatened with loss (being far away from home may threaten the spouse relationship or even the marriage). (c) Because of the mobility of the workforce and the high level of subcontracting within the construction industry, construction employees are disconnected from management (Schwatka and Rosecrance, 2016). Consequently, formal controls from management to intervene in safety behavior may have little effect (Dekker, 2002). In contrast, family members usually serve as key parties to employees, and their concern about workplace safety may play an important role in influencing employees.

6.2.2. Job strain

Occupational safety and well-being are closely related; however, these two streams of research seem to be separate. Health-related outcomes such as stress and work-related illness are a focus on the one hand, and safety behavior and accidents a focus on the other (Hansez and Chmiel, 2010). Their research focuses also seem to be different. At its outset, well-being research looked mainly at what is wrong with employees, such as job burnout, a syndrome of chronic exhaustion, a cynical, negative attitude to work, and reduced professional efficacy that could occur in any job (Maslach et al., 2001). Thereafter, with the introduction of the concept of work engagement, this stream of research moved to investigate employees' flourishing at work (Schaufeli and Bakker, 2003; van Horn et al., 2004). In contrast, since the introduction of safety compliance and safety participation concepts, occupational safety research seems to have focused largely on the positive aspects of individual states, such as safety knowledge, skills, and motivation (Christian et al., 2009; Hansez and Chmiel, 2010). This research focus was also supported by our reviewed construction literature, in which safety knowledge, skills, and motivation were studied in 24 of the 101 articles (see the supplementary material titled "Antecedent"). Because both negative and positive well-being can influence employees' work performance, and negative states such as job burnout may also reduce employees' engagement to work and then work performance (Bakker and Demerouti, 2017), we suggest that future research should pay more attention to job strain.

6.2.3. Multi-level and multi-culture

From the review, strong and almost equal efforts have been devoted to individual characteristics (N = 52), workgroup interactions (N = 64), and project management and organization (N = 52). In addition to investigations on the individual effects of the individual, group, or organizational antecedents on employee safety behavior, we suggest that more attention should be paid to cross-level interactions among resources and hindrances, namely how and under which conditions do resources and hindrances at different levels produce stronger or weaker resource loss and gain flow that would influence employee safety behavior (Propositions 1 to 5 within the safety behavior resource flow model). This call for cross-level studies is also implied by the fact that only eight of the 77 questionnaire surveys used hierarchical linear models, and it conforms to a recent call in the job demands-resources theory (Bakker and Demerouti, 2017). The rationale of our call for cross-level studies is rooted in the multilevel nature of key constructs in our proposed models, for example, work hindrances and work resources can be conceptualized and measured at the individual-, the group-, and the organizational- level (Demerouti et al., 2001; Dollard and Bakker, 2010). As one specific type of work resources, safety climate can also be an individual-, group-, and organizational- level construct (James et al., 1990; Zohar and Luria, 2005). As mentioned in Section 2, safety behavior has often been measured at the individual level (Burke et al., 2002). But it can also be aggregated from the individual to the group level (Neal and Griffin, 2006). Therefore, using hierarchical linear models would give a much more valid picture of the study constructs and their interaction processes than that obtained with individual-level data in the same analysis without using such models (Wang et al., 2018a).

Only two of the 101 articles used samples from different countries or regions. As we propose in Proposition 7 within the safety behavior resource flow model, industry and society variation may act as broad contextual resources or demands, which would nurture or block resource loss and generation in relation to safety behavior. Therefore, investigations of the relationships from antecedents to safety behavior in different countries or regions with diverse industrial organization modes and cultures are greatly warranted. Spangenberg et al. (2003) found that Danish construction workers experienced more accidents than did Swedish workers despite both being on the same site. They further concluded that nationality *per se* does not influence risk perceptions and behavior, but the factors to which it relates to do. However, the role of cross-cultural factors in the formation of safety behavior of construction employees remains largely unexplored to date. Generic occupational safety research also calls for investigations of the role of culture in determining workplace safety behavior (Reader et al., 2015). In addition, testing the two conceptual models proposed in our work in multiple culture contexts is of course necessary.

6.3. Future method designs

To test the proposed two models empirically, validated types and measures of contextual demands and resources must first be constructed. Types of demands and resources may vary across sectors (Hobfoll, 1989; Nahrgang et al., 2011). We argue that the structure of the safety behavior antecedent analysis and classification model and resource flow model may endure across industries, but the elements are likely to vary. For example, in the construction industry, workers are greatly exposed to hazards such as asbestos, chemicals, and lead (Goldenhar et al., 2003), whereas in the health-care industry, nurses usually face inherent role conflict based on opposing demands made by medical and administrative staff (Hemingway et al., 1999). Nevertheless, hazard exposure for construction employees and role conflict for health-care employees are both manifestations of the construct of *work demands*, which refer to those physical, psychological, social, or organizational constraints of the job that require sustained physical and/or psychological (cognitive and emotional) effort and interfere with or inhibit an individual's ability to achieve valued goals. Therefore, when applying the models to a particular industry, types and measures of contextual demands and resources specific to the industry should be developed. That is, operationalization of contextual demands and resources should match construct definition, and measures should be validated.

Next, most surveys (73 of 77) used cross-sectional data, precluding our ability to make conclusive inferences concerning the causal relationships between safety behavior and its antecedents. Research has indicated reverse relationships between safety behavior and its antecedents such as safety motivation (Neal and Griffin, 2006); therefore, future research should adopt a longitudinal design to provide greater ability to infer causation. This suggestion is consistent with the call in general occupational safety research, in which safety researchers continue to lament the scarcity of longitudinal studies (Christian et al., 2009; Nielsen et al., 2016). Researchers in the construction domain should rise to answer this call. Furthermore, using longitudinal designs is consistent with the expectations in our theoretical models. Specifically, as we propose in Proposition 6 within the safety behavior resource flow model, it is presumable to distinguish between short- and long-term processes, explicitly addressing the issue of causality and change. For example, fatigue presumably reflects daily resource depletion due to daily demands in the home, work, or work–home interface system, which may possibly influence work-related well-being and then the motivation for and levels of safety behavior on the day. To test this short-time process involving causality and change, the experience sampling method (Bolger et al., 2003) could be of great help. Furthermore, longitudinal relations do not necessarily imply causation or change, because both the hypothetical predictor and outcome may be influenced by a third variable or confounder (MacKinnon and Pirlott, 2015). A more rigorous test of causality or change requires manipulation of the hypothetical causes and a test of whether this manipulation generates the expected effects. In the reviewed 101 papers, only nine employed the experimental method.

This review also highlighted the lack of qualitative and mixed-method research. Quantitative methods dominated (92 of 101), providing a general view of the quantitative relationships between various factors and safety behavior. However, to enable an in-depth understanding of the relationships, we recommend that qualitative research methods, such as case studies, be used in future research. Additional qualitative data analysis could also act as cross-validation as per the triangulation method (Cooper and Schindler, 2006).

Finally, most surveys (70 of 77) on the antecedents of safety behavior assessed predictors and safety behavior by self-reports from the research subjects. The problem with such assessment is that the same person (the focal employee) provides all information, and therefore statistical relationships between constructs may be inflated as a result of common method bias (Podsakoff et al., 2003). In addition to self-descriptions, Andriessen (1978) has suggested another three alternative ways to measure employee safety behavior: (a) inference from the number of accidents one has had, (b) observation by the researcher, and (c) judgment by someone else (e.g., the supervisor). Because previous work has found discrepancies between worker self and supervisor assessment of worker safety behavior (Xia et al., 2018c), we suggest that future research considers alternative sources for assessing safety behavior. As such, the potential for common method bias can be avoided, and future research can provide a more rigorous empirical examination of the relationships between safety behavior and its antecedents.

To recapitulate, specific types and measures of contextual demands and resources, longitudinal, and experimental research designs, as well as mixed methods, together with data from multiple sources will be necessary to obtain additional information and gain a better understanding of the mechanisms through which safety behavior is either promoted or inhibited, thereby making stronger recommendations for interventions.

7. Conclusion

This paper brings together the research on antecedents of safety behavior in construction. Despite a recent surge in publications on this topic, there have been few attempts to integrate knowledge on what we know of factors that influence safety behavior. To correct this, we conducted a systematic review of 101 eligible papers, identifying 83 factors that were categorized into five groups, namely (a) individual characteristics, (b) workgroup interactions, (c) work and workplace design, (d) project management and organization, and (e) family, industry, and society.

Accident causation models, such as Swiss Cheese Model (Reason, 1990) and the Human Factors Analysis and Classification System (Wiegmann and Shappell, 2001), suggest that accidents are merely an ostensible symptom and that there are many factors behind an accident. From our systematic review, it is also evident that the causes of safety behavior are manifold. Various factors from different systems likely work in concert to create situations in which an individual chooses to comply with safety rules and participate voluntarily in safety activities. Given this, drawing on bioecological system theory (Bronfenbrenner, 1994), we propose that safety behavior is only an ostensible symptom of a more complex system, and causes of safety behavior can be attributed to different aspects of “The Self–Work–Home–Industry/Society” systems. This safety behavior antecedent analysis and classification model is expected to help researchers and practitioners to establish a holistic picture of what may contribute to safety behavior.

To further reveal the underlying mechanisms of how these five systems of factors work together to influence safety behavior, we propose a safety behavior resource flow model in which we posit seven propositions describing why, how, and under which conditions safety behavior is more likely to occur, or instead, to decrease. At the broadest level, contextual demands and resources from the work, the home, and the work–home interface systems act as distal contextual factors that will influence safety behavior through the processes of resource loss or generation in the self system. During these processes, personal energies and well-being are intermediators, while personal key resources and industrial and societal factors are moderators. This resource flow model for safety behavior is based mainly on the theoretical lenses of resources theories, namely conservation of resources theory (Hobfoll, 1989), job demands-resources theory (Bakker and Demerouti, 2017), and work–home resources model (ten Brummelhuis and Bakker, 2012). These resources theories have been used mainly to explain employees' work-related well-being, whereas well-being and safety are in fact related. On the other hand, theoretical perspectives on employee safety behavior usually rely on Griffin and Neal's (2000) safety performance model and Campbell et al.'s (1993) theory of work performance. In the safety behavior resource flow model, we synthesize the resources theorizing of work-related well-being and the performance theorizing of safety behavior, bridging occupational health and safety literature. In addition, the use of resources theories leads to the proposition concerning the short- and long-term effects, which supplements prominent theories in workplace safety that are not well-equipped to explain within-person variation in safety behavior (Beus et al., 2016). For simplicity, we illustrate only key propositions within this conceptual model, and more details should develop later.

Table 5 summarizes the functions and propositions of the two conceptual models. Certainly, future empirical studies are warranted to test and modify these conceptual models; we also give some suggestions on further development in terms of theory and method designs.

1069 **Table 5**

1070 Summary of the two proposed models.

Function	Summary of propositions
The first model: Safety behavior antecedent analysis and classification model	
To integrate and group numerous safety behavior antecedents into "The Self–Work–Home–Industry/Society" systems, thereby providing a holistic picture of the causes of safety behavior	**Proposition 1: Multiple systems**. Antecedents of safety behavior can be attributed to different aspects of "The Self–Work–Home–Industry/Society" systems."
	Proposition 2: Contextual demands and resources within the environmental system. Antecedents relating to the environmental system (the work, home, work–home interface, and industry and society systems) can be categorized into two groups: contextual demands and resources.
	Proposition 3: Energies, key resources, and work-related well-being within the self system. Antecedents relating to the self system can be categorized into three different but related groups, namely energies, key resources, and work-related well-being.
The second model: safety behavior resource flow model	
To describe why, how, and when the five-system antecedents work in concert to create situations in which safety behavior is promoted or prevented, thereby illustrating the underlying theoretical mechanisms relating safety behavior and its numerous antecedents in a unified way from a resource flow perspective	**Proposition 1: Resource loss**. Contextual demands will diminish personal energies and then impair well-being, resulting in diminished safety motivation and behavior.
	Proposition 2: Resource generation. Contextual resources will promote personal energies and then improve well-being, resulting in enhanced safety motivation and behavior.
	Proposition 3: Cross-system effects. Work–home conflict—including work-to-home conflict and home-to-work conflict—as cross-system demands will trigger resource depletion and then health impairment processes, resulting in diminished safety motivation and behavior; work–home enrichment—including work-to-home enrichment and home-to-work enrichment—as cross-system resources will trigger resource accumulation and then health enhancement processes.
	Proposition 4: Demands and resources coupling. "Demand × demand" within a system or across systems will result in more severe resource loss and subsequent detrimental effects; "resource × resource" within a system or across systems will generate more personal energy resources, subsequently benefiting individual well-being and then safety behavior; different combinations of demands and resources will produce either stronger or weaker resource loss and gain.
	Proposition 5: Boundary of resource loss and generation. Key resources will alleviate the resource depletion process and in turn its detrimental effects on employee well-being and then safety; key

	resources will strengthen the resource accumulation process and in turn its beneficial effects on employee well-being and then safety.
	Proposition 6: Short- and long-term effects. Resource depletion and accumulation will produce short- or long-term effects on well-being and safety behavior.
	Proposition 7: Industry and society context. Factors in the industry and society system either foster and nurture or limit and block the resource loss and generation of safety behavior.

This literature review should be considered in light of its limitations, especially those concerning the literature sampling criteria and analysis (Denyer and Tranfield, 2009). Literature searching can never be exhaustive. Certain relevant articles may have been excluded; for example, they may use “risk-taking behavior” to refer to the unsafe behavior notion but not the searched terms (“*safety behavior*” OR “*safety behaviour*” OR “*safe behavior*” OR “*safe behaviour*”OR “*safety compliance*” OR “*safety participation*” OR “*safety citizenship behavior*” OR “*safety citizenship behaviour*” OR “*safety performance*” OR “*unsafe behavior*” OR “*unsafe behaviour*” OR “*safety violation*”). Also, although the present first and second authors conducted rigorous content analysis, cognitive biases can never be eliminated, and thus there may be drawbacks in the analysis.

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