

Individual Risk Factors Influencing Safety Climate in Construction Projects

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ABSTRACT

The construction industry is widely recognized as a sector with a high risk of occupational accidents, despite the implementation of occupational safety and health management systems. Differences in workers' individual characteristics are believed to influence safety perceptions and behaviors. This study aims to analyze the influence of individual factors on safety climate in construction projects through a systematic literature review. Articles were searched in Google Scholar, PubMed, and Scopus databases using the keywords "individual factors," "safety climate," and "construction projects," with predefined inclusion and exclusion criteria. A total of 7,246 articles were identified, and after systematic screening, 16 studies published between 2021 and 2025 met the eligibility and quality criteria for analysis. The findings indicate that individual factors—including age, gender, education level, work experience, job position, and knowledge—are associated with safety climate perceptions, although the magnitude of their influence varies across studies. Job position emerged as the most consistent factor influencing safety climate, while organizational aspects such as management commitment and supervision remained dominant determinants. This review concludes that individual characteristics contribute to workers' perceptions of safety climate; however, strengthening organizational-level factors remains essential to support sustainable occupational safety in the construction sector.

Keywords: individual factors; safety climate; construction projects

INTRODUCTION

As a labor-intensive sector with a high level of occupational risk, the construction industry places occupational safety and health (OSH) as a fundamental priority. The importance of OSH in this sector is reinforced by Government Regulation No. 50 of 2012 concerning the implementation of OSH management systems [1]. Work characteristics in construction include hazardous environmental conditions, complex operational processes, and the involvement of multiple stakeholders with diverse backgrounds, all of which create major challenges in controlling occupational accident risks.

According to the International Labour Organization (ILO), approximately 2.3 million workers die each year from occupational accidents and work-related diseases, of which about 60,000 occur in the construction sector [2]. It is estimated that around 20–30% of all fatal occupational accidents occur in construction [3]. In Indonesia, data from BPJS Ketenagakerjaan show an alarming trend over the past five years, with increasing claims for occupational accidents and fatalities each year. Accident cases rose from 221,740 in 2020 to 234,370 in 2021 (an increase of about 5.7%), then to 265,334 in 2022 (an increase of 13.2%). The number surged to 370,747 in 2023 and reached 462,241 in 2024, with compensation claims totaling IDR 3.49 trillion [4]. These increases highlight the urgency of implementing robust and sustainable OSH systems.

Overall, occupational accidents are largely dominated by behavioral factors. In the construction sector specifically, majority of accidents are associated with unsafe actions or non-compliance with work standards, which ultimately generate unsafe site conditions [5, 6]. Therefore, efforts to improve safety cannot rely solely on technical and procedural measures but must also address workers' behavioral and perceptual factors regarding safety.

Although occupational safety and health management systems have been widely implemented in construction companies, hazards remain insufficiently controlled and accident rates remain high. Many safety problems in construction originate from weak safety culture [7]. Transforming safety culture requires attention to three interrelated aspects: psychological (safety climate), behavioral, and situational dimensions [8]. Among these, strengthening the safety climate is considered one of the most effective approaches to accident prevention.

Safety climate is defined as workers' shared perceptions regarding the extent to which safety is prioritized within an organization [9,10]. It represents a dimension of organizational climate that reflects structure, processes, working conditions, social relations, and individual perceptions of safety. Safety climate functions as an early indicator of safety culture and has been shown to influence safe work behavior [11-13]. Positive safety perceptions contribute to safer work practices, reduced accident rates, and improved productivity [14, 15], whereas a poor safety climate may encourage unsafe behavior and increase accident risk [16].

The consequences of occupational accidents extend beyond lost work time or fatalities, generating financial losses for companies [17] and broader social and economic impacts, including compensation costs and reduced quality of life [18]. Companies that fail to implement adequate safety measures may also face reputational risks [19]. Consequently, previous studies emphasize that improving safety climate is essential for reducing accident rates [20]. Despite the growing body of research on safety climate, most studies still emphasize organizational determinants such as management commitment, communication, and supervision [21]. Previous research has identified several dimensions of safety climate, including management commitment, safety empowerment, fairness, worker participation and engagement, organizational learning, communication, innovation, and trust [22]. However, a positive safety climate is not shaped solely by organizational systems; it is also strongly influenced by workers' individual characteristics [23, 24].

Individual worker characteristics play a crucial role in determining how safety values and practices are implemented at the operational level. Differences in personal background may produce diverse safety perceptions and levels of compliance. This issue is particularly relevant in Indonesia, where construction workers are largely dominated by temporary daily laborers with relatively low educational backgrounds and varied work experience. Such differences may influence how workers understand, evaluate, and respond to safety policies and practices at project sites. Understanding individual factors in the national construction context is therefore essential for strengthening the effectiveness of OSH management systems.

Individual perceptions can influence co-workers and contribute to the development of a sustainable safety climate [25, 26]. Understanding the contribution of individual factors is therefore key to preventing recurring accidents, which can be assessed through indicators such as safety climate. Previous studies indicate that individual factors shape perceptions, which subsequently influence safety behavior [27, 28]. Safety values may vary across job positions depending on assigned responsibilities [29]. Demographic characteristics such as age, gender, education level, and work experience also contribute to shaping safety behavior [30]. Similar findings have been reported in other studies [31], while some research suggests that work experience may exert a stronger influence on safety perception than education level [32]. Conversely, other studies report that education, job position, and department are not significantly associated with safety climate [33].

These inconsistent findings suggest that mediating variables or contextual conditions may influence the relationship between individual characteristics and safety climate perception. The complexity of individual characteristics and their interactions with organizational and environmental factors highlights the need for a more comprehensive synthesis of evidence. Workers' perceptions ultimately determine how they evaluate organizational commitment to safety and how they translate it into safe work behavior. Therefore, understanding the relationship between individual factors and safety climate is essential for designing OSH interventions tailored to worker characteristics in construction settings.

In practice, most construction companies already possess formal safety procedures and OSH management systems in compliance with regulations. However, non-compliance among workers remains common and often leads to occupational accidents. This indicates that the existence of formal systems alone is insufficient to guarantee safe behavior without individual awareness, creating a gap between procedures and actual practice. Furthermore, safety climate measurement in the construction sector remains limited, meaning that the overall level of safety climate is not yet fully understood. Safety climate surveys can help identify critical issues that hinder performance development and reveal perceptions held by both management and workers who play a role in shaping safety climate [34].

Based on these research gaps and the complexity of the problem, a comprehensive synthesis is required to analyze workers' perceptions and identify individual factors influencing safety climate in construction projects. Therefore, this study aims to systematically review and analyze the influence of individual worker characteristics on safety climate in construction projects. The findings of this study are expected to provide evidence-based input for developing OSH strategies tailored to worker characteristics, enabling more adaptive planning and supporting the creation of safer, more productive, and sustainable construction work environments.

METHODS

This study employed a systematic literature review method, utilizing a structured strategy to search for research articles through scientific databases. Articles were retrieved from Google Scholar, Scopus, and PubMed using combinations of keywords and Boolean operators applied in the literature search process, namely "Individual Factors," "Safety Climate," and "Construction Projects." Subsequently, inclusion and exclusion criteria were established for the literature to be reviewed. The inclusion criteria comprised: (1) articles examining the relationship between individual factors and safety climate; (2) studies conducted in the construction sector or similar industries; (3) research published between 2021 and 2025; (4) full-text publications in reputable scientific journals with clear data and methods; and (5) articles written in Indonesian or English relevant to the topic. The exclusion criteria included: (1) review articles lacking explicit search and analytical methods; (2) non-scientific publications such as project reports, conference abstracts, or popular articles; (3) studies that did not explicitly assess individual variables or safety climate; (4) articles not available in full text; (5) publications not written in Indonesian or English; (6) non-quantitative studies; and (7) studies lacking relevance to the research topic.

The search and selection process was conducted in several stages: (1) Identification (initial search and reference collection), (2) Screening (title and abstract filtering and removal of duplicates), (3) Eligibility assessment of articles examining individual factors related to safety climate in construction projects (full-text review based on inclusion/exclusion criteria), and (4) Inclusion (final studies analyzed). The entire documentation of the search and selection process is presented following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram and supported by reference management software such as Mendeley. The conceptual framework and inclusion criteria of this study were developed based on the Population, Intervention, Comparison, Outcome, and Context (PICOC) framework to ensure alignment between research questions and literature selection, as presented in Table 1.

Table 1. PICOC framework for inclusion criteria

Population	Intervention	Comparison	Outcome	Context
Workers in construction projects	Individual factors (including age, sex, education level, work experience, job position, and knowledge)	-	Perceptions or assessments of safety climate	Studies conducted in construction projects

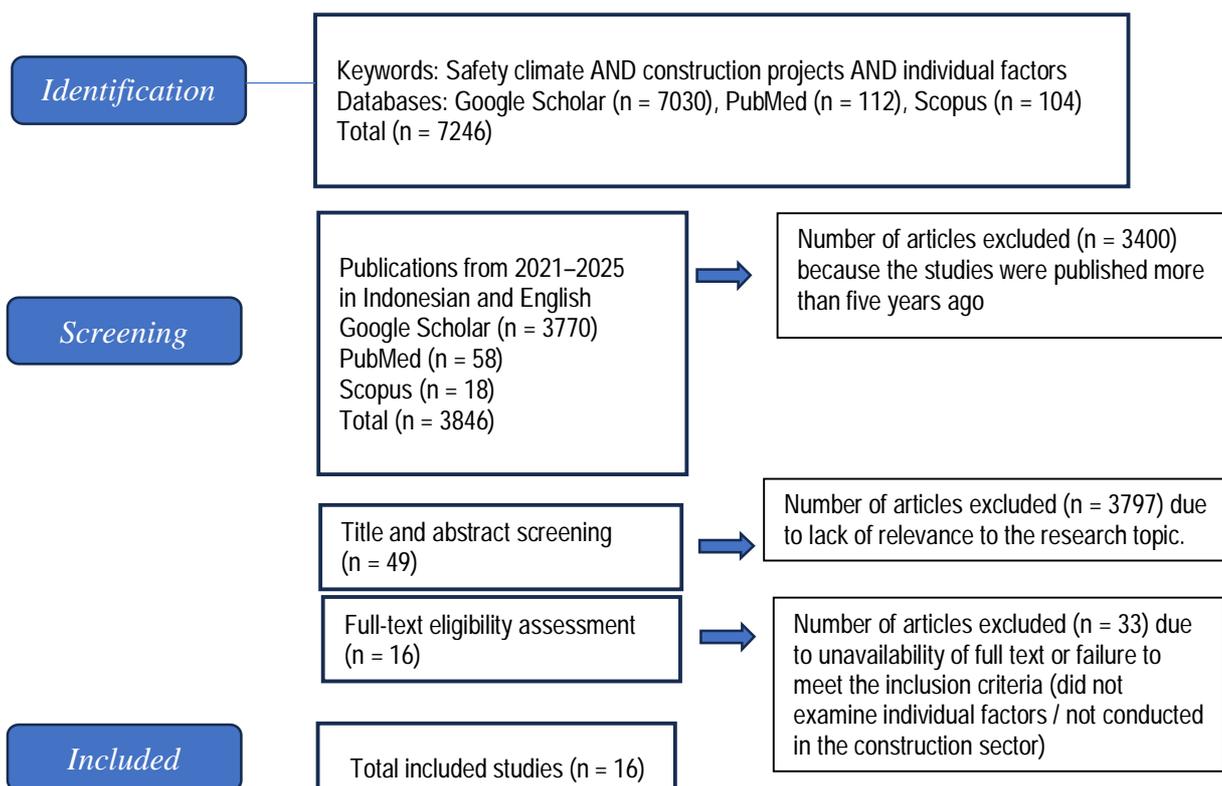


Figure 1. PRISMA flow diagram for article selection

RESULTS

The literature search conducted through the Google Scholar, PubMed, and ScienceDirect databases yielded a total of 7,246 articles, consisting of 3,770 Indonesian-language articles and 78 English-language articles. After restricting the publication period to 2021–2025, a total of 3,797 articles remained. From these articles, screening based on relevant titles and abstracts was performed, and non-full-text articles were removed, resulting in 49 eligible articles. Subsequently, article quality was assessed using the following criteria: (1) a clear description of the analysis of individual factors in relation to safety climate; (2) consistency between research objectives and findings; (3) population drawn from the construction sector; and (4) clearly described research methods, measurement approaches, and instruments. After further screening, 16 published articles were identified as meeting the study eligibility criteria.

The analysis of the 16 selected articles indicates that the primary objective of the studies was to identify individual factors associated with safety climate in construction projects. Most studies involved construction worker respondents ranging from 100 to 500 participants. The reviewed articles examined various individual factors influencing safety climate, including: age (12 articles), sex (8 articles), education level (10 articles), length of employment (9 articles), job position (11 articles), and safety knowledge (6 articles). However, the findings varied, with some studies reporting significant relationships while others found no association. The benefit of this analysis is that it provides a comprehensive overview of the consistency of findings across studies and identifies individual factors that may potentially influence safety climate. Nevertheless, further research using appropriate analytical methods is still required to confirm the causal relationship between individual factors and safety climate.

Details of each article are presented in Table 1, which summarizes the characteristics and main findings of the analyzed studies.

Table 1. Summary of articles in process of synthesis

No	Author, year	Article title	Methods	Results
1	Sendya Martviyori, Siti Rahmah H. Lubis (2022) [36]	Safety climate description among construction project workers	Descriptive cross-sectional; LSCAT questionnaire; Sample: 127 workers	The study found that the safety climate in the project was still in the low category. Further analysis showed no relationship between age, education, or length of employment and safety climate ($p > 0.05$). Conversely, the work environment factor showed a significant association with age ($p = 0.008$) and length of employment
2	Gavin Andre Irhandy, Dadan Erwandi (2022) [38]	Analysis of the influence of personal and organizational factors on unsafe behavior among construction workers	Cross-sectional; Sample: 165 workers	Age showed a positive but non-significant effect ($p = 0.196$). Education level, work experience, working hours, and organizational factors showed negative but non-significant effects on unsafe behavior. Safety knowledge had a significant negative effect on unsafe behavior ($p < 0.05$; OR < 1).
3	Diah Listyaningsih, Feri Harianto (2021) [37]	Occupational safety climate in construction projects in Surabaya	Descriptive; NOSACO-50 questionnaire; Sampling: three construction projects	Safety climate was generally good. The safety priority dimension showed no significant difference across projects. Chi-Square tests indicated no significant relationship between safety climate and education, age, or length of employment.
4	Ghina Shafa Nafisa (2022) [43]	Relationship between safety climate and safety behavior among workers at PT Indonesia Connets Plus (ICON+)	Quantitative cross-sectional; Sample: 124 workers	Education was significantly associated with safety behavior ($p = 0.035$; OR = 2.316). No significant relationship was found between age and safety behavior ($p = 0.974$). Several safety-climate dimensions—management commitment, empowerment, justice, and communication & innovation—were significantly related to safety behavior.
5	Allisa Dzakwan Rosyada, Anik Setyo Wahyuningsih (2022) [33]	Relationship between individual characteristics and occupational safety climate in production department 1, Perumda Air Tirta Moedal Semarang	Analytical cross-sectional; NOSACO-50; Sample: 33 workers	Safety climate was categorized as “moderate” with an average score of 2.89. Age ($p = 0.045$), length of employment ($p = 0.019$), and education level ($p = 0.005$) were significantly related to safety climate, while other variables were not.
6	Deni Eri Zulfirman, Zulkifli Djunaedi (2021) [45]	Analysis of occupational safety climate at PT XYZ Balikpapan	Cross-sectional; Sample: 55 workers	Safety climate was categorized as good (74.5%). No significant association was found between individual factors (age, education, tenure) and safety climate ($p > 0.05$). Management commitment and supervision were more dominant influences.
7	Abdul Kadir et al. (2022) [51]	Safety climate in the Indonesian construction industry: strengths, weaknesses, and influential demographic characteristics	Cross-sectional survey; NOSACO-50; Respondents: 610 workers	Safety climate was moderate. Education ($p=0.005$), tenure ($p=0.001$), job position ($p=0.007$), employment status, work location, and project type were significantly associated with safety-climate perception.
8	Tinashe Muzira (2024) [46]	Assessing the influence of demographic factors on safety climate in construction projects	Quantitative survey; Sample: 206 workers	Gender significantly influenced safety-climate perception ($p < 0.001$), as did work experience ($p = 0.019$). Age, education, and marital status were not significant.
9	Changquan He et al. (2023) [39]	Effects of demographic characteristics on safety climate and construction worker safety behavior	Quantitative survey	All demographic factors (sex, age, tenure, education, company size) significantly affected safety climate ($p < 0.05$).
10	Saeed Shojaee Barjoe et al. (2025)	Occupational injuries associated with safety climate among ceramic industry workers in Iran	Descriptive cross-sectional; Sample: 51 workers	Low safety-climate scores were associated with higher injury incidence. Descriptive data indicated low scores among male workers aged 38–43, tenure < 1 year, and morning shifts.
11	Maimoona Roghani et al. (2022) [52]	Laboratory safety climate assessment and its correlation with safety procedures	Cross-sectional; NOSACO-50 & WHO Lab Safety Survey; Sample: 199 workers	Job position had the strongest influence on safety climate across several dimensions. A very strong positive correlation was found between safety climate and safety practice ($r = 0.91$; $p < 0.001$).
12	Norah AlMousa et al. (2022) [47]	Occupational safety climate and hazards in the industrial sector: gender differences perspective	Cross-sectional; NOSACO-50; Sample: 2,349 workers	Significant gender differences were observed: female workers reported lower safety-climate perceptions than males ($p < 0.05$).
13	Marta Znajmiecka et al. (2022) [50]	Differences in the perception of safety climate by employees of an international manufacturing company	Exploratory survey; Safety Climate Questionnaire; Sample: 203 workers	Job position was the most influential individual factor on safety-climate perception. Department and education showed the smallest statistical influence.
14	Anugrah Budi Utama, Baiduri Widanarko (2022) [41]	Analysis of occupational safety climate level in construction project PT X	Cross-sectional; NOSACO-50	Safety climate was categorized as good (mean score 3.03). Significant differences were found based on job position and education. No association with age, but significant association with tenure.
15	Venii Novrizza, Fatma Lestari (2021) [49]	Safety climate dimensions and variable comparison at PT XYZ	Cross-sectional study	Mean safety-climate score was 4.10 (scale 1–6), categorized as satisfactory. Job level contributed to the achievement of safety climate.
16	James Evert Adolf Liku et al. (2025) [40]	Safety climate analysis at PT Quantum Energi Khatulistiwa RDMP Project	Analysis using NOSACO-50; Chi-Square test	Four safety-climate dimensions were categorized as good, while three were poor. Relationships were tested with age, tenure, education, and safety knowledge.

DISCUSSION

Based on the review of the selected articles, the findings generally indicate that individual factors in construction projects—such as age, sex, education, length of employment, job position, and knowledge—contribute to shaping workers’ perceptions of management commitment and safety practices in the construction sector. Individual perceptions have been shown to influence safety behavior and accident occurrence [35]. This finding is consistent with the objective of the study, which aims to identify the contribution of individual factors to the formation of safety climate in the construction sector. However, several other studies reported that individual characteristics did not significantly influence safety

climate [36, 37]. The influence of each factor was not consistent across studies, suggesting differences in context, project characteristics, and safety management systems applied in each research setting.

In general, age and length of employment were found in several studies to be positively associated with safety climate, indicating that older and more senior workers tend to possess longer experience, which provides opportunities to learn from risks and increases vigilance [38]. Mature workers tend to have higher risk awareness and work responsibility. Conversely, other findings indicate that age may have a significant negative effect on safety-climate perception, meaning that younger workers may be more optimistic and demonstrate stronger safety commitment than older workers. This may occur because experienced workers who have been involved in multiple projects may become more comfortable and less alert, thereby perceiving safety commitment as lower [39]. Work experience also contributes to worker maturity in learning and recognizing risk exposure, thereby increasing vigilance and compliance with procedures.

Length of employment is closely related to workers' ability to perform and understand their tasks [40]. However, project experience may also show a negative effect on unsafe behavior [38]. Longer work experience tends to reduce unsafe behavior, although other studies found no significant relationship [41]. These differences may be explained by age homogeneity within samples, which limits contrasts between individuals in influencing safety-climate perception. Organizational and cultural context factors—such as managerial influence, leadership, and safety policies—may be more dominant than worker characteristics, thus explaining the non-significant differences.

Education level and knowledge also emerged as factors influencing safety climate, although not consistently [42]. Workers with higher education levels tend to better understand procedures and the importance of safety standards at work [43]. Educational background influences worker quality, and in construction—where many workers are daily laborers without formal employment contracts—this may complicate occupational safety and health management [44]. This condition affects workers' awareness in recognizing risks and encourages more critical attitudes at work, improving information acceptance and communication ability. Education is therefore linked to safe work attitudes and behavior. Low educational levels may limit technical understanding, which in turn influences how workers perceive safety climate and interpret management directives. Nevertheless, several studies report that education is not associated with worker perception, indicating that in the construction sector, knowledge is often shaped collectively through daily safety norms and practices on site. Thus, formal academic knowledge may be less decisive than organizational safety culture [45]. In this context, individual knowledge and understanding act as important mediators in the relationship between organizational policies and safe behavior in the field.

Most studies indicate that sex influences safety climate in some cases, although findings vary [46]. Some results report that female workers tend to perceive safety climate as lower than male workers. In construction projects dominated by male workers, differences in safety perception between men and women may arise due to differences in roles and responsibilities, as well as workforce imbalance on site [47]. Male workers are more often assigned to high-risk tasks such as heavy physical work, working at heights, and operating heavy equipment, where safety procedures are more frequently emphasized.

A production-oriented construction environment may also lead female workers to feel less psychosocially supported, which may affect safety-climate perception. However, in terms of compliance and caution, studies suggest that women tend to adhere more closely to safety rules, whereas men are more willing to take risks. These behavioral differences contribute to shaping safety-climate perceptions [39]. Such variation is likely influenced by differences in work culture and gender role distribution in the construction sector.

Organizational position appears to be one of the most consistent individual factors influencing safety climate. Workers in higher positions and permanent employment status tend to report more positive safety-climate perceptions than contract workers [48]. Higher-ranking positions involve responsibilities for supervision, reporting, and determining safety implementation, which leads to more positive perceptions because of closer involvement with safety policies and management practices, as well as better understanding of management commitment to occupational safety and health [49]. Staff in higher positions also tend to receive broader access to information, training programs, and management meetings related to safety policies [50, 51]. In contrast, lower-level workers are directly exposed to physical risks and therefore may hold different safety-climate perceptions, which can be more critical or negative compared with management.

Overall, the findings of this review reinforce the view that safety-climate formation is not determined solely by organizational policy but also by worker characteristics. Differences in findings across studies indicate that individual factors do play a role, but they cannot be regarded as the sole determinants influencing safety practices [52]. Although individual characteristics may contribute to the success of safety climate, it is more strongly shaped by organizational culture, implemented systems, and project context. Organizational factors that shape safety climate include management commitment, leadership, communication, supervision, and training [43]. Therefore, strategies to improve safety climate in construction projects should be designed by considering variations in individual characteristics—for example, through experience-based training, intergenerational mentoring approaches, and safety communication adapted to workers' educational levels. Accordingly, it is important for construction industry management to understand differences in individual characteristics while simultaneously strengthening organizational dimensions.

The limitation of this study lies in the data source, which only includes published articles from the period 2021–2025, and therefore may not fully represent long-term global research developments. Nevertheless, the findings still provide a comprehensive overview of the relationship between individual factors and safety climate in the construction sector.

The differences in findings across the 16 reviewed articles indicate that variations in influencing factors may be attributed to differences in sample characteristics, research methods, and construction work culture in each research location. Therefore, further research using stronger methodological approaches is required in order to identify the individual factors that most consistently influence safety climate.

CONCLUSION

This review indicates that individual factors—such as age, sex, education, work experience, job position, and knowledge—contribute to safety-climate perception in construction projects, although their effects vary across studies. Job position and work experience appear to be the most consistent predictors, while organizational factors remain the dominant determinants of safety climate.

Improving safety climate therefore requires integrating worker characteristics with stronger organizational safety culture. Tailored training, targeted safety communication, and periodic safety-climate assessment are recommended. Further research using stronger and context-sensitive methods is needed to identify the most consistent individual determinants and support more effective and sustainable occupational safety policies in the construction sector.

Ethical consideration, competing interest and source of funding

-Ethical approval was not required for this study because it was based solely on previously published literature and did not involve human participants or primary data collection.

- There is no conflict of interest related to this publication.
- Source of funding is authors.

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