

Safety culture in gas companies: a case study of an LPG reseller network

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This research aimed to analyze the maturity stage of the safety culture within a network of Liquefied Petroleum Gas (LPG) reseller companies located in Salvador, Bahia, Brazil. The relevance of the topic lies in the importance of LPG to the national energy matrix and in the inherent risks of resale operations, which involve direct exposure of workers and the surrounding community to a highly flammable product. The study is grounded in well-established theoretical models that conceptualize safety culture as a set of collective values, practices, and behaviors that evolve through different stages of maturity. A mixed-methods approach was adopted, combining quantitative and qualitative techniques through the application of structured questionnaires based on six analytical dimensions (leadership, commitment, involvement, information, communication, and organizational learning), along with a checklist of documentary evidence. The sample comprised 289 workers from 82 reseller companies of varying sizes. The results revealed that the analyzed network is positioned at an intermediate level of safety culture maturity, between the reactive and bureaucratic stages, showing relevant progress but still constrained by gaps in effective communication, organizational learning, and leadership engagement. Statistical analyses indicated a positive correlation between safety culture maturity and variables such as education level, age, length of employment, monthly sales volume, and sector of activity, suggesting that experience, company size, and formal education contribute to stronger awareness and adherence to safe practices. It is concluded that advancing the maturity of the safety culture depends on interventions tailored to the profiles of both employees and reseller companies, focused on strengthening safety-oriented leadership and management, enhancing communication, information, and organizational learning, promoting frontline engagement and safe behavior, and improving governance, performance indicators, and distributor/reseller integration.

Keywords: safety, safety culture, maturity, liquefied petroleum gas, LPG companies, organizational culture.

1. Introduction

Over recent decades, organizational safety has advanced significantly, driven by stricter regulations, technological innovations, and heightened awareness of risk management. Despite these improvements, international and national data still reveal concerning accident rates across various sectors (International Labour Organization, 2023). This paradox highlights that technical and regulatory frameworks, while essential, are insufficient to ensure safe operations. In this context, safety culture emerges as a critical factor for effective preventive practices. Reason (1997) defines safety culture as “the product of values, attitudes, competencies, and patterns of behavior that determine the commitment and proficiency in

managing occupational health and safety”. In other words, procedures and equipment only become effective when supported by a collective, integrated, and continuous commitment to safety at all organizational levels.

Research shows that organizations with well-developed safety cultures experience lower accident rates, whereas those in early or reactive stages remain vulnerable to human and systemic failures (Cooper, 2000; Hudson, 2007). Therefore, fostering and consolidating a safety culture is essential to transform safety management beyond mere legal compliance, promoting sustainable behavioral changes within organizations.

Literature indicates that safety culture evolves through maturity stages, ranging from a pathological stage, where safety is neglected, to a

constructive culture, where safety is embedded in the organization's DNA (Hudson, 2007). This progression requires more than new processes; it demands profound changes in beliefs, attitudes, and practices among individuals and groups.

In the liquefied petroleum gas (LPG) distribution sector, safety is a non-negotiable value due to the inherent risks of operations. LPG resale companies play a vital role in this chain, being responsible for direct consumer service and maintaining strict operational safety standards. Lima (2021) notes that these organizations face specific challenges, from storage and transportation to product delivery, requiring a prevention-oriented organizational culture.

Despite the sector's relevance, there is a lack of studies on the maturity level of safety culture in Brazilian LPG resale companies. This gap underscores the need for research that provides accurate diagnoses and supports organizational strategies and public policies aimed at promoting safety.

This study seeks to analyze the maturity stage of safety culture within a network of LPG resale companies in Salvador, Bahia, Brazil. It aims to identify the current level, influencing factors, and propose recommendations to strengthen safer and more sustainable practices, contributing to both operational safety and academic knowledge (Guldenmund, 2000).

2. The Safety Culture

2.1. Origin, definition and importance of safety culture

The concept of safety culture was formally introduced in 1988 by the International Nuclear Safety Advisory Group (INSAG) following the Chernobyl disaster, initially applied to the nuclear sector (INSAG, 1988). According to the International Atomic Energy Agency (IAEA, 1991), safety culture refers to a set of individual and organizational characteristics and attitudes that prioritize safety in operations. Over time, the concept expanded to other organizational contexts, although a universally accepted definition remains elusive (Cooper, 2000).

Several authors have contributed to broadening this understanding. Turner et al.

(1989) associate safety culture with norms and practices aimed at risk reduction, while Guldenmund (2000) emphasize the influence of organizational culture and shared beliefs on risk-related attitudes. Cooper (2000) proposes a three-dimensional structure encompassing perceptions, behaviors, and organizational factors. Richter and Koch (2004) highlight symbolic experiences, and Gonçalves Filho et al. (2011) identify recurring elements grouped into three cores: individual aspects (values and beliefs), work-related aspects (risk behaviors), and organizational aspects (management and structure). These factors will guide this research.

The importance of safety culture has grown alongside organizational changes and efficiency demands. Accidents have severe human and economic impacts (Gonçalves Filho et al., 2013). Technical management alone is insufficient; commitment across all organizational levels, particularly leadership, is essential (Oliveira, 2003). Internal cultural barriers may limit effectiveness, making it crucial to diagnose safety culture maturity (Gonçalves Filho et al., 2011) to guide preventive actions and foster safer, sustainable workplaces.

2.2. Concept of maturity

The concept of maturity originated in the 1980s through the Software Engineering Institute (SEI) in the United States, addressing the federal government's need to assess contractors' capabilities in software development. The model classified companies into five stages: initial, repeatable, defined, managed, and optimizing (Paulk et al., 1993). Later, this concept was adapted to other fields, including project management, human resources, quality, and safety culture (Fleming, 2001; Gonçalves Filho et al., 2011; Hudson, 2007). For safety culture, several maturity models have been developed, as discussed below.

2.3. Safety culture maturity models

Various models assess organizational safety culture maturity. Fleming (2001) proposed a model based on best practices in oil and gas and other sectors, defining five stages: emerging, managed, involved, cooperative, and continuous improvement. It considers factors such as

management commitment, communication, training, employee participation, and organizational learning.

Hudson (2001) introduced a widely recognized model with five levels: pathological (minimal legal compliance, low safety value), reactive (actions only after accidents), calculative (formal systems but limited risk vision), proactive (leadership anticipates problems), and generative (safety fully integrated with continuous improvement) (Parker et al., 2006). While comprehensive, its linear progression may limit applicability in complex, heterogeneous organizations.

Building on Hudson, Gonçalves Filho et al. (2011) adapted the model to Brazilian contexts, maintaining five stages, pathological, reactive, bureaucratic, proactive, and constructive, while considering factors such as information, organizational learning, involvement, communication, and commitment. This model acknowledges cultural asymmetry, allowing different sectors to be at distinct stages, making it more realistic for Brazilian organizations. Its flexibility suits LPG distributors, which range from small family businesses to complex companies. Limitations include reliance on respondents' perceptions and lack of universal normative criteria, reinforcing the need for contextual analysis. Despite this, the model is effective for situational and comparative diagnoses in high-risk sectors like LPG.

Recent studies confirm the applicability of these models across industries. For instance, Silva (2023) assessed safety culture maturity in a logistics unit of a plastic packaging factory, identifying factor-specific patterns that validate the models' sensitivity. Similarly, petrochemical companies have applied Hudson's model and adaptations to diagnose maturity levels and identify critical organizational factors, commitment, information, learning, and communication, that explain variations among units. These findings demonstrate that locally adapted maturity models are robust tools for sectoral diagnosis and intervention design.

3. Methodology

3.1. LPG resale companies

This study was conducted within a network of LPG resale companies affiliated with a Brazilian distributor located in Salvador, Bahia. The geographic delimitation aimed to ensure greater socioeconomic, cultural, and regulatory homogeneity. An LPG resale company is defined as an establishment that sells LPG cylinders purchased from a distributor, without any corporate linkage, although sharing the same brand. Figure 1 illustrates the LPG supply chain, highlighting the position of resale companies within the distribution process. Each resale company operates independently, with its own management and staff, and competes with others in the same regional network.

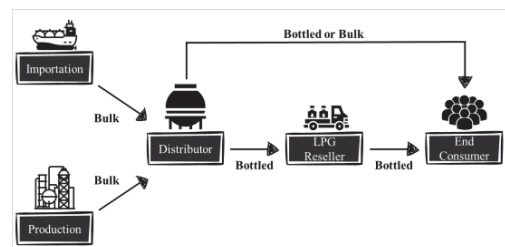


Figure 1. LPG Supply Chain
Agência Nacional do Petróleo, Gás Natural e
Biocombustíveis (2023)

3.2. Population and sample

The target population comprised 106 LPG resale companies in Salvador that met the following criteria: operating within the municipality, having a minimum structure with a manager or owner, an administrative employee, and a salesperson, and focusing on retail. Wholesale resellers were excluded due to their distinct operational dynamics. The sample was defined by convenience (Trujillo, 2009), considering accessibility and willingness to participate. Using the finite population formula (Trujillo, 2009), the minimum sample size was estimated at 80 companies.

The final sample included 289 respondents from 82 resellers, averaging 3.52 participants per company. Most companies (82%, $n=67$) had up to four respondents, reflecting the sector's predominantly small size. In contrast, only 5% ($n=4$) had more than ten respondents, indicating significantly larger structures. This disparity underscores the heterogeneity among resellers.

Participants included 88 administrative workers, 70 owners or managers, and 131 salespeople, ensuring diversity of roles and perspectives.

3.3. Data collection instruments

Two main instruments were used: a structured questionnaire and a documentary evidence checklist. The questionnaire consisted of 21 statements based on established safety culture assessment models. Items were adapted from the model proposed by Gonçalves Filho et al. (2011), which evaluates five dimensions of safety culture maturity. Additional items related to leadership were incorporated following Momesso (2017) to enhance diagnostic capacity regarding leadership's role in consolidating safety culture. Responses followed a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), as suggested by Nóbrega (2019), enabling quantitative analysis of maturity levels across dimensions.

The documentary evidence checklist was applied exclusively to managers or owners to confirm the existence of institutional safety-related documents. The study did not assess document quality.

Ethical approval was not required under Resolution No. 510/2016 of the Brazilian National Health Council, as the research posed no direct or indirect risk to participants. Data collection excluded biological, clinical, or personally identifiable information and did not involve vulnerable groups. All responses were anonymous and analyzed in aggregate, ensuring confidentiality and scientific rigor.

3.4. Pre-test and validation

To ensure clarity and relevance, the questionnaire was validated by five commercial consultants during an in-person meeting (July 24, 2024), who suggested minor adjustments in wording and question order. A pre-test was then conducted with ten resale company owners in August 2024. No significant issues were identified, confirming the instrument's adequacy for field application.

3.5. Instrument application

Data collection occurred in person between August 6 and December 20, 2024, using Google

Forms. All employees of selected companies were invited to participate anonymously, completing the questionnaire individually. The average response time was approximately 10 minutes and 47 seconds. Monthly distribution was as follows: 53 responses in August, 83 in September, 17 in October, 73 in November, and 63 in December.

The checklist was also applied via Google Forms, requiring managers or owners to indicate whether they possessed each requested document. To ensure credibility, respondents were asked to upload copies of documents when available. This procedure allowed objective verification of evidence, strengthening methodological consistency and reducing reliance on declarative responses.

3.6. Data treatment and analysis

Data were organized by sociodemographic profile and sector characteristics (e.g., gender, role, education, tenure). Statistical analysis included measures of central tendency and dispersion and graphical visualizations (histograms and boxplots). Reliability was assessed using Cronbach's alpha (Field, 2024). Safety culture maturity was analyzed by dimension and correlated with sociodemographic variables to identify patterns and perceptual differences. All statistical processing was performed using Microsoft Excel®.

Documentary evidence was examined for the presence of relevant records without content analysis. The integrated analysis of questionnaire and checklist data provided a comprehensive view of safety culture maturity across the reseller network. Each factor was evaluated individually and collectively, generating an overall maturity index and identifying convergences and divergences among functional profiles. Interpretation followed the adapted model of Gonçalves Filho et al. (2011) and incorporated elements from Nóbrega (2019) and Momesso (2017). Conclusions were based on coherence between respondents' perceptions and documentary evidence. From this diagnosis, improvement proposals aligned with literature and best practices were developed to support the evolution of organizational safety culture maturity in LPG resale companies.

4. Results and Discussion

4.1. Reliability of the questionnaire

Before analyzing results, it was essential to confirm the questionnaire's reliability, ensuring stability and consistency of responses. Cronbach's Alpha (α), introduced by Cronbach (1951), is widely used to assess internal consistency in multi-item scales (Field, 2024). The coefficient ranges from 0 to 1; values above 0.70 are acceptable for exploratory studies, while those above 0.80 indicate good reliability (Gonçalves Filho et al., 2015; Nunnally & Bernstein, 1994). In this study, $\alpha = 0.8863$, demonstrating strong internal consistency and aligning with previous research on safety culture (Silva et al., 2019; Santos et al., 2021), which reported values between 0.78 and 0.91. Item deletion analysis showed minimal variation, with "Alpha if item deleted" ranging from 0.8755 to 0.8959, so all items were retained. These results confirm the instrument's robustness, strengthening confidence in subsequent analyses of safety culture maturity.

4.2. Respondent profile

The study included 289 participants from LPG resale companies in Salvador, Bahia, to contextualize safety culture maturity analysis. Most respondents were male (76%), with females representing 23% and 1% undisclosed, reflecting the sector's historical profile. Men predominated among delivery staff (99%) and managers (81%), while women were the majority in administrative roles (60%). Regarding age, 81% were between 21 and 50 years, and education levels varied: 46% completed high school, 24% incomplete, and 20% had or pursued higher education. Tenure was mostly under four years (63%), with only 17% exceeding ten years, mainly managers. Functional distribution: 45% delivery, 30% administrative, 24% managerial.

4.3. Stage of safety culture maturity

The questionnaire consisted of 21 Likert-scale items, each linked to a specific maturity stage. Responses allowed identification of the

predominant stage for each aspect of safety culture across LPG resale companies.

Results reveal significant variation. Questions P19 ("the company's manager is committed to issues related to safety") and P20 ("the company's manager encourages employees to report all accidents and incidents"), related to leadership engagement, concentrated in the constructive stage, indicating high maturity and integration of safety as an organizational value. Similarly, P1 ("employees feel comfortable reporting any abnormal occurrence, regardless of whether it is a serious accident or not"), P3 ("there is an open communication channel between the company and employees to discuss workplace safety"), P4 ("the workplace safety communication provided by the company reaches all employees correctly"), P8 ("the company informs all employees about the results of the analyses of abnormal occurrences to share the lessons learned"), P16 ("the company provides all the necessary resources to ensure that procedures are carried out safely"), and P21 ("the company's manager acknowledges and recognizes employees who work according to safety procedures") showed predominance in the proactive stage, reflecting consolidated practices. Conversely, P2 ("the company has workplace safety performance indicators, such as work accident rates"), P5 ("the workplace safety information shared by the company is diverse, such as: use of personal protective equipment (PPE), accident rates, health protection, results of abnormal occurrence analyses, safety talks, and improvements made in workplace safety"), P7 ("the company analyzes all abnormal occurrences, regardless of severity or whether they resulted in accidents"), P13 ("the company has workplace safety planning integrated with its overall planning"), and P15 ("the company continuously provides workplace safety training to all employees") scored mainly in pathological and reactive stages, signaling critical gaps such as lack of planning, performance indicators, and continuous training. P13 was particularly concerning, with most responses in the pathological stage. Questions P6 ("employees understand the need to follow safety rules and procedures and are aware of the risks associated with not complying with them"), P10

(“employees participate in matters related to workplace safety in the company”), P11 (“employees are interested in participating in issues related to workplace safety in the company”), P12 (“employees proactively and constantly look for ways to perform their activities more safely”), P14 (“the company continuously invests in workplace safety across all its departments”), P17 (“the company’s workplace safety procedures represent best practices for performing tasks and are always reviewed to align with actual working conditions”), and P18 (“workplace safety is the highest priority in the company”) clustered in the bureaucratic stage, suggesting formal processes exist but lack cultural internalization.

Overall, seven questions fell within the bureaucratic stage, indicating that safety processes are institutionalized but primarily compliance-driven rather than value-based (Hudson, 2001; Gonçalves Filho et al., 2011). The coexistence of pathological, reactive, and bureaucratic stages highlights heterogeneity and transitional maturity. These findings underscore the need for integrated actions to strengthen leadership visibility, employee involvement, and genuine prioritization of safety, moving beyond formal compliance toward a deeply embedded safety culture.

4.4. Demographic determinants of safety culture maturity

Understanding safety culture maturity in LPG resale companies requires analyzing demographic factors that influence perceptions and behaviors. This study examined associations between maturity stages and variables such as education, age, gender, tenure, monthly volume, and work sector using the chi-square independence test and Cramer’s V coefficient (Field, 2024). Table 1 summarizes the results.

Table 1. Consolidated Results of the Association Tests between Demographic Determinants and Safety Culture Maturity (Chi-square)

Determinant	Chi-square (χ^2)	Degrees of Freedom	P-value	Cramer's V
Education Level	49.93	18	0.0001	0.2400

Monthly Volume Range	33.35	18	0.0151	0.1961
Gender	2.01	3	0.5711	0.0836
Age	37.05	15	0.0012	0.2067
Work Sector	28.09	6	0.0001	0.2205
Time in Company	43.61	15	0.0001	0.2243

Education showed the strongest association ($\chi^2 = 49.93$; $p < 0.001$; $V = 0.24$), indicating that higher schooling levels favor greater safety culture maturity. Monthly volume also correlated significantly ($p = 0.015$), suggesting that larger operations adopt more robust safety practices. Age and tenure demonstrated moderate associations, with older and longer-tenured employees showing higher maturity, though slight declines occur after ten years, signaling the need for continuous training. Work sector was highly significant, with operational roles exhibiting greater maturity than administrative or sales positions. Gender showed no significant effect, confirming similar perceptions when training is standardized.

Overall, findings highlight that education, experience, and operational context strongly influence safety culture maturity, reinforcing the need for tailored strategies to strengthen engagement and embed safety as a core organizational value.

4.5. Safety culture maturity by research factor

Statistical analysis revealed an overall maturity score of 3.12, placing LPG resale companies between bureaucratic and proactive stages (Gonçalves Filho et al., 2011). Among factors, leadership scored highest (mean = 3.74; CV = 0.21), indicating consistent perceptions and strong managerial influence on safety practices (Fleming, 2001). Conversely, information (mean = 2.61) and commitment (mean = 2.70) showed the weakest performance and greatest variability, signaling gaps in communication flow and prioritization of safety (Westrum, 2004). Communication (3.47),

organizational learning (3.17), and involvement (3.29) ranked intermediate, though communication displayed high variance, reflecting uneven message dissemination (Mearns et al., 2003). These findings highlight the need for targeted strategies to strengthen weak areas while leveraging leadership as a foundation for advancing toward a proactive and constructive safety culture.

4.6. Analysis of documentary evidence

The analysis of documentary evidence revealed that legal compliance remains the primary driver of recorded safety practices. Mandatory documents such as the Fire Department permit (92.5%), municipal license (87.5%), and ANP authorization (62.5%) showed the highest presence among LPG resale companies. This pattern aligns with Gonçalves Filho et al. (2011), indicating that organizations in early maturity stages adopt a reactive or bureaucratic posture, focusing on regulatory requirements rather than internalizing safety as a cultural value.

Conversely, documents reflecting voluntary and structured actions were almost absent. Factors such as communication, organizational learning, and commitment showed evidence rates near zero. No company had action plans based on incident analysis, formal communication channels, or annual safety planning. This contrasts sharply with questionnaire responses, where participants reported practices like training and preventive actions.

The discrepancy between perceived practices and documented evidence highlights a structural gap between declared and actual culture (Hudson, 2001; Reason, 1997). Informal actions, such as verbal instructions or ad hoc problem-solving, are often interpreted as formal processes, creating a “cognitive-operational gap.” Lack of documentation limits organizational learning and cultural evolution (Westrum, 2004), reinforcing dependence on external compliance.

These findings confirm that LPG resale companies predominantly operate at a bureaucratic maturity stage, characterized by minimal formalization and weak institutionalization of safety practices.

Advancing maturity requires systematic documentation, structured processes, and continuous improvement to transform informal routines into verifiable organizational standards.

4.7. Limitations and future research

This study's limitations include its geographic scope and non-probabilistic sampling, restricting generalization. Future research should expand to other regions and sectors, incorporating qualitative approaches such as interviews and focus groups.

5. Conclusion

The findings reveal a multifaceted panorama of safety culture maturity within LPG resale networks. While progress is evident in certain dimensions, practices largely remain informal or limited to meeting legal requirements. Integrated analysis of questionnaires and documentary evidence shows that, despite workers' recognition of safety's importance, actual practices, particularly in information flow, commitment, and organizational learning, are fragmented and weakly structured. This confirms a predominantly bureaucratic maturity stage, with reactive traits in critical areas.

Leadership emerged as the strongest factor, achieving the highest score and demonstrating visible managerial engagement and reinforcement of safe behaviors. This aligns with Fleming (2001) and Hudson (2001), who emphasize leadership as a key driver of cultural consolidation. However, leadership alone has not sufficed to integrate other cultural dimensions, which still exhibit significant gaps.

A notable discrepancy exists between employees' perceptions and the absence of supporting documentation. While respondents reported activities such as training and incident analysis, formal records were scarce. This gap suggests fragile safety management routines and a declared culture that does not fully translate into practice (Hudson, 2001). Mandatory documents, permits and licenses, dominate, while action plans, performance reports, and training records are virtually absent, reinforcing regulatory compliance as the primary motivator (Gonçalves Filho et al., 2011).

Demographic factors also influence maturity. Older, more experienced, and better-educated employees demonstrated higher alignment with safe practices, consistent with literature linking these attributes to risk awareness and adherence to norms (Reason, 1997; Cooper, 2000). Conversely, frontline workers with lower education levels scored lower, underscoring the need for tailored training strategies using accessible language and practical approaches.

Interestingly, smaller resale companies outperformed larger ones in maturity levels. This counterintuitive result reflects closer leadership-team interaction, streamlined communication, and cultural cohesion in smaller structures (Guldenmund, 2000; Fleming, 2001). Larger organizations face challenges such as high turnover, operational complexity, and hierarchical distance, which hinder cultural integration.

Advancing safety culture maturity requires coordinated efforts across three pillars: (i) strengthening operational leadership to assume a pedagogical role; (ii) systematizing communication, monitoring, and learning processes currently absent in most companies; and (iii) adapting engagement strategies to frontline profiles, fostering ownership and risk awareness.

Ultimately, evolving safety culture depends not only on formal compliance but on creating an environment where continuous learning, collective commitment, and transparent communication are core values. Practically, this study offers a replicable methodological model and a detailed diagnostic to guide corporate policies and strategic interventions.

Academically, it enriches safety culture literature by addressing an underexplored sector and confirming theoretical correlations between cultural maturity and organizational factors.

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