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ORAL PRESENTATION

A Review of Localized Food Safety Frameworks for Risk-Based Inspections

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Abstract

Emerging economies face an "enforcement deficit" when aligning with international food safety standards. Modern frameworks rely heavily on quantitative risk-scoring architectures like Multicriteria Decision Analysis (MCDA), which require exhaustive digital infrastructure and laboratory integration. For resource-constrained authorities, importing these data-heavy systems often turns risk assessment into performative compliance rather than functional market surveillance. This study analyzes dominant regulatory models to propose a novel, "lightweight" MCDA framework tailored for emerging economies. By using a targeted Weighted Compliance Score (WCS), this model decouples risk prioritization from exhaustive data demands, shifting the algorithmic focus to easily observable compliance vectors like food labeling and packaging. This approach categorizes regulatory non-conformities into clear risk tiers without needing advanced diagnostic equipment or centralized data silos. Modeled as a proof-of-concept for the Albanian regulatory context, this localized framework provides a highly scalable tool. It enables regulatory bodies to establish objective inspection priorities immediately while progressively building the digital foundations necessary for future integration into global food safety networks.

Keywords: Food Safety Surveillance, Risk Assessment, Emerging Economies, MCDA, Regulatory Compliance, Resource-Constrained Settings

INTRODUCTION

Historically, food safety management relied on reactive regulatory inspections and end-product testing (Koutsoumanis & Aspridou, 2016). However, complex global supply chains require modern control systems to shift toward a risk-based paradigm, using risk analysis for preventative control (Codex Alimentarius Commission, 2007; Food and Agriculture Organization of the United Nations, 2008; Koutsoumanis & Aspridou, 2016). This approach optimizes limited resources by prioritizing Food Business Operators (FBOs) based on their public health impact, targeting interventions precisely where risks are highest (Food and Agriculture Organization of the United Nations, 2008). Despite international consensus, the methodologies used for risk categorization vary significantly across national bodies.

In the European Union, 1990s crises like Bovine Spongiform Encephalopathy (BSE) highlighted the failure of isolated systems, driving the need for a unified, standardized approach (European Parliament and Council of the European Union, 2002; Havinga, 2014). The transition from legal text to actionable metrics typically relies on two dominant models: continuous single-layer numerical algorithms or categorical two-layer grouping matrices (Ze, van Asselt, Focker, & van der Fels-Klerx, 2025). While quantitative models offer high empirical precision, they demand robust digital infrastructure, creating implementation challenges for agencies transitioning to unified standards. This review evaluates the trade-offs between these architectures, assessing how frameworks balance algorithmic prioritization with practical data availability (van Asselt, Hoffmans, Hoek- van den Hil, & van der Fels-Klerx, 2021; Ze et al., 2025). Ultimately, this paper conducts an architectural analysis to propose a novel risk-scoring framework tailored for emerging economies.

MATERIALS AND METHODS

To identify relevant literature on risk categorization methodologies and regulatory enforcement, a structured literature search on risk categorization and regulatory enforcement was conducted across Scopus, Web of Science, and Google Scholar. Primary keywords included "food inspection", "risk-based food inspection", "food inspection in emerging economies", and "risk-based food safety". Selection prioritized peer-reviewed articles, international guidelines, and European Commission regulations, screening sources for their focus on risk assessment mechanics and regulatory behavior. Studies strictly focused on chemical toxicity without a regulatory context were excluded.

This review then employs a comparative structural analysis of contemporary inspection frameworks. The methodology evaluates the operational mechanics and data dependencies of the two dominant FBO categorization models (Patton, 2015; Yin, 2018): categorical two-layer grouping matrices and continuous single-layer numerical scoring algorithms (Ze et al., 2025). Authorities generally use one of these two frameworks (World Health Organization, 2024). Grouping architectures sort FBOs into broad tiers based on static variables like business type and scale. Contrarily, continuous scoring architectures, such as Multicriteria Decision Analysis (MCDA), calculate dynamic risk values by weighting continuous variables like past compliance and third-party audits, offering superior mathematical precision (van Asselt et al., 2021; Ze et al., 2025). The trade-offs between these architectures are evaluated against the institutional capacities of emerging economies.

RESULTS AND DISCUSSION

Comparing risk categorization frameworks reveals a stark trade-off between measurement precision and operational feasibility (Table 1). Two-layer grouping architectures offer procedural simplicity, allowing authorities to allocate inspection frequencies rapidly based on static FBO cohorts. However, they lack internal discrimination, treating compliant and non-compliant operators identically before an inspection. In contrast, single-layer scoring models (MCDA) use weighted continuous variables to calculate dynamic risk indices, isolating systemic non-compliance across similar establishments (van Asselt et al., 2021; World Health Organization, 2024; Ze et al., 2025).

While quantitative scoring offers superior precision, its success depends entirely on continuous, standardized empirical data (Asselt et al. 2021; Maiberger and Sunmola 2023). For emerging economies aligning with EU frameworks, this dependency creates an "enforcement deficit". Though statutory mandates exist on paper, operational reality relies on manual checklists and paper-based silos (Food and Agriculture Organization of the United Nations & World Health Organization, 2020). Without digital infrastructure, comprehensive multi-parameter models become performative rather than functional tools. Furthermore, without robust data, agencies often use the framework's flexibility to codify pre-existing practices instead of adopting objective mandates (Borraz et al., 2022).

Table 1. Comparative Analysis of Dominant Risk Categorization Architectures

Framework Feature	Two-Layer Grouping (World Health Organization, 2024)	Standard MCDA (World Health Organization, 2024)	Targeted/Lightweight MCDA (Proposed) (Harizaj, Troja, & Dhamo, In press; World Health Organization, 2024)
Mathematical Precision	Low (Static cohorts)	High (Dynamic, continuous scoring)	Moderate-High (Weighted scoring on targeted metrics)
Data Infrastructure Required	Low (Paper-based, basic registration)	High (Continuous digital silos, lab integration)	Low-Moderate (Standardized checklists, visual audits)
Primary Data Inputs	Business type, scale, volume	Process controls, historical compliance, lab results	Discrete, easily observable compliance vectors
Suitability for Emerging Economies	High feasibility, but lacks enforcement sensitivity	Low feasibility (creates enforcement deficit)	High feasibility, establishes algorithmic prioritization

To overcome this deficit while maintaining empirical advantages, resource-constrained authorities must decouple scoring from exhaustive data demands. Single-layer MCDA frameworks can be localized toward discrete, standardized compliance vectors (World Health Organization, 2024). These vectors allow non-conformities to be categorized into clear tiers without advanced diagnostics. Algorithmic prioritization is driven by a targeted Weighted Compliance Score (WCS) calculated as:

$$WCS = \Sigma(x \times w)$$

where x represents the empirical compliance score and w represents the designated risk-weight based on statutory severity. This approach, modeled as a proof-of-concept in Albania (Harizaj et al., In press), demonstrates how authorities can establish algorithmic prioritization immediately while building digital foundations for future modernization.

CONCLUSION

Emerging economies face a systemic barrier when implementing international food safety regulations: the operational gap between statutory mandates and the empirical data required for enforcement. While continuous risk-scoring models (MCDA) offer superior precision, their reliance on exhaustive digital infrastructure makes them largely incompatible with resource-constrained environments, causing an enforcement deficit. This paper proposes a pragmatic bridge to overcome this deficit: a targeted, "lightweight" MCDA framework. Rather than attempting whole-system diagnostics, this research shows that quantitative scoring can be localized by focusing on discrete, observable compliance vectors. By isolating parameters that do not require advanced laboratory integration, authorities can deploy algorithmic risk prioritization immediately. Ultimately, this approach provides

a highly scalable model that delivers an actionable tool for market surveillance while laying the institutional foundation for a gradual transition toward fully integrated food safety networks.

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