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Proposal of a new method for the risk scoring and categorization of Brazilian food services

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A R T I C L E I N F O

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A B S T R A C T

Risk scores are used worldwide to predict foodborne disease (FBD) outbreaks in the food service industry. This study aims to develop and validate a new method for the calculation of the FBD risk score for the checklist used to categorize food service outlets. The proposed novel method is based on a risk score for each item using a risk matrix (consequence × probability), overcoming the limitations of the previous scoring process used during the World Cup in Brazil, which was based on a factorial analysis. The classification of consequences was based on critical points identified by experts prior to the World Cup in Brazil. Probability was defined based on the violation percentage of each item evaluated during inspections from 1536 food service outlets. Validation was performed using a secondary database of 3072 food service assessments in two inspection cycles. The risk scores of the new method were compared with those used during the World Cup. Each food service was classified based on their risk score into four categories: A, B, C, and pending. Good concordance (Lin's correlation coefficient = 0.8711 and 0.9205) was observed between the new and previous scores in the two inspection cycles, respectively. Comparison of the classifications showed substantial agreement (Kappa = 0.749, $p < 0.001$) to the first inspection cycle and near-perfect agreement (Kappa = 0.821; $p < 0.001$) to the second inspection cycle. This new method allows the inclusion and exclusion of assessment elements depending on local reality. Simpler methods can be used throughout Brazil and serve as a model for other countries' food safety assessments.

1. Introduction

In 2012, the Brazilian government introduced the Food Service Categorization project before the start of the 2014 *Fédération Internationale de Football Association* (FIFA) World Cup in Brazil, because they were concerned about the large influx of tourists to the country. They sought strategies to reduce the risk of foodborne diseases (FBD) (Brazil, 2013b; Da Cunha et al., 2014) to keep the population safe. Outbreaks of FBD during the games could also compromise the country's image in the international community. These diseases are responsible for the loss of 33 million healthy lives worldwide, and cause expressive medical expenses, lost productivity, and barriers to socio-economic development (Fung et al., 2018; Havelaar et al., 2015; Mangen et al., 2015; Soon et al., 2020).

The Food Service Categorization project was conducted by the Brazilian National Health Surveillance Agency (ANVISA) and was named

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the Brazilian Pilot Project, because of its innovative features and the prospect of in the future (Da Cunha et al., 2016). The Brazilian Pilot Project was inspired by successful experiences with food service categorization and scoring, such as in Los Angeles (Simon et al., 2005), New York (Wong et al., 2015), and the United Kingdom (Food Standards Agency, 2017). In Brazil, the Food Service Categorization also demonstrated success in reducing the risk of FBD during the World Cup (Da Cunha et al., 2016). Before the event, health authorities inspected 1927 food service outlets located in Brazilian host cities over two inspection cycles. During the first cycle, food service outlets received a report of the inadequacies, and in the second cycle, they received a stamp based on the obtained risk score (Da Cunha et al., 2014). The score and characteristics for each stamp/category are described in Table 1. The detailed process of creation and validation of this method has been published elsewhere (Da Cunha et al., 2014).

The development of methods for FBD risk calculation is aligned with discussions held at the European Food Safety Authority (EFSA) Scientific Conference, 2019. The EFSA indicated the need for novel forms of risk assessment that are more contextual, socially responsible, and accountable while remaining scientifically robust (Devos et al., 2019). Instruments for food safety rating have been developed in several countries (Da Cunha, De Rosso & Stedefeldt, 2016) e.g., the Oiva system, created in 2013, in Finland. The Oiva system is a publication system for food-control inspection information coordinated by the Finnish Food Authority (Finnish Food Authority, 2020). Kaskela et al. (2021) reveal the need for improvements in the consistency of food safety inspection grading to increase the credibility of the Finnish system, highlighting that risk-based food control requires an understanding of hazards by inspectors and food business operators.

Disclosure of the results of a food safety ratings (or grading system) promotes a cycle of public health transparency that balances the asymmetry of information between owner and consumer (Fleetwood, 2019). Food safety ratings can complement regulatory measures taken by public health authorities. However, several socio-demographic factors may affect the use of such a system and should be considered in its design and implementation (Aik et al., 2018). The efficacy of risk scoring and classification is evident by the successful experience during the World Cup in Brazil, which changed the background of food services, and boosted the reduction in violations (Da Cunha et al., 2016) reaffirmed with the findings of Kaskela et al. (2019) in the use of the Finnish dissemination system and Aik et al. (2018) in Singapore also boosted the reduction in violations. If the system is done correctly, with consistent, valid, and reliable measures, it can reduce FBD (Fleetwood, 2019).

Table 1
Score and characteristics for each category of the Pilot Project of Categorization of food services at Brazil's 2014 FIFA World Cup.

Stamp/ Category	Score used	Characteristics
A	Equal to or greater than 0 and less than 13.3, compliance with the eliminatory items* and at least one of the qualifying items**.	Very good quality
B	Equal to or greater than 13.3 and less than 502.7 and fulfillment of elimination items.	Good quality
C	Equal to or greater than 502.7 and less than 1152.3 and fulfillment of elimination items.	Acceptable quality
Pending	Equal to or greater than 1152.3 and/or non-compliance with elimination items.	Unacceptable quality Urgent improvement needed

Source: Brazil (2013a; 2014).
* Eliminatory items: Exclusive use of drinking water for food handling (public water supply or alternative solution with semiannual tests confirming that the water is safe to drink according to laboratory reports); Facilities with running water; Facilities have connections to the sewer system or septic tank.
** Presence of a properly trained individual responsible for food handling activities (technical manager, owner, or designated employee); The company follows a Manual of Good Handling Practices and the Standard Operating Procedures.

Despite the positive results, the Brazilian Pilot Project has not been continued and transformed into public policy, as observed in other cities and countries such as the United Kingdom, Finland and New York (United States). However, local efforts, such as Santa Maria, a municipality in southern Brazil, implemented Brazilian Pilot Project principles five years after the World Cup using the same checklist and risk scoring as a reference (Santa Maria, 2019). Authorities from the state of Rio de Janeiro, Brazil, adapted the checklist used in the 2014 FIFA World Cup, with a new risk score motivated by the need for the local reality and need to update (Rio de Janeiro, 2020). Lundén et al. (2021) confirm that differences in regional classification explained by factors related to the economic situation and urbanization of the area must be considered in a categorization system.

The scores used in the original proposal, the Brazilian Pilot Project, were established using factorial analysis and several methodological approaches. Through factorial analysis, it is possible to "reduce the number of dimensions needed to describe data derived from a large number of measures" (Matos & Rodrigues, 2019). The aim of factor analysis in the Brazilian Pilot Project was to reduce the dimensionality of the data to obtain a single score representing the food safety of the inspected food service. Thus, the items considered most critical were studied from a multivariate perspective. However, factor analysis is an interdependent method in which all the variables are considered simultaneously. Each variable was predicted by all others (Hair et al., 2005). Therefore, there is no possibility of making changes in the assessment items, such as exclusions or inclusions, and when changes are necessary, a new factor analysis should be performed. This makes it impractical to adapt the instruments required in different contexts. A new method that overcomes this limitation and is more flexible would facilitate its use by local authorities. Thus, this study aims to develop and validate a new method for the calculation of the FBD risk score for the checklist used to categorize food service outlets.

2. Method

The present study was conducted from March 2020 to March 2021. It is semi-quantitative research of a descriptive nature and was conducted in three phases: (1) establishment of a risk matrix, (2) pretest, and (3) the validation of risk scoring.

The instrument used was a checklist from the Brazilian Pilot Project comprising 45 items (Da Cunha et al., 2014). The items are divided into eight blocks: (1) water supply; (2) structure; (3) sanitation of facilities, equipment, furniture, and utensils; (4) integrated control of vectors and urban pests; (5) handlers; (6) raw materials, ingredients, and packaging; (7) food preparation; and (8) storage, transportation, and exhibition of prepared food (supplementary material).

2.1. Phase 1 – Establishment of a risk matrix

The objective of this phase was to establish a reliable risk matrix, defining risk as a measure of probability and consequence (Brazilian Association for Technical Standards, 2018). A risk matrix is a visual tool that supports classification and interpretation of results, in which high probability and high consequence result in a high risk (Food and Agriculture Organization, 2020). Probability was defined as "the chance of a certain event happening," and consequence as "the result of an event that affects the objectives" (Brazilian Association for Technical Standards, 2018). The new method presented the degree of risk according to the probability of a violation and its consequences In the development of this study, two different risk scoring methods were tested. The risk was calculated by multiplying probability and consequence, as described below.

The probability was defined based on a secondary database with

1536 food service assessments from all regions of Brazil, inspected during the first cycle of categorization for the 2014 FIFA World Cup (Da Cunha et al., 2016). The results of the second inspection cycle were not used for probability definition because they could pose some bias, as inspectors guided food service owners immediately after the first cycle. All verification items were divided into quartiles based on the violation percentage. The quartiles were scored according to the recommendations of ISO 31000:2018 (Brazilian Association for Technical Standards, 2018), with one being the lowest probability and four as the highest probability, as shown in Table 2. Table 3 presents the percentage of violation for each inspection item.

The consequence was scored based on two previously validated methods (Stedefeldt et al., 2013; Da Cunha et al., 2014). These methods were selected because they were already in use in the country and weighed the items based on the critical points of food and meal production.

Method 1: Based on the Stedefeldt et al. (2013) criteria, with the consequence determined by experts. The experts were five professionals from the food safety area (food microbiology, risk analysis, and food handling), of whom three had doctoral degrees and two were master's students. The authors assigned scores in arithmetic progression for consequence:

- Score = 8: inspection items that presented conditions or situations that prevent the multiplication of microorganisms;
- Score = 4: inspection items with conditions or situations that prevent the survival of microorganisms;
- Score = 2: inspection items that presented conditions or situations that avoid cross-contamination through direct contact with food;
- Score = 1: inspection items that presented conditions or situations that avoid cross-contamination without direct contact with food.

Method 2: Based on the consequence determined by experts, as described by Da Cunha et al. (2014). The group of experts consisted of 24 professionals from various food safety areas (health surveillance, food microbiology, risk analysis, food handling, and statistics). Among the participants, 9 had doctoral degrees, 1 was a PhD student, 2 had master's degrees, 1 was a master's student, and 11 had some type of postgraduate certification on food safety.

The consequence of method 2 was understood as "the occurrence of an outbreak of an FBD" considering the main factors that can cause outbreaks in Brazil. The authors assigned linear scores in consequence:

- Score = 4, inspection items related to the 1st FBD causal factor in Brazil: Failures associated with the time and temperature of food preparation, storage, transportation, and exposure. This is defined as a situation that can directly lead to FBD. In general, these are situations that allow the multiplication or survival of pathogenic microorganisms;
- Score = 3, inspection items related to the 2nd FBD causal factor in Brazil: Failures associated with the contamination of equipment, utensils, and handlers. This is defined as a situation that can lead to food contamination. It generally involves situations of cross-contamination that may lead to FBD when factors such as time and

Table 2
Probability scale with the range of non-compliance percentage of the scored items from the 2014 FIFA World Cup Categorization Evaluation List, Brazil, 2020.

Probability Scale	Range of % of violation of the items
4 (very high)	25.76 to 52.30
3 (high)	18.01 to 25.75
2 (low)	11.81 to 18.00
1 (very low)	4.40 to 11.80

Table 3
Inspection items with violation percentage, probability, and consequences.

ITEM	Violation percentage (%)*	Probability	Consequence Method 1 (Stedefeldt et al., 2013)	Consequence Method 2 (Da Cunha et al., 2014)
Availability of a properly calibrated thermometer with which to measure the temperature of food.	52.3	4	8	4
Temperature of the raw materials and perishable ingredients checked at reception and storage	46.8	4	8	4
The effectiveness of the heat treatment is evaluated.	39.7	4	8	4
Temperature of the display equipment regularly monitored.	37.9	4	8	4
Raw materials properly portioned, packaged, and labelled with at least the following information: name of product, date of portioning, and expiration date after opening or removal of the original packaging.	37.4	4	2	2
Sinks in the food preparation area equipped with products for hand hygiene (odourless antiseptic liquid soap or odourless liquid soap and antiseptic product, non-recycled paper towels, or other hygienic and safe system for drying the hands).	35.5	4	4	3
Prepared food stored under refrigeration or freezing is labelled with at least the following information: name, date of preparation,	33.9	4	2	2

(continued on next page)

Table 3 (*continued*)

ITEM	Violation percentage (%)*	Probability	Consequence Method 1 (Stedefeldt et al., 2013)	Consequence Method 2 (Da Cunha et al., 2014)
and expiration date.				
Existence of a set of effective and continuous actions to prevent attraction, shelter, access, and dissemination of vectors and urban pests.	33.7	4	4	1
Facilities, equipment, furniture, and utensils kept in proper hygienic-sanitary condition.	28.4	4	2	3
Toilets have hand sinks and products for personal hygiene (toilet paper, odourless antiseptic liquid soap or odourless liquid soap and antiseptic, collectors with lids operated without manual contact, and non-recycled paper towels or other hygienic and safe system for drying the hands).	28.0	4	4	3
Appropriate frequency of sanitisation of equipment, furniture, and utensils	27.7	4	2	3
Prepared food kept refrigerated at a temperature equal to or below 5 °C.	23.8	3	8	4
During the food preparation process, persons that handle raw foods wash and disinfect their hands before handling prepared food	23.3	3	8	3
Employees wash hands thoroughly when arriving at work, before and after handling food, after any interruption of work, after touching contaminated materials, after using the toilet, and whenever it is needed.	23.1	3	8	3
Prepared food kept at temperatures above 60 °C.	22.0	3	8	4
Heating of foods to ensure that all parts of the food reach a temperature of at least 70 °C, or other combination of time and temperature that ensures the hygienic-sanitary quality of food.	19.6	3	8	4
Subjected to inspection and approval at reception.	19.5	3	4	2
After cooling, prepared food kept refrigerated at temperatures below 5 °C or frozen at temperature equal to or below − 18 °C.	19.4	3	8	4
Thawing performed as directed by the manufacturer and using one of the following techniques: refrigeration at a temperature below 5 °C or in microwave oven when the food is to be cooked immediately	18.6	3	8	4
Food to be consumed raw, when applicable, subjected to a sanitisation process with an appropriate certified product applied in such a way as to avoid residues.	18.4	3	8	4
Preparation areas cleaned as often as needed and immediately after the	18.3	3	4	1

(*continued on next page*)

Table 3 (*continued*)

ITEM	Violation percentage (%)*	Probability	Consequence Method 1 (Stedefeldt et al., 2013)	Consequence Method 2 (Da Cunha et al., 2014)
completion of work				
Temperature of the prepared food reduced from 60 °C to 10 °C within 2 h during the cooling process.	18.3	3	8	4
The maximum period for the consumption of prepared and refrigerated food is 5 days if the storage temperature is equal to or below 4 °C. When temperatures above 4 °C and below 5 °C are used, the maximum period for consumption is reduced.	18.0	2	8	4
Food preserved at hot temperatures maintained at temperatures above 60 °C; time from preparation to display of the food not to exceed 6 h.	17.4	2	8	4
Dilution, contact time, and method of use or application of sanitising products follows the manufacturer's instructions	16.5	2	2	3
Perishables products exposed to room temperature for only the minimum time required for food preparation	16.4	2	8	4
Water reservoir sanitised at intervals not exceeding six months, keeping records of the operation	16.4	2	8	1
During food display, handlers follow procedures that minimise the risk of contamination of prepared food by hand antisepsis and by the use of utensils or disposable gloves, if applicable.	15.7	2	2	3
Presence of physical separation or another effective means of separation of different activities to prevent cross-contamination.	15.2	2	2	1
Avoidance of direct or indirect contact between raw foods, semi-ready and ready-to eat food	14.7	2	2	3
Constructions, facilities, equipment, furniture, and utensils free from the presence of animals, including vectors and urban pests	13.8	2	4	1
Prepared foods maintained in the storage area or awaiting transportation are labelled (name of product, date of preparation, and expiration date) and protected from contaminants.	13.4	2	2	3
Foods subjected to thawing are kept under refrigeration if they are not immediately used and not refrozen.	12.7	2	8	4
Control of vectors and urban pests performed by a specialised and properly legalised company.	11.9	2	8	1
Utensils used for the sanitisation of the facilities different from those used for the sanitisation of the equipment and utensils in	11.7	1	1	3

(*continued on next page*)

Table 3 (*continued*)

ITEM	Violation percentage (%)*	Probability	Consequence Method 1 (Stedefeldt et al., 2013)	Consequence Method 2 (Da Cunha et al., 2014)
contact with food.				
Raw materials, ingredients and packaging used for preparation are maintained under proper hygienic-sanitary conditions.	10.8	1	4	2
Use of raw materials and ingredients within the expiration date, taking into consideration the order of receipt.	10,8	1	4	4
Reservoir in proper hygienic condition.	9.0	1	8	1
Ice used in food made from drinking water and kept under hygienic-sanitary condition.	8.3	1	2	2
Storage and transportation occur under time and temperature conditions that do not compromise the hygienic-sanitary quality of the prepared food.	8.0	1	8	4
Food handlers do not smoke and speak when unnecessary and do not sing, whistle, sneeze, spit, cough, eat, handle money or engage in other activities that may contaminate food.	7.1	1	4	3
Reservoir properly covered and maintained (absence of cracks, leakage, infiltrations, and peeling, among other defects).	6.6	1	8	1
Handlers removed from the food preparation when they have injuries or symptoms of diseases	5.9	1	4	3
	5.1	1	8	2
Intact primary packaging of raw materials and ingredients.				
Sanitising products regulated by the Ministry of Health.	4.6	1	1	3
Material that internally coats the water reservoir does not compromise the water quality.	4.4	1	8	1

* Based on the evaluation of 1536 food services during the Brazilian Pilot Project.

temperature enable the multiplication and survival of microorganisms;

- Score = 2, inspection items related to the 3rd FBD causal factor in Brazil: Failures associated with raw materials and water. This is defined as a situation that can lead directly to an FBD. Generally, it involves situations of contamination of origin;
- Score = 1, inspection items related to the 4th FBD causal factor in Brazil: Failures associated with the lack of equipment/utensils and environmental aspects. This is defined as a situation that may enable FBD (cross-contamination without direct contact with the food).

Table 3 also presents the probability and consequence for each inspection item for Methods 1 and 2. The risk score for each item is determined by first multiplying the probability and consequence per item and then adding these together to obtain food service's final risk score. The risk score has a positive magnitude, i.e., the higher the risk, the higher the score. In this case, each violation sums up a final risk score. Adequate items receive no score (zero).

The number of points assigned to each level of the probability and consequence scale (Fig. 1) was used to establish a risk matrix (probability × consequence). Each item was scored using Methods 1 and 2.

2.2. *Phase 2 – Pretest*

A secondary database of 45 food services assessed in 2019 (in a municipality of 280,000 inhabitants in southern Brazil) was used to pretest the new risk scoring methods (Santa Maria, 2019). This database initially used the risk scoring method adopted during the Brazilian Pilot Project (Da Cunha et al., 2014). The risk scores were compared through statistical tests (Section 2.4) with those from the newly proposed method (Fig. 2). The method with greater concordance and agreement was selected as the new method.

2.3. *Phase 3 – Validation*

To validate the new method (Fig. 3), we used the secondary database of 1536 food services assessed during the Brazilian Pilot Project (Da Cunha et al., 2016). Since there were two inspection cycles, 3072 distinct scores were obtained. Then, the classification generated by the risk score proposed in the 2014 FIFA World Cup was statistically tested (s=Section 2.4) compared to the classification determined by the best proposal in the Phase 2. The categories characterized by A, B, C, and pending stamps were also compared between the Brazilian Pilot Project (Table1) and the new method (Table 4) (Brazil, 2014). The classification

		Probability			
		1	2	3	4
Consequence	4/8*	4/8*	8/16*	12/24*	16/32*
	3/4*	3/4*	6/8*	9/12*	12/16*
	2	2	4	6	8
	1	1	2	3	4

Fig. 1. Matrix for scoring FBD risk method 1 and 2, Brazil, 2020.

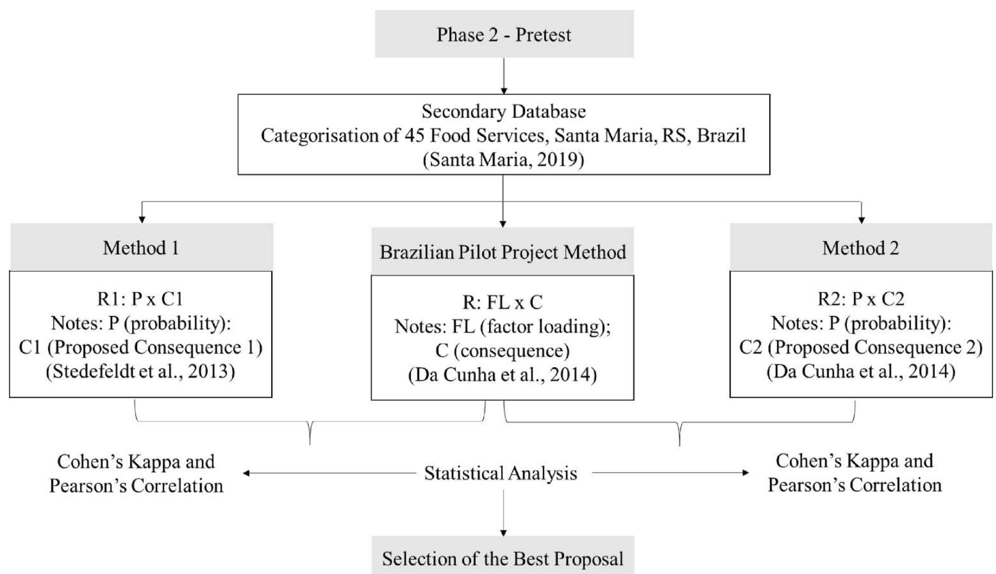

Fig. 2. Pretest for the new method for risk scoring according to food service categorisation, Brazil, 2020.

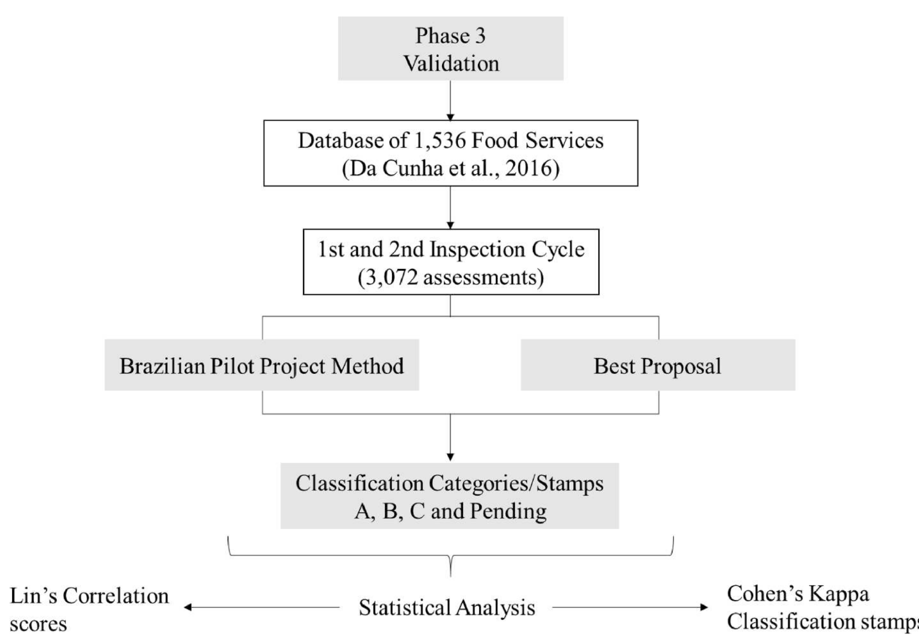

Fig. 3. Validation of the proposed new method for risk scoring according to Food Service Categorisation, Brazil, 2020.

Table 4
Classification Stamps based on the new FBD risk scoring for food service categorization, Brazil, 2021.

Classification stamps	Final score—new method	Characteristics
A	Risk greater than 0 and less than 2	Very good quality
B	Risk greater than 3 and less than 68	Good quality
C	Risk greater than 69 and less than 155	Acceptable quality
Pending	Risk higher than 155	Unacceptable quality Urgent improvement needed

stamps were established following the same proportions used in the Brazilian Pilot Project (Da Cunha et al., 2014, 2016).

2.4. Statistical tests

In phase 2, the association between risk scores and classification of the 45 food services using the Brazilian Pilot Project, Method 1, and Method 2 were calculated using Pearson's correlation and Cohen's kappa tests. Pearson's correlation was used to allow multiple comparisons using z-statistics.

In phase 3, the risk scoring previously used in the Brazilian Pilot Project (3072 food service assessments) was compared to the new method through Cohen's kappa agreement and Lin's correlation coefficient to measure agreement and concordance.

In kappa analysis, in both phases, agreement levels were evaluated according to the recommendations of Landis and Koch (1977), where a kappa value of 0.81–1.00 indicates near-perfect agreement, 0.61–0.80 indicates substantial agreement, 0.41–0.60 corresponds to the moderate agreement, 0.21–0.40 indicates a low agreement and 0.0–0.20 is not concordant. Concordance was considered when Lin's values were closer to 1.0 (Lin, 1989). The 95% confidence interval (95 %CI) of statistics was calculated. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) v.20.0.1 (IBM, 2011) and MedCalc v.19.8 (MedCalc, 2020) software.

3. Results

The supplementary material presents the checklist with detailed risk scores. Method 1 showed substantial agreement (0.738; 95 %CI = 0.572–0.904) and strong correlation (0.947; 95 %CI = 0.905–0.971), and Method 2 near-perfect agreement (0.888; 95 %CI = 0.769–1.00) and strong correlation (0.962; 95 %CI = 0.931–0.979); kappa was used to assess agreement and correlation was used to assess the correlation between risk scores. No differences were observed when multiple comparisons were used to test the strengths of the correlations ($z = -0.937$; $p = 0.17$). However, Method 2 was selected as the basis of the new method because it presented near-perfect agreement and was simpler than Method 1. Method 2 had the same scale for probability (4, 3, 2, 1) and consequence (4, 3, 2, 1).

Thus, the validation phase was performed using Method 2. It was found that there is a positive and increasing relationship, with correlation coefficients of Lin = 0.8711 (95 %CI = 0.8626; 0.8792) in the first cycle (Fig. 4a) and equal to 0.9205 (95 %CI = 0.9149; 0.9257) in the second cycle (Fig. 4b), between the new method and the method adopted in the Brazilian Pilot Project. This result indicates that although the new method is simplified, it converges to a result similar to that validated in the Brazilian Pilot Project.

The substantial and near-perfect agreement was observed when calculating Cohen's kappa with 0.749 ($p < 0.001$) for the first cycle and 0.821 ($p < 0.001$) for the second cycle. Table 5 shows the number of food services in each classification category in the inspection cycles. In the first evaluation cycle of the new method and the Brazilian Pilot Project, 157 food services were classified as C and B, respectively, while 85 food services were classified as pending in the new method and as C in the Brazilian Pilot Project. In the second cycle, 26 food services were classified as B with the new method and in the Brazilian Pilot Project as A. The classifications show a tendency for the new method to be more rigorous.

4. Discussion

4.1. Theoretical implications

The health risk of the new method was calculated using assumptions from the Brazilian Pilot Project for categorization of food services for the 2014 FIFA World Cup (Da Cunha et al., 2014). For the probability scale, we used the Brazilian Pilot Project data, which provided a more comprehensive diagnosis of the food safety violations presented in health inspections across all regions of Brazil.

The new method allows public health authorities to conduct risk assessment in food services, focusing on biological hazards. Risk assessment is internationally recognized as a component of risk analysis that guides decision-making and enables effective risk management (Food and Agriculture Organization, 2020; World Health Organization, 2006). Several researchers have used this approach to determine, for example, the public health risk associated with biological hazards in food (Membré & Boué, 2018; Omac et al., 2017; Pujol et al., 2013).

According to Codex Alimentarius Commission (2020), the risk is a

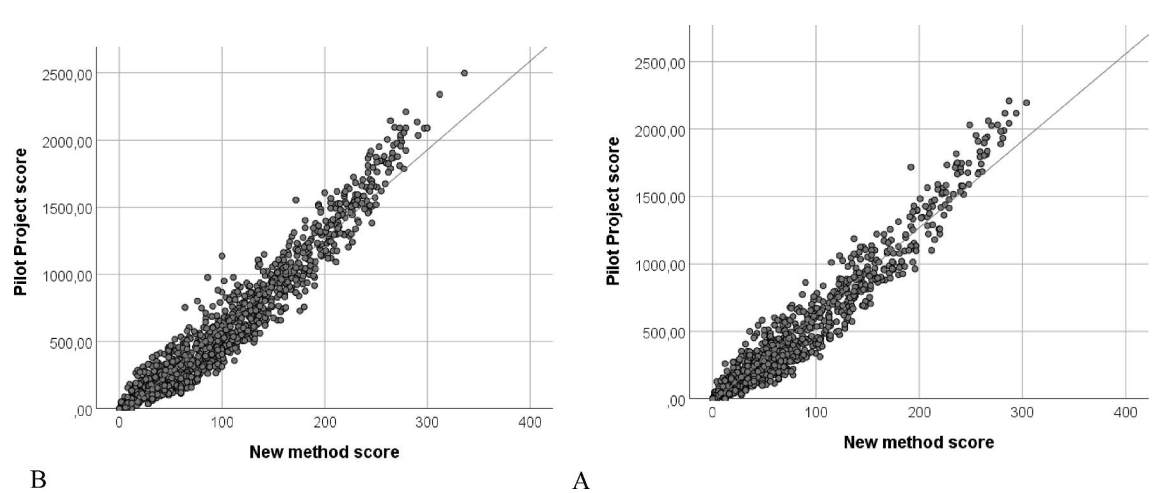

Fig. 4. Relationship of the calculation for scoring risk Pilot and new method in the first (A) and second (B) inspection cycle, Brazil, 2020.

Table 5
Number of food services participating in the 2014 FIFA World Cup assessed in the first and second cycle and their classification according to the methodology applied in the Brazilian Pilot Project and new method, Brazil, 2020.

		New Method									
		First cycle					Second cycle				
		A*	B*	C*	Pending*	Total	A*	B*	C*	Pending*	Total
Classification in the Pilot	A*	260	20	0	0	280	556	26	0	0	582
	B*	5	513	157	0	675	7	521	100	0	628
	C*	0	9	293	85	387	0	12	176	44	232
	Pending*	0	0	3	194	194	0	0	4	93	94
Total		265	542	450	279	1536	563	559	277	137	1536

Note: stamp A = very good quality; stamp B = good quality; stamp C = acceptable quality; and stamp pending = unacceptable quality—urgent improvement needed.
* Classification Stamps (A, B, C, pending) according to the risk value of the inspections performed in food services presented in Tables 1 and 4 (Brazil, 2014).

function of the probability of an adverse health effect and the severity of the effect caused by hazards present in the food. In the Brazilian Pilot Project, the adverse health effects and severity of the effects were based on the multiplication of the consequence with the factor loading of each inspection item. Therefore, to build the scoring system a factorial analysis was performed (Da Cunha et al., 2014). Since it was impossible to establish the probability for each assessment item, a raw score was determined and adjusted based on the factor analysis results. The factor loadings ranged from 0.0001 to 0.6274 and were determined for each assessment item. The sum of risk score of each inspection item established a food service's final risk score ranged from 0 (all assessment items compliant) to 2565.95 (all assessment items inadequate), resulting in four classification categories (Brazil, 2014; Da Cunha et al., 2014). It is possible to verify that under the factorial analysis, the calculation is quite complex, making it impossible to update the instrument by the health authorities. This difficulty was solved by the new method. Professionals could use their database to establish the probability and measure the consequences using Method 2 guidelines or adaptation (Da Cunha et al., 2014).

International organizations emphasize the importance of risk classification for the work of regulatory agencies (Food and Agriculture Organization 2020; Food and Agriculture Organization, & World Health Organization, 2020; World Health Organization, 2006). In many countries, such as Brazil, health legislation is extensive and detailed; routine inspections usually do not meet all requirements (Saccol et al., 2015) and do not provide a method for risk assessment. Therefore, the same checklist used for the Brazilian Pilot Project was used to evaluate the new method. The items presented in the checklist with a greater health impact can enable more frequent inspections by health authorities. As depicted in Table 5, the new method shows that the categories established are consistent with those assessed in the Brazilian Pilot Project.

Ordinance No. 78 of the state of Rio Grande do Sul, Brazil (Rio Grande do Sul, 2009) updated specifications pertinent to the state, making the checklist more specific to the reality of the region (Saccol et al., 2015). Using the calculation proposal performed in this study, the Health Surveillance team can determine the risk score for all inspection items of its legislation or the items of greatest impact. It is important to point out that the sanitary legislation and checklists must be used in their entirety during licencing inspections, complaints, and even during routine inspections, for effectively scoring the compliance or non-compliance of the inspection item. These checklist options, with a reduced number of items based on requirements with the greatest impact on the consumer's health, are aligned with the process while emphasising effective risk assessment.

In Brazil, the National Health Surveillance Agency works with the Resolution of the Collegiate Directory (RDC) No. 216/2004 (Brazil, 2004), which deals with the technical requirements for the implementation of the Good Handling Practices for Food Services. It is worth noting that the instruments commonly used by both health authorities and those responsible for good handling practices in food services are based on adequacy percentage and not on the health risk score; this can cause misinterpretation and inadequately reflect the risk of FBD (Da Cunha et al., 2016).

The availability of checklists used by the regulatory sector strengthens the regulated sector as it enables self-assessment (Saccol et al., 2015). Furthermore, if these tools include health risk scoring, auxiliary technologies are needed, such as applications and software, to help calculate the overall health risk and classification. According to Williams et al. (2019), electronic surveillance systems enable efficient information access and exchange.

4.2. Practical and policy implications

The change in the calculation of health risk of items provides greater flexibility and accessibility to the categorization checklist for food services. The local health authorities, whether municipal, state, or district, can change and adjust what they deem necessary, both in the probability values and in approximating the local reality. They can also add or exclude items to the checklist that are not relevant to the community in question.

The new method for calculating the health risk score makes it possible to change the score determined for probability, according to the local reality, without changing the criteria established in the proposed method (Table 3). However, inspection services that choose to present a classification, must take steps to ensure that the proportionality of the scales remains intact for each classification group and stamp.

For the inclusion of new inspection items, the Health Surveillance team can determine the probability of occurrence of that item in its assessment spectrum based on the local reality, then analyse the consequence and classify as described in Method 2. This is a great strategy for the categorization of food services by health surveillance because the visibility of the stamp enables consumers to make safer choices (Da Cunha et al., 2016), as they look for greater safety in food consumption, both on-site and by delivery (Hakim et al., 2021). This proposal is aligned with the Global Food Safety Strategy (World Health Organization, 2021).

The way health quality stamps are displayed to consumers differ worldwide; e.g., Denmark uses a smiley face, which is considered a hedonic scale (Denmark, 2020), Canada uses DineSafe, which is demonstrated by colours (Toronto, 2021), and New York (New York, 2012), Los Angeles (Pytka & Fellow, 2005), and North Carolina (North Carolina Environmental Health Establishments, 2021) all use letters, the same model adopted in Brazil.

The inspection system strengthens consumer trust in food services, as sanitary quality improves, and in the reliability of its management, as it has chosen to invest in inspection services. This is one of the more notable benefits of food safety protection. However, it is impossible to ensure that an "A" stamp food service outlet is 100% safe (Da Cunha et al., 2016). In any case, this strategy is becoming increasingly popular with consumers, who positively evaluate food service outlets that display the results of health inspections through stamps, cards, or reports posted in a visible place (Choi & Scharff, 2017; Firestone & Hedberg, 2020; Wong et al., 2015).

Implementing public programmes for food service assessments can change the overall picture of food sanitary quality by encouraging service outlets to comply with the legislation and regular assessments. The national legislation does not quantify the health risk value, which is a more effective sanitary control measure to minimize FBD and enable the consumer to make safer choices. Minimizing food safety risk requires food business operators to consistently play their part in producing safe food and minimizing FBD risks. Unlike traditional food inspection, risk-based food inspection provides the opportunity to build systems to prevent food safety incidents by identifying risk factors and assessing the effectiveness of existing control measures (World Health Organization, 2021).

The new method to calculate FBD risk may facilitate, motivate, and make feasible the implementation of the categorization system in the inspections of health surveillance agencies in Brazil and serve as a basis for other countries doing so. We believe that further research involving FBD risk assessment within the Good Handling Practices tools could greatly benefit the country.

Finally, this proposal may be useful to other countries seeking risk-based inspection and categorization of food services. The detailed description of the new health risk assessment methodology for the categorization of Brazilian food services will allow other researchers or managers of international regulatory agencies to make the necessary adaptations to their countries' legislation. Shared responsibility can take several forms. One simple but potentially very effective tool to improve food safety is to provide targeted and accurate food safety information and health messages to consumers (World Health Organization, 2021).

4.3. Limitations and future research

More research is needed using this new scoring method to verify its feasibility, applicability, and functionality. Other methods can be tested and a new scale for probability and consequence can be determined. Also, the classification determined for probability must be revaluated according to the reality of each location. At the same time, the consequence scores are not expected to change, unless it is revalidated by the scientific method after epidemiological demands emerge.

Most published risk assessment research measures consequences by looking at direct short- or long-term human health impacts using concepts such as disability adjusted life years (DALYs), which are linked to the type of microorganisms that might be present in the event of a failure. A 2015 WHO publication proposes a metric for DALYs and a methodology, but discussion is still needed for food services (World Health Organization, 2015).

5. Conclusion

The statistical tests conducted in this study identified a new method for calculating the health risk score for the Brazilian Food Service Categorization checklist. The validated methodology allows adaptations to be made to the checklist, enabling the inclusion and exclusion of assessment items (that follow the risk matrix defined by the method), and provides a scale of four levels for probability and four for consequence. The new method also offers more flexibility in the checklist for categorization because it can be changed to take account of local considerations, based on the health landscape of different countries and regions. The generated health risk score is used to categorize food services, thus making a food safety stamp available and thereby adding a new risk communication to consumers. This process will encourage safe consumer choice and motivate food service outlets to invest in food safety.

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CRediT authorship contribution statement

Fernanda Dineia Viera: Conceptualization, Methodology, Writing – original draft, Visualization. **Elke Stedefeldt:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Patricia Arruda Scheffer:** Writing – original draft. **Lidiane Viera Machado:** Writing – original draft. **Raísa Moreira Dardaque Mucinhato:** Writing – original draft, Writing – review & editing, Visualization. **Angela Karinne Fagundes de Castro:** Writing – review & editing. **Thalita Antony de Souza Lima:** Writing – review & editing. **Diogo Thimoteo da Cunha:** Formal analysis, Writing – original draft. **Ana Lúcia de Freitas Saccol:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodres.2022.111127.

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