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Comparative analysis of existing food safety culture evaluation systems

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22

23 **Keywords**

24 Food safety culture, research quality, trustworthiness, cultural dimensions, culture evaluation

25 **Highlights**

- 26 - The research discusses standards and guidelines for evaluating research quality and
27 trustworthiness
- 28 - The research compares eight models for evaluating culture for validation strategies
29 and content
- 30 - It is discovered that common validation techniques are applied but that only two
31 methods make use of predictive validation.
- 32 - Based on a qualitative content analysis of each model a suggested framework of five
33 cultural dimensions are proposed to unify the research field.

34

35 **1.0 Introduction**

36 The problem of food safety culture – what is it and how do you know how good yours is– is
37 probably one of the main issues in modern thinking about food safety (Christopher James Griffith, 2010;
38 Jespersen, Griffiths, Maclaurin, Chapman, & Wallace, 2016; Jespersen & Huffman, 2014; Nyarugwe,
39 Linnemann, Hofstede, Fogliano, & Luning, 2016; Powell, Jacob, & Chapman, 2011; Yiannas, 2009).
40 Although it is now subject to much discussion, the concept of food safety culture is still poorly
41 understood. Incidents that prompted attention to food safety culture include, but are not limited to, the
42 listeriosis outbreak 2008– Canada (Canadian Food Inspection, 2013), Melamine poisoning 2007 – China
43 (Gossner et al., 2009; Ingelfinger 2008), EHEC outbreak 2011 – Germany (Bernd Appel, 2011; Weiser et
44 al., 2016), *Clostridium botulinum*, 2013 – New Zealand (Incident, 2014), John Barr 1996 and J.E. Tudor
45 2005 EHEC outbreaks, U.K. (H. Pennington, 2009; T. H. Pennington, 2014).

46 Culture, be it organisational, employee health and safety or food safety culture, can be described
47 through Schein’s organizational culture definition as *a pattern of shared basic assumptions that was*
48 *learned by a group as it solved its problems of external adaptation and internal integration, that has*
49 *worked well enough to be considered valid and, therefore, to be taught to new members as the correct*
50 *way to perceive, think, and feel in relation to those problems* (Schein, 2004). As such, culture is
51 formulated in groups, the same groups who often make decisions on how to strengthen culture and invest
52 their resources based on attitudes and assumptions and perhaps the results of culture evaluation systems.
53 Food safety culture has been defined as *the aggregation of the prevailing, relatively constant, learned,*
54 *shared attitudes, values and beliefs contributing to the hygiene behaviours used in a particular food*
55 *handling environment* (C. J. Griffith, K. M. Livesey, & D. Clayton, 2010a). The definition relates cultural
56 values, beliefs, and learned hygiene behaviour to food. It is often a breakdown of learned and shared
57 attitudes, values, and beliefs that causes deadly failures in food safety management systems and for such

58 failures to become embedded in food safety in the food manufacturer's psyche. Evaluating culture is one
59 approach to bring transparency to cultural strengths and weaknesses, which may help prevent consumer
60 illness and mortality due to foodborne illness. Some food manufacturers use cultural evaluation systems
61 to avoid consumers from being exposed to foodborne hazards and for brand protection and employment
62 security (Cameron, 2006; Jespersen & Huffman, 2014; Seward, 2012). Thus, if cultural evaluation
63 systems are used in this way, it is necessary to determine the trustworthiness of results against accepted
64 methods to assess their validity and reliability.

65 Current systems for evaluating culture have been referred to as fragmented and built on disparate
66 scientific theories (De Boeck, Jacxsens, Bollaerts, & Vlerick, 2015; F. W. Guldenmund, 2000). Many of
67 these evaluation systems are developed using qualitative research methodologies. There is an ongoing
68 need for qualitative research to be demonstrated as a scientifically-based, learned, and robust
69 methodology and this can only be done by recording, systematizing, and disclosing methods of analysis
70 (Attride-Stirling, 2001). It is a concern that some researchers in the culture domain, embrace qualitative
71 methods but do not provide adequate insight into, nor justifications for selected methods, findings, or
72 conclusions; not unlike the approaches taken in other domains, e.g., educational research and employee
73 health and safety (F. W. Guldenmund, 2000; Howe & Eisenhart, 1990)

74 The objectives of this research were, firstly, to analyze existing culture evaluation systems for
75 commonalities and differences in research quality, applied validation strategies, and content; secondly, to
76 suggest a simple structure of food safety cultural dimensions to help unify the culture evaluation field.

77 **2.1 Research quality**

78 The National Research Council (NRC) and others have described guidelines that shape scientific
79 understanding and that are frequently used to frame the discourse on the quality of research. This has led

80 to the term ‘scientifically-based research’ being used in some settings to address research quality
81 (Gersten, 2000; Greenhalgh, 1997). Principles for assessing the quality of research include the following:

- 82 1. Pose a significant, important question that can be investigated empirically and that
83 contributes to the knowledge base;
- 84 2. Test questions that are linked to relevant theory;
- 85 3. Apply methods that best address the research questions of interest;
- 86 4. Base research on clear chains of inferential reasoning supported and justified by a
87 complete coverage of the relevant literature;
- 88 5. Provide the necessary information to reproduce or replicate the study;
- 89 6. Ensure the study design, methods, and procedures are sufficiently transparent and ensure
90 an independent, balanced, and objective approach to the research;
- 91 7. Provide sufficient description of the sample, the intervention, and any comparison
92 groups;
- 93 8. Use appropriate and reliable conceptualization and measurement of variables;
- 94 9. Evaluate alternative explanations for any findings;
- 95 10. Assess the possible impact of systemic bias;
- 96 11. Submit research to a peer-review process;
- 97 12. Adhere to quality standards for reporting (i.e., clear, cogent, complete).

98 While there is no consensus on a specific set of guidelines that will ensure the quality of research,
99 the more research studies are aligned with or respond to these principles, the higher will be the value of
100 the research (Feuer, 2002; Richard J. Shavelson and Lisa Towne, 2002).

101 **1.2 Research trustworthiness**

102 Research should be as trustworthy as possible and every research study must be evaluated in
103 relation to the methods used to generate the results. Describing trustworthiness of qualitative research is
104 different than that of quantitative research. Some believe alternative terms are required to evaluate
105 qualitative research (Graneheim, 2004). Regardless of research type, ambiguous or meaningless findings
106 may result in wasted time and effort, while findings that are simply wrong could result in adoption of

107 dangerous and harmful practices (Long and Johnson, 2000). Untrustworthy research can be caused by
108 error and bias related to both participants and observers (Robson, 2011) and it is the responsibility of the
109 researcher to have a rigorous and transparent validation strategy to eliminate untrustworthy results.
110 Krippendorf reflects on the trustworthiness of scientifically-based research by stating *quoting from the*
111 *works of other scholars cannot absolve anyone from the responsibilities for investigating and judging*
112 *what they thereby enter into literature* (Krippendorf, 2004).

113 **1.3 Valid and reliable research**

114 The qualitative researcher must constantly search for techniques to demonstrate rigour of the
115 research process to ensure trustworthiness and usefulness of research findings and to avoid misleading
116 those who use the outcomes of the research (Louis Cohen, 2007; Roberts, 2006). Applying traditional
117 quantitative tests of validity and reliability to qualitative research methods can be difficult, as the
118 subjectivity of respondents' and observers' opinions, attitudes, and perspectives contribute to a degree of
119 bias. Thus, the validity of qualitative research must be seen in relative rather than absolute terms
120 (Gronlund, 1990). This suggests that the quality of trial design could influence the reliability of the final
121 results, which are crucial for their interpretation and subsequent recommendations and implementation
122 (Armijo-Olivo, 2012).

123 Results and inferences made from any culture evaluation methodology are impacted by the
124 validity and reliability of the research. Researchers must strive to balance the impossibility of reaching
125 100% validity with avoidance of untrustworthy, invalid research (Louis Cohen, 2007). Validity indicates
126 the system's accuracy; whereas reliability indicates the system's ability to produce consistent and
127 repeatable results (Trochim, 2006). Reliability measures are important parts of the system's overall
128 validity. Reliability is necessary but cannot be considered in isolation. For a system to be reliable, it must
129 be valid. A system can be reliable e.g., through internal consistency but not valid but mostly if it is valid it

130 is more often than not reliable (Louis Cohen, 2007). However, there is some disagreement with these
131 statements as Robson states that *unless a measure is reliable, it cannot be valid* (Robson & Robson,
132 2011). There is general consensus that reliability is necessary but not sufficient. Reliability can also be
133 seen to relate to the coherence theory of truth in social research, i.e. a statement is considered a true
134 representation of a socially constructed reality when it is confirmed by several reports (Richie, 2003) .
135 The concepts of validity and reliability have great importance for evaluating the trustworthiness of any
136 results and inference generated by a culture evaluation system (Robson & Robson, 2011). The
137 applicability of different validity and reliability measures is directly linked to the type of research
138 conducted. It is therefore important, when developing a culture evaluation system by which organizations
139 plan to introduce change, to consider the full research process including e.g., research questions, data
140 collection, and data analysis, before designing the final research study, selecting methods, and the specific
141 validation and reliability measures necessary to ensure trustworthiness and usefulness of the results
142 (Louis Cohen, 2007; Meyrick, 2006; Robson & Robson, 2011; T. Long, 2000).

143 ***1.3.1 Validation and validity***

144 Validity theory has evolved over time (Shepard, 1993, 2016) and it is important to note that many
145 have engaged in the discussion on defining and selecting the most appropriate validation measures and
146 concluded that not one approach fits all situations. It is not the intent of this paper to give a
147 comprehensive review of all validity and reliability measures but a broad enough view to compare and
148 contrast validity of existing culture evaluation systems. Concepts of measuring validity have been applied
149 to various fields of research and it is clear how quantifiable validation tests are a fit with quantitative
150 scientific research but it is less clear what validity measures are a fit for naturalistic and qualitative
151 research carried out by sociologists, psychologists, and other researchers using qualitative techniques.
152 Here it becomes more difficult to meet the expectations of validity as applied to quantitative data.
153 Borsboom, Mellenbergh, and Van Heerden (2004) discuss this and highlight how, in some cases, outright

154 mistakes were made when applying quantitative validity measures to qualitative research. They also
155 challenge the dependency on correlation as a proof of validity and argue that, simply put, *a test is valid*
156 *for measuring an attribute if variation in the attribute causes variation in the test score*. As such, they
157 present an argument for causation and not correlation (Borsboom, 2004). Validity thereby expresses the
158 degree to which the system accurately reflects the value or the change in the measure. Views also exist
159 that qualitative and quantitative data do not calibrate exactly but that this does not undermine either
160 tradition. This view underlines the value of combined approaches, using different forms of evidence for
161 *complementary extension* of insight of the social world (Richie, 2003). Nevertheless, it is important that
162 each facet of evidence is as valid and reliable as it can be based on the research design and methods used.

163 **2.0 Materials and methods**

164 **2.1 Sample**

165 Eight culture evaluations systems already applied within the food industry were included in the
166 comparative analysis. Five systems, referred to in this paper by the name of the authors who first
167 described them: Ball, Denison, De Boeck, Jespersen, and Wright, as well as three systems referred to in
168 this paper by their commercial names, CEB, TSI, and NSF. It is important to note that other commercial
169 evaluation systems are available but these three were the most often applied in the food industry and have
170 been included here for reference. Content from these systems was included in the analysis however,
171 details regarding validation strategies either do not exist or are not available and therefore not included in
172 the comparison of applied validation strategies.

173 **2.2 Method**

174 A six step process was used for the comparative analysis (Figure 1). To obtain data from existing
175 culture evaluation systems specific to the quality, trustworthiness, and content of each system a structured
176 content analysis was completed. Publically available material was gathered e.g., peer reviewed papers,

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178 white papers, and books and imported into NVivo 11 [Computer Software] QSR International,
179 Doncaster, Australia, for deductive, textual data analysis. The NVivo software is designed specifically for
180 qualitative coding of textual and other types of qualitative data. A content analysis framework (Table 1)
181 was developed based on initial reading and descriptions of the eight systems. The framework consists of
182 three levels of textual analysis: basic themes, organizing themes, and global themes (Attride-Stirling,
183 2001).

184 **Table 1: Content Coding Framework**

185

Global	Organizing	Basic
Values and Mission	Statements related to; direction, goals, compliance, improvement, measures, metrics, plan, roadmap, long-term plan, long-term direction. Also, statements as “just the right thing to do...”	<ul style="list-style-type: none"> • Compliance. • Measures/metrics/KPIs. • Mission, vision, goals. • Ownership/owning, • Plan/roadmap, direction. • Recall/recalls/withdrawals. • Responsibility, accountability, commitment. • Direction
People Systems	Statements related to; role, group, team, accepted behaviour, rejected behaviour, accepted practices, rejected behaviours, training, education, learning, consequences, escalation, celebrations, punishment, communication, group and individual pride.	<ul style="list-style-type: none"> • Any reference to person’s role/education/job and group or team (e.g., name of team, established teams, established groups). • Behaviour/practice, work routine. • Communications (e.g., written, spoken, and dialog (e.g, interview)) and involvement. • Consequence, escalation. • Pride. • Rewards and celebration. • Training, education, learning, proficiency. • Cross-functional • Unionized. • Rotation and retention.
Consistency	Statements related to; leader communication of system, leader communication of system, due date met, due date missed, tasks, projects, basic tools missing, basic tools available, data collection, data collection tools, data usage,	<ul style="list-style-type: none"> • Actioned data and performance metrics. Actions, tasks, action due date. • Non-conformance, reoccurring, • Technology • Tools and infrastructure (missing infrastructure, appropriate/right tools, appropriate infrastructure, missing tools). • References to third party standards.

	performance reports, performance, decisions and use of technology.	
Adaptability	Statements related to, improvement, continuous improvement, system improvement, change readiness, change challenges. Also, look for readiness in adoption of new tools, technology, or processes. E.g., will adopt when there is a legal requirement but will not take a broader look to process improvement investments.	<ul style="list-style-type: none"> • Change readiness, open to change, change ready. • Improvement, must improve, continuous improvement, improvement process, improvement system, continuous improvement, Six Sigma, Lean manufacturing.
Risk awareness	Statements related to; review of risks, hazards identification and assessments, risk assessments, leaders pay attention to control of risks and hazards, operators pay attention and speak up if a risk or hazard gets out of control.	<ul style="list-style-type: none"> • Leaders risk awareness and perception. • Operator risk awareness and perception. • Risks, hazards.

186
187 The aggregation of basic and organizing themes was used to define the global themes later
188 translated into suggested food safety culture dimensions. The degree of agreement or disagreement in
189 content of each system was evaluated using the coverage of each system for each of the global themes.

190 Coverage was evaluated by quantifying manifest codes per system per global theme and qualitatively by
191 looking for latent meaning of detailed system content. A summary was written for each system which
192 focused on structure, compliance to the National Research Council (NRC) guidelines, validation
193 strategies, and references to the material included in the comparative analysis. By summarizing the
194 manifest and latent codes per system a comparative figure was developed to visually analyze for
195 agreement or disagreement across the five suggested food safety cultural dimensions.

196

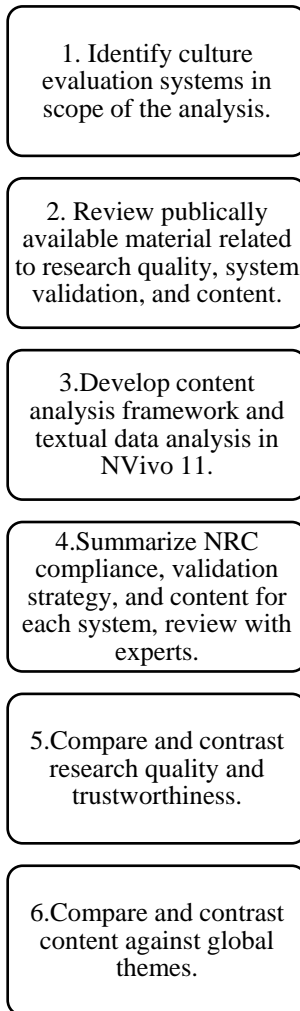
197 **Figure 1: Six step process applied in the comparative analysis**

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202 **2.3 Research trustworthiness**

203 A four step validation strategy was applied to assess trustworthiness of the research results;

204 (1) External population and ecological validity to ensure generalizability. This was achieved
205 through literature review, expert consultation, and coverage of global codes found in each system,
206 analysis and inclusion of language found in content analysis and currently applied in the food safety
207 domain. The experts were chosen for their expertise in the area of culture and independent of the research
208 and/or the models. The experts were trained in the NRC guidelines and reviewed samples of
209 documentation against these.

210 (2) Internal face and construct validity to ensure the content reflects what it is intended to and that
211 the evaluation construct is robust. Peer review was conducted, adding representative quotes linked to the
212 global themes from each evaluation system (Graneheim, 2004). Each system owner was given the
213 opportunity to approve the system summary and assessments.

214 (3) Internal validity to ensure replicability. This was accomplished through the systemic search
215 and inclusion of most often cited evaluation systems both academic and commercial. Although this, might
216 be influenced by how well a given method is marketed through commercial channels.

217 (4) Reliability through evaluation of technical accuracy. Group discussions with practitioners and
218 academicians were conducted to ensure that the construct and results are representative of the concept it is
219 intended to measure.

220 **3.0 Results**

221 **3.1 Summary of in-scope culture evaluation systems**

222 The following provides a short summary of the eight culture evaluation systems; focus domain,
223 structure, general adherence to the twelve principles in the NRC guidelines, validation strategies, and
224 references.

225 ***3.1.1 Ball model***

226 This system was developed by Brita Ball in 2009 as part of her doctorate work at the University
227 of Guelph (Ball, Wilcock, & Aung, 2009; Wilcock, Ball, & Fajumo, 2011). The system is focused on the
228 food safety domain, specifically food safety climate, and was tested with five food manufacturers in
229 Canada. There is not reference to a definition in the papers and this is likely to be due to the early date of
230 the research when no formal definition had been published. Thirteen in-depth interviews were conducted
231 with five small to medium sized processing plants; together with two focus group sessions with interest
232 groups. The model consists of six themes and 20 sub-themes, each measured through a self-assessment
233 survey, in-depth interviews, field observations, and a second self-assessment survey. Analysis of data
234 generated was conducted in NVivo 7 [Computer Software] QSR International, Doncaster, Australia, by
235 applying validated content analysis principles using both deductive and inductive analysis. Multiple
236 methods of data collection allowed researchers to apply some triangulation. A model was developed
237 following Fishbein and Ajzen's reasoned action model (Ajzen, 2011). The model showed strong
238 significance of work unit commitment to food safety as a key driver of the food safety behaviours of food
239 handlers. The system research meets 11 of the 12 NRC guidelines (Figure 2) as it is not clear from
240 publically available material how alternative explanations of the findings were explored.

241 3.1.2 De Boeck model

242 This system was developed by Elien De Boeck in 2015 as part of her doctorate work at the
243 University of Gent (De Boeck, Jacxsens, Bollaerts, Uyttendaele, & Vlerick, 2016; De Boeck et al., 2015).
244 The researchers use the terms *culture* and *climate* interchangeably in their research. Food safety culture,
245 they defined as *the interplay of the food safety climate as perceived by the employees and the managers of*
246 *a company (so called ‘human route’) and the context in which a company is operating, the current*
247 *implemented FSMS, consisting out of control and assurance activities (so called ‘techno-managerial*
248 *route’) resulting in a certain (microbiological) output* whilst food safety climate was considered as
249 *employees’ (shared) perception of leadership, communication, commitment, resources and risk awareness*
250 *concerning food safety and hygiene within their current work organization* (De Boeck et al., 2015).
251 However, the authors themselves state that the concepts remain vague and with no unanimous definitions
252 (De Boeck et al., 2015); therefore, for the purpose of this analysis no differentiation is made between the
253 terms in evaluating the De Boeck model. The system is focused on the food safety domain and piloted at
254 eight affiliates of a large, centrally coordinated meat distribution company in Belgium. The model
255 consists of five indicators, with 27 sub-indicators, assessed through a self-assessment survey. A detailed
256 study was completed in eight butcheries and butcher shops in Belgium, and though a small sample, some
257 statistical differences were detected in the food safety climate of the participating organizations. The
258 authors define culture and climate and it is not apparent how precisely these definitions are based on
259 existing research (C. J. Griffith et al., 2010a; Frank W. Guldenmund, 2007; Schein, 2004) in the domains
260 of culture and climate. The research meets nine of the 12 NRC guidelines (Figure 2) as it is not clear from
261 publically available material how comprehensive the literature review was that lead to the model, how
262 alternative explanations of the findings are explored, and if there is a potential impact of systematic bias.

263 **3.1.3 Denison model**

264 This system was developed by Dan Denison in 1989 and applied extensively with global
265 organizations since as the Denison Model (D. R. Denison, 1997; D. R. Denison & Mishra, 1995; D. R. H.
266 N. L. Denison, and Colleen Lief, 2012). The system is focused on organizational culture with a branch in
267 the people safety domain and is therefore broader than food safety culture. It consists of four traits
268 assessed through a self-assessment survey. Details of the research have been widely published in books
269 and peer reviewed papers. This method represents the strongest proof of validity based on both
270 quantitative and qualitative research and documented evidence against all 12 NRC guidelines are
271 available in publically available material (Figure 2).

272 **3.1.4 Jespersen model**

273 This system was developed by Lone Jespersen in 2010 as part of her Masters work and
274 subsequently her Doctoral work in 2014 at the University of Guelph (Jespersen et al., 2016; Jespersen &
275 Huffman, 2014). Jespersen et al (2016) state that food safety culture in food manufacturing is rooted in
276 the definition, dimensions, and characteristics of organizational culture, as defined by Schein (2004). The
277 system is focused on the food safety domain and consists of five capability areas. The system was tested
278 with a global food manufacturing company in North America. The evaluation was conducted using
279 triangulation between self-assessment survey; behavioral observations and interviews; and performance
280 assessments and made use of combined deductive and inductive content analysis and quantitative self-
281 assessment data. The research makes use of both quantitative and qualitative research methods and the
282 results were evaluated using a food safety maturity model. The authors openly declare a validation gap
283 since the system was tested in one organization and to demonstrate the validation principle of
284 generalizability the model needs to be tested on other organizations. The system research meets eight of
285 the 12 NRC guidelines (Figure 2) as it is not clear from publically available material how comprehensive

286 the literature review was that lead to the development of the model, how alternative explanations of the
287 findings are explored, and if there is a potential impact of systematic bias.

288 **3.1.5 TSI model**

289 This system was developed by TSI in 2015 and applied to food service in Dubai and small food
290 manufacturers in the U.K (J. Taylor, Garat, J. P., Simreen, S., & Sarieedine, G., 2015). The authors
291 describe food safety culture as *prevailing attitudes, values and practices related to food safety that are*
292 *taught, directly and indirectly, to new employees.* The system was built on research in the area of HACCP
293 application conducted in U.K. small and medium size companies and food service restaurants (Gilling,
294 2001; E. A. Taylor & Taylor, 2004) and the authors also state that their model is based on research from a
295 broad range of academic disciplines and industry sectors (Taylor et al, 2015). The system is an audit tool
296 and focuses on the food safety domain and consists of four categories assessed through a self-assessment
297 survey. Collectively the four categories cover 16 factors and when applied commercially the findings
298 from the self-assessment survey were reported and discussed with clients. It is not clear from the
299 publically available material how the detailed 16 factors were derived and details regarding research
300 methods and validation strategies for this model were not published.

301 **3.1.6 Wright model**

302 This system was developed by Wright, Leach and Palmer on commission for the U.K. Food
303 Standards Agency (FSA) and intended for use by the agency's public health inspectors (Wright & Leach,
304 2013). The authors use the Griffith et al (2010) definition of food safety culture and the system is focused
305 on the food safety domain and consists of eight elements. The elements are assessed using a self-
306 assessment scale and behavioral observations. The system research meets nine of the 12 NRC guidelines
307 as it is not clear from publically available material how alternate explanations were explored, how
308 potential systemic bias was assessed, and the material was not submitted for peer-review.

309 **3.1.7 CEB model**

310 The system was developed by CEB (CEB, 2016) and makes use of a five level maturity model
311 evaluating quality culture across five categories; organizational scope, employee ownership, peer
312 involvement, message credibility, and leadership emphasis (Srinivasan & Kurey, 2014) The assessment is
313 made thorough employee self-assessment and makes use of a social cognitive model with four
314 characteristics; hear, see, transfer, and feel, in guiding actions based on the assessment. Details regarding
315 validation strategies for this model were not published.

316 **3.1.8 NSF model**

317 The system was developed by NSF (NSF, 2016) in collaboration with Cognisco Ltd. Cranfield,
318 Bedford, U.K. The basis for the system is an NSF assessment of approximately 10,000 food handlers and
319 the theories of social cognitive theory and behavioral science (Fone, 2010) The Culture Maturity system
320 has five phases that go beyond the evaluation of culture into the areas of tactics for changing behaviours
321 and evaluating a company and the efficacy of their food safety and quality management systems. The
322 system evaluates behaviour across six core markers, (1) Regulatory Governance, (2) Management
323 Systems, (3) Policies & Standards, (4) Assessments, (5) Talent Development, and (6) Culture &
324 Behaviours. The evaluation scores are a combination of employee self-assessment and on-site activities
325 and scores are mapped on a scale of four progressive generations, ranging from reactive to core-values.
326 Details regarding validation strategies for this model were not published (D.Fone, Personal
327 communication, November 11, 2016).

328 **3.2 Differences in Validation strategies**

329 Each of the scientifically-based culture evaluation models make use of unique validation
330 strategies and, in exploring the differences, it was found that many models make use of internal face and

331 construct validation but only two show predictive validation (Ball and Denison). Reliability testing is
 332 shared in two culture evaluation systems and not clear in the remaining (Ball and Denison) (Table 2).

333 **Table 2: Differences between the validation strategies applied in the eight culture**
 334 **evaluation models.**

Culture evaluation model	Validity methodology
Ball	Internal face and construct validation through expert solicitation. External population validation through focus groups and peer review. Respondent validation through responds transcript validation. Internal consistency through Cronbach’s Alpha. Predictive validation through behavioural model and triangulation.
De Boeck	External population validation through peer review. Internal, face and construct validation through twenty experts, cross-sector, from Belgium.
Denison	External population and historical validation through analysis of existing performance data. Internal validation through peer review and expert solicitation. Internal construct and predictive validation through correlation analysis using the Survey of Organizations and The Organizational Survey Profile data. Reliability through stability of time.
Jespersen	External population and ecological validation through review of existing food safety performance data and adoption language

Culture evaluation model	Validity methodology
Wright	<p data-bbox="581 289 1344 590">from existing food safety standards. Internal construct and face validity through an 18 member expert panel cross-sectional, from US, UK, and Canada, consisting of academicians and practitioners. Predictive validation through behavioural model and triangulation.</p> <p data-bbox="581 653 1344 884">External population and ecological validation through focus groups. Internal construct and face validation through expert solicitation and transparency in audit trail through publically available reports.</p>

335

336 **3.3 System Content comparison**

337 The findings from the content analysis provided data for comparison of the content between the

338 eight culture evaluation systems. It should be noted that not all systems apply the food safety culture

339 definition introduced earlier. The content was grouped to provide a graphical representation of dimension

340 coverage by each culture evaluation system (Figure 3).

Constructs (Ball)	Indicators (De Boeck)	Traits (Derison)	Drivers (CEB)	Capability area (Jespersen)	Markers (NSF)	Categories (TSI)	Elements (Wright)
Management commitment	Leadership	Mission	Leadership emphasis	Perceived Value	Culture and Awareness	Purpose	Perception of safety
Supervisor commitment	Commitment	Involvement	Message credibility	People systems	Management	People	Business priority
Training	Communication	Consistency	Peer involvement	Process thinking	Training	Process	Leadership
Infrastructure support	Resources	Adaptability	Employee ownership	Technology enabler	Regulatory Compliance	Proactivity	Ownership of safety
Worker commitment	Risk awareness			Tools and infrastructure	Policies and standard		Competence
Worker behaviours					Auditing		Employee communication
					Traceability		Employee involvement
					IT Systems		Risk perception

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Figure 2: Content comparison of the eight culture evaluation systems. Five affinity groupings emerged from the analysis; red = values and mission, green = people systems, blue = consistency, yellow = adaptability, and purple = risk and hazards

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As such, five dimensions of food safety culture were identified, which all culture evaluation

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systems cover to varying degrees. The dimension are Values and mission, People systems, Consistency,

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Adaptability, and Risk awareness.

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349 **3.3.1 Values and mission**

350 This dimension covers cultural content related to 1) management and employee commitment to
351 food safety (Ball, De Boeck, Taylor), 2) how leadership sets objectives, motivates, and addresses food
352 safety (De Boeck), 3) direction for the organization (Denison), 4) the organization's perceived value and
353 priorities related to food safety (Jespersen, Wright), and 5) food safety ownership (Wright). Wright covers
354 this dimension in four of the eight elements and Ball also covers this in three of six constructs. As such,
355 Ball and Wright have the most detail of any of the cultural evaluation systems in this dimension.

356 **3.3.2 People systems**

357 This dimension covers cultural content related to 1) knowledge, qualifications, and team
358 effectiveness (Ball), 2) training, integration of new employees, and expectations of competency level
359 (Ball, De Boeck, Jespersen, Taylor), 3) leaders and employees' communication of food safety (De Boeck,
360 Wright), 4) actual and expected involvement, autonomy, degree of membership input (Denison, Taylor,
361 Wright), 5) expectations of tasks or behaviours (Jespersen), 6) knowledge of risk (Wright). Wright covers
362 this dimension in three of the eight elements of the model and provides the most detail around this
363 dimension. Wright is also the only one that includes "risk" in the people system dimension. Ball covers
364 this dimension in two of six constructs and is the only one that speaks of "infrastructure" as part of the
365 people system and how this drives food handler food safety behaviours.

366 **3.3.3 Consistency**

367 This dimension covers cultural content related to; 1) degree of following rules (Ball, Taylor), 2)
368 good procedures and instructions are in place (De Boeck), 3) systems are enforced vs. allowance for by-
369 passing (Denison), 4) technology enabled behaviours (Jespersen), 5) access to the right tools and
370 investment in infrastructure (Jespersen). Jespersen covers this in two of five capability areas and Wright
371 does not cover this dimension directly in any elements.

372 **3.3.4 Adaptability**

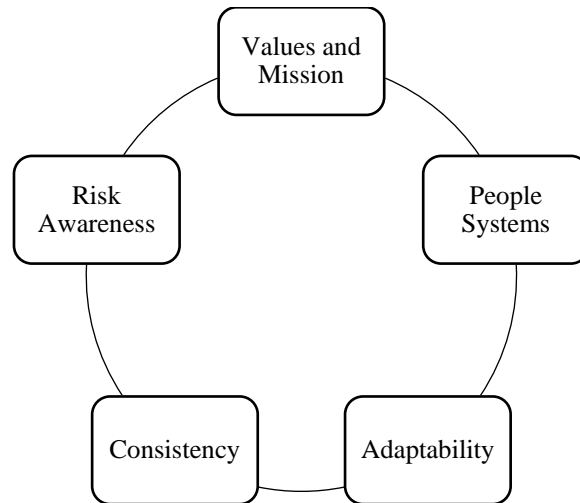
373 Dimension covers cultural content related to; 1) how the organization embraces or resists change
374 (Denison, Taylor), 2) how problem solving is approached (Jespersen). Three cultural evaluation systems
375 cover this dimension but no direct relation was found in Ball, De Boeck, and Wright.

376 **3.3.5 Risk awareness**

377 Dimension covers cultural content related to; 1) risks are known, under control, and employees
378 are alert to actual and potential food safety risks (De Boeck, Wright). De Boeck and Wright are the only
379 ones that identify this as a separate indicator. Others have risk awareness incorporated in other
380 dimensions but have not assigned as much importance to this dimension as De Boeck and Wright.

381 **3.4 Suggested framework to unify the research field**

382 Based on the analysis of the eight evaluation models and the above discussion a five dimension
383 framework is suggested to provide some unification of the food safety culture research field. These
384 dimension were found to most extensively cover the content of the existing models and that found in
385 supporting literature (Figure 3).



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Figure 3: Food Safety Culture - Dimensional Framework

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4.0 Discussion and conclusion

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Five scientifically-based and three commercial culture evaluation models were within the scope of the comparative analysis; Ball, CEB, Denison, De Boeck, Jespersen, NSF, TSI, and Wright. Analysis included whether the models had been applied in the food industry and therefore directly relevant for the evaluation of food safety culture. Each system was evaluated for compliance to the National Research Council (NRC) guidelines (Richard J. Shavelson and Lisa Towne, 2002), through a comparison of validation strategies, and through results from analysis of available textual data using content analysis. Differences were found in the degree to which the systems were developed according to NRC guidelines, from meeting all to meeting five of the research quality principles (reference). The largest gap was the lack of evidence in the assessment of systemic bias and its documentation. Ball and Denison were found to do this well through transparent assessment of literature and documented path between literature findings and research outcomes. The second area where weaknesses were discovered was related to the assessment of data for alternative interpretation of results. Again, Ball and Denison were found to cover

401 this most comprehensively through discussion of focus group discoveries and missing evidence around
402 impact on culture assessment through organizational levels.

403 Validation and reliability measures are important for the validity of any type of research (Louis
404 Cohen, 2007; Robson & Robson, 2011). Validation and reliability measures were reviewed and sorted
405 according to type of research conducted. Each culture evaluation system was analyzed for the validation
406 strategy applied. Most make use of external validation through population, ecology, and peer review.
407 Only the Ball and Denison models document predictive validity. Ball constructed a predictive model
408 based on the Reason Action model and Denison showed a predictive relation between strength of culture
409 assessment and existing financial and organizational performance data. Few models document reliability
410 measures and this is considered a considerable gap. Again, Ball and Denison do incorporate reliability
411 measures into their models and document the method chosen to do this in detail.

412 Content was compared through content analysis of the textual data. It was found that almost all
413 culture evaluation systems contain some content related to an organization's values and mission. The
414 Wright model dedicates four of five elements to this dimension. Five of the six culture evaluation systems
415 cover content related to people systems. Four of the six cultural evaluation systems cover consistency and
416 Jespersen was found to cover this in three of five dimensions. Adaptability was covered by the models of
417 Ball, Denison, whereas the Taylor and Ball models dedicated two of six constructs to this dimension. Risk
418 awareness was only covered in detail by the De Boeck and Wright models. The content findings suggest
419 that the proposed five dimensions cover all of what each system independently cover and it suggests some
420 areas that could be strengthened in some systems e.g., adaptability, consistency and risk awareness. By
421 reviewing the detailed basic, organizing, and global themes, it is clear that by looking at all content from
422 all systems a very strong picture of not simply organizational culture but food safety culture emerges. It is
423 concluded that the five proposed dimensions could be used to unify research in the food safety culture

424 domain and also provide each system owner with input into the continuous improvement of each system
425 independently.

426 The analysis of NRC compliance rate and validation strategy provides information about the
427 quality and trustworthiness of the culture evaluation systems; both of which are critical characteristics of
428 research leading to culture evaluation systems by which food manufacturers make decisions regarding
429 resources for culture transformation. It was surprising to find few of the culture evaluation systems had
430 documented reliability measures and predictable validation strategies. Also, few made use of structured
431 triangulation, a method commonly applied to qualitative and mixed method research (Denzin, 2012) and a
432 method to validate research findings. It was also unexpected that systems named *climate* and those named
433 *culture* had such great similarities in content. If these terms were used consistently and according to
434 historical textual data then it might help guide the specialization of content and truly deliver on both
435 climate and culture evaluation systems. It was an unexpected finding that the global themes and suggested
436 food safety culture dimensions resemble organizational culture dimensions with the important exception
437 of the dimension Risk awareness, which appears to be more specific to food safety. One limitation of the
438 research is the lack of detailed access to the methods behind the Taylor and CEB culture evaluation
439 systems. More documented details for each of these two systems could have contributed further to the
440 comparative analysis.

441 The definition of food safety culture and that of organizational culture suggest that culture is
442 learned and shared among people (C. J. Griffith et al., 2010a; Schein, 2004). It is based on accepted
443 assumptions, values, and beliefs, is dynamic and impacted by an array of factors and situations. By
444 evaluating culture, food manufacturers can get a snap-shot of strengths and weaknesses and make
445 decisions about actions and resources. Such decisions can make the difference between a group's
446 assumptions and beliefs regarding food safety practices; whether or not to implement them; and

447 subsequently if consumers are put in harms way or not. Hence the research behind a culture evaluation
448 system must optimize quality, trustworthiness, and cover the broadest possible content to inform the food
449 manufacturer correctly. These results must be given the same importance of quality and trustworthiness
450 as, for example, microbiological testing, sampling for presence of allergens, and detecting metal
451 contamination. The lack of an appropriate food safety culture is an emerging risk (C. J. Griffith, K. M.
452 Livesey, & D. A. Clayton, 2010b) and both academicians and practitioners must hold each other to a high
453 standard to minimize this risk. It is suggested that more research is conducted in the field of unifying food
454 safety dimensions through a common glossary, empirical research and predictive studies and to develop
455 models to assess the maturity of food safety culture within organizations based on these dimensions.

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