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Jespersen, Lone, Griffiths, Mansel, Maclaurin, Tanya, Chapman, Ben and Wallace, Carol A.

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Lone Jespersen, Dr. Mansel Griffiths, Dr. Tanya Maclaurin, Dr. Ben Chapman, Carol A. Wallace, Prof.



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1 Measurement of Food Safety Culture using Survey and Maturity

2 Profiling Tools

3 Author names and affiliations

4 Lone Jespersen, ^{University of Guelph(1)}, Dr. Mansel Griffiths, ^{University of Guelph (1)}, Dr. Tanya Maclaurin,
5 ^{University of Guelph (1)}, Dr. Ben Chapman, ^{North Carolina State University (2)}, and Prof. Carol A Wallace, ^{University}
6 ^{of Central Lancashire (3)}.

7 (1) University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2M7, Canada (2) North
8 Carolina State University, Raleigh, NC 27695, United States, (3) University of Central
9 Lancashire, Preston, Lancashire PR1 2HE, United Kingdom.

10 Corresponding author

11 Lone Jespersen, University of Guelph, 50 Stone Road East, Guelph, ON N1G 2M7, Canada.
12 +41792460807. lone@uoguelph.ca

13 Abstract

14 Organizational culture is defined by dimensions and characteristics that can be used to
15 measure food safety culture in food manufacturing through a food safety maturity model.
16 Maturity models from quality, health care, and information technology have been used since
17 early 1970 and this work presents a novel food safety culture maturity model with five capability
18 areas and food safety pinpointed behaviours specific to functions and levels in a food
19 manufacturing company. A survey tool linked to the model is used to measure a company's
20 position within the maturity model framework. The method was tested with a Canadian food

21 manufacturer and proved valuable to measure food safety culture across the five capability areas,
22 which provides the manufacturer with a map for prioritizing future efforts to strengthen food
23 safety culture.

24 **Highlights**

- 25 - Theory of organizational culture was applied to measure food safety culture dimensions
26 and characteristics
- 27 - Food safety culture was measured using a self-assessment survey with function and role
28 specific pinpointed food safety behaviours
- 29 - A food safety maturity model was developed to measure food safety culture in food
30 manufacturing
- 31 - The survey was tested with a Canadian food manufacturer across six meat plants
32 resulting in a measure of the organization's food safety culture across six capability areas
33 specific to food safety.

34 **Keywords**

35 Food safety, food safety culture, food manufacturing, food safety maturity model, capability
36 areas, culture measurement.

37

38

39 **1. Introduction**

40 The World Health Organization's Foodborne Disease Burden Epidemiology Reference
41 Group estimated that there were 582 million cases and 351 000 deaths associated with 22
42 different foodborne enteric diseases in 2010 (WHO FERG group, 2010). These diseases and
43 deaths are often linked to a breakdown in food safety programs because of improper human
44 behaviour or an appropriate food safety culture (Griffith, 2010a, Jespersen and Huffman,
45 2014). The issue remains how to minimize population exposure to foodborne pathogens. In
46 addition, it is known that older and immunocompromised members of society are more
47 susceptible to foodborne illness (FDA, 2015; Lund and O'Brien, 2011). By 2035, the
48 proportion of people over the age of 60 globally will have doubled from 11% (2012) to 22%
49 (2035) (United Nations, Department of Economic and Social Affairs, 2012). Although this
50 increase in the elderly population is generally seen as an indicator of global health, it is also a
51 measure of a growing number of people who are vulnerable to infectious diseases, including
52 foodborne infections or intoxications (International Union of Food Science and Technology
53 (IUFoST), 2015). This, along with other disease trends, such as a 1.5-fold increase in the
54 number of cases of diabetes expected during the same period (International Diabetes
55 Federation, 2014), and continued foodborne illness outbreaks and recalls will maintain food
56 safety as paramount for the near future.

57 The objective of this research was to develop a method to characterize and measure food
58 safety culture. It was decided, based on the structure, content, and usage of existing maturity

59 models, to develop a food safety maturity model and a behaviour-based method for assessing the
60 performance of food manufacturers against the model.

61 **2. Organizational culture**

62 Food safety culture in food manufacturing is rooted in the definition, dimensions, and
63 characteristics of organizational culture. Schein (2004) defines organizational culture as,

64 “A pattern of shared basic assumptions that was learned by a group as it solved its
65 problems. The group found these assumptions to work well enough to be
66 considered valid and, therefore, to be taught to new members as the correct way to
67 perceive, think, and feel in relation to those problems.”

68 Cultural dimensions and characteristics (Table 1) adapted from Schein’s work serve as a
69 theoretical framework to characterize an organization’s food safety culture

70 **3. Food safety culture and food manufacturing**

71 Food safety culture has been discussed by various authors from general practices relating
72 food safety culture to organizational leadership (Griffith, 2010b; Powell et al, 2011; Yiannas,
73 2009), to specific studies of connecting food safety culture to food safety climate (De Boeck et al,
74 2015). Studies have also investigated different behavioural techniques that can be applied within
75 food safety culture and demonstrated that general psychological and behavioural frameworks can
76 also be applied to the context of food safety (Yiannas, 2015; Taylor, 2010). Two measurement
77 systems for assessing food safety climate and food safety culture have emerged (Wright, 2013;
78 De Boeck, 2015), one from the perspective of regulators (Wright et al) and, more recently, one

79 for food processing organizations (De Boeck et al). Other commercial measurement systems
80 (e.g., Campden BRI/TSI, Taylor, 2015) exist and, although the measurement systems element of
81 these may not have been subject to peer-review publication, they do add to the very important
82 discussion of quantifying food safety culture. The work described here was constructed with a
83 view to measuring food safety culture in manufacturing organizations.

84 Few food safety culture research studies have been completed in food manufacturing
85 plants and the studies completed identify food safety culture as an interdisciplinary challenge
86 that can be resolved by applying tools from cognitive social sciences to provide further
87 knowledge about what drives food handlers to perform food safety behaviours (Hinsz, Nickell, &
88 Park, 2007; Wilcock, Ball, & Fajumo, 2011). The reasoned action approach (Fishbein & Ajzen,
89 2009) was applied to predict food handler behaviours in a turkey manufacturing plant. The study
90 identified attitude, perceived norm, and perceived control as predictive variables of food handler
91 behaviours (Hinsz, Nickell, & Park, 2007). A follow up study proved that work habits also
92 predicted food handler behaviours when confounded with the other reasoned action model
93 variables, attitude, perceived control, and social norms. (Hinsz et al., 2007). To further explain
94 what impacts food handlers to practices food safety behaviours Ball et al. (2009) studied the
95 impact of working groups on food handler behaviours and found a significance relationship
96 between the work units' commitment to food safety and food handler behaviours. The viability
97 of using performance standards, e.g. audit reports, performance monitoring and audit records, to
98 measure food safety culture was investigated by Jespersen et al. (2014), who suggested that data
99 from performance standards were useful to assess food safety at a particular point in time but did
100 not provide a complete measure of organizational food safety culture. This suggested that a

101 measurement system using multiple methods and specific to food safety culture in food
102 manufacturing should be developed against which manufacturers could measure their current
103 state and progress of improving their food safety culture.

104 **4. Theories and perspectives**

105 Food safety culture it is proposed as the interlinking of three theoretical perspectives:
106 organizational culture, food science and social cognitive science. Organizational culture is seen
107 as different from other cultural definitions (e.g., geographical, national culture) (Hofstede,
108 Hofstede, and Minkov, 2010) and consists of generic attributes such as artifacts, espoused values,
109 beliefs, and ways to characterize culture regardless of the area, function or discipline (Schein,
110 2004). Performance of organizations can be measured using tools such as the Denison model
111 where organizational culture and leadership are measured to diagnose an organizations
112 effectiveness and as such is seen as a direct link to the financial performance of the organization
113 (Denison, 2012). The food science perspective allows food-specific considerations, such as risks
114 associated with food and how to measure and evaluate these. For example, food science enables
115 the search for answers to questions of definition and quantification of risks associated with a
116 given product and process. It includes risk management concepts, such as HACCP, to evaluate
117 how an organization manages food safety risk through its long term management systems and
118 daily decisions about product safety. An organization has to identify, assess, and mitigate
119 hazards such as biological hazards e.g., pathogens such as *Listeria monocytogenes*, chemical
120 hazards e.g., sanitation residue and pesticides, and physical hazards such as bones, stones, and
121 metal fragments from manufacturing equipment. Social cognitive science can be applied to

122 define, measure, and predict human behaviours. Methods from social cognitive science can be
123 applied specifically to measure the intent of an organization, a manager, a team, and an
124 individual to perform behaviours within the scope of the organization's own rules and values.
125 For example, a manufacturer's value might be *dare to be transparent*, which could be translated
126 into a behaviour such as: "Today I told a new colleague that he missed sanitizing his hands after
127 washing and helped him understand why this is important to the safety of our food."

128 **4.1 Cultural dimensions.**

129 A number of authors have researched and written about organizational culture. Brown
130 (1998) and Denison (1997) both cite the work of Edgar Schein as the one of the pioneers in
131 dimensionalizing organizational culture. Principles from Schein has also been reviewed and
132 applied in food safety to demonstrate the linkage between these proven principles and food
133 safety culture (Griffith, 2010b).

134 Schein's five dimensions of organizational culture (Schein, 2004) were therefore chosen
135 as the theoretical framework to organize the various theoretical perspectives, food safety
136 capability areas, and food safety culture measures. Cultural dimensions can be applied to the
137 study of organizational culture and are essentially defined across measurable characteristics. A
138 dimension can be thought of as an area of the overall traits of organizational culture that contains
139 components which can be actioned and measured for strength and effectiveness. By applying
140 dimensions such as those defined by Schein it makes it simpler to understand what
141 organizational culture is and how better to design measurements systems and actions to
142 strengthen an organizations culture. Schein suggests five dimensions (Table 1).

143 **Table 1: Cultural dimensions and components of organizations adapted from**
 144 **Schein, 2004 (Jespersen et al, 2014)**

Dimension	Components
External adaptation	Mission and goals, means (e.g., day-to-day behaviours, skills, knowledge, time and technology) to reach goals, degree of autonomy, how does the organization decide what to measure, measures (what and how), how to judge success, remediate and repair processes, and crisis history.
Internal integration	System of communication, common language, group selection and exclusion criteria, allocation systems (e.g., influence, power and authority), rules for relationships and systems for rewards and punishment.
Reality and truth	High vs. low context, definition of truth, information, data, and knowledge needs; training and competencies; systems (e.g., sign-off), continuous improvement.
Time and space	Four different dimensions for characterizing time orientation; assumptions around time management.
Human nature, activity and relationship	Theory x/y managers, the doing/being/being-in-becoming orientation, and four basic problems solved in a group: identity and role; power and influence; needs and goals; acceptance and

Dimension	Components
	intimacy, individualism/groupism, power distance and accepted behaviours & practices.

145

146 **4.2 Measuring using maturity models.**

147 Maturity models are tools to evaluate a current state of a given culture, system, business
 148 or process, and to develop improvement plans against a scale of maturity. Maturity models are
 149 most often specific to a subject matter (e.g., information technology or occupational health and
 150 safety) and wide ranges of industries have defined maturity models to improve effectiveness of
 151 organizational culture. A maturity model can help an organization understand how industry peers
 152 are performing and how this performance compares to its own. The model summarizes
 153 acceptable industry practices and allows the organization to assess what is required to reach a
 154 certain level of management and control of these practices.

155 Three maturity models were reviewed to investigate their structure, content, and
 156 potential for measuring food safety culture. These were chosen as examples of maturity models
 157 that are topic/function specific not unlike food safety and also based on the great level of detail
 158 available for each model about their development and use. Each model was researched with
 159 emphasis on the results that the topic or function sought to improve. As such, the health care
 160 model was tied to health care organizations striving for and receiving the Baldrige Quality

161 Award and the CobiT to organizations receiving IS Certification. Both were considered to
 162 generate specific results through improved maturity in the organizations researched (Table 2).

163 **Table 2: Stages/levels and assessment methods of maturity models applied to**
 164 **other disciplines**

Maturity Model (Name)	Stages/Levels	Assessment Method
Quality management (Quality Management Grid)	Five stages; <i>Uncertainty</i> , <i>Awakening</i> , <i>Enlightenment</i> , <i>Wisdom</i> , and <i>Certainty</i>	Subjective assessment by raters
Health care (Baldrige)	Five stages; <i>Reaction</i> , <i>Projects</i> , <i>Traction</i> , <i>Integration</i> , and <i>Sustaining</i>	Document reviews, audits, and interviews
Information technology (CobiT)	Six levels; <i>Non-existent</i> , <i>Initial/ad hoc</i> , <i>Repeatable</i> <i>but Intuitive</i> , <i>Defined</i> <i>Process</i> , <i>Managed</i> and <i>Measurable</i> , and <i>Optimized</i>	Third party assessors through procedural reviews and interviews

165

166 **4.2.1 Quality Management.**

167 In 1972 Crosby first published “Quality is Free” (Crosby, 1972). In this work, he presents
 168 one of the first written references on the use of maturity models. The need for long-range

169 programs in quality can be deduced through Crosby's *Management Maturity Grid*. Anyone can
170 spend a few minutes with the grid, decide where an organization is currently positioned, and
171 know what needs to be done to move forward. The grid is divided into five stages of maturity
172 and six management categories serve as the experience relations that anyone must go through to
173 complete the matrix. By reading the experience condensed in each block within the grid, it is
174 possible for the reader to assess a specific organization's quality management culture. Crosby
175 recommended that the assessment was done separately by three managers and compared;
176 nevertheless, it is recognised that this is a subjective evaluation of maturity (Crosby, 1972). In
177 the food industry, food safety management and quality management are considered to be closely
178 related and food safety is often thought of as a subset of quality (Mortimore & Wallace, 1994;
179 Rohr et al, 2005). The Quality Management Maturity Grid is, therefore, a logical starting point
180 when developing a maturity model for food safety.

181 **4.2.2 Health Care.**

182 Goonan et al. (2009) describe the journey taken by health care organizations towards
183 receiving a Baldrige award. The Baldrige award is part of the U.S. National Quality Program
184 and the Malcolm Baldrige National Quality Improvement Act, which was signed into law in
185 1987. The focus of the program is to help companies improve quality and productivity and
186 recognize these achievements as an example for others to follow. The program has established
187 guidelines with evaluation criteria and provides specific guidance to companies who wish to
188 improve quality and pursue the Baldrige award. While none of the recipients characterized

189 receiving the award as the “silver bullet”, most described it as an opportunity to seek a systems
190 model to help unify to one common framework (Goonan, Muzikowski, & Stoltz, 2009).

191 The maturity model developed by Goonan et al. (2009) describes a specific journey to
192 performance improvement and the maturity model specifies the content of this journey for health
193 care organizations. The assessment against the maturity model is through document reviews and
194 visits to the organizations for system audits and interviews. This multi-method approach is not
195 unlike that carried out in food safety by third party auditors against food safety standards such as
196 SQF and FSSC22000.

197 ***4.2.3 Control Objectives for Information and related Technology.***

198 Control Objectives for Information and Related Technology (CobiT) (“COBIT 5”, 2014)
199 develops and maintains tools, such as maturity models, performance goals, and metrics and
200 activity goals for use within the information technology industry. The maturity model, as defined
201 by CobiT, has five maturity stages and six attributes; (1) Awareness and communication, (2)
202 Policies, plans and procedures, (3) Tools and automation, (4) Skills and expertise, (5)
203 Responsibility and accountability, and (6) Goal setting and measurements.

204 A generic definition is provided for the maturity scale and interpreted for the nature of
205 CobiT’s IT management processes. A specific maturity model is provided for each of CobiT’s 34
206 processes. The purpose is to identify issues and set improvement priorities. The processes are not
207 designed for use as a threshold model where one cannot move to the next higher level without
208 having fulfilled all conditions of the lower level, rather as a practical and easy to understand
209 maturity scale that can facilitate raising awareness, capture broader consensus, and motivate

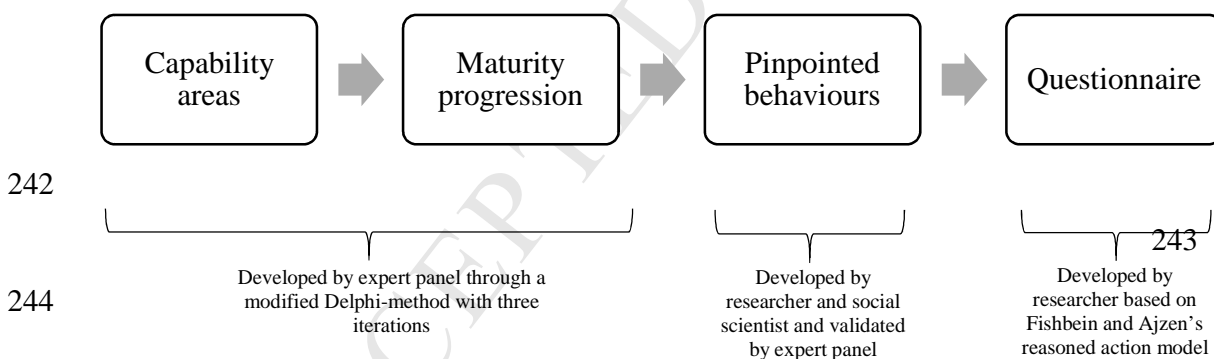
210 improvement. Thus, the maturity model is a way to measure how well developed the
211 management process and supporting culture is.

212 As shown in the above review, maturity models are already used to characterize a given
213 area of focus (e.g., quality, health care culture, and information technology) and through
214 definition of specific areas that the subject matter area has deemed important for an organization
215 to demonstrate capability within. A maturity model can also be used to measure a process or an
216 organization's current state and thereby help prioritize the actions needed to progress. The
217 following learnings can be derived from each of the models described, (1) culture can be
218 segmented into areas of focus to a specific area such as food safety, (2) maturity of culture can
219 be linked to results and performance, (3) structure of five levels/stages of maturity and five to
220 seven focus areas have been successfully applied to improve performance in health care and
221 IS/IT. Thus it is likely that a similar structure could be useful for measuring food safety culture
222 performance and maturity. The models reviewed used a variety of assessment approaches to
223 pinpoint an organisations position (maturity profile) within the given model, including
224 management rating (Crosby, 1972) document review and site assessment (Goonan, Muzikowski,
225 & Stoltz, 2009) and 3rd party audit (COBIT 5, 2014). Although the models are intended to
226 indicate maturity of culture and performance, there are few behaviour-based elements in the
227 assessment processes. This would seem to be an oversight since behaviour is understood to play
228 a major role in culture (Hofstede, Hofstede, and Minkov; Schein, 2004; Denison, 2015; Yiannas,
229 2015). Work on social cognitive models (Hinsz et al, 2007; Ball et al, 2009) suggests that
230 behaviour-based assessment can give a useful measure as part of food safety assessment.

231 Therefore, a behaviour-based maturity profile approach might provide an effective measure of an
 232 organisation's food safety culture.

233 5. Method

234 Two methods were applied, a modified Delphi method and definition of pinpointed
 235 behaviours based on Ajzen and Fishbein's characteristics of behaviours (Fishbein & Ajzen, 2009).
 236 The modified Delphi consisted of three rounds of feedback where panel members were asked to
 237 provide feedback through group discussion. The feedback was integrated into the maturity model
 238 after each round. An industry panel was established to lead in the development of the content of
 239 the model and behaviours were developed with input from a social scientist to assist in breaking
 240 down the individual components of the model to pinpoint and simply define behaviours (Figure
 241 1).



245 **Figure 1: Cascading process for development of the components of the**
 246 **measurement system**

247 The capability areas, and the subsequent food safety maturity model, were developed
 248 with the panel of industry experts. The experts were selected based on their practical experience
 249 in food safety leadership within international food manufacturing organizations. The experience

250 and knowledge of leaders in food manufacturing was critical to ascertain the practical input into
 251 the definition of capability areas and the pinpointed behaviours as there was no existing
 252 published food safety maturity model. The individual expert panel members were chosen based
 253 on their demonstrated knowledge, experience, and leadership. A seven-person panel was
 254 identified to meet quarterly during the development phase of the maturity model.

255 **5.1 Development of Capability Areas.**

256 The purpose of a capability area is to translate an organizational cultural dimension into
 257 areas of specific importance to food manufacturers. Each theoretical perspective was mapped to
 258 a culture dimension. This mapping was used to provide guidance during the modified Delphi
 259 sessions for the industry experts to ensure linkage between the food safety capability areas and
 260 dimensions of organizational culture (Table 3). For example, the organizational cultural
 261 dimension *reality and truth* was translated into specific language used in food manufacturing and
 262 content related to e.g., measurement systems, and data captured in the *technology enabled*
 263 capability area. A capability area is defined as “an area thought to be critical to food safety
 264 performance and thought to exist in food manufacturing organizations at progressive levels.”

265 **Table 3: Mapping theoretical perspective to organizational cultural**
 266 **dimensions and food safety capability areas**

Theoretical perspective	Culture dimensions	Capability areas
Organizational culture	External adaptation	Perceived value
	Internal integration	People systems

Theoretical perspective	Culture dimensions	Capability areas
Social cognitive science	Human nature, activity, and relationship	People systems
	Human nature, activity, and relationship	Process thinking
Food science	Reality and truth	Technology enabled
	Reality and truth	Tools and infrastructure

267

268 Five capability areas define the core of the food safety culture measurement system. Each
 269 capability area was further defined individually on a scale of maturity in the food safety maturity
 270 model. One of Schein's dimensions – time and place – was found through the expert panel not to
 271 be of specific relevance to food safety and through the Delphi method it was decided to exclude
 272 this in the food safety capability areas.

273 There are five stages of maturity in the model. Stage 1 is *Doubt* and is described by
 274 questions such as “Who messed up?” and “Food safety – QA does that?” Stage 2 is *React to* and
 275 described by questions and situations such as “How much time will it take?” and “We are good
 276 at fire-fighting and reward it.” Stage 3 is *Know of* and is described by statements such as “I know
 277 it is important but I can fix only one problem at a time.” Stage 4 is *Predict* and described by
 278 statements such as “Here we plan and execute with knowledge, data and patience.” Stage 5 is

279 *Internalize* and described by situations such as “Food safety is an integral part of our business.”
280 The *Perceived value* describes the extent to which food safety is seen as a regulatory requirement
281 only (stage 1) or as critical to business performance and sustainability (stage 5). The *People*
282 *system* describes an organization, which is task-based and lacks clearly defined accountabilities
283 (stage 1) or an organization that clearly defines accountabilities and behaviour-based working
284 groups (stage 5). *Process thinking* describes how the organization solves problems as
285 independent tasks when problems occur (stage 1) or one where problem solving is seen as an
286 iterative process built on critical thinking skills and data (stage 5). *Technology enabled* describes
287 how the organization turns data into information as a manual and fragmented task (stage 1) or
288 automatically and part of a company-wide information system (stage 5). *Tools and infrastructure*
289 describes the availability of resources and can be illustrated as whether an employee needs to
290 walk far to a sink (stage 1) or sinks are conveniently located (stage 5).

291 **5.2 The pinpointed behaviours and the behaviour-based scale.**

292 An inventory of behaviours was defined based on the descriptor in each maturity stage
293 and capability area. The inventory was discussed with food safety and operations leaders in the
294 company where data were collected and those behaviours believed to have the most impact on
295 the descriptor in the maturity model were identified following discussion by the expert industry
296 panel. Pinpointed behaviours can be thought of as those behaviours that are most likely to impact
297 a given result, in this case food safety performance. The pinpointed behaviours in the maturity
298 model were defined at two stages of maturity; doubt and internalized. By defining pinpointed
299 behaviours at the endpoints of the maturity model it was possible to create a self-assessment

300 survey with fewer questions and, by use of a 1-5 Likert scale, measure across the entire maturity
301 model.

302 The objective of the questionnaire was to gather participant's self-assessment results
303 against the pinpointed behaviours and collect demographic data pertaining to plant, function
304 group, and work role. Each participant was asked to rate their own behaviour against a series of
305 questions and statements. The answers to the self-assessment scale were analyzed based on
306 demographics and behaviour predicting variables (attitude, perceived control, social norm and
307 past behaviour and intention).

308 Each statement in the questionnaire was constructed in a standardized format for each
309 pinpointed behaviour. For example, a question regarding the variable *attitude* would read "My
310 behaviour to always design my own tools to gather food safety data is..." and the participant was
311 asked to rate how strongly this reflected the respondent's attitude on a scale from 1 (beneficial)
312 to 5 (harmful). Every question related to the variable *attitude* was structured in this way and
313 rated on similar scales (Table 4).

314 **Table 4: Variable and statement format for describing pinpointed behaviours**

Variable	Standard start	Example pinpointed behaviour
Attitude	My behaviour toalways design my own tools e.g. spreadsheet to gather food safety data...
Perceived	I am confident that for the	...always design my own tools e.g.

Control	next three months I will ...	spreadsheet to gather food safety data
Social Norm	Most people, outside –and at work, whose opinion I value would approve ofalways design my own tools e.g. spreadsheet to gather food safety data
Past Behaviour	I have in the past three monthsalways design my own tools e.g. spreadsheet to gather food safety data
Behavioural Intent	I intend toalways design my own tools e.g. spreadsheet to gather food safety data

315

316

5.4 Pinpointed behaviours.

317

Behaviours were defined specific to function and roles and were used in the self-

318

assessment scale to determine maturity level (Table 5). As such, a Food Safety and Quality

319

supervisor might associate with the following behaviour “I rarely have time to identify root cause

320

of problems and mostly find myself firefighting.” This behaviour is the pinpointed behaviour for

321

the *process thinking* capability area when the supervisor finds her or himself at the maturity stage

322

of *doubt*. If the supervisor found her or himself in the maturity stage of *internalized* within the

323 *process thinking* capability area the behaviour “I collect, analyze and report food safety data
324 daily to plant staff to bring transparency to emerging challenges” might resonate better.

325 Each pinpointed behaviour was designed to include four components: action, target,
326 context and timing for consistency and specificity in the definition of each of the behaviours
327 (Fishbein & Ajzen, 2009). For example, “I always design my own tools to gather food safety
328 data,” may represent a pinpointed behaviour for the Food Safety supervisors in a maturity stage
329 of *doubt* and within the capability area *technology enabled*. The list of pinpointed behaviours
330 cannot be considered an exhaustive list but were determined to be a list of critical behaviours in
331 each maturity stage and capability area for the individual function and role.

332 The leading hypothesis was that pinpointed behaviours were different for the two
333 functional areas: manufacturing and food safety. It was also hypothesised that pinpointed
334 behaviours differed between the four roles of increasing seniority: supervisor, leader, functional
335 leader, and executive (Table 5).

336 **Table 5: Sample pinpointed behaviours for the food safety and quality**
 337 **function by role for the People System capability area in the maturity stages of doubt**
 338 **and internalized**

Capability area	Supervisor (Execute)	Leader (Tactic)	Functional Leader (Strategy)	Executive (Vision)
People System (DOUBT)	I immediately remove food safety issues by myself to avoid negative consequences for my team and myself.	I provide my direct reports with direction to remove food safety problems immediately to avoid negative consequences.	I always have to manage negative consequences when a food safety problem occurs.	I make sure somebody is managing negative consequences every time a food safety problem occurs.
People System (INTERNALIZED)	I take action daily to let anybody know when they go over and beyond for food safety.	I take action daily to provide positive feedback when others take action to remove perceived food safety risks.	I take action daily to complement my peers in other functions of their demonstrated food safety ownership.	I minimum monthly check in with functional - and business leaders to ensure food safety is built into their business plans.

339

340

341 **5.3 The food safety maturity model.**

342 The food safety maturity model (Table 6) was developed based on the findings of the

343 literature review and input from the industry expert council.

344 Each intersection of a capability area (e.g., *perceived value*) and a stage (e.g., *doubt*) was
345 defined by completing the sentence “We [STAGE] food safety and our [CAPABILITY AREA]
346 are described by X.” For example, in the case of *doubt* the perceived value X would become
347 “completing tasks because regulations make us.” Each definition was discussed and the industry
348 expert panel reached a consensus on the most important one or two definitions but did not
349 produce a comprehensive list of definitions, as this was thought to be of little value when
350 defining a measurement system.

351

352 **Table 6: Food Safety Maturity Model**

	Stage name				
Capability Area	Stage 1 Doubt	Stage 2 React to	Stage 3 Know of	Stage 4 Predict	Stage 5 Internalize
Perceived Value	<p>Completing tasks because regulators make us do so.</p> <p>Food safety performance data is not collected and reported regularly to all stakeholders.</p>	<p>Little to no investment in systems (people and processes) to prevent food safety firefighting.</p> <p>Little understanding of true food safety performance.</p>	<p>Food safety issues are solved one at a time, getting to the root of the issue, to protect the business.</p> <p>Strong, databased understanding of true food safety performance.</p>	<p>Reoccurrence of food safety issues is prevented by used of knowledge and leading indicators.</p>	<p>Ongoing business improvement and growth is enabled by food safety.</p>

<p>People System</p>	<p>Tasks are only completed when senior leader's demand, without understanding responsibility, the task, or why it is important.</p> <p>Tasks being completed out of fear for negative consequences.</p> <p>Top management having to individually certify the accuracy of food safety information.</p>	<p>Responsibilities for problems are established as the problems are discovered and solved mostly by use of negative consequences.</p> <p>Tools are invented as new problems arise and the tools are rarely incorporated into systems for future use.</p>	<p>Deeper understanding for the importance of foods safety systems, where responsibilities are clearly defined and communicated, is gained one issue at a time.</p> <p>Consequences are mostly managed when mistakes happen, seldom through a defined plan, with both positive and negative consequences.</p>	<p>Develop and assess tools for improving processes through knowledge and data.</p> <p>Responsibilities and accountabilities are discussed, communicated, and assessed with patience.</p> <p>Processes are developed, including consequences (positive and negative), and managed preventive through communication and assessment.</p>	<p>Strategic direction is set across the complete organization with defined accountabilities, responsibilities, and food safety as one of the business enablers.</p> <p>Preventive definition and continuous improvement of specific food safety behaviours, consequences and tools.</p>
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Process Thinking	Unstructured problem solving to remove the immediate pain.	"Plan, Do, Check, Act" with emphasis on control in the check phase and expectation of an immediate 100% perfect solution.	Structure problem solving with significant risk of over analyzing.	"Plan, Do, Study, Act" with emphasis on study and not control. Problem solving is accepted as an iterative process.	Horizon scanning and continuous improvement are used to identify risks. Risks inform the development and/or improvement of mitigation plans. Mitigation plans are integrated in the global business management system.
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<p>Technology Enabled</p>	<p>Little technology being adopted and few see this to be an issue.</p>	<p>Responsibility is left to the individual to identify data needed and there is a high reliance on the individual to derive information from the data.</p>	<p>Standard technology is adopted on going and standardized training provided to individuals as needed.</p> <p>It is unlikely to see that issues are prevented by use of data-driven information.</p>	<p>Data is collected in a precise and accurate manner to constantly improve processes.</p> <p>Automation is used in a limited or fragmented way.</p>	<p>Integrated, global information systems (e.g., ERP) are in place in the organization making it quick to adapt, improve, and use automated workflows.</p>
<p>Tools and Infrastructure</p>	<p>Minimal tools in the hands of few individuals.</p>	<p>It takes a problem to get the right tools. This often leads to findings the right tools in a hurry and resulting in rework.</p>	<p>The organization invests readily in the right tools and infrastructure when solving a problem calls for it.</p>	<p>Food safety tools and infrastructures are in place and are continuously improved for ease of use and cost of the organization.</p>	<p>Investment in tools and infrastructure is evaluated long-term and prioritized along with other business investments.</p>

354

355 5.5 Questionnaire administration.

356 Data were collected from a Canadian food manufacturing company between February
357 and April 2014. The company employed approximately 19,000 employees across 47 plants at the
358 time of data collection and manufactured bakery and meat products, and meals. The
359 questionnaire was constructed to gather data for all capability areas in the food safety maturity
360 model. The scale was administered through an online survey tool, all responses were anonymous,
361 and each respondent was rewarded with a \$5 product voucher for their participation. Employees
362 in supervisory roles and leadership positions (n=1,030) within the two functions food safety and
363 quality and manufacturing were given the opportunity to participate. Survey responses were
364 received from 219 employees (21.3% response rate). The responses from the questionnaires were
365 analyzed after import into Minitab 10 (Minitab Inc. State College, PA) using a numbering
366 convention to ensure anonymity. Minitab 10 is a general-purpose statistical software package
367 designed as a primary tool for analyzing research data. The examination of the data was
368 conducted using descriptive statistical principles and statistical tests (e.g., ANOVA) to explore
369 differences between levels, roles, plants, and maturity stages.

370 6. Results**371 6.1 Overall company behaviour-based maturity.**

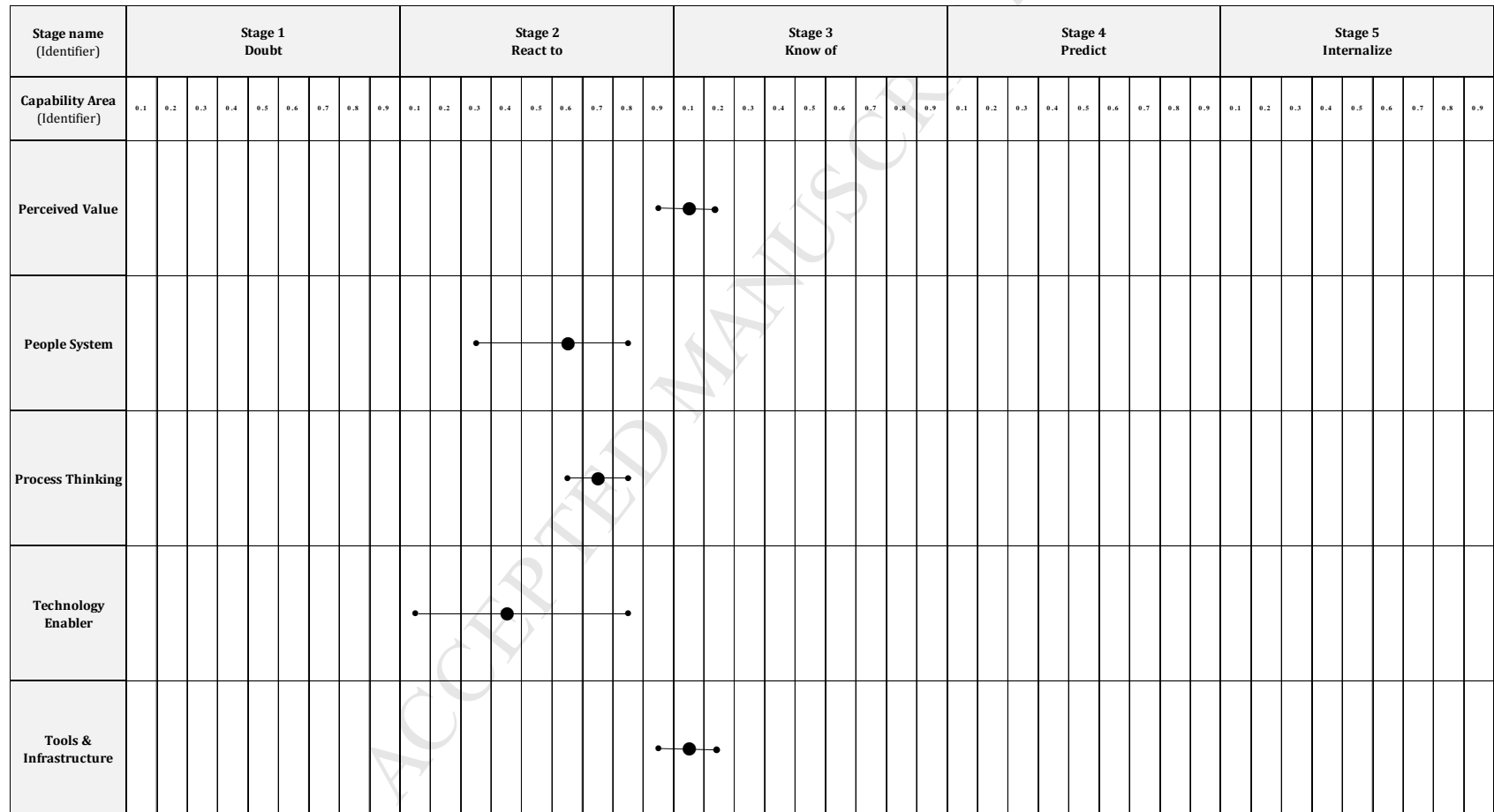
372 Based on the data analysis the company maturity is between the stages *react to* and *know*
373 *of*. The capability areas *perceived value* and *tools and infrastructure* scored the highest average
374 scores of 3.1 in both areas. The capability areas *people systems* and *process thinking* scored

375 within the maturity stage of *react to* just ahead of the capability area *technology enabled* also
376 within the maturity stage of *react to*. Mean maturity scores for each capability area and range
377 (minimum and maximum average by plant) were plotted on the maturity model (Figure 2).

378 The figure shows the five capability areas down the left side of the model and the five
379 stages of maturity across the top. Based on the results from the questionnaire the mean, min, and
380 max score are calculated and plotted against each capability area. The numeric scale (0.1-5.0) is
381 show below the maturity stage identifiers. For example, the mean score for the company in the
382 study for *perceived value* is 3.1 with minimum score of 2.9 and maximum score of 3.2.

383

Figure 2: Overall company behaviour-based maturity



384

385 Overall, a significant difference ($p = 0.003$) was found between maturity perceived by the
386 food safety and quality function ($n=306$) and the manufacturing function ($n=724$). A difference
387 was found for one of the five capability areas, namely *technology enabled*, with the
388 manufacturing function rating the enablement through technology at a higher maturity than the
389 food safety and quality function. The data collected by role, supervisory ($n = 890$), leader ($n =$
390 223), and functional leader ($n = 98$), showed a significant ($p < 0.001$) difference in overall
391 maturity, leaders ranked maturity the highest on the maturity scale (mean = 2.096) in *know of*,
392 followed by functional leader (mean = 2.080) in *know of*, and lastly supervisors who ranked
393 maturity the lowest (mean = 1.983) in *react to*.

394 **6.2 Plant behaviour-based maturity.**

395 Plant specific data were plotted on the maturity model and the difference between the
396 plant's overall maturity score was analyzed using a one-way ANOVA analysis. It was
397 determined that there was a statistically significant difference between one or more of the plants
398 ($p < 0.001$).

399 Mean maturity score was calculated for overall maturity of the plant and by capability
400 area. The percentage of maximum score (5) for each plant's overall maturity was calculated as a
401 measure of the strength of an individual plant's food safety culture (Table 9).

402

403

Table 9: Maturity score by plant; mean score and score by capability area

Plant	Capability Area						Mean score (% of total)
	Perceived value	People systems	Process thinking	Technology enabler	Tools and infra-structure		
1	2.9	3.0	2.8	2.7	3.1	2.9 (58%)	
2	2.9	2.4	2.6	2.4	3.3	2.7 (54%)	
3	2.6	2.6	2.9	2.3	3.0	2.7 (53%)	
4	3.0	2.6	2.4	2.6	3.0	2.7 (54%)	
5	2.9	2.1	2.5	1.8	2.7	2.4 (48%)	
6	3.3	2.7	3.0	2.5	3.2	2.9 (58%)	
7	3.3	2.7	3.0	2.9	3.2	3.0 (60%)	
8	2.9	2.8	2.8	2.4	2.5	2.7 (53%)	

404

Table legend: Food safety culture score by plant for each capability area. Each capability area could range

405

between 1 and 5 depending on the participants responses to each capability area statement. Minimum maturity level

406

equals a score of 1 indicating a *doubt* state of maturity and a score of 5 indicating an *internalized* state of maturity.

407 Average for each plant was calculated and a percentage achieved calculated to quantify strength of each plants food
408 safety culture.

409 The results show the average maturity of the eight plants is between stages *react to* and
410 *know of*. Three plants (P1, P6, and P7) had the strongest food safety culture with scores between
411 58% and 60% ranging from 2.9 - 3.0 in average maturity score. Extrapolating from these scores
412 and the food safety maturity model, the culture in these plants can be described as one where
413 food safety issues are solved one at a time and a solid understanding of food safety performance
414 through data acquisition and analysis exists. There is a clear understanding of responsibility and
415 consequences are mostly managed when a problem occurs. These plants make good use of data
416 but sometimes over analyze issues. Technology has been adopted to help manage food safety
417 systems but it is unlikely that these plants use data to prevent problems from occurring.
418 Investments in tools and infrastructure are made when required to solve a problem.

419 The plant (P5) with the lowest score (48%) was placed in the *react to* stage. The culture
420 in this plant can be described as one where there is little to no investment in food safety and the
421 perceived value of such an investment is not clear. Responsibility for problems is assigned as
422 they occur and antecedents (e.g., training, job descriptions, and performance measures) are
423 developed in reaction to food safety problems. Problems are solved as they arise and there is
424 little evidence of systematic continuous improvement. In this plant, the responsibility to decide
425 what data to collect is placed on the individual and not the group and decisions for investment in
426 tools and infrastructure change are made as new problems arise.

427 7. Discussion and conclusions

428 The purpose of this research was to search for ways to characterize and measure food
429 safety culture. Some research and publications are available linking food safety culture to factors
430 such as leadership, communications, and learning (Griffith, 2010b; Powell et al, 2011; Yiannas,
431 2009a). A few studies propose methods for assessing food safety climate and food safety culture
432 (De Beock, 2015, Taylor, 2015, Wright, 2013) and another few have conducted detailed research
433 specific to behaviours in food manufacturing (Ball, Wilcock, & Aung, 2009; Nickell & Hinsz,
434 2011). The results of this research applied dimensions and characteristics found in organizational
435 culture theory to measure and explain maturity of food safety in food manufacturing
436 organizations. A behaviour-based food safety maturity model was applied as a method to
437 measure food safety culture and this was tested at the case study organization.

438 The food safety maturity model was built on the experience of a food safety industry
439 expert panel and knowledge acquired from maturity models applied to other disciplines (e.g.,
440 quality management, health care, and information technology). The overall food safety culture
441 was measured using a behaviour-based scale derived from the reasoned action model (Fishbein
442 & Ajzen, 2009) and the food safety specific maturity model stages.

443 As a result of applying the food safety maturity model and behaviour-based scale, the
444 food safety culture for plants in this specific company ranges between maturity stage 2 *react to*
445 and maturity stage 3 *know of*. The organization finds itself in a stage of maturity where food
446 safety is accepted as an important part of business, decisions are increasingly made based on

447 science and data, training is increasingly standardized, and investment in infrastructure and tools
448 are readily available as needs arise. There is a tendency to not invest in systems (protocols or
449 technology); to assign responsibility for problems as problems arise, and on occasion, the
450 company reacts to problems more than prevents them.

451 Mapping of the food safety capability areas of the food safety maturity model to Schein's
452 Culture dimensions (Schein, 2004) and the theoretical perspectives on food science, social
453 cognitive science and organisational culture was shown in Table 3. Considering the company's
454 overall food safety culture position between stages 2 (React to) and Stage 3 (know of), this
455 illustrates a culture where the organisational cultural dimensions of *Internal Integration* and
456 *Human Nature, activity and relationship* are at a level where individuals have limited power,
457 problem solving has emphasis on control of checking and responsibility for problems is
458 generally solved by the use of negative consequences. *External Adaptation* relates to food safety
459 firefighting to solve crises one at a time, and *Reality and truth* shows a high reliance on the
460 individual to derive meaning from data although the organisation is willing to invest in tools and
461 infrastructure if solving a problem calls for it. Knowing this, the company can now make
462 informed decisions on where resources should be allocated to make the most important change in
463 the strength of the organization's food safety culture. Also, the organization can cross-reference
464 to generic organizational culture to ensure improvements are made to food safety as an integrated
465 part of overall organizational culture. For example, the organizations score showed a statistically
466 significant difference between leaders and supervisors perception of food safety maturity. This

467 was especially shown in *People Systems* (cross-referenced to *Internal Integration*.) To action this
468 the organization can look at their overall strategies, structure, and processes related to
469 supervisors and make use of the food safety findings to improve that the translation of food
470 safety policies through the supervisory group.

471 Maturity models are widely used in organizations to improve processes and cultures
472 (Crosby, 1972; Goonan et al., 2009), however, no maturity model had previously been developed
473 specifically for food safety culture. Two published assessment tools were reviewed and brought
474 insight into the assessment of food safety climate (De Boeck et al., 2015) and assessments of
475 food safety culture by regulatory inspectors in small manufacturing (Wright, 2013). However, it
476 is believed there is still a gap of food safety culture measurement tools specific to food
477 manufacturing built on organizational theory which the maturity model described here aims to
478 fill. The findings of this study are unique in that they highlight potential for incorporating a
479 behaviour-based maturity model into a food safety measurement system. This will provide an
480 indication as to how well an organisation's employees know of and deal with issues related to
481 food safety as well as depicting the state of the organization and its performance specific to food
482 safety.

483 A key feature of this novel food safety maturity model approach is that it combines the
484 maturity profiling and behavioural-based approaches and thus provides a cultural element to food
485 safety maturity estimates. Performance scoring systems such as the Baldrige award follow a
486 similar maturity model approach but, in contrast to the present study, the Baldrige model does

487 not take specific food safety requirements or situations into account, nor does it give a behavior-
488 based analysis from the perception of the workforce. Behaviour-based studies have proved the
489 applicability of social cognitive models to assess food safety behaviours (Ball, Wilcock, & Aung,
490 2009; Nickell & Hinsz, 2011) and these studies clearly indicate the opportunity for the use of
491 these models in food safety, although they have not previously been used as part of maturity
492 profiling. By putting these two areas together, this behaviour-based food safety maturity profile
493 tool could be embedded into food safety management systems monitoring and verification,
494 giving an objective measure of the food safety culture from the perspective of the workforce
495 functions and roles to be considered alongside objective views of the effectiveness of food safety
496 management system elements provided by, for example, third party audit.

497 Given the lack of a control group or other validation activities in this study, it cannot be
498 concluded that the self-assessment score covers all characteristics of food safety culture. For
499 future studies, additional validation activities such as semi-structured interviews and group based
500 behavioural observations at a participating plant could validate the findings. The research was
501 conducted within one food manufacturing organization and without the opportunity to compare
502 with other organizations. Therefore, it is not possible to say at this stage if the measurement
503 system is robust enough to detect differences caused by the individual organization, its
504 geographical location, and the role it plays in the global food chain (e.g., grower versus
505 manufacturer versus retailer). It is recommended that further research be carried out to validate

506 the measurement system and test the model's applicability to assess food safety culture across
507 multiple organizations.

508 The measurement system developed in this research can be used as a practical tool for
509 manufacturers to assess the strength of their food safety culture and allocate resources in those
510 areas that need it the most in this changing environment. It is also a system that can help
511 organizations to tie food safety into their overarching organizational culture, thereby linking food
512 safety to overarching organizational effectiveness. In this way the food safety culture maturity
513 profiling tool could bring clarity and benefit to many organizations in the global food
514 manufacturing industry.

515 **8.0 Acknowledgements**

516 The researchers would like to acknowledge Dr. John Butts, Raul Fajardo, Martha Gonzalez,
517 Holly Mockus, Sara Mortimore, Dr. Payton Pruett, John Weisgerber, and Deirdre Conway for
518 their contributions. Special thanks to Dr. Randy Huffman for his on-going support and
519 encouragement.

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- 587

Table 1: Population subgroup and relative susceptibility adapted from WHO and FAO (2009), PHAC (2010, and CDC data (2010).

Population Sub-Group	Relative Susceptibility
Health members of population < 60 years old	1.0
>60 years old	2.6
>65 years old	7.5
75-79 years old	9.0
Alcoholism	18.0
Pregnant woman	20.0
Diabetes – type 2	25.0
Diabetes – type 1	30.0
Aids and HIV	865.0
Organ transplant recipients	2,584.0

Table 2: Cultural dimensions and components of organizations adapted from Schein, 2004 (Jespersen et al, 2015)

Dimension	Components
External adaptation	Mission and goals, means (e.g., day-to-day behaviours, skills, knowledge, time and technology) to reach goals, degree of autonomy, how does the organization decide what to measure,

Dimension	Components
Internal integration	<p>measures (what and how), how to judge success, remediate and repair processes, and crisis history.</p> <p>System of communication, common language, group selection and exclusion criteria, allocation systems (e.g., influence, power and authority), rules for relationships and systems for rewards and punishment.</p>
Reality and truth	<p>High vs. low context, definition of truth, information, data, and knowledge needs; training and competencies; systems (e.g., sign-off), continuous improvement.</p>
Time and space	<p>Four different dimensions for characterizing time orientation; assumptions around time management.</p>
Human nature, activity and relationship	<p>Theory x/y managers, the doing/being/being-in-becoming orientation, and four basic problems solved in a group: identity and role; power and influence; needs and goals; acceptance and intimacy, individualism/groupism, power distance and accepted behaviours & practices.</p>

Table 3: Structure and rigour of maturity models applied to other disciplines

Maturity Model (Name)	Stages/Levels	Results from application
Quality management (Quality Management Grid)	Five stages; <i>Uncertainty, Awakening, Enlightenment, Wisdom, and Certainty</i>	No
Health care (Baldrige)	Five stages; <i>Reaction, Projects, Traction, Integration, and Sustaining</i>	Yes
Information technology (CobiT)	Six levels; <i>Non-existent, Initial/ad hoc, Repeatable but Intuitive, Defined Process, Managed and Measurable, and Optimized</i>	Yes

Table 4: Mapping theoretical perspective to organizational cultural dimensions and food safety capability areas

Theoretical perspective	Culture dimensions	Capability areas
Organizational culture	External adaptation	Perceived value
	Internal integration	People systems
Social cognitive science	Human nature, activity, and relationship	People systems

Theoretical perspective	Culture dimensions	Capability areas
Food science	Human nature, activity, and relationship	Process thinking
	Reality and truth	Technology enabled
	Reality and truth	Tools and infrastructure

Table 5: Variable and statement format for describing pinpointed behaviours

Variable	Standard start	Example pinpointed behaviour
Attitude	My behaviour toalways design my own tools e.g. spreadsheet to gather food safety data...
Perceived Control	I am confident that for the next three months I willalways design my own tools e.g. spreadsheet to gather food safety data
Social Norm	Most people, outside –and at work, whose opinion I value would approve ofalways design my own tools e.g. spreadsheet to gather food safety data
Past Behaviour	I have in the past three monthsalways design my own tools e.g. spreadsheet to gather food safety data

Behavioural	I intend toalways design my own tools e.g.
Intent		spreadsheet to gather food safety data

ACCEPTED MANUSCRIPT

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Table 6: Food Safety Maturity Model

	Stage name				
Capability Area	Stage 1 Doubt	Stage 2 React to	Stage 3 Know of	Stage 4 Predict	Stage 5 Internalize
Perceived Value	Completing tasks because regulators make us do so. Food safety performance data is not collected and reported regularly to all stakeholders.	Little to no investment in systems (people and processes) to prevent food safety firefighting. Little understanding of true food safety performance.	Food safety issues are solved one at a time, getting to the root of the issue, to protect the business. Strong, databased understanding of true food safety performance.	Reoccurrence of food safety issues is prevented by used of knowledge and leading indicators.	Ongoing business improvement and growth is enabled by food safety.

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<p>Tools and Infrastructure</p>	<p>Minimal tools in the hands of few individuals.</p>	<p>It takes a problem to get the right tools. This often leads to findings the right tools in a hurry and resulting in rework.</p>	<p>The organization invests readily in the right tools and infrastructure when solving a problem calls for it.</p>	<p>Food safety tools and infrastructures are in place and are continuously improved for ease of use and cost of the organization.</p>	<p>Investment in tools and infrastructure is evaluated long-term and prioritized along with other business investments.</p>

4 **Table 7: Sample pinpointed behaviours by function (food safety and quality),**
 5 **role and competency areas in the maturity stages of doubt and internalized**

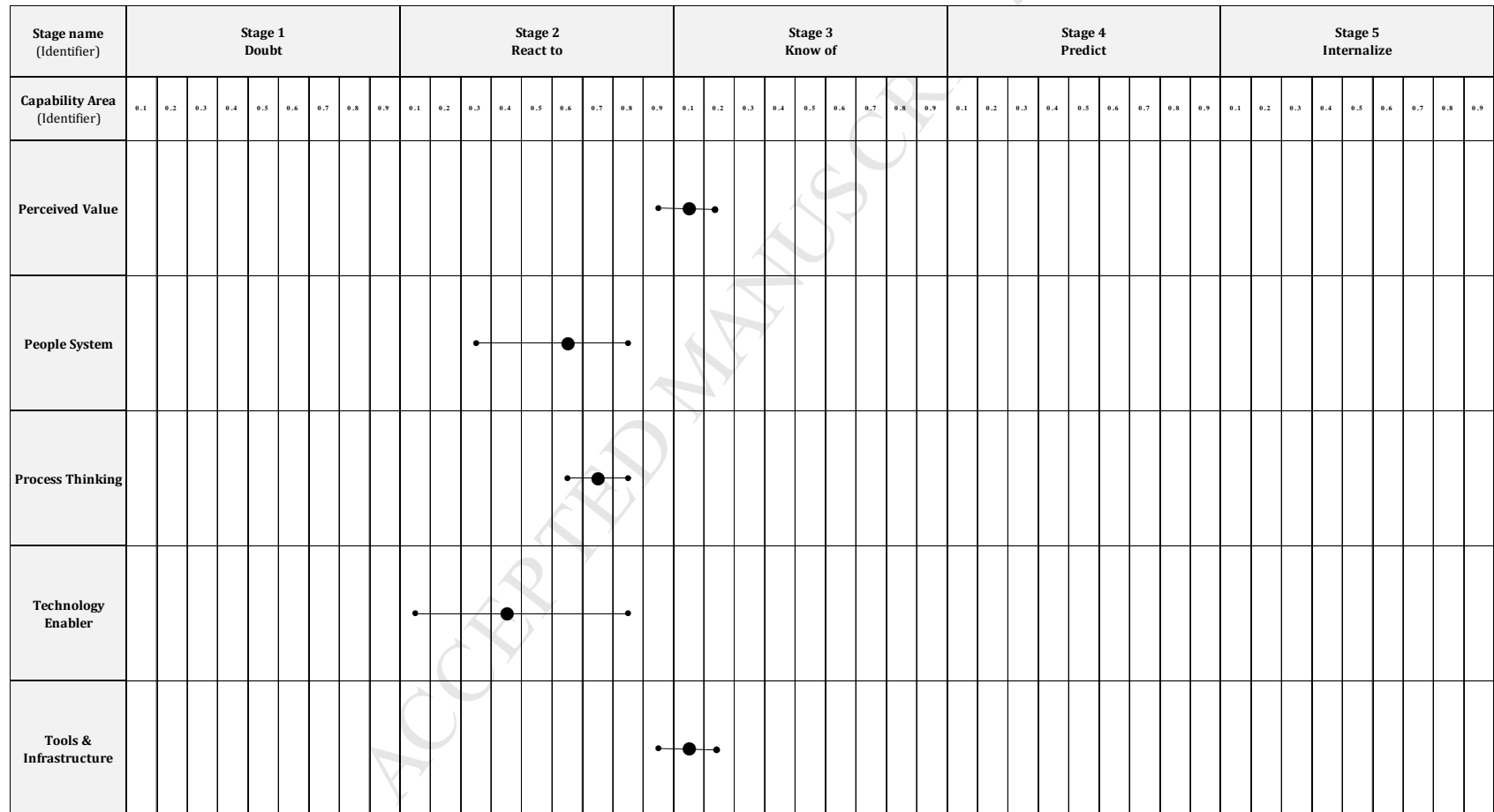
Capability area	Supervisor (Execute)	Leader (Tactic)	Functional Leader (Strategy)	Executive (Vision)
People System (DOUBT)	I immediately remove food safety issues by myself to avoid negative consequences for my team and myself.	I provide my direct reports with direction to remove food safety problems immediately to avoid negative consequences.	I always have to manage negative consequences when a food safety problem occurs.	I make sure somebody is managing negative consequences every time a food safety problem occurs.
People System (INTERNALIZED)	I take action daily to let anybody know when they go over and beyond for food safety.	I take action daily to provide positive feedback when others take action to remove perceived food safety risks.	I take action daily to complement my peers in other functions of their demonstrated food safety ownership.	I minimum monthly check in with functional - and business leaders to ensure food safety is built into their business plans.

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Figure 1: Overall company behaviour-based maturity



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10 **Table 9: Maturity score by plant; mean score and score by capability area**

Plant	Capability Area						Mean score (% of total)
	Perceived value	People systems	Process thinking	Technology enabler	Tools and infra-structure		
1	2.9	3.0	2.8	2.7	3.1	2.9 (58%)	
2	2.9	2.4	2.6	2.4	3.3	2.7 (54%)	
3	2.6	2.6	2.9	2.3	3.0	2.7 (53%)	
4	3.0	2.6	2.4	2.6	3.0	2.7 (54%)	
5	2.9	2.1	2.5	1.8	2.7	2.4 (48%)	
6	3.3	2.7	3.0	2.5	3.2	2.9 (58%)	
7	3.3	2.7	3.0	2.9	3.2	3.0 (60%)	
8	2.9	2.8	2.8	2.4	2.5	2.7 (53%)	

11 Table legend: Food safety culture score by plant for each capability area. Each capability area could range
 12 between 1 and 5 depending on the participants responds to each capability area statement. Minimum maturity level
 13 equals a score of 1 indicating a *doubt* state of maturity and a score of 5 indicating an *internalized* state of maturity.

- 14 Average for each plant was calculated and a percentage achieved calculated to quantify strength of each plants food
15 safety culture.

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