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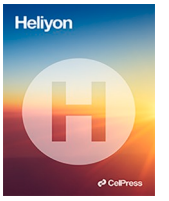

Food safety culture maturity and its relation to company and employee characteristics

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ABSTRACT

Three facets of food safety culture (FSC) (i.e., food safety management system (FSMS), human-organizational and human-individual building block), were diagnosed through a validated mixed-method assessment in twenty food processing companies. Many underdeveloped dimensions were detected in the FSMS and the human-organizational building block, while the human-individual building block was more mature. It was explored whether company (e.g., company size) and employee characteristics (e.g. leaders vs. non-leaders) are associated with FSC maturity (based on 1410 employee responses) through a cluster analysis and statistical (Mann-Whitney U and Kruskal-Wallis) tests. Results revealed significant differences (p-value <0.05) based on company characteristics (significant differences based on: size, belonging to a larger group, product type, place in the supply chain, training frequency, certificates, maturity of control and assurance activities) and employee characteristics (significant differences based on: leaders vs. non-leaders, daily direct contact with food or not, seniority, time since training and psychosocial well-being). These findings are useful to develop tailored food safety culture improvement interventions to enhance the maturity of food safety culture in food companies, as these might focus on lower perceiving (sub)groups of employees or lower perceiving (sub)groups of companies.

1. Introduction

In this study food safety culture (FSC) is defined by the conceptual model by Spagnoli [1], including three building blocks (i.e., the food safety management system (FSMS), human organizational and human individual building block), each containing multiple dimensions. The FSMS includes assurance and control activities. The human-organizational building block consists of nine dimensions: "leadership", "communication", "commitment", "resources", "risk awareness", "consistency", "adaptability", "beliefs and values", and "mission, vision, strategy". Following De Boeck et al. food safety climate is defined as "employees' (shared) perception of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization" [2, p.244]. The third building block, the human-individual building block, contains the dimensions "participation", "compliance", "knowledge", "motivation", and "psychosocial well-being". The conceptual framework positions food safety culture within a broader internal company environment, in which company characteristics concerning product, process and organization are

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important factors influencing food safety culture. FSC maturity is also subject to employees' perceptions pertaining to the various dimensions. The question arises whether the maturity of the food safety culture can be associated with company (e.g., size) and/or employee characteristics (e.g. leaders vs. non-leaders).

The effect of company characteristics of food businesses on FSMS maturity, the essential technical part in food safety culture, has been studied for example by Refs. [2,3]. Going beyond the FSMS [4,5], studied food safety climate in view of company characteristics [6]. found no link between FSC, and riskiness of the product produced [7]. found significant differences in FSC perception among respondents of different gender (perception females > males), age (perception older employees > younger employees), work status (perception part-time employees > full-time employees), with different years of foodservice experience (perception less experienced employees > more experienced employees) and among respondents with different experience levels (perception new employees > senior employees) [8]. found that managers generate higher FSC scores then operators.

This cross-sectional study examines the perceived FSC in the food processing industry and its relation to both company and employee characteristics. Two main research questions are addressed: what is the overall FSC maturity in the sample of twenty Belgian food businesses? And is the perceived FSC maturity associated with characteristics of the employee and/or the company employing the respondent (as independent variables)? Two dependent variables are included, the food safety climate (perceptions of five dimensions in the human-organizational building block) and the perceived maturity of the human-individual building block. Perceived FSC data of 1410 employees (operators and management) are first explored descriptively based on the number of gaps identified in the prevailing FSC, followed by a two-step cluster analysis. Non-parametric statistical tests are conducted to solidify findings from the cluster analysis.

This work gives a unique view of subgroups in FSC perceptions as both company and employee characteristics are included. It is the first paper including both levels of characteristics and both the human-organizational and the human-individual building block, in the context of the food processing industry. Because of the exceptionally large scale, this study can support food authorities in offering specialized support to enterprises with company characteristics that tend to have a lower food safety culture maturity, as FSC brings many challenges for inspectors [9]. Differences in perceived FSC amongst employees could support FSC improvement within companies, as efforts might focus on lower perceiving (sub)groups of employees or would want to counter existing subcultures [10]. Finally, dimensions or indicators that are clearly underdeveloped in the food industry can offer inspiration for companies to begin their food safety culture improvement journey.

2. Material and methods

2.1. Assessment of perceived food safety culture

FSC was assessed based on the methodology described by Ref. [1]. A mixed-method assessment methodology was applied to enhances the assessment's validity and to concur the effects of biases. All assessment techniques based on employees' perceptions were applied and are described below. The by Ref. [1] described on-site evidence collection visits were used, as these entailed objective assessments like document analysis, which cannot be linked to individual employees and therefore cannot be used is this research (as there is no link with employee characteristics).

2.1.1. Food safety management system building block

The FSMS was assessed using the validated FSMS diagnostic instrument (FSMS-DI) containing 34 indicators on core control [11] and core assurance activities [12]. For each indicator, the quality manager of the company selected a score between 0 and 3: with level zero indicating the activity is not applicable and level 1, 2 and 3 respectively indicating a low, medium, and high level of this activity. The perceived riskiness of context was also evaluated using the 17 designated indicators in the tool, with level 1, 2 and 3 respectively indicating an increasing need for a strongly developed FSMS.

For the analysis of the data from the FSMS-DI assigned scores were calculated for the control and assurance activities and for the riskiness of the context per company (Jacxsens et al., 2010; Sampers et al., 2012). For the control and assurance activities the score 0 was assigned when the mean value was between 0 and 0.2, 1 for means between 0.3 and 1.2, 1_2 for means between 1.3 and 1.7, 2 for means between 1.8 and 2.2, 2_3 for means between 2.3 and 2.7 and 3 for means between 2.8 and 3.0. For the riskiness of the context, the score of 1 was assigned when the mean was between 1 and 1.2, 1_2 for means between 1.3 and 1.7, 2 for means between 1.8 and 2.2, 2_3 for means between 2.3 and 2.7 and 3 for means between 2.8 and 3.0 [13,14].

2.1.2. The human-organizational building block

The human-organizational building block was assessed using the food safety climate tool [15] and the card-aided management interview [1]. In the food safety climate tool, which was aimed to be applied with all employees in each company, the respondent is presented 28 statements relating to five FSC dimensions ('leadership', 'communication', 'commitment', 'resources' and 'risk awareness'). For each indicator, the respondent is asked to select a number on a 5-point Likert scale (from totally disagree to totally agree). As done by Ref. [4], a total food safety climate score was calculated for each respondent, by making the sum of the scores (1–5 Likert scale) on the 28 indicators collected. With these total food safety climate scores per respondent, a mean food safety climate score for each company was also calculated (as described in section 2.5.). These total food safety climate scores range from 28 (all 28 indicators received the score 1 on the 5-point Likert scale) to 140 (all 28 indicators received the score 5 on the 5-point Likert scale). Cronbach's Alfa was calculated with SPSS [16] to assess scale reliability, revealing high internal consistency: a value of 0.967.

In the card-aided management interview, a validated qualitative research method, company managers are presented three maturity

levels (reactive, active, proactive) of ten indicators, belonging to four FSC dimensions ('adaptability, 'consistency', 'beliefs and values' and 'mission, vision, strategy'). Each manager was asked to anonymously select a maturity level for each of the indicators in a group session, followed by open discussions. In total, 107 managers participated.

2.1.3. The human-individual building block

Food safety compliance, participation, knowledge and motivation were assessed using four self-report indicators developed by Ref. [17], and adapted to a food safety context by Ref. [18]. All indicators of these four included dimensions were scored on a five-point Likert scale by employees, ranging from totally disagree (point 1) to totally agree (point 5). Job stress was measured using one indicator: "How often do you feel stressed because of your job?" [19]. Burnout was measured using three indicators selected from the 'Utrechtse Burnout Schaal' (UBOS) [20]. Psychosocial well-being indicators (job stress and burnout) were scored using a 7-point Likert scale ranging from never (point 1) to always (point 7). A total score was calculated per respondent for this building block, by making the sum of scores selected on the Likert scale for the dimensions compliance, participation, motivation, and knowledge. The dimension 'psychosocial well-being' was not included in this summation, as the goal is to make a typology of FSC, and psychosocial well-being (job stress and burnout) is conceptualized more as a moderating or influencing factor. With the total human-individual scores per respondent, a mean human-individual score for each company was also calculated (section 2.5.). These total human-individual scores have a range of 16 (all 16 indicators received the score 1 on the 5-point Likert scale) to 80 (all 16 indicators received the score 5 on the 5-point Likert scale). Cronbach's Alfa was calculated to assess reliability, revealing high internal consistency of 0.929 [16]. For psychosocial well-being the mean was calculated of the four included questions per respondent, to obtain a mean psychosocial well-being score per respondent.

2.1.4. Data integration and gap analysis of food safety culture maturity

Through the data integration (re-scaling), the number of gaps (or underdeveloped FSC dimensions) can be identified for each company, ranging from zero to maximum sixteen gaps (as sixteen dimensions are included) per company. For the FSMS-activities, the assigned scores (section 2.1.1.) can be used directly. For results obtained with the food safety climate tool, rescaling was done: score 1 (low maturity) was assigned to the dimension if the mean of the dimension was between 1 and 2.3 (mean of all respondents in the company on the 5 point Likert scale), score 2 for means between 2.4 and 3.7, score 3 for means between 3.8 and 5, in line with the methodology applied in the FSMS-DI [13,14]. For data from the management interview, the overall mode (responses of all managers per company) was calculated for each of the four assessed dimensions (when two scores have the same occurring frequency this becomes score1_score2). This overall mode ranges between 1 (the most selected card/situation was the reactive situation) and 3 (proactive score). For the human-individual building block (questionnaire on the 5-point Likert scale), rescaling was necessary and executed in the same way as for the food safety climate tool. For the questions on the 7-point Likert scale (psychosocial well-being, human-individual building block), rescaling was also necessary: score 1 is assigned for means (mean of responses of all respondents in the company) between 5.1 and 7, score 2 for means between 3.1 and 5, score 3 for means between 1 and 3 on the 7-point Likert scale. Any dimension with a score lower than 2_3 was considered a gap. However, a score lower than 2_3 for the control and assurance activities was only considered a gap if the riskiness of the context was equal to/higher than 2 (and thus a high level of assurance and control activities are needed [13,14].

2.2. Selection and data collection of characteristics

2.2.1. Employee characteristics

Six employee characteristics were selected for the analysis. Five of them were measured through additional introductory questions added to the questionnaire. These questions asked whether the respondent occupied a leadership position [5,8,21], what type of contract the employee has [7,22], how long the employee is working for their current employer [4,7,22], time since food safety training [7] and whether the respondent comes in direct contact with food products on a daily basis [22]. The self-reported psychosocial well-being (i.e. mean score of jobstress and burnout indicators) was considered as a sixth employee characteristic.

2.2.2. Company characteristics

To collect data on the company characteristics (twelve characteristics in total), a questionnaire was made on Google Forms in Dutch and sent to the quality managers of the 20 companies. This form included the following questions, based on available literature: 'is your company part of a corporate group containing multiple companies (yes/no)' [4], 'how many full time employees work at your company (open answer)' [3,5,23,24], 'how many food safety trainings are given to employees each year (1/2/3/4/>4)' [4], 'what is the place of your company in the food supply chain (only transformation/transformation and distribution)' [3,22], 'do you produce plant or animal based products (plant based/animal based/both)' [3,6,22], 'does your company export internationally, outside of Europe (yes/no)' [25], and 'what certificates does your company hold (BRC/IFS/FSSC22000/SCS, multiple answers possible)' [22,25]. Based on discussion amongst authors, two more parameters were added. As Belgian food industry contains many family-owned food businesses [22], the question 'is your company a family-owned business (yes/no)' was added. Furthermore, it could be that FSC maturity differs depending on whether the company produces premium brand products (from which their company can be more clearly identified), so 'is your company producing premium brand or private label products (premium brand/private label/both)' was added.

The perceived maturity of the four human-organizational dimensions included in the management interview (section 2.1.2.) and the control and assurance activities (see section 2.1.1) were also used as company characteristics. In other words, the influence of

company managers' perceptions in the management interview and quality managers' perception of the maturity of the assurance and control activities (as assessed in each company's FSC assessment) on both the food safety climate and the maturity of the human-individual building block is also investigated.

2.3. Sample and data collection

Twenty food processing companies in Belgium joined the research (Table 1). Company inclusion was based on voluntary participation, so this convenience sample is not representative for the food processing industry as a whole. The food safety climate tool and indicators on the human-individual building block were combined in one questionnaire. Translations were provided. Questionnaires were filled in digitally or on paper during working hours. Participation from all employees (all departments and levels) was aimed for in each company (for participation rates see Table 1). Informed consent was obtained from all subjects (Appendix). All data remained anonymous. Employees who left questions blank in the questionnaire were excluded for further analysis, which yielded 1410 full responses.

2.4. Statistical analysis

[26] tested and compared eleven clustering algorithms, from which the two-step cluster analysis emerged as the highest-ranking. Consequently, this technique was selected to explore the data (as e.g. applied by Ref. [27]. The total food safety climate score and total human-individual score for each respondent (n = 1410) (sections 2.1.2. and 2.1.3.) were given as input, with the number of clusters determined automatically. The log-likelihood distance measure was selected. Percentages of employees among clusters were calculated [5,25]. To solidify observed patterns, Mann-Whitney U tests and Kruskal-Wallis tests were done (Dunn tests as post hoc analysis with Bonferroni corrected p-values) (significance level: 5 %). As differences in sample size between companies can influence the statistical analysis, the comparison of the company characteristics was also done on a company level, with the mean total food safety climate score of all respondents per company and the mean total human-individual score of all employees (sections 2.1.2. and 2.1.3.). All statistical analyses were executed with IBM SPSS Statistics version 28 [16].

Table 1
Company characteristics in the sample of twenty food companies in Belgium.

Company	Part of a larger group	Family-owned company?	#[a] FTE[b]	#FS training each year	Place in food chain	Plant/ animal	International export	Premium brand, private label/both?	Certificates	Response rate
1	No	Yes	48	1	Trans[c]	Plant	Yes	Both	BRC, IFS, SCS	77 %
2	No	Yes	31	1	Trans	Animal	Yes	Both	IFS, SCS	100 %
3	Yes	No	55	1	Trans	Plant	Yes	Both	BRC, SCS	78 %
4	No	Yes	13	2	Trans/ distr[d]	Plant	No	Both	BRC	92 %
5	No	No	30	>4	Trans	Plant	Yes	Private label	IFS	90 %
6	No	Yes	42	>4	Trans/ distr	Mix	No	Both	/	64 %
7	No	Yes	9	1	Trans/ distr	Plant	No	Premium brand	SCS	100 %
8	No	Yes	60	2	Trans	Plant	Yes	Both	BRC, IFS, SCS	27 %
9	Yes	No	330	1	Trans/ distr	Animal	No	Private label	IFS, SCS	43 %
10	Yes	No	850	1	Trans/ distr	Plant	Yes	Private label	IFS, SCS	53 %
11	No	No	140	>4	Trans	Plant	Yes	Premium brand	FSSC 22000	36 %
12	No	Yes	30	1	Trans	Plant	No	Both	IFS	63 %
13	No	Yes	17	>4	Trans/ distr	Plant	Yes	Private label	IFS	35 %
14	No	Yes	77	>4	Trans	Plant	Yes	Private label	BRC, IFS, SCS	62 %
15	Yes	Yes	335	>4	Trans	Plant	Yes	Both	BRC, IFS	58 %
16	No	Yes	75	1	Trans	Mix	No	Premium brand	BRC	57 %
17	Yes	No	250	1	Trans	Mix	No	Both	IFS, SCS	58 %
18	Yes	Yes	31	1	Trans/ distr	Plant	No	Both	IFS	84 %
19	No	No	95	>4	Trans	Mix	No	Premium brand	IFS, SCS	77 %
20	No	Yes	15	2	Trans	Plant	Yes	Both	BRC	53 %

[a] '#': number of.
[b] 'FTE': full time employees.
[c] 'Trans': transformation (processing).
[d] 'distr': distribution.

3. Results and discussion

3.1. Food safety culture maturity in the sample

Fig. 1 displays the FSC maturity in the sample. Companies can be divided into four groups based on the number of identified gaps or underdeveloped FSC dimensions (with the possible range from none to maximum sixteen gaps per company). The first group are the four companies (or 20 % of the companies in the sample) with nine or more gaps. The second group contains seven companies (35 % of the companies in the sample) with three to eight gaps, but who also have at least one dimension with a perceived maturity level of 1 (on a scale 1–3). The third group, including seven companies as well (35 % of the companies in the sample), are those companies that also have between three and eight gaps, but without any dimension with a perceived maturity score of 1. The fourth group (two companies or 10 % of companies in the sample) includes the FSC front runners of the sample, with two gaps or less. From these results (Fig. 1) it can be concluded that there is a big range in the sample, going from thirteen gaps (a wholesaler and repackager specialized in organic products) to zero gaps (a spice producing company).

When discussing the gaps per dimension (Table 2), it can be concluded that twelve of the twenty companies (60 %) have a gap for control activities, and six of the twenty companies (30 %) have a gap for assurance activities. This low maturity of the FSMS is surprising as many efforts have been made in the past decade to improve the tailoring of the control and assurance activities, e.g. the legal obligation to have a self-checking system (SCS) based on HACCP principles for all operators in the Belgian food chain [28]. Certification of this self-checking system is not mandatory but promoted by the government [3]. Furthermore, there is constant research and innovation in control activities, e.g. new techniques for surface hygiene monitoring [29] or novel cleaning and disinfection techniques [30],; [31]. It could be that food companies keep their control activities on a level of compliance, or stay compliance based as described by Ref. [32]. Maybe this is caused by limited resources (e.g. financial resources or time) or the multitude of challenges a food business faces (e.g. environmental impact [33] and digitalization [34]. Ten of the twenty companies (50 %) have a gap for the dimension 'resources', but no clear link between having a gap for the dimension resources and having generic control or assurance activities is observed.

Table 2 reveals some variability regarding the number of gaps in the human-organizational building block. It is clear that the dimension 'adaptability', 'consistency', 'beliefs and values' and 'mission, vision, strategy' might still be overlooked in the food industry, in spite of the fact that these dimensions are already represented in many FSC frameworks (e.g. Ref. [35]. It should be mentioned that the difference in maturity could be because these four dimensions were assessed with the management team only, while the first five dimensions were assessed with all employees through the food safety climate tool. However, leaders have significantly better perceptions on the food safety climate dimensions compared to non-leaders (section 3.2.2.) when perceptions are compared (as confirmed by previous research, e.g. Ref. [8]), which underlines the low maturity of these dimensions even more. It is remarkable that the dimension 'consistency' is considered a gap in nineteen of the twenty companies. When each indicator is studied separately (Fig. 2), it becomes clear that low scores for the dimension 'consistency' are mainly attributed to the indicator 'reward expectancy'. Seventy-eight of the one hundred and seven interviewed managers (73 %) chose the reactive (not active or proactive) card in the management interview: 'There is no elaborate system for rewarding (financial/recognition) good food safety behavior. Occasionally someone is rewarded, but this does not happen in a pre-planned way or at a fixed time'. This is consistent with previous research, e.g. Ref. [36] found that the lowest scoring FSC dimension was 'rewards' and [37] found rewards to be one of the FSC dimensions that received the lowest overall scores. However, to have a mature FSC it is essential to have a fair and comprehensive reward system [38].

In contrast to the FSMS and the human-organizational building block, the human-individual building block is more mature in the sample (Table 2). The most recurring gap (four companies or 20 % of companies included in the sample) is in the dimension 'psychosocial well-being'. An explanation for this could be the high occurrence of shift and night work in the food industry to guarantee continuation of processes. Several studies showed that shift and night work are disadvantageous for employees' psychosocial well-being (e.g. Refs. [39,40]).

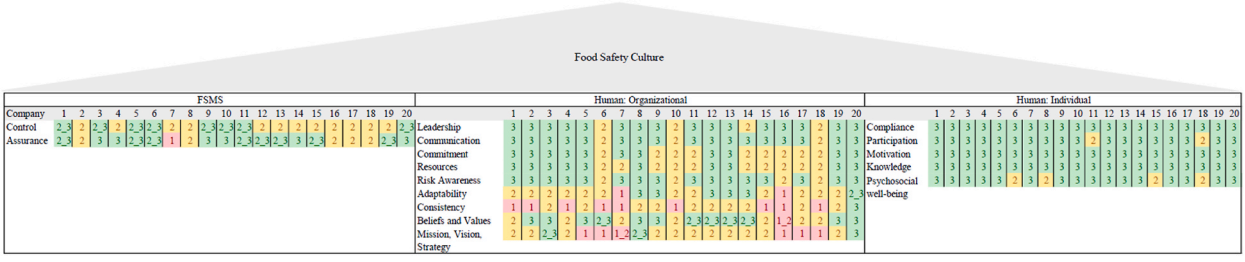

Fig. 1. Perceived food safety culture maturity in the study sample (20 food companies). The three building blocks of the food safety culture conceptual framework of [1] are displayed (i.e. the food safety management system or FSMS, the human-organizational building block and the human-individual building block) with the dimensions and the assessed maturity per company (each column presents one of the 20 companies). If a score is lower than 2_3, or colored yellow or red, this dimension is considered a gap for this company. This representation permits to observe trends and patterns in maturity, e.g. the human-individual building block is much more mature compared to the other two building blocks. 'FSMS' is the food safety management system.

Table 2
Frequency of gaps for each of the FSC dimensions, relating to the three FSC building blocks, based on the mixed-method FSC assessment in twenty food producing companies. This table is a summary of Fig. 1. For example, for the dimension leadership, four out of twenty companies had a gap, i.e. a low maturity for this dimension.

Food safety management system		Human-organizational building block		Human-individual building block	
Dimension	Frequency of gaps	Dimension	Frequency of gaps	Dimension	Frequency of gaps
Core control activities	12	Leadership	4	Compliance	0
		Communication	3	Participation	2
Core assurance activities	6	Commitment	9	Motivation	0
		Resources	10	Knowledge	0
		Risk awareness	4	Psychosocial well-being	4
		Adaptability	14		
		Consistency	19		
		Beliefs and values	8		
		Mission, vision, strategy	17		

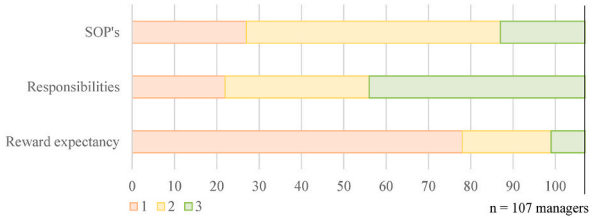

Fig. 2. Frequency of maturity levels for the indicators 'SOPs', 'responsibilities' and 'reward expectancy' belonging to the dimension 'consistency': 1 (black) represents the reactive level, 2 (white) the active level and 3 (grey) the proactive level as selected by 107 managers (max X-axis is 107) in the 20 companies. 'SOP' stands for standard operating procedure.

3.2. Effect of company and employee characteristics on food safety culture

Two dependent variables are included, the food safety climate (human-organizational building block) and the perceived maturity of the human-individual building block of FSC. Fig. 3 displays the clusters made by the two-step cluster analysis, with each color representing a cluster. The automatically selected number of clusters was two, with the cluster quality 'good' as provided by SPSS. Fig. 4 displays the distributions of each of the two clusters. From this Figure, it can be concluded that cluster 1 contains those respondents that have the highest perceptions, both for food safety climate as the human-individual dimensions. Cluster 2 contains all other respondents, so those that perceive either both the food safety climate and the human-individual dimensions, or one of the two, on a relatively lower level. Cluster 1 and 2 hold respectively 962 and 448 respondents. The 'largest cluster to smallest cluster ratio' is 2.15.

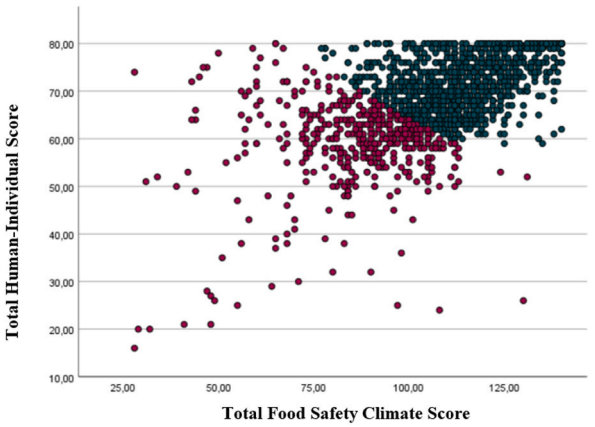

Fig. 3. Scatter plot of the sum of the food safety climate dimensions (X-axis), vs. the sum of the perceptions of the human individual dimensions 'knowledge', 'motivation', 'participation' and 'compliance' (Y-axis), for each respondent (n = 1410), separated in two clusters by a two-step cluster analysis (cluster 1 green and cluster 2 red).

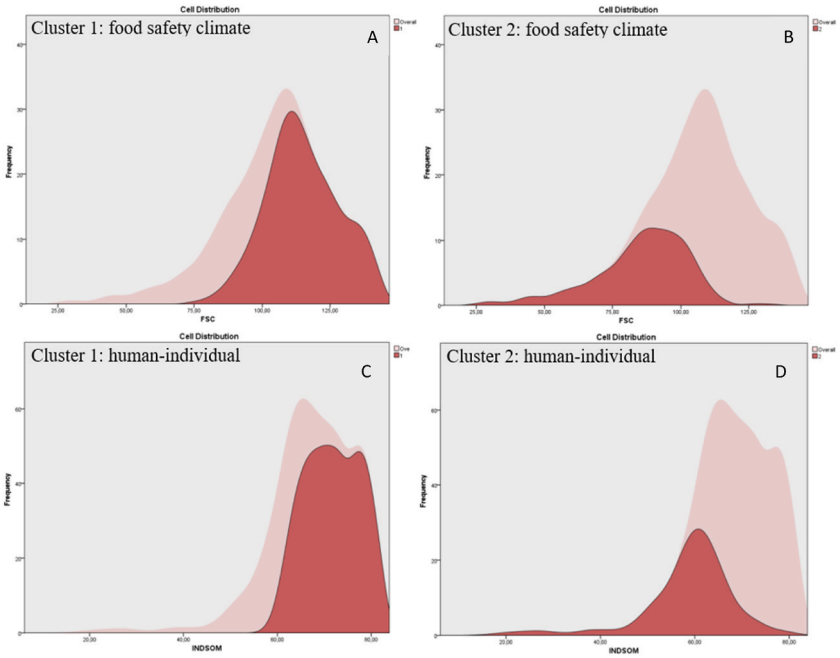

Fig. 4. Distributions per cluster (panels A and C for cluster 1 and panels B and D for cluster 2) of total food safety climate scores (figure panel A and B) and total scores for the human-individual building block (figure panel C and D), including perceptions of all respondents (n = 1410). Darker red: the distribution of the concerning cluster is shown, lighter red: the distribution of all data is shown (cluster 1 and 2 together).

3.2.1. *Effect of company characteristics*

The effect of twelve company characteristics was evaluated. Significant differences in perceptions were discovered between groups based on nine of them (Table 3). No significant differences in perceived FSC maturity were found based on the company being a family business or not, doing international export or not or based on the product (plant vs. animal based). Only significant differences in perception are discussed below. It is clear from Table 3 that more statistically significant differences in perception can be detected on the respondent level compared to on the company level, and there are no cases were a statistically significant difference was found on the company level and not on the respondent level. This was expected due to the large reduction in the dataset for the company level which diminished statistical power.

3.2.2. *Company size*

Table 3 shows that 88.6 % of employees working in companies with less than 20 employees are part of cluster 1. For the bigger companies (more than 100 employees), this distribution of employees among clusters is very different: only 65.2 % of these employees are part of cluster 1. Keeping in mind that cluster 1 contains those respondents with the highest perceptions, it can be that employees working in smaller companies have better perceptions, as a relatively very high percentage of them is part of cluster 1. To validate these findings, statistical tests were done (Table 3). Based on a Kruskal-Wallis test on the respondent level (p-value: <0.001) (Table 3), respondents working in a smaller company (2.5 % of respondents) perceive the food safety climate dimensions significantly higher than employees working in medium (27.7 % of respondents) and bigger (69.9 % of respondents) companies. Also, employees working in medium size companies have significantly higher perceptions of food safety climate compared to employees working in bigger companies. For the human-individual building block, the test revealed that respondents working in a small company perceive the included dimensions significantly higher than employees working in both medium and big companies (p-value: 0.003). From the analysis on the company level, the same conclusions can be made: smaller companies perceive the food safety climate dimensions and the human-individual dimensions significantly higher than big companies (p-values 0.026 and 0.016). Literature is divided about the effect of company size. Some researchers claim there no effect of company size on safety climate (e.g. Ref. [41], some researchers claim a positive effect i.e. the bigger the company the better the perceptions [5], while other researchers also concluded a negative effect (e. g. Ref. [24]). Many different factors could be the cause of why this study found a negative effect of company size on food safety climate maturity whilst the study by Ref. [5] found a positive effect. First of all there are geographical differences. This study was done in 1 country in Western Europe, namely Belgium, while [5] focused on Central and Eastern European countries. A second reason could be that in the sample from Ref. [5], 28 % of small food companies had no certified food safety system in place versus only 6 % of big companies. Based on the results from this study, the higher perceived maturity in smaller companies could be due to the fact that in small organizations, managers usually talk to people directly [23], there are close social contacts and a relatively large influence of workers on their own work practices [42]. It is frequently stated in literature that resources are a limiting factor for small companies, more so then for big companies, negatively influencing safety (climate) [43]. However, amongst the four companies categorized in this

Table 3
Characterization of clusters based on food safety climate and the perceived maturity of the human-individual dimensions (n = 1410 respondents), in view of company characteristics and % of respondents in these clusters. Cluster 1 contains those respondents that have the highest perceptions while cluster 2 contains all other respondents (perception of either the food safety climate or the human-individual dimensions, or both, on a relatively low level). *P*-values of the statistical analysis both on the level of the respondents and on company level are included and displayed in bolt when they are lower than the significance level of 5 %. Only categories of characteristics that contain companies are included, e.g. for the FSMS control activities there were no companies for which this was on level 1, so the category of control activities on level 1 is not included in the Table.

Company Characteristic	Categories	Total Sample (cluster 1 and 2)	Cluster 1	Cluster 2	*P*-value Mann-Whitney U/ Kruskal-Wallis test FS climate		*P*-value Mann-Whitney U/Kruskal-Wallis test human-individual	
					Respondent level (n = 1410)	Company level (n = 20)	Respondent level (n = 1410)	Company level (n = 20)
1.Number of employees	<20	2.5 %	88.6 %	11.4 %	< **0.001**[a]	**0.026**[b]	**0.003**[c]	**0.016**[b]
	20–100	27.7 %	74.1 %	25.9 %				
	>100	69.9 %	65.2 %	34.8 %				
2.Part of a larger group	Yes	71.1 %	66.3 %	33.7 %	< **0.001**[d]	0.070	0.452	0.099
	No	28.9 %	73.0 %	27.0 %				
3.Family business	Yes	33.8 %	70.6 %	29.4 %	0.089	0.501	0.810	0.452
	No	66.2 %	67.0 %	33.0 %				
4.Plant/animal-based products	Plant-based	67.2 %	68.0 %	32.0 %	0.092	0.189	0.116	0.302
	Animal-based	12.3 %	74.1 %	25.9 %				
	Both	20.4 %	65.3 %	34.7 %				
5.International export	Yes	64.8 %	68.6 %	31.4 %	0.879	0.138	0.053	0.184
	No	35.2 %	67.6 %	32.4 %				
6.Premium brand/ private label	Premium brand	12.5 %	68.8 %	31.3 %	**0.010**[e]	0.677	0.040 (No Bonferroni correct p-values <0.05)	0.583
	Private label	47.9 %	65.5 %	34.5 %				
	Both	39.6 %	71.3 %	28.7 %				
7.Place chain	Transformation	52.1 %	72.1 %	27.9 %	< **0.001**[f]	0.405	0.151	0.843
	Trans[m] & Distr[n]	47.9 %	64.0 %	36.0 %				
8.Number of FS trainings/year	1	67.2 %	67.7 %	32.3 %	< **0.001**[g]	0.075	**0.005**[g]	0.087
	2	2.6 %	83.3 %	16.7 %				
	>4	30.2 %	68.1 %	31.9 %				
9.Certificates	BRC	28.4 %	73.3 %	26.7 %	**0.029**[h]	0.247	0.163	0.217
	IFS	86.3 %	68.3 %	31.7 %	0.114	0.643	0.203	0.938
	SCS[o]	70.7 %	68.7 %	31.3 %	0.591	0.762	0.178	0.821
	FSSC22000	3.6 %	54.9 %	45.1 %	0.552	0.544	< **0.001**[i]	0.099
10.FSMS-DI[p]: Control activities	2	44.1 %	69.8 %	30.2 %	0.179	0.939	**0.036**[j]	0.643
	2_3/3	55.9 %	67.0 %	33.0 %				
11.FSMS-DI: Assurance activities	0/1/1_2	0.6 %	88.9 %	11.1 %	0.739	0.709	**0.008**[k]	0.311
	2	18.5 %	65.5 %	34.5 %				
	2_3/3	80.9 %	68.7 %	31.3 %				
	1/1_2	5.6 %	58.2 %	41.8 %	**0.019**[l]	0.284	0.136	0.303
12.Management interview	2	87.4 %	68.5 %	31.5 %				
	2_3/3	7.0 %	72.7 %	27.3 %				

[a] Perceptions of employees who work in a company with less than 20 employees are significantly higher than perceptions of employees who work in a company with 20–100 employees and than perceptions of employees who work in a company with more than 100 employees (p-values post hoc tests: 0.001, 0.000). Also, perceptions of employees who work in a company with 20–100 employees are significantly higher than perceptions of employees who work in a company with more than 100 employees (p-value post hoc test: 0.000).

[b] Perceptions of employees who work in a company with less than 20 employees are significantly higher than perceptions of employees who work in a company with more than 100 employees (p-value post hoc test:[b]0.023,[d]0.012).

[c] Perceptions of employees who work in a company with less than 20 employees are significantly higher than perceptions of employees who work in a company with 20–100 employees and than perceptions of employees who work in a company with more than 100 employees (p-values post hoc tests: 0.028 and 0.004).

[d] Perceptions of employees who work in a company that is not part of a larger group have significantly higher perceptions than employees who work in a company that is part of a larger group.

[e] Perceptions of employees who work in a company that produces both private label and premium brand products are significantly higher than perceptions of employees who work in a company that only produces private label products (p-value post hoc test: 0.017).

[f] Perceptions of employees who work in a company that only does transformation are significantly higher than perceptions of employees who work in a company that does both transformation and distribution activities.

[g] Perceptions of employees who work in a company that organizes two food safety trainings each year are significantly higher than perceptions of employees who work in a company that organizes 1 training and than employees in companies that organize more than 4 food safety trainings each year (p-values post hoc tests: h both 0.000, i 0.007, 0.003).

[h] Perceptions of employees who work in a company that has a BRC certificate are significantly higher than perceptions of employees in companies without a BRC certificate.

[i] Perceptions of employees who work in a company that has no FSSC22000 certificate are significantly higher than perceptions of employees in companies with a FSSC22000 certificate.

[j] Perceptions of employees in companies where the control activities are on a level of 2_3 or 3 are significantly higher than perceptions of employees in companies where the control activities are on a level of 2.

[k] Perceptions of employees in companies where the assurance activities are on a level of 2_3 or 3 are significantly higher than perceptions of employees in companies where the assurance activities are on a level of 2 (p-value post hoc test: 0.006).

[l] Perceptions of employees in companies where the overall mode of the management interview is 2_3 or 3 are significantly higher than perceptions of employees in companies where the overall mode of the management interview is 1 or 1_2 (p-value post hoc test: 0.020).

[m] 'Trans': transformation.

[n] 'Distr: distribution.

[o] 'SCS': self-checking system.

[p] 'FSMS-DI': food safety management system diagnostic instrument.

study as small (less than 20 employees) in the sample, only 1 had a gap in for the dimension resources while all five included big companies (>100 employees) had a gap for this dimension (i.e. the dimension was perceived on a low level by employees). It should be noted that in this study, the categorization small (<20 employees), medium (20–100 employees), large (>100 employees) was made based on the number of employees and based on the companies in the sample, to have a more homogenous distribution between groups so more solid conclusions (power of the statistical tests) on the effect of company size could be made. The European commission however defines companies with less than 10 employees as micro, companies with less than 50 employees as small and companies with less than 250 employees as medium [44]. These differences in categorization could also cause discrepancies between studies' results.

3.2.3. Belonging to a group of companies

The food safety climate dimensions are perceived significantly (p-value <0.001) higher by employees working in companies that are not part of a larger group (71.1 % of respondents work in a company that is part of a larger group, 28.9 % of respondents work in a company that is not) (for the analysis on the respondent level) [4]. however found that food safety climate is higher in companies with multiple sites compared to one-site companies. The research by Ref. [4] included a very different sample (136 managers, 1 per contributing company) compared to the current study, which could explain the differing results.

3.2.4. Private label or own company brand and position in the food chain

Food safety climate is higher in companies that produce both private label and premium brand (39.6 % of respondents) compared to companies that only produce private label products (47.9 % of respondents) (for the analysis on the respondent level, p-value: 0.010). This could be because private label offers retailers more control over production processes [45], which introduces additional food safety demands complementing the already implemented company-own requirements for the premium brand. Based on the position in the food production chain, food safety climate dimensions are perceived better in companies that only do transformation (52.1 % of respondents), compared to companies that do transformation as well as distribution (47.9 % of respondents, no companies doing only distribution activities were included in the sample) (for the analysis on the respondent level, p-value: <0.001) [3]. concluded that there are still many growth opportunities food safety wise for companies active in the food distribution sector.

3.2.5. Training

Food safety climate (p-value: <0.001) and human-individual dimensions (p-value: 0.005) are perceived higher in companies that provide two food safety trainings each year (2.6 % of respondents), compared to companies that give one (67.2 % of respondents) and four trainings (30.2 % of respondents) (for the analysis on the respondent level) [4]. also demonstrated that food safety climate was significantly higher in companies providing more than one training session per year compared to companies providing less training. The fact that perceptions are lower in companies in which 4 trainings are given, could be because of "overtraining". Overtraining, or giving employees too much training, could cause cognitive strain and potentially stress or burnout which can in turn influence perceptions [46].

3.2.6. Certification status

Respondents from companies that obtained a BRC certification (28.4 %) perceive the food safety climate dimensions on a higher level, compared to respondents in companies that do not hold BRC certification (for the analysis on the respondent level, p-value: 0.029). Employees in companies that have a FSSC22000 certification (3.6 % of respondents) have lower perceptions on the human-individual dimensions, compared to companies that do not hold FSSC22000 certification (for the analysis on the respondent level, p-value: <0.001). Here it should be noted that only one small company has FSSC22000 certification, which influences this analysis [22]. discovered that companies with FSSC 22000 or IFS certification demonstrated a higher food integrity work climate, which could be because of the difference in subject (food integrity climate vs. food safety climate) or the small sample size of the FSSC 22000 certificate in this study [4]. concluded that third party certification may influence FSMS maturity but not food safety climate. Certification schemes have been increasingly including FSC, making companies more aware, which could explain this evolution since [4].

3.2.7. Other characteristics

The maturity of the FSMS control activities has a significant influence on employees' perceptions: human-individual dimensions are perceived on a higher level in companies with more mature control/assurance activities (for the analysis on the respondent level, p-values: 0.036 and 0.008 respectively). This demonstrates a positive relationship between these two building blocks of the FSC conceptual model of [1] (FSMS and the human-individual building block). Lastly, the perceived maturity of 'adaptability', 'consistency', 'beliefs and values', and 'mission, vision, strategy' (assessed with the management interview) is also linked with climate: food safety climate is higher in companies with more mature perceptions in the management interview (p-value: 0.019).

3.2.8. Effect of employee characteristics

Significant differences in perceived FSC were discovered for all employee characteristics (Table 4), except for contract type. Food safety climate is significantly higher (p-value: 0.012) amongst leaders (30.8 % of respondents), compared to non-leaders (69.2 % of respondents) [5]. detected no significant difference in perceptions between management and operators, while [8] also found that managers generate higher FSC scores [21]. further confirmed this by reporting a misalignment of management's and employees' perceptions. Human-individual dimensions are perceived significantly higher (p-value: <0.001) by employees who are in daily direct contact with food (65.4 % of respondents) compared to those who are not (34.6 % of respondents). During data collection for the current study, employees not in direct contact with food often deemed food safety as not relevant for them, which could explain the lower scores for the human-individual building block containing of dimensions like food safety participation, knowledge and motivation. However, having food safety as a shared responsibility of all employees is essential for a mature FSC [47]. [22] detected no significant difference in food integrity behavior between operators who are and who are not in daily contact with food, which could again be because of the difference in topic (food integrity versus food safety) or because of the fact that [22] only compared operators while in this study all employees were included in this comparison. Next, human-individual dimensions are perceived better by senior employees (p-value: 0.002). In the research by Ref. [41], food safety climate was generally lowest after 1–3 years of employment, compared to less and more senior employees [7]. found that the perceptions of new employees are higher than perceptions of senior employees. This differences could be because of the very different sample: the food industry versus health care and schools. Furthermore, food safety climate and human-individual dimensions are perceived lower (p-values are both <0.001) by employees who received food safety training more than 1 year ago, compared to employees who received a training less than three months ago and between 3 and 12 months ago. This confirms, as reported in section 3.2.5., that giving only 1 or less than 1 training a year lowers FSC perceptions. Lastly, food safety climate and human-individual dimensions are both perceived better by employees who experience lower levels of stress and burnout (p-values: 0.000 and < 0.001) [18]. could not confirm a moderation effect of jobstress and burnout in the relationship between food safety climate and food safety behavior [48]. could also not confirm any moderating effect. This could indicate that psychosocial well-being does not per se have any effect on the relationship between climate and behavior but does influence individual perceptions of both.

Table 4
Characterization of clusters based on food safety climate and the perceived maturity of the human-individual dimensions (n = 1410 respondents), in view of employee characteristics and % of respondents in these clusters. Cluster 1 contains those respondents that have the highest perceptions while cluster 2 contains all other respondents (perception of either the food safety climate or the human-individual dimensions, or both, on a relatively low level). *P*-values of the statistical analysis are displayed in bold when they are lower than the significance level of 5 %.

Employee Characteristic	Categories	Total Sample	Cluster 1	Cluster 2	*P*-value Mann-Whitney U/ Kruskal-Wallis test FS climate	*P*-value Mann-Whitney U/ Kruskal-Wallis test human-individual
1.Leadership position	Yes	30.8 %	74.4 %	25.6 %	**0.012**[a]	0.075
	No	69.2 %	65.5 %	34.5 %		
2.Daily direct contact food	Yes	65.4 %	71.1 %	28.9 %	0.451	< **0.001**[b]
	No	34.6 %	62.7 %	37.3 %		
3.Type of contract	Open-ended	89.2 %	68.5 %	31.5 %	0.831	0.696
	Fixed term	10.8 %	65.8 %	34.2 %		
4.Seniority	<2 years	19.3 %	66.2 %	33.8 %	0.061	**0.002**[c]
	2–5 years	22.3 %	70.2 %	29.8 %		
	>5 years	58.4 %	64.8 %	35.2 %		
5.Time since FS training	<3 months ago	24.4 %	75.9 %	24.1 %	< **0.001**[d]	< **0.001**[d]
	3–12 months ago	32.3 %	76.0 %	24.0 %		
	>1 year ago	43.3 %	58.1 %	41.9 %		
6.Psychosocial well-being (lower score = better well-being)	5.0 < mean ≤ 7.0	3.8 %	44.4 %	55.6 %	**0.000**[e]	< **0.001**[f]
	3.0 ≤ mean ≤ 5.0	42.2 %	58.0 %	42.0 %		
	1.0 ≤ mean < 3.0	54.0 %	77.9 %	22.1 %		

[a] Perceptions of leaders are significantly higher than perceptions of non-leaders.
[b] Perceptions of employees in direct contact with food are significantly higher than perceptions of employees not in daily direct contact with food.
[c] Perceptions of employees with more than 5 years seniority are significantly higher than perceptions of employees with less than 2 years seniority and than perceptions of employees with 2–5 years' experience (p-values post hoc test: 0.016, 0.014).
[d] Perceptions of employees who received a food safety training more than 1 year ago, are significantly lower than perceptions of employees who received a training less than three months ago and between 3 and 12 months ago (p-values post hoc tests are both 0.000).
[e] Perceptions of employees with 1.0 ≤ mean < 3 of self-reported psychosocial well-being are significantly higher than perceptions of employees of both other groups (p-values post hoc tests are both 0.000).
[f] Perceptions of employees with 1.0 ≤ mean < 3 of self-reported psychosocial well-being are significantly higher than perceptions of employees with 3.0 ≤ mean ≤ 5.0 of self-reported psychosocial well-being (p-value post hoc tests is 0.000).

4. Conclusions and perspectives for future research

A big maturity range of perceived food safety culture maturity was identified in the participating food businesses. The currently implemented food safety management systems are not yet at the tailored and fit-for-purpose level, but are elaborated more generically. This was surprising because of the European hygiene legislation endorsed for some decades and high frequency of certification in the Belgian food industries. In the human-organizational building block, the dimensions 'adaptability', 'consistency', 'beliefs and values' and 'mission, vision, strategy' were generally still relatively underdeveloped. The indicator 'reward expectancy' scored very low, as companies made clear they do not have any systems to recognize good food safety behavior. In contrast to the food safety management system and the human-organizational building block, the human-individual building block was very mature in the sample. The cluster analysis combined with non-parametric tests revealed patterns in the data and significant differences in food safety culture maturity based on company and employee characteristics, revealing groups of companies and subgroups within companies with lower perceptions and therefore lower food safety culture maturity.

A future research perspective could be to include a measure of assessing biases in the data collection. No assessment of the social desirability bias or optimistic bias was done in this study, which could be considered a study limitation [49]. developed a self-assessment survey allowing to assess social desirability. Another interesting addition would be to further delineate certain included characteristics, for example the employee characteristic of occupying a leadership position. In this study the separation leaders and non-leaders was made, but this could be specified further, for example: non-leaders, team leaders, operational leaders, management. A last suggestion for future research is to combine data from this paper with previous work by other researchers and to preform a multidisciplinary reanalysis study to integrate data collected and solidify findings. For this objective other statistical techniques could be applied like a multilevel analysis.

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Data availability statement

Data will be made available on request.

Ethics statement

The research is in full accordance with the ethical standards of the institutional research committee. All participants provided informed consent to participate in the study. All participants provided informed consent for the publication of their companies' fully anonymized results. Review and/or approval by an ethics committee was not needed for this study because the research does not meet any situation in which an application to an ethics committee is necessary.

Ethical statement

In this statement we declare that the study was conducted in accordance with the ethical standards of first authors' institutional research committee and with the 1964 Helsinki declaration and its later amendments. All appropriate protocols for protecting the rights and privacy of all participants were utilized during the execution of the research, e.g. no coercion to participate, full disclosure of study requirements and risks, written and verbal consent of participants, no release of participant data without their knowledge, ability to withdraw from the study at any time. All participant were fully informed why the research was being conducted and how their data would be used. Written informed consent was obtained from all participant as the first page of the questionnaire, (also in appendix to the manuscript) following university guidelines, stating:

I declare that.

- My participation is completely voluntary and that I know that I can stop my participation at any given moment;
- I give permission to anonymously use the collected results, also for other researchers;
- I am aware that not participating or stopping my participation will never cause negative consequences for me;
- I know that I can get a summary of the study on request after the study has been completed and the results are all collected;

An affirmative reply was required to enter the research. All participants remained fully anonymous throughout the entire research and after. They were able to withdraw from the survey at any time without giving a reason. No personal data (e.g. gender, age) was collected. No vulnerable populations were part of this research. Because of this no ethical approval was required by national laws and institutional guidelines.

CRediT authorship contribution statement

Pauline Spagnoli: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration,

Visualization, Writing – original draft, Writing – review & editing. **Peter Vlerick:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing. **Liesbeth Jacxsens:** Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e21561.

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