Contribution to a Mixed Assessment of Patient Safety Culture

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Abstract

Purpose: The evaluation of patient safety culture is conducted using quantitative methods based on the use of questionnaires and qualitative ones focused on the deployment of cultural maturity models. These methods are known to suffer from certain major limits. This article aims to overcome the difficulties encountered by both methods and to propose a novel approach to the assessment of PSC.

Methodology: The approach proposed in this article consists of applying a combined method, based on Principal Component Analysis (PCA) and K-means algorithm, to group together PSC dimensions into macro-dimensions whose exploitation allows to overcome the difficulties encountered with dimensional analysis of PSC and then, serve as a basic support for the development of a patient safety culture maturity model.

Findings: The results of the combined method PCA / k-means shows that PSC dimensions can be grouped into three macro-dimensions that were capitalized in a first place using factors related to the development of PSC and in a second place to develop a quantitative maturity matrix that helped in the identification of PSC maturity levels.

Originality: The merit of our proposal is to work towards a quali-quantitative evaluation of safety culture recommended by a good number of researchers but, to our knowledge, few or no studies are devoted to this hybrid or systematic evaluation of safety culture. Thus, the results can also be projected to implicate PSC actors and to frame the evaluation of PSC maturity by international standards.

1. Introduction

Safety culture (SC) is a recent concept that has been widely used in various high-risk industries to address safety issues due to organizational deficiencies (1). It first appeared after the Chernobyl nuclear accident in 1986 and has since attracted the attention of the scientific community in various sectors (2). However, it is not until recently that this concept has shifted to the healthcare sector, where a positive patient safety culture (PSC) is linked to a decrease in the number of adverse events and, therefore, an improvement in the quality and safety of care (3, 4).

Given its importance, the assessment of PSC has become a major priority for healthcare organizations (5). Thus, three main approaches have been developed and proposed to understand the underlying values that affect the behavior of healthcare professionals in terms of patient safety (6):

- The analytical (psychological) approach, currently predominant, evaluates PSC quantitatively through self-administered questionnaires;
- The sociological approach, where PSC is qualitatively assessed during medical meetings, such as multidisciplinary consultation meetings or feedback cells;
- The socio-anthropological approach, the least frequently used approach, is based on an association approach is the richest in terms of information collected.
From these three approaches arise two main methods (i.e. quantitative & qualitative), which allow an in-depth study of PSC. In this context, Halligan and Zecevic (7) found in a review of 139 studies carried out in the healthcare sector that 126 of them used quantitative methods to assess PSC versus only 13 studies where qualitative methods were used under the form of PSC maturity models.

As far as quantitative methods are concerned, it should be noted that questionnaires occupy a place of choice; because, they make it possible to define the complex concept of PSC in a set of dimensions that can be quantified in mean scores. A dimension is said to be developed (D) if it had a score of 75% or more, on the other hand if the dimension had a score less than or equal to 50%, it is qualified as non-developed (ND). Finally, the dimensions with scores between 50% and 75% are considered to be underdeveloped (UD) (5).

This type of dimensional evaluation of PSC through questionnaires is favored by managers; because, it makes it possible to describe the current state of PSC while identifying the problematic PSC dimensions in order to establish action plans to improve them (8). This choice to use questionnaires can be explained by their feasibility and their capacity to collect a maximum of information in a minimum of time and with the least possible effort, and also the guarantee of the respondents’ anonymity (9).

Despite the widespread use of questionnaires, many authors point out that the quantitative method using questionnaires suffer from certain limitations (10):

- The focus attributed to the measure of individual attitudes and practices in a given context and at a given time;
- The number of dimensions varies from one questionnaire to another as well as their names, which makes comparative studies inappropriate;
- Action plans are established according to each problematic dimension; which will cause a possible loss of efforts;
- The calculation of scores by PSC dimension does not allow representing its overall level. In other words, there is a problem of aggregating dimensional scores to be able to assess the overall PSC level.

As for qualitative methods supported by cultural maturity models, they offer the advantage of classifying organizations using a scale of typologies ranging from pathological organizations (Non-existent PSC) to generative organizations (Continuous improvement of PSC) while passing by intermediate levels where organizations act reactively or proactively towards PSC (11).

PSC Maturity Models (PSCMM) can be used as tools for improving PSC by identifying weaknesses and proposing action plans to improve the organization's PSC and therefore advance its position in the cultural scale (11). However, the qualitative methods associated with them suffer from several limitations (12):
• The use of tools (e.g. interviews, audits, observations, etc.) to establish the current level of maturity requires too much time;
• The final results of the evaluation depend on the evaluators' judgments, thus making them subjective;
• The maturity models of PSC highlight the progressivity of its promotion but without providing explanations on the progress, making it possible to concretize this gradual evolution;
• The maturity levels of PSC differ from one model to another, which poses a problem of PSC levels similarity.

Despite the respective limits of quantitative methods, on the one hand, and qualitative methods, on the other hand, the current trend is to use quantitative methods separately from qualitative methods. This article aims to solve this problem by proposing a mixed and systematic evaluation of PSC as recommended in order to have reliable findings in regards of PSC (6).

Indeed, the aim of merging quantitative and qualitative methods in a single PSC evaluation is twofold. First, it allows overcoming the constraints posed by the dimensional evaluation of PSC using questionnaires (quantitative methods) by proposing an aggregation of these dimensions into macro-dimensions. Secondly, the macro-dimensions are capitalized to propose an objective PSCMM.

The rest of this article is organized into four sections. In Sect. 2, the proposed mixed assessment method of PSC (MAM-PSC) is described. The results of applying this method and their discussions are presented in Sect. 3 and 4. Finally, in the conclusion (Sect. 5), the multiple contributions of the suggested method are recalled as well as the possible prospects for its future promotion.

2. Method

The recommended MAM-PSC (Fig. 1) consists of a hybrid PSC assessment (i.e. quantitative & qualitative). Consequently, the first step is based on a quantitative PSC evaluation using questionnaires. In this regard, Halligan and Zecevic (7) identified the most cited questionnaires in the healthcare sector that are the, Hospital Survey On Patient Safety Culture (10 dimensions of PSC), Patient Safety Culture in Healthcare Organizations Survey (9 dimensions of PSC), Safety Attitudes Questionnaire (6 dimensions of PSC) and Modified Stanford Patient Safety Culture Survey Instrument (5 dimensions of PSC). The author confirms that the greater the number of dimensions, the better that PSC is framed.

Consequently, the HSOPSC questionnaire is by far the most used in the evaluation of PSC (5, 8, 13). However, the more dimensions of PSC the more difficult it is to have an idea of PSC overall level in an organization. Hence the research hypothesis that we propose for a quantitative evaluation of PSC: “The more the dimensions of PSC are, the more there is a need to aggregate them into macro-dimensions in order to be able to assess the overall level of PSC”.

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This hypothesis push us, therefore, to retain the questionnaire entitled "Hospital Survey On Patient Safety Culture -HSOPSC-" that was developed in 2004 under the supervision of the American Agency of Healthcare Research (14), where it has already been tested and validated. Then, it was translated, tested and validated by the Coordination Committee for Clinical Evaluation and Quality in Aquitaine-France (15).

In its French version, this questionnaire is organized in two Sect. (8): the first section, relating to general information, is composed of five questions while the second section makes it possible to explore the perceptions of staff regarding PSC in their work unit. This second section consists of 38 questions arranged in ten dimensions: (Dim 1) Overall perceptions of patient safety; (Dim 2) Frequency of reporting adverse events; (Dim 3) Supervisor/manager expectations and actions promoting safety; (Dim 4) Organizational learning-continuous improvement; (Dim 5) Teamwork within units; (Dim 6) Communication openness; (Dim 7) Non-punitive response to error; (Dim 8) Staffing; (Dim 9) Management support for patient safety; (Dim 10) Teamwork across hospital units.

**Figure 1 near here**

The application of Principal Component Analysis (PCA) in step 1 (Figure. 1) aims to visualize the dimensions of PSC in a space formed by a minimum of principal components, which are generally in number of two main components. They help to keep as much as possible the linear links between the said dimensions and consequently to identify the potential grouping of the dimensions (16).

As a reminder, PCA is one of the most used methods to reduce the dimensionality of data while retaining important information (17–19). It identifies the similarities between individuals. These similarities are explained by the notion of linear link or correlation coefficient between the variables. Then, these variables are combined into a smaller set of uncorrelated artificial variables called principal components (20). This combination is defined so that the first principal component represents the greatest possible variability.

To illustrate our point, we assume the existence of $m$ variables (Dimension scores) and $n$ individuals (PSC dimensions) and consider the data matrix $n \times m$: $D = (d_1, d_2, ..., d_m)$ where each line represents the values of each variable for each dimension.

The process of applying PCA can be summarized according to the following steps (21):

- Preparation of data matrix;
- Calculation of the correlation matrix;
- Calculation of eigenvalues and eigenvectors;
- Calculation of PSC dimensions' coordinates;
- Representation of PSC dimensions in the space $(F1, F2)$.

To ensure the statistical validity of the results, the sample must be relatively large. However, a ratio of ten
The second step (Fig. 1) concerns the validation of clustering PSC dimensions into distinct groups called macro-dimensions. Clustering Analysis provides a better understanding of data by dividing individuals into Clusters, so that individuals of a group are more similar than individuals in other groups (23).

The K-means algorithm is one of the most well-known group analysis techniques (24, 25). It is an unsupervised classification algorithm, which attempts to find from \( n \) individuals, \( K \) non-overlapping groups. These groups are represented by their prototypes or also known as centroids (24). As a reminder, a centroid of a group is usually the average of points in this group.

The K-means algorithm can be expressed by an objective function, which depends on the proximities of data points to the centroid of the group, as follows:

\[
\min_{\{m_k\}, 1 < k < K} \sum_{k=1}^{K} \sum_{x \in c_k} \pi_x \text{dist}(x, m_k) < / > \text{cript} >
\]

Where: \( \pi_x \) is the weight of \( x \), \( n_k \) is the number of variables assigned to the group \( C_k \), \( K \) is the number of clusters defined by the user, and the function "dist" calculates the distance between the individual \( x \) and the centroid \( m_k \).

In Eq. (1), \( m_k \) is expressed by:

\[
m_k = \sum_{x \in c_k} \frac{\pi_x x}{n_k}
\]

It is not uncommon for PCA to be used to project individuals into a smaller subspace and then apply the K-means algorithm in that subspace (25, 26). Therefore, the K-means algorithm follows the following steps:

- Preparation of the data provided by the PCA in matrix form;
- Random Choosing of initial centroids;
- Assign individuals to the nearest centroid;
- Re-calculating the center of each group and modifying the centroids;
- Iteration until convergence.

The final results of the K-means algorithm make it possible to define the number \( K \) of groups of individuals \( G = \{G_1, G_2, ..., G_k\} \).
These groups are capitalized later in step 3 (cf. Figure 1) to define PSC dimension groups where the dimensions of each group share the same properties. The purpose of this group is to guide the hospitals in their action plans for the improvement of PSC by linking each group with action factors.

It should be noted that depending on the groups obtained from the PCA / K-means approach, the score for each group of dimensions is calculated according to the following formula:

\[
S_{G_i} = \frac{\sum_{i=1}^{n} S_{D_i}}{N}
\]

With: \( S_{G_i} \) being the overall score of the \( i \)th group, \( S_{D_i} \) is the score of the \( i \)th dimension of PSC belonging to the \( i \)th group and \( N \) the number of the dimensions of the \( i \)th group.

Macro-dimensional (groups) scores vary, as for PSC dimensions, on a scale ranging from "non-developed" to "developed". Therefore, it is now possible to identify the group of dimensions, also called problematic macro-dimension (score < 50%), which requires priority improvement actions.

In order to consolidate the achievements of quantitative evaluation in the form of macro-dimensions (step 4), it is possible to establish a maturity model of PSC, the levels of which are the results of the combination of PSC macro-dimensions.

Figure 2 near here

As a reminder, the three possible levels of the macro-dimensions are ND, UD and D. The levels “ND and UD”, on the one hand, and “UD and D”, on the other hand are considered to be neighboring levels while the levels "ND and D" are considered non-neighboring.

Furthermore, it should be noted that the levels of the matrix (Figure.2) were obtained by retaining the level of:

- The most penalizing in the case of a combination of two neighboring levels. This is the case for the level ‘ND’ which results from the combination of levels ‘ND & UD’ or the level ‘UD’ which results from the combination of levels ‘UD & D’;
- Intermediate in the case of a combination of two non-neighboring levels. This is the case of the "UD" level, which results from the combination of the "ND & D" levels.

The interest of aggregating PSC levels in a matrix is that it goes in the direction of promoting PSC, on the one hand, and respects the symmetry of PSC matrix (i.e. It is square), on the other hand. Likewise, the quantitative analysis of the matrix quantifies the three levels of PSC from the scores associated with the levels of macro-dimensions \((0 < \text{ND} < 0.5; 0.5 \leq \text{UD} < 75 & 0.75 \leq \text{D} \leq 1)\).
Indeed, if one is interested in the zoning of the matrix (Fig. 2) it is possible to calculate the areas of the zones associated with the levels of this grid: \( S_{\text{ND}} = \frac{3}{9} \); \( S_{\text{UD}} = \frac{5}{9} \) & \( S_{\text{D}} = \frac{1}{9} \). The normalization of these surface scores on a scale \([0–1]\) makes it possible to obtain quantitative scores for the maturity levels in the PSC matrix: \( 0 < S_{\text{ND}} \leq 0.33; 0.33 < S_{\text{UD}} \leq 0.89 \) & \( 0.89 < S_{\text{D}} \leq 1 \).

3. Results

Recall that the condition of using the MAM-CSS method requires the evaluation of PSC in a set of hospitals. In this regard and to illustrate the use of this method, we consider ten hospitals whose PSC has been evaluated using the HSOPSC questionnaire.

The responses from the dissemination of the questionnaire on professionals in the studied establishments made it possible to obtain the results provided in Table 1 where the dimensions of PSC (\( \text{Dim} \)) are considered as individuals and their scores in the ten hospital establishments (\( \text{HE} \)) are variables.

|          | \( \text{HE} 1 \) | \( \text{HE} 2 \) | \( \text{HE} 3 \) | \( \text{HE} 4 \) | \( \text{HE} 5 \) | \( \text{HE} 6 \) | \( \text{HE} 7 \) | \( \text{HE} 8 \) | \( \text{HE} 9 \) | \( \text{HE} 10 \) |
|----------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| \( \text{Dim 1} \) | 50,3             | 76,3             | 65,9             | 56               | 51,4             | 70,1             | 42,2             | 50,6             | 33,2             | 71,4             |
| \( \text{Dim 2} \) | 57,4             | 56,1             | 44,8             | 62,5             | 62               | 60,8             | 52,1             | 48,4             | 28,3             | 66,7             |
| \( \text{Dim 3} \) | 63,9             | 66,4             | 48,7             | 66,8             | 50,7             | 63,7             | 59,5             | 50               | 31,3             | 57,1             |
| \( \text{Dim 4} \) | 70,9             | 68,1             | 54,1             | 70,2             | 58,9             | 66,3             | 65,1             | 57,7             | 36,1             | 68,6             |
| \( \text{Dim 5} \) | 74,8             | 78,5             | 69,4             | 78,4             | 68,1             | 76,5             | 70,4             | 64               | 48,6             | 76,8             |
| \( \text{Dim 6} \) | 66,1             | 24,3             | 28,7             | 55,8             | 47,2             | 33,7             | 55,9             | 41,1             | 23,2             | 40,5             |
| \( \text{Dim 7} \) | 41,6             | 27,2             | 35,1             | 30,8             | 28,7             | 31,7             | 39,5             | 34,1             | 14,9             | 35,7             |
| \( \text{Dim 8} \) | 38,7             | 14,3             | 24,7             | 42,9             | 40,7             | 20,9             | 29,9             | 26               | 14,1             | 26,2             |
| \( \text{Dim 9} \) | 32,2             | 57,9             | 53,4             | 33,7             | 37               | 63,1             | 33,7             | 38,8             | 27,2             | 52,4             |
| \( \text{Dim 10} \) | 37,7             | 77,3             | 50,9             | 38,1             | 41,2             | 76,6             | 44,1             | 42,1             | 35               | 44               |

Recall that the responses on the survey from hospital professionals are recorded on a 5-point scale ranging from (5) strongly agreeing to (1) strongly disagreeing. Scores 4 and 5 are considered "positive" in relation to SC, score 3 is "neutral" and scores 1 and 2 are considered "negative" in relation to SC. The dimensional score is obtained by dividing the total number of positive answers to questions in this dimension by the total of the answers to these questions:
With: $S_{Dj}$ being the score of the $i^{th}$ dimension of SC, $np_j$ is the number of positive responses for this $i^{th}$ dimension and $N_j$ is the total number of responses for this $i^{th}$ dimension including positive, negative and neutral responses.

Table 1 near here

### 3.1. Application of PCA & K-Means

The use of PCA begins with the calculation of the correlation matrix where Table 2 shows that the variables are positively correlated with each other (correlation coefficient varies from 0 to 1). The majority of variables are highly correlated (correlation coefficient > 0.5) with the exception of two cases (‘EH 1 and EH 2’ = 0.276; ‘EH1 and EH 3’ = 0.293).

|      | HE 1 | HE 2 | HE 3 | HE 4 | HE 5 | HE 6 | HE 7 | HE 8 | HE 9 | HE 10 |
|------|------|------|------|------|------|------|------|------|------|-------|
| HE 1 | 1    |      |      |      |      |      |      |      |      |       |
| HE 2 | 0.276| 1    |      |      |      |      |      |      |      |       |
| HE 3 | 0.293| 0.928| 1    |      |      |      |      |      |      |       |
| HE 4 | 0.931| 0.454| 0.462| 1    |      |      |      |      |      |       |
| HE 5 | 0.812| 0.538| 0.543| 0.941| 1    |      |      |      |      |       |
| HE 6 | 0.261| 0.991| 0.909| 0.432| 0.541| 1    |      |      |      |       |
| HE 7 | 0.947| 0.469| 0.431| 0.884| 0.793| 0.469| 1    |      |      |       |
| HE 8 | 0.785| 0.788| 0.806| 0.847| 0.848| 0.777| 0.868| 1    |      |       |
| HE 9 | 0.570| 0.889| 0.876| 0.691| 0.752| 0.893| 0.722| 0.914| 1    |       |
| HE 10| 0.605| 0.810| 0.870| 0.747| 0.816| 0.802| 0.659| 0.930| 0.837| 1     |

Table 2 near here

The calculation of eigenvalues and eigenvectors will help identify the two principal components that will be used to represent the data with maximum retention of the initial information. The analysis in Table 3 shows that the eigenvalue of F1 is equal to 7.528 and the total variability is preserved at 75.3% if we represent the variables on the F1 axis. For the F2 axis, we find that the eigenvalue is equal to 1.862 and the total variability is preserved at 18.6%. For the other axes F3, F4, F5, F6, F7, F8, F9 the variability is preserved at 6.1%. Therefore, the first two principal components are used for the rest of the application given that the variability is preserved at 93.8%.
Table 3  
The eigenvalues obtained by PCA.

|          | F1   | F2   | F3   | F4   | F5   | F6   | F7   | F8   | F9   |
|----------|------|------|------|------|------|------|------|------|------|
| Eigenv    | 7,528| 1,862| 0,301| 0,167| 0,085| 0,046| 0,006| 0,005| 0,001|
| Variability (%) | 75,279| 18,620| 3,009| 1,668| 0,849| 0,460| 0,061| 0,048| 0,006|
| % accrued | 75,279| 93,899| 96,908| 98,576| 99,425| 99,885| 99,946| 99,994| 100,000|

Table 3 near here

After having calculated the coordinates of the dimensions with respect to F1 and F2 and since the groups cannot be identified, therefore, a recourse to a grouping algorithm is therefore necessary, in particular the K-Means algorithm.

Indeed, the application of the K-means algorithm on the subspace defined by the PCA makes it possible to identify PSC macro-dimensions where their dimensions share the same properties. The most representative number of groups (K = 3) for this sample was deduced from within-class variances and by repeating the process several times considering that it is an unsupervised clustering technique (Fig. 3).

Figure 3 near here

3.2. Capitalization of the macro-dimensions obtained and deduction of the PSC maturity levels

The results of the combined method PCA / K-means shows that PSC dimensions can be grouped into three groups that can be qualified as macro-dimensions. These three macro-dimensions are named according to the common characteristics of the dimensions that compose them; MD<sub>1</sub> = Hospital level dimensions= {Dim<sub>1</sub>; Dim<sub>9</sub>; Dim<sub>10</sub>}; MD<sub>2</sub> = Unit level dimensions= {Dim<sub>2</sub>; Dim<sub>3</sub>; Dim<sub>4</sub>; Dim<sub>5</sub>}; MD<sub>3</sub> = Outcome dimensions = {Dim<sub>6</sub>; Dim<sub>7</sub>; Dim<sub>8</sub>}.  

Hence the first merit of MAM-PSC method which allows to highlight an action plan allowing the development of PSC macro-dimensions or so-called problematic ones for patient safety (scores in bold in Table 4). The second merit is that the three macro-dimensions contribute to deducing PSC maturity levels of the ten hospitals studied (Table 4).
Table 4
Macro-dimensional scores as well as PSC maturity levels of the hospitals studied.

| MD 1 | HE 1 | HE 2 | HE 3 | HE 4 | HE 5 | HE 6 | HE 7 | HE 8 | HE 9 | HE 10 |
|------|------|------|------|------|------|------|------|------|------|-------|
| MD 2 | 40, 1 | 70,5 | 56, 7 | 42, 6 | 43, 2 | 69,9 | 40   | 43,8 | 31, 8 | 55, 9 |
| MD 3 | 66, 8 | 67,3 | 54, 3 | 69, 5 | 59, 9 | 66,8 | 61, 8 | 55   | 36, 1 | 67, 3 |
| Maturation level | UD | UD | UD | UD | UD | UD | UD | UD | ND | UD |
| Non-developed PSC | Under-developed PSC | Developed |
| Bureaucratic | Integrat ed |
| Fat alistic | Sho p Flo or |

Table 4 near here

4. Discussion

A first comment relating to the scores of the macro-dimensions obtained (Table 4) is that the level of PSC is non-developed in HE9. Hence the obligation to review the policy of patient safety in a categorical manner in this establishment. Another observation is that the macro-dimension MD3 is qualified as problematic for 40% of the hospitals. In other words, the management style is the major obstacle to PSC development within the studied institutions.

Finally, no establishment has reached a level of maturity qualified as developed. This prompts the managers of these establishments to urgently implement an action plan essentially focused on: (i) facilitating PSC development (i.e. commitment of top management to improve PSC as well as the strengthening of communication and the information flow) and (ii) strengthening PSC through rewards.
and punishments consistent with behaviors at work. In the latter case, it is important to guide PSC promotion measures by improving the physical environment and working conditions, adjusting working hours and recognizing individual initiatives.

A second comment relating to the matrix (Fig. 2) is that the maturity levels are deduced from the scores obtained on the macro-dimensions. Hence the quali-quantitative evaluation of PSC. In addition, the advantage of presenting the levels in the form of a grid is that it indicates, from a PSC level, the possibilities offered to reach the highest level (developed). In other words, the PSC maturity matrix constitutes a real decision-making tool for PSC promotion within hospitals by acting in an optimized manner on the problematic macro-dimensions.

Another advantage of presenting PSC maturity levels in the form of a grid is that this form of presentation makes it possible to deduce another form of PSC maturity matrix (Figure. 4) known as the “Simard model” (27).

This “macro-dimensions / actors” association makes it possible to deduce other levels of PSC maturity which are four in number: fatalistic, managerial, shop floor and integrated. These four levels can be quantified directly from the macro-dimensions scores: $0.33 < W_{I_w} \leq 0.89$ ; $0.33 < W_{I_M} \leq 0.89$ ; $0.89 < S_{I_w} \leq 1$ ; $0.89 < S_{I_M} \leq 1$.

It is important to remember that the model of Simard (27) is the same as that of DuPont™ (28) where only the callings of maturity levels that change: Fatalistic = Reactive; Shop Floor = Independent; Bureaucratic = Dependent and Integrated = Interdependent. In other words, the merit of the MAM-PSC method is that it provides the possibility of quantifying the PSC maturity levels of two different maturity models.

5. Conclusion

The purpose of the MAM-PSC is twofold: to solve the problems of aggregating the dimensions of PSC and to provide a framework for a quantitative deduction of its maturity levels. Thus and for what is related to the aggregation of PSC dimensions in macro-dimensions, the proposed approach is based on the combined use of ACP / K-Means methods, which allowed to group the PSC dimensions into macro-dimensions from the results of the processing of HSOPSC questionnaires. The merit of this first contribution is the evaluation of PSC using the three macro-dimensions. As a result, the dimensional evaluation problems of PSC will no longer be faced.

The second contribution presented in this article is the use of macro-dimensional scores obtained for the quantitative assessment of PSC maturity levels where a PSC maturity matrix is designed. The merit of this matrix is that it serves as a decision-making tool for promoting PSC. Likewise, the contributions of the designed matrix are multiple. For example, the possibility of including in all the levels of maturity mentioned by many authors (27–30). Another contribution of the presentation of PSC maturity model in
the form of a matrix is that we project as a perspective for this study, to frame the evaluation of PSC maturity by the ISO 45001 standard and more particularly by the use of the “Relevant of PSC levels / Opportunities” and “Power / Influences of Stakeholders” grids. Indeed, and in addition to internal stakeholders (managers and workers), it is appropriate to integrate external stakeholders in the evaluation of PSC (public authorities, patients, customers and suppliers, etc.)

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Conflicts of interest/Competing interests

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Figures

Figure 1

Steps of the proposed MAM-PSC method.
Figure 1

Steps of the proposed MAM-PSC method.

Figure 2

Proposed PSC matrix.
Figure 3
Visualization of macro-dimensions issued from the k-means algorithm.

Figure 4
PSC Maturity model of adapted from (Daniellou, Simard and Boissières, 2010).
Figure 4

PSC Maturity model of adapted from (Daniellou, Simard and Boissières, 2010).