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Unfolding Analysis of Work Conditions Affecting Employees' Health According to their Positions in the Area of Solid Waste

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ABSTRACT

Due to the peculiarities of the tasks performed, the area of Municipal Solid Waste (MSW) has a long tradition in implementing risk prevention plans. But are these plans equally received by workers involved in the production chain? This research explores the concerns and worries of MSW sector employees in the Southern Spanish region of Andalusia; it deals with aspects of their work that may affect their health and that can be directly related to the plans and programs designed for the prevention of occupational hazards applied by their companies. The study is conducted through the multivariate statistical unfolding model and the graphic sets it generates. Perceptual maps are analyzed from a representative sample of household MSW workers doing business in Andalusia. The variables studied correspond to 18 work-related issues that can affect their health, such as lighting, body posture and positioning, physical exertion, noise and exposure to toxic substances. The aim is to create a map with all these aspects and employees' positions held in the company so that, through their interpretation, differences in perceptions on issues related to safety at work can be identified depending on their jobs. The study carried out demonstrates that both senior and middle managers are highly concerned and involved in prevention plans. The biggest concern of the administration are work schedules and the noise in the place they work. Operators, on the other hand, are more concerned about aspects of their work related to the design of their tasks, such as timing, rhythm, monotony and relationships with peers and managers and, less so, with the danger involved in the tasks they often perform. This kind of information enables the various industry players to know the aspects of health and occupational risks that concern different groups operating in the sector, so as to identify needs for action and the necessary corrective and informative measures in the field of prevention of occupational hazards.

Keywords: unfolding; risk prevention; solid waste industry.
JEL Classification: C12; Q53; J81.
MSC2010: 62H15; 62P20; 91B76.

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Análisis unfolding de las condiciones de trabajo que afectan la salud de los empleados según sus puestos en el área de residuos sólidos

RESUMEN

A causa de las peculiaridades de las tareas realizadas, el área de residuos sólidos municipales (RSM) tiene una larga tradición en la implementación de planes de prevención de riesgo. Pero ¿son estos planes igualmente recibidos por los empleados trabajando en la cadena de producción? Esta investigación explora las preocupaciones y ansiedades de los empleados de este sector en Andalucía; se tratan aspectos del trabajo realizado por estos empleados que pueden afectar a su salud y que están relacionados directamente con los planes y programas diseñados por las compañías para prevenir riesgos ocupacionales. El estudio emplea el modelo estadístico multivariable de unfolding y los conjuntos gráficos que éste genera. Se analizan los mapas de percepción a partir de una muestra representativa de trabajadores de RSM que trabajan en Andalucía. Las variables estudiadas corresponden a 18 puntos relacionados con el trabajo realizado y que podrían afectar a la salud, como iluminación, postura y posición corporal, esfuerzo físico o ruido y exposición a sustancias tóxicas. Se pretende crear un mapa con todos estos aspectos y los puestos ocupados por los empleados en la compañía; a partir de su interpretación, quieren identificarse diferencias en las percepciones sobre estos puntos relativos a seguridad en el trabajo según el puesto ocupado. El estudio muestra que tanto los directivos superiores como intermedios están sumamente preocupados e involucrados en los planes de prevención. La principal preocupación de la administración recae en los horarios de trabajo y el ruido en los puestos. Por su parte, los operarios se preocupan más por aspectos relacionados con el diseño de sus tareas (temporización, ritmo, monotonía y relaciones con compañeros y directivos) y con los peligros de las tareas a realizar. Este tipo de información permite que los distintos actores conozcan los aspectos de salud y riesgo ocupacional que preocupan a los diferentes colectivos del sector; y además ayuda a identificar las necesidades de acción y las medidas tanto informativas como correctivas necesarias en el campo de la prevención de riesgos ocupacionales.

Palabras clave: unfolding; prevención de riesgos; industria de residuos sólidos.
Clasificación JEL: C12; Q53; J81.
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1. Introduction

Time and experience have demonstrated that risk prevention plans help reduce casualties and the amount of sick leave taken in companies, therefore increasing productivity. Certain sectors are, by their working conditions, of particular interest and relevance. They have thorough and comprehensive legislation, along with a wide experience in the implementation of these plans.

The Municipal Solid Waste (MSW) sector is one of the most traditional and innovative in risk prevention plans. Due to the peculiarities of the tasks performed, this sector has a long tradition in implementing risk prevention plans. But are these plans equally received by workers involved in the production chain?

This research explores the concerns and worries of MSW sector employees in the Southern Spanish region of Andalusia; it deals with aspects of their work that may affect their health and that can be directly related to the plans and programs designed for the prevention of occupational hazards applied by their companies.

It is necessary for managers and administrators to be aware of occupational hazards that employees may suffer at high risk areas, such as the Municipal Solid Waste sector, in order to make tools and preventive plans available to them. Moreover, it is highly useful to gather knowledge about these employees' perceptions on the action plans implemented by their companies as well as the potential health risks to which they may be exposed in their jobs.

In this research, we have analyzed employees' perceptions of certain aspects related to health in the MSW sector in the Southern Spanish region of Andalusia. Data used have been provided by the Andalusian Institute of Occupational Risk Prevention (belonging to the Regional Government of Andalusia). The study on working conditions and preventive management in companies managing urban solid waste covers those companies operating in Andalusia in 2010.

The goal of this study is to analyze whether the actions taken in risk prevention plans, implemented in each area of the sector by companies, are sufficiently understood by employees, therefore reducing the risk perceived by them when carrying out their tasks.

To do this, we have analyzed the information provided by 572 workers on the issue on “health damage” specified in question #75 of the questionnaire[1], which asks them to indicate to what extent they are concerned about 18 aspects of their work that may affect directly or indirectly to their health. In a scale from 0 to 4 (with 0 representing no concern and 4 indicating their highest concern), employees value how much they care about these issues. This information, provided by workers, is the basis for the analysis and unfolding perceptual maps of the 18 health aspects studied. Employees are classified into nine groups according to job categories: senior manager, middle manager, road operator, classification operator, landfill operator, composting plant operator, vehicle operator, operator (other), and administrative personnel. This information generates a rectangular data matrix of dissimilarity, which aims to create a common map of the positions and their health-related aspects. Through its interpretation, differences in perceptions can be identified according to the stratum, as well as the aspects each group perceives as the most important for health.

2. Objectives and methodology

The objective of this study is to detect major concerns developed within each group so that the necessary actions to improve the health of the various company workers in the sector can be

[1] More information can be found in the report on risk prevention plans entitled “Condiciones de trabajo y gestión preventiva en las empresas de residuos sólidos urbanos en Andalucía” (Instituto Andaluz de Prevención de Riesgos Laborales, 2011).

carried out. Moreover, the results allow to generate risk prevention plans tailored specifically to each position. This information will be also useful for business managers, who will benefit from the awareness of any gaps in the information channels related to the prevention of occupational risks in the sector.

The first stage was to find out whether the procedures carried out by companies when implementing risk prevention plans are equally perceived by employees, regardless of the position they hold in their companies. Moreover, if prevention plans are properly implemented in companies, and channels of communication and information fulfil their mission, employees will not have a negative perception of the tasks performed and the effects on their health.

The study population is a working population belonging to the sector of municipal solid waste of household origin in Andalusia. Table 1 shows the number of employees from the sector classified in nine professional profiles in 2009.

Table 1: Distribution of the population according to the position held

	Total population	Stratum
Senior managers	119	1%
Middle managers	399	4%
Operators		
Road Operators	3,802	41%
Classification operator	559	6%
Landfill Operators	107	1%
Composting plant Operators	313	3%
Vehicle Operators	3,509	37%
Operators (Other)	236	3%
Administrative positions	377	4%
TOTAL	**9,421**	**100%**

The type of sample design carried out is a random stratified sampling with proportional affixation to a confidence level of 95% and a maximum sample error of 5%. As sampling unit, we have selected employees from companies operating in the sector, who have been classified according to nine professional profiles.

A stratification of employees in 9 professional profiles looks like reasonable to consider the different perceptions on health damage in their diary activity. However, in order to ensure full representation of the population under study, a quota for each province (according to its total waste volume) has been considered. Data of total waste volume for each province have been taken from the report published by the Ministry of Environment for the year 2008.

A random process was used to select the units which form part of the sample. The so-obtained sample consists of 572 employees. Individuals participating in the survey were randomly selected among the companies with workplace in each of the eight Andalusian provinces, taking into account the quotas considered for each province.

The process of information gathering was carried out through personal interviews conducted in the premises where each person worked. The questionnaire used is based on the model which was previously applied to the first Andalusian survey on working conditions (Instituto Andaluz de Prevención de Riesgos Laborales, 2008) and consists of 75 questions. Field work was conducted between October 22nd and December 23rd, 2010.

The statistical technique used to analyze perceptions is an unfolding multivariate method (Cox and Cox, 2001). This procedure provides a common quantitative scale allowing visual examination of relationships between the sets of rows and columns for a matrix of preferences; groups are studied according to geometric distances. This technique offers considerable advantages over others with graphical representations, but not so simple to be interpreted. Personal or group judgments (of either similarity or preference) are transformed into distances, represented in a multidimensional space, which reflects a perceptual map and comparisons across objective and perceived (or subjective) dimensions. Unfolding method differs from cluster analysis or factor analysis in the following fact: it does not use the theoretical value and a solution is provided for each individual. Due to its procedural difficulty and calculations, the unfolding statistical technique has not been usually applied, being underestimated to date. However, statistical software (as SPSS Statistics v.20) allows both researchers and users to discover the potential of this method. One of the weaknesses for the analysis of preferences is that the principle of subjects perception homogeneity must be checked as an initial hypothesis. Consequently, all individuals must undergo the same perception process in order to assure that the results obtained can be attributed to differences in preferences or perceptions based on the position they hold in their companies.

Depending on the type of data and the previous hypotheses, these models can be categorized as metric or non-metric, and as non-probabilistic or probabilistic.

Coombs and Kao (1960) and Coombs (1964) began to observe the unfolding metric method using a principal component analysis on the correlation matrix obtained from correlations between pairs of scales. Ross and Cliff (1964) assumed a more extensive technique and Schönemann (1970) provided an algebraic solution for the metric unfolding model.

The method requires a rectangular table of frequencies I × J; that is, a contingency table where both the observed and marginal frequencies are represented.

Given N individuals who value M stimuli, the *i*-th individual produces Δ_{ij} dissimilarities with *i* = 1, 2, ...N and *j* = 1, 2, ...M. Then (N + M) points are plotted in a *p*-dimensional Euclidean space where each individual and each stimulus is represented by one of the points.

To do so, an unfolding model of closeness is considered where the two sets of points in the *p*-dimensional space are represented; so the bigger closeness, the higher frequency, therefore, the shorter distance.

The model aims to identify and represent groups of categories in the rows with similar behaviour, in relation with the categories in the columns. Therefore, the expected frequencies, according to the multiplicative model described by Rooij and Heiser (2005), can be written as:

$$\mu_{ij} = \mu\alpha_i\beta_j\theta_{ij}$$

where the value μ is constant and α_i, β_j y θ_{ij} are the marginal and joint probability.

This model has an expected frequency for the categories in the row i and the category of the column j; that is:

$$\mu_{ij} = \mu\ \alpha_i\ \beta_j\ \theta_{ij}\ \exp(-d^2_{ij}(x_i, y_j))$$

The coordinates of the points drawing individuals will be X_i (i = 1, 2, ..., N) and the coordinates of the points that represent stimuli will be Y_j (j = 1, 2, ... , M). Thus, the distance between points X_i (i-th individual) and Y_j (j-th stimulus) will be "d_{ij}".

Once the model has been specified, the objective is to minimize the errors between the expected and obtained frequencies. This is equivalent to maximize the sample probability function or likelihood function.

The highest difficulty in the metric unfolding method is to find a configuration so that the d_{ij} distances best represent the Δ_{ij} dissimilarities.

In addition, authors such as De Soete and Heiser (1993), Rooij and Heiser (2005) and Zinnes and Mackay (1995) widely developed probabilistic unfolding models.

3. Study of perception about employees' occupational health according to job position

To carry out the analysis of employees' perceptions, an input matrix allowing the application of the multivariate statistical unfolding model is established. Perceptions are analyzed according to employees' positions in their companies and the 18 work-related aspects affecting their health. This matrix is a rectangular array of preferences in 2 ways and 2 modes, where each piece of data p_{ij} indicates the mean concern of group i (corresponding to employees in position i) in aspect j; hence, the greater value in the matrix, the greater concern for this aspect.

Moreover, the initial matrix is a 9x18 matrix of dissimilarities. If a group has a high rating on a particular stimulus, this indicates much concern about that given health aspect. Thus, it will reflect a smaller distance in the perceptual map for both points. Similarly, the lower the score in the evaluated aspect, the lower the concern about that aspect; so the points representing the row and column will be found at a greater distance in the studied two-dimensional space.

The set of rows represents each of the nine positions held in the company: senior managers (1), middle managers (2), road operators (3), classification operators (4), landfill operators (5), composting plant operators (6), vehicle operators (7), operators (other) (8) and administrative personnel (9).

The set of columns indicate the 18 stimuli that employees have rated on aspects of their jobs related to health, namely: 1. autonomy to do the job; 2. work pace; 3. work schedule; 4. task difficulty or complexity; 5. Monotony; 6. Workload; 7. peer relationships; 8. relations with managers; 9. relationships with people outside their company; 10. body posture; 11. physical exertion; 12. noise in workplace; 13. light intensity in workplace; 14. temperature and humid levels in workplace; 15. handling or breathing noxious or toxic substances; 16. risk of having an accident; 17. risk of having a disease; and 18. risk of job loss.

Points representing the workplace on the solution space indicate the area where the highest concern for each group is found; so the further from one of these points in either direction, the lower the work-related preoccupation.

The following analysis focuses on the statistical values showing that the solution has a proper fit and has no problem of degeneration. In fact, the stress values obtained in the solution as well as on the indexes measuring the validity of the unfolding model are statistically good.

A stress convergence of 0.000001, a minimum stress of 0.0001 and a maximum number of 5,000 iterations have been considered. As for the penalty term, a magnitude of 0.5 and 1.0 range have been observed.

A solution, computed using SPSS, converges after 132 iterations, with a final penalized stress of 0.5284. The coefficient of Kruscal's Stress-I is a measure of goodness of fit of the model and takes the value 0'1331. This suggests that the solution is not degenerate. Moreover, there are no major differences between the coefficient of variation for the transformed proximities (0'4770)

and the coefficient of variation for the original proximities, which also indicates the goodness of the solution reached by the unfolding. The sum of squares of DeSarbo's intermixednes indices takes the value of 0'0842, that is very close to 0 and, therefore, shows that the obtained solution is valid and that the points of the two sets are well interlaced.

In this sense, the rate of Shepard's non-approximate degeneration is high enough, taking the value of 0'7596. This index indicates the percentage of different distances so that, when setting to 0, it shows that the solution is likely to be degenerate. In the solution obtained, the percentage of different distances is about 76%, which indicates a sufficiently high percentage of different distances.

All these values show that the solution is properly fitting and has no problem of degeneration.

The generated unfolding model returns a graph with the 9 different job positions analyzed in the company (see Figure 1), i.e. the categories in the initial matrix rows.

When interpreting the individual space for rows in this graph, three different groups can be observed. These groups or clusters consist of, on the one hand, senior and middle managers (groups 1 and 2), all types of operators (groups 3 to 8) and, finally, a cluster constituted by administrative personnel (group 9).

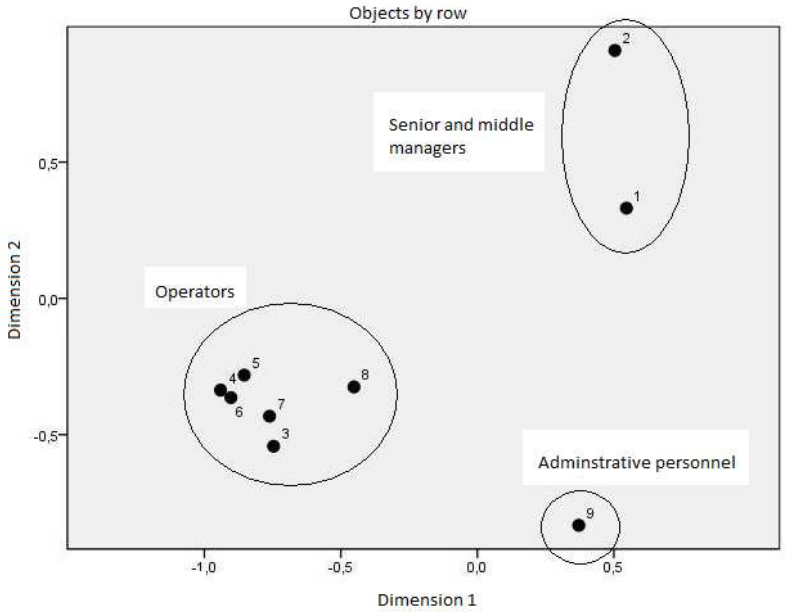

Figure 1: Professional profiles by groups

Consistency of results can be clearly observed since this is a sector with very different tasks in terms of dangerousness, handling of hazardous substances, body posture and positioning, level of physical exertion at work and personal relationships (depending on positions). This suggests that the perception of the different groups of workers on health issues concerning them at their workplace is significantly different.

Figure 2 shows individual spaces for categories and their columns; the distribution of the 18 work-related aspects valued by employees can be observed there. If we analyze this solution, three different groups can be observed once more:

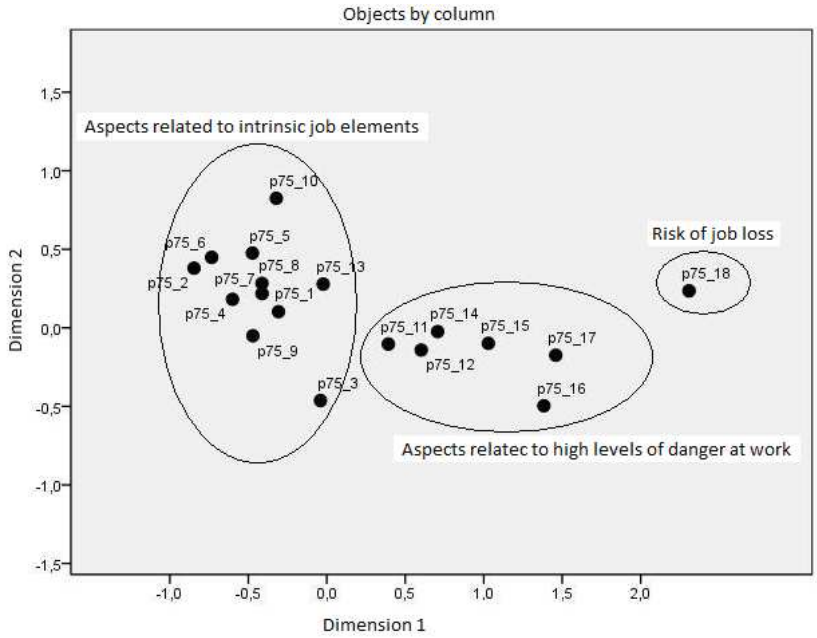

Figure 2: Stimuli under study by groups

On the one hand, there is a group formed by stimulus #18, which indicates the risk of job loss, a concern affecting all groups of employees. Although the municipal solid waste sector is a sector with great stability, it should not be forgotten that there exists a crisis in the temporary frame when data have been collected. All employees, regardless of the position they hold in the company, have a great concern about job losses, even if in this sector there is a predominance of stable contracts and low employee turnover. This stimulus has a great psychological connotation that should be emphasized and that separates it from other stimuli.

A second group consists of aspects related to intrinsic job elements such as autonomy, pace, schedule, complexity, monotony, workload, lighting, body postures and relationships with other people.

Finally, a third group is formed by stimulus concerning the most dangerous job aspects or those that can affect health at a more direct or high levels, such as physical exertion, noise, temperature and humidity, exposure to harmful substances, the risk of having an accident and the risk of developing a disease. These are present aspects in the work of the operators of the municipal solid waste sector.

Analyzing the common area, formed in the joint plot of rows and columns provided by the unfolding model (see Figure 3), the major concerns regarding health aspects according to the position held in the company can be interpreted as a whole. In the following chart differences in perceptions in each of the three job groups can be again observed.

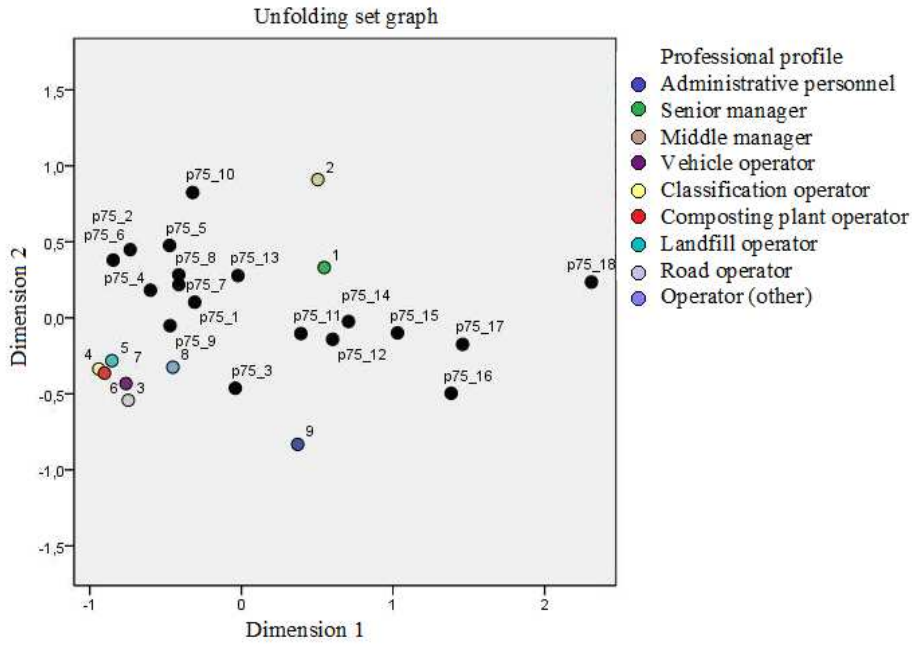

Figure 3: Unfolding set graph

There is a group formed by senior and middle managers whose major concerns are not derived from their own tasks but related to the their employees' safety, physical exertion, body posture and positioning, lighting, noise, the handling of hazardous substances, and risks of having an accident or developing a disease. This indicates that senior and middle managers from the sector of urban solid waste are aware of the risks affecting their employees and show an active concern for them. They are involved in the development and implementation of risk prevention plans and are aware of the importance of such plans and their management within their companies.

The major concern of the administration personnel is their schedule (p75_12), followed by noise in workplace (p75_3); both issues that are directly related to their daily work. This group is neither handling harmful substances nor doing physically demanding tasks. They do not need to adopt body postures that may affect their health: Consequentely, it is logical to obtain a greater distance from these issues not affecting them directly.

Regarding the group of operators, the chart indicates that their main concerns are those aspects related to the nature and design of the tasks they perform instead of their inherent danger, as could be initially expected. Their biggest concern is the relationship with people who do not work for the company, followed by the autonomy to do their tasks. They also show concerns about their schedule, their work pace, the complexity of their tasks, the possible monotony and the relationships with peers and managers. This suggests that these workers have a good perception of prevention plans implemented in the company. They feel safe when they perform their tasks, sometimes highly dangerous, and do not consider that their job position as operators can directly harm their health.

Although it is a sector with great job stability and a reduced turnover, Stimulus #18 about the concern of job loss is at a great distance from all the groups analyzed, for its special psychosocial significance and the environment of crisis in which data were collected.

Finally, the study of the decomposition of the stress allows the identification of the positions and stimuli with a higher contribution to solving the joint stress. The analysis shows how much of the stress among different job categories can be attributed to job position 4, landfill operator (0'107), while an analysis of stimuli displays that much of the stress is attributed to Stimulus

#15, handling or breathing noxious or toxic substances (0'109), and Stimulus #9, relations with other people who do not work in the company (0'08).

When interpreting the horizontal dimension, we can observe how this axis discriminates precisely between the individual aspects of any job or task, especially those related to low-skilled positions, regardless of sector, and those aspects of inherent danger and occupational risks of the analyzed sector.

On the contrary, the interpretation is not as clear as above for the vertical dimension, which presents difference between aspects such as their schedule or the thought of having an accident and stimuli on issues that may lead to a higher level of stress or fatigue on the employee, such as their body posture and positioning, their pace of work, their workload or monotony.

Shepard's graphs, analysing scatter and waste obtained in the model, indicate that the solution adopted by the unfolding technique is not a degenerate solution and that interpretations in the previous analysis have great consistency, as is shown by a measure of goodness of fit of the model presented. These graphs show that there is a high linear correlation between adjusted distances and transformed proximities with net proximities. Equally, waste draws a random point cloud.

4. Conclusions

Several agents can benefit from this study, which gathers information on employees' perceptions about the different occupational risks, as well as their concerns about important aspects of their jobs (such as those related to health in the municipal solid waste sector) and prevention plans implemented by their companies. They can also have access to the information being necessary to develop preventive, corrective or informative action plans, together with procedures for improvement, that can facilitate numerous conditions - in the economic, labor, psychological, exchange, occupational hazards fields - necessary in today's society.

Due to the unfolding statistical method considers sets according to geometric distances, significant advantages can be drawn over other techniques which also use graphical representations but not so simple to be interpreted. Let us note that the difficulty of the process and calculation for the unfolding technique has generally provoked its underestimation and, consequently, its less use. However, at present, both researchers and users have the possibility to discover the full potential of this technique thanks to widely distributed statistical programs such as SPSS.

This study provides an analysis of preferences concerning to 18 work aspects of the municipal solid waste sector in Andalusia, which can affect employees' health depending on the position they are holding in the company (corresponding to each of nine different profiles being considered).

Among the results obtained in this study, the concern and high involvement level which can be observed in senior and middle managers with respect to the prevention and occupational risks of their employees are remarkable. Workers, on the other hand, are generally more concerned with their work rate, timing and other aspects related to the daily task burden that can cause them stress. These operators (on the whole, low-skilled) often perform very simple routine tasks, but repetitive, are working in different shifts, and are exposed to awkward body postures or dangerous situations. However, it is also worth noting that these workers neither judge these aspects of their daily work tasks as dangers nor regard the effect they can have on their health. This is due to the fact that, in the MSW sector, there is an extensive experience in the implementation of prevention and occupational risks plans and these plans seem to be effective.

Administration personnel, unaware of the peculiarities of this sector, are concerned about their schedule and the noise at their workplace. This aspect should be certainly considered by the managers of these companies.

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