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Preventive activity in the greenhouse-construction industry of south-eastern Spain

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ABSTRACT

Preventive action in companies is one of the bases of ergonomic intervention. Therefore, in the present work, the preventive activity of greenhouse-construction companies in south-eastern Spain is character-ized. A sample was taken by means of a questionnaire structured in four groups of variables: general characteristics of the company, characteristics of safety and health in the construction procedures, char-acteristics of prevention and management in safety and health, and characteristics of the coordination during the execution of the work. The results indicate that the prevention is very poor, not adopting any preventive-management model for internationally recognized work hazards so that the information and training in preventive matters of companies and workers is insufficient. In addition, the companies have been classified into three clusters, correlating the company size and prevention management of labour hazards, revealing that the companies with higher gross income and number of workers showed better prevention management.

1. Introduction

Spain has among the largest surface areas of plastic-covered greenhouses worldwide, reaching some 45,000 ha (Castilla and Hernández, 2005), with extremely dense concentrations in south-eastern Spain, particularly in the province of Almería, with 26,500 ha, mainly for table vegetables (Fundación Cajamar, 2007). This intensified cultivation, has given rise to a greenhouse-construction industry, especially for light, low-cost structures (Soriano et al., 2004). The traditional greenhouse model being used in south-eastern Spain is called "*parral*" type, although in recent decades, this has been replaced by improved models, such as the "*raspa y amagado*" and the multispan type, which provide more precise climatic control, including automation (López and Pérez, 2006). Some 96.5% of the greenhouses in the area are called "*Almería type*" (Fernández and Pérez, 2004), with three main variants: flat *parral* (38.2%), "*raspa y amagado*" (55.0%) and asymmetric (3.3%), which have been developed over the last 40 years. In Almería, the companies that construct greenhouses are relatively small, with a mean of 13.46 workers per company (VV.AA., 2005).

Globally, the construction industry is the most dangerous sector in terms of job health and safety (Kartmam et al., 2000; Jannadi and Bu-Khamsin, 2002; Colak et al., 2004; Fang et al., 2004; Tam et al., 2004; Behm, 2005, 2008; Calderón, 2006; Marika et al., 2008; Zeng et al., 2008). Many studies have investigated the causes of construction accidents, such as the size of the construction company, preventive coordination in the planning and execution phase of the work, and worker attitudes, (Hinze et al., 1998; Haslam et al., 2005), as well as safety management of the company (Dawson et al., 1988; Gun, 1993; Jaselskis and Recarte-Suazo, 1994; Blockley, 1995; Mohamed, 1999; Rowlinson and Matthews, 1999; Goldenhar et al., 2001; McCann, 2003; Tam et al., 2004; Haslam et al., 2005; Zeng et al., 2008). Thus the main factors affecting safety in construction companies include: the heads of the company having low awareness of the importance of safety; deficient training; poor safety awareness among safety coordinators and those who draw up projects; reticence to enact safety programmes; and the undertaking of hazardous tasks (Tam et al., 2004).

Also, many studies have examined the hazard-prevention design, i.e. integrating preventive measures for worker safety in the planning phase of the project, designed by architects and engineers (Gambatese, 1996, 1998, 2000; Hecker et al., 2004; Behm, 2005; Weinstein et al., 2005; Rubio et al., 2005; Toole, 2005; Van Gorp, 2007; Gambatese et al., 2007; Toole and Gambatese, 2008). In short, four paths have been proposed in relation to the incorporating prevention in the design: (1) The use of more prefabricated construction elements; (2) greater use of safer systems and materials; (3) increased application of engineering in construction; and (4) more thorough consideration and spatial investigation in the design.

In addition, several studies state that small companies have a greater frequency index of accidents because resources to avoid accidents are more limited (Suruda, 1992; Oleinick et al., 1995; Suruda and Wallace, 1996; Stevens, 1999; Beaver, 2003; Benavides et al., 2003; Guadalupe, 2003; Fabiano et al., 2004; Sorensen et al., 2007; Camino-López et al., 2008; Hasle et al., 2008). Within the construction sector, company size has been associated with falls of workers from heights, the main and most frequent cause of mortality (Sorock et al., 1993; Chi and Wu, 1997; Hinze et al., 1998; Janicak, 1998; Jeong, 1998; Kines, 2002; Larsson and Field, 2002; Huang and Hinze, 2003; Tam et al., 2004; Chi et al., 2005; Chia-Fen et al., 2005; Haslam et al., 2005; Hoonakker et al., 2005; Macedo and Silva, 2005; Müngen and Gürcanli, 2005; Adam et al., 2009; BLS, 2008). Thus, the larger the company, the lower the accident incidence (Buskin and Paulozzi, 1987; Chi et al., 2005).

Many recent studies on work safety in construction have focussed preferentially on residential and industrial construction (Haslam et al., 2005; Zeng et al., 2008; Camino-López et al., 2008), but few specific studies treat greenhouse construction, these being limited to investigating methodology and typology (Matallana and Montero, 2004; Briassulis et al., 1997; Von Elsner et al., 2000a,b; Peña et al., 2004; Pérez et al., 2008). There are no works available that analyse health and safety prevention or man-agement and coordination systems in greenhouse-construction companies. One work on accident prevention in Swedish agricul-ture analyses 55 accidents in greenhouses (Lundqvist and Gustafsson, 1992), while a previous work concludes that the great-est accident risk involves the maintenance and repair of the greenhouse roof, as well as the use of chemical products (Lundq-vist, 1982). In Spain, safety research in this field are scarce. Thus, when the Spanish normative on safety and health measures in con-struction works took effect (BOE, 1997), Callejón-Ferre et al. (1998) studied the implementation of these guidelines in the greenhouse-construction sector. Also, Callejón-Ferre et al. (2009) analysed the conditions of workers within the greenhouses in south-eastern Spain in general, without considering those directing greenhouse construction. Ponce (2005), reported great deficiencies in the sec-tor, primarily in applying the normative together with the lack of means and training, mainly, but also the failure to keep records on accident rates.

Greenhouse-construction companies at times hire non-specialized workers, who lack training and experience, a situation which sometimes triggers accidents, as occurs in other sectors (Ban-field et al., 1996; Cattledge et al., 1996; Gervais, 2003; Guadalupe, 2003; Benavides et al., 2003; Saha et al., 2004; Waehrer et al., 2007; Camino-López et al., 2008; Fabiano et al., 2008). All this, together with the fact that the greenhouse-construction systems are often quite rudimentary, has given rise to an average accident-incidence index for greenhouse construction of 141.8 for the period 2001–2005. The main causes of accidents are overexertion, falls from height, lacerating blows, and punctures from wire, tools, and other objects. The falls from height caused the most serious accidents.

2. Objectives

Due to the high accident rate in the greenhouse-construction industry of south-eastern Spain indicated in the Introduction, it becomes necessary to ascertain the situation of labour-risk management of these companies, as this is a determining factor for improving the safety and health of workers over the middle and long term. For this, the general goal of the present work is to characterize the preventive activity and labour-risk management of the greenhouse-construction companies in south-eastern Spain. The specific objectives of the paper are:

i. To outline the structure of the general organization of the companies.
ii. To assess the safety and health in the greenhouse-construction procedures.
iii. To determine the activities of accident prevention and health management of the companies.
iv. To specify the activities of coordination of health and safety during the building of the greenhouses by the companies.
v. To correlate the size of the company with its prevention and management of labour risks, as well as to identify groups of companies having homogeneous characteristics in this prevention and management.

3. Materials and methods

3.1. Sampling characteristics

Greenhouse-construction companies working in Almería were sampled, since this is the province of south-eastern Spain with the greatest surface area of greenhouses (Castilla and Hernández, 2005; Fundación Cajamar, 2007). A simple random sampling tech-nique was used with a sample size of 10 companies, this being 20%of the population previously censused. The sampling plan had two stages: first, a previously designed questionnaire was validated and, second, the sampling itself was performed. The information was collected by personal interview with the head or a representa-tive of the company, this being complemented by direct observation and questions posed to workers on the job while constructing greenhouses.

3.1.1. Census of greenhouse-construction companies

The census of 2007 for companies of the Chamber of Commerce, Industry and Navigation of Almería was adopted, counting 50 greenhouse-construction companies.

3.1.2. Model of polling

For the design of the questionnaire, the information was organized and systematized based on prior research (Calderón, 2006), as well as the opinion of experts both in private industry as well as public administration. The definitive questionnaire was arranged in four blocks of 30 items each with the parameters and variables that characterize the greenhouse-construction companies:

- General data on the company (eight items).
- Characteristics of health and safety in the construction procedures (five items).
- Characteristics of health and safety prevention and management (eleven items).
- Characteristics of coordination activities of the company during construction (six items).

3.2. Variables studied

For the characterization of the preventive activity implemented by the greenhouse-construction companies, the study variables, both quantitative and qualitative are listed in Tables 1 and 2, arranged in four groups used in the questionnaire. Only in the first group—i.e. those describing general features of the company—are there four quantitative variables number of workers (C), number of work teams (E), annual activity of the company (H), and gross income of the company in the last fiscal year; all the other variables were qualitative. However, three of these quantitative variables were categorized for more detailed study and correlation. Tables 1 and 2 display all the variables and terminology, while for the qualitative and quantitative variables categorized, the categories and terminology are presented.

3.3. Data analysis

First, a data analysis was made to identify the data absent, and afterwards it was checked whether the data verified the condition

Table 1
Terminology of variables and categories, frequency of categories of variables.

Blocs of variables in the questionnaire	Terminology variables/ categories	Variables/categories of variables	Frequency (%)
1. General description of the company	*B*	*Type of construction activity*	
	a	Construct only Almería-type greenhouses	30.0
	b	Construct all types of greenhouses	30.0
	c	Construct greenhouses and undertake other activities	40.0
	C	*Number of workers*	
	d	Fewer than 10 workers	50.0
	e	10–20 workers	20.0
	f	>20 workers	30.0
	D	*Code of economic activity (CNAE)*	
	g	Crops and activities related to agriculture	30.0
	h	Fabrication of metal structures and their parts	10.0
	i	General construction of building, single edifices, roofs, and walls	50.0
	j	Technical services of architecture and engineering	10.0
	E	*Number of work teams*	
	k	<5 teams	40.0
	l	5 or more teams	60.0
	H	Annual period of activity (in months)	
	G	*Gross income of the company for the last fiscal year*	
	m	<1 million €	50.0
	n	>1 but < 2 million €	20.0
	o	2 million € or more	30.0
2. Health and safety in the construction work	*S*	*Hiring modality of the company for construction*	
	jj	Only as a contractor	80.0
	kk	As contractor or subcontractor	20.0
	T	*Technical project drawn up for the greenhouses built*	
	ll	Never	70.0
	mm	Sometimes	30.0
	U	*Preventive measures adopted during the work*	
		Personal protection	100.0
		Collective protection	0.0
		Signposting at the jobsite	0.0
		Personal and/or collective protection and signposting at the jobsite	0.0
	V	*Individual protective gear used*	
	nn	Gloves and safety footwear	40.0
	oo	Gloves and safety footwear and tinted safety goggles	60.0
	W	*Type of work clothes worn*	
	pp	Street clothes	40.0
	qq	Work vest	60.0

of independence, homoscedasticity, and normality. To ascertain the interrelationship of the variables, a bivariate correlation analy-sis was made, calculating Pearson's correlation coefficients. In addition, a descriptive analysis of the variables studied, and for the qualitative ones the frequencies (%) were noted for each cate-gory of each variable, while for the quantitative ones the mean values and standard deviations were determined. Afterwards, a univariate analysis of variance (ANOVA) was used for the quantita-tive variables correlated with the size of the company, such as the number of workers (*C*), annual gross income of the company (*G*), with respect to the significant qualitative variables. Finally, a multiple correspondence analysis (HOMALS) was made to identify the variables and categories of each variable as well as to group companies with common characteristics.

4. Results

4.1. Consistency

The consistency of the variables was studied by correlation analysis, calculating the bivariate correlation coefficients of each pair of variables, since this coefficient tells the degree of superposition of the fields of the variables, so that if its value is very great (e.g. >0.80), there would be multicollinearity, indicating that they represent identical fields, and therefore some of the variables would have to be removed from the statistical analysis. In this sense, the variables listed in Tables 1 and 2 were removed without terminology for the categories of the variables, for having presented correlation coefficients >0.80, and in this way the multicollinearity of the variables was controlled, the correlation coefficients for the rest of the variables remaining between 0.15 and 0.728.

4.2. Description of the sample

The companies of the sample presented a mean the number of workers (*C*) of 13.3 (s.d. 11.53), a mean gross income (*G*) of 1.56 million euros (s.d. 1.43), and a mean number of work teams (*E*) of 4.4 (s.d. 2.59), carrying out the work of the company (*H*) over a mean of 6.4 months (s.d. 0.69). Tables 1 and 2 show the frequency of each of the categories of the qualitative variables analysed, as well as the quantitative ones categorized.

4.3. Univariate analysis of variance (ANOVA)

Given that many authors indicate that the size of the company determines their index of accident incidence and preventive activities (Gun, 1993; Jaselskis and Recarte-Suazo, 1994; Hinze et al., 1998; Tam et al., 2004; Haslam et al., 2005; Zeng et al., 2008), a univariate analysis of variance was made (ANOVA) for the quantitative variables correlated with the size of the company, such as the number of workers (*C*) and the annual gross income of the

Table 2
Terminology of variables and categories, frequency of categories of variables.

Blocs of variables of the questionnaire	Terminology variables/ categories	Variables/categories variables	Frequency (%)
3. Prevention activities and management in health and safety in the company	*I*	Type of prevention planning	
		Assumed personally by the company owner	10.0
		Outside prevention service hired	90.0
	J	The responsible party for health and safety conditions at work according to the intermediate heads of the company	
		Directors	10.0
		Intermediate heads	20.0
		Directors, intermediate heads, and prevention service	70.0
	K	Health and safety interferes with the construction process	
	p	No	40.0
	q	Sometimes	60.0
	L	Prior medical checkups are made	
	r	Yes	70.0
	s	No	30.0
	M	The company provides specific health and safety training of new workers	
	t	Prior to starting work	50.0
	u	During the period hired	20.0
	v	No worker lacking previous training is hired	30.0
	N	Prior certification mandatory for certain tasks is verified	
	w	Never	30.0
	x	Sometimes	30.0
	y	Always	40.0
	O	An identification list exists for work teams	
	aa	Yes	50.0
	bb	No	50.0
	P	A quadrant for checking work teams exists, indicating who is in charge of doing so	
	cc	Yes	60.0
	dd	No	40.0
	Q	Preventive resources are formally named	
	ee	No	10.0
	ff	Yes, but not documented	70.0
	gg	Yes, and documented	20.0
	R	The preventive resource provides specific training	
	hh	Yes	60.0
	ii	No	40.0
	AC	Initial and periodic evaluations of work risks are made	
	xx	Yes	70.0
	yy	No	30.0
4. Coordination activities of the company during the construction	*X*	A health and safety plan is made for the work being undertaken	
		Yes	0.0
		No	100.0
	Y	A coordinator for health and safety exists for the work being undertaken	
		Yes	0.0
		No	100.0
	Z	Promoters value the safety measures offered by the contractor bidding on the work projected	
	rr	Never	40.0
	ss	Sometimes	60.0
	AA	Coordination is undertaken periodically with the subcontractors in questions of health and safety	
	tt	Never	50.0
	uu	Sometimes	50.0
	AB	Way in which subcontractors are supervised	
	vv	No supervision is made	30.0
	ww	Periodic inspections are made	70.0

company (*G*). Tables 3 and 4 show the results of the ANOVA for the variables (*C*) and (*G*), respectively, showing only the qualitative variables for which the means registered significant differences.

In this sense, for the variable (*C*), significant differences in the ANOVA were registered by variables: worker certification for certain specific tasks (*N*) was confirmed, there was a list of identification of work teams (*O*), there was a quadrant of checks on the work team indicating who was to do it (*P*), and the type of teams of individual protection used (*V*). In this way, for the variable *N*, which presented three factors, significant differences appeared in the means ($p < 0.05$) between the factor that the company always verifies worker certification for certain specific tasks (y) with respect to each of the other two factors, which never undertake the verification (w), and that the verification is sometimes made (x). In the first case, the mean is 23.75 workers, in the second 4.00, and in the third 8.66.

Table 3
Results of the univariate analysis of variance (ANOVA) for the variable *C*.

Independent variables/factors ANOVA *F*; significance; degrees of freedom		Count	Mean	Homogeneous groups
N	w	3	4.00	w–y*
$F = 6.115$; $p = 0.029$; df = 9	x	3	8.66	x–y*
	y	4	23.75	
O	aa	5	21.80	aa–bb**
$F = 12.204$; $p = 0.008$; df = 9	bb	5	4.80	
P	cc	6	19.33	cc–dd*
$F = 6.719$; $p = 0.032$; df = 9	dd	4	4.25	
V	nn	4	4.25	nn–oo*
$F = 6.719$; $p = 0.032$; df = 9	oo	6	19.33	

The notation of the variables and categories of variables are shown in Tables 1 and 2.
* Level of significance for the differences of means with the *post hoc* DMS test: $p < 0.05$.
** Level of significance for the differences of means with the *post hoc* DMS test: $p < 0.01$.

Table 4
Results of the univariate analysis of variance (ANOVA) for the variable *G*.

Independent variables/factors ANOVA *F*; significance; degrees of freedom		Count	Mean	Homogeneous groups
AC	xx	7	2.14	xx–yy*
$F = 5.791$; $p = 0.043$; df = 9	yy	3	0.21	

The notation of the variables and categories of variables are shown in Tables 1 and 2.
* Level of significance for the differences of means with the *post hoc* DMS test: $p < 0.05$.

Also, for the variable *O*, which presents two factors, significant differences appeared in the means ($p < 0.01$) between the factor that there in fact was a documented list of work teams (aa) as opposed to the factor that there was no such list (bb), presenting a mean of 21.8 workers in the first case as opposed to 4.8 in the second case. With respect to the variable *P*, which presents two factors, the means significantly differed ($p < 0.05$) between the factor there was a list of checks of the work teams (cc) as opposed to there not being such as list (dd), the former case presenting a mean of workers of 19.33 as opposed to 4.25 in the latter. Finally, the variable *V*, which presented two factors, showed significant differences in the means ($p < 0.05$) between the factor that gloves and safety footwear were used (nn) as opposed to using gloves, safety footwear as well as tinted safety goggles (oo), in the first case registering a mean of 4.25 workers as opposed to 19.33 in the second case.

For variable gross income of the company (*G*) showed significant differences in the ANOVA with the variable that reflects whether the company makes initial and periodic assessments of labour risks (*AC*), so that the means significantly differed ($p < 0.05$) between the factor that assessments were made (xx) and that they were not (yy). For the first factor, the mean gross in-come of the company was 2.14 million euros, while for the second factor it was 0.21 million euros.

4.4. Multiple correspondence analysis

The results of the multiple correspondence analysis made of the variables representative of the model identified the correlations of the categories of the variables as well as the variables themselves. The resulting model after this analysis presented two significant dimensions in such a way that the first explained 56.21% of the

Table 5
Discrimination measures of the variables in each dimension.

Variables	Dimension		Mean
	1	2	
B	0.271	0.503	0.387
C	0.743	0.314	0.529
D	0.418	0.492	0.455
E	0.832	0.118	0.475
G	0.593	0.798	0.696
K	0.022	0.000	0.011
L	0.778	0.006	0.392
M	0.739	0.569	0.654
N	0.822	0.045	0.433
O	0.733	0.000	0.367
P	0.832	0.118	0.475
Q	0.475	0.051	0.263
R	0.282	0.488	0.385
S	0.603	0.001	0.302
T	0.432	0.038	0.235
V	0.832	0.118	0.475
W	0.282	0.488	0.385
Z	0.398	0.073	0.235
AA	0.689	0.002	0.346
AB	0.595	0.100	0.348
AC	0.434	0.130	0.282
Total active	11.804	4.454	8.129
% Of variance	56.210	21.210	38.710

The notation of the variables are shown in Tables 1 and 2.

variance with a Cronbach coefficient of 0.961 and a self-value of 11.804, while the second dimension explained 21.21% of the variance with a Cronbach coefficient of 0.814 and a self-value of 4.454. Hence, for the whole of the factorial model the mean of the variance explained was 38.71%, with the mean coefficient of Cronbach α of 0.921 and the mean self-value of 8.129, indicating that the reliability of the model was good.

Table 5 shows the discrimination measures of each variable with respect to each of the two dimensions of the model and the mean. As can be seen, the leading variable in the ranking of the explicative variables of the variance of the homogenizing model was *G* (0.696), since it presented the highest discrimination, followed in descending order of explanation by the variables *M* (0.654), *C* (0.529), *E* (0.475), *P* (0.475), and *V* (0.475). Meanwhile, the least explanatory variable was *K* (0.011), followed by *T* (0.235), *Z* (0.235), *Q* (0.263), and AC (0.282). In terms of the dis-crimination in both dimensions, the first dimension presented very strong discriminations with variables *E* (0.832), *P* (0.832), *V* (0.832), *N* (0.822), *L* (0.778), *C* (0.743), *M* (0.739), and *O* (0.733), while the second dimension presented strong discriminations (but less than those of dimension 1) with the variables *G* (0.798), *M* (0.569), and *B* (0.503).

Each discrimination measure coincides with the variance of the coordinates on each dimension of the modalities of each variable, so that the variables for which the modalities had coordinates on a different dimension will present on that dimension high discrimination measures. In addition, the similar measures of discrimination of one variable in the two dimensions reflect the difficulties of assigning that variable to a given dimension. It would be ideal for a variable to have a high value in a single dimension and low in the other, as occurs with the variables *N*, *L*, *O*, *E*, *P*, and *V*, which are more closely correlated to dimension 1, and therefore this dimension discriminates better the categories of these variables, and the variables *B*, *R*, *G*, and *W*, which are more correlated with dimension 2 and therefore this dimension discriminates better the categories of these variables.

The model of multiple correspondences identified the categories of each variable that best discriminated the objects (companies) and therefore the most important for this, the variables

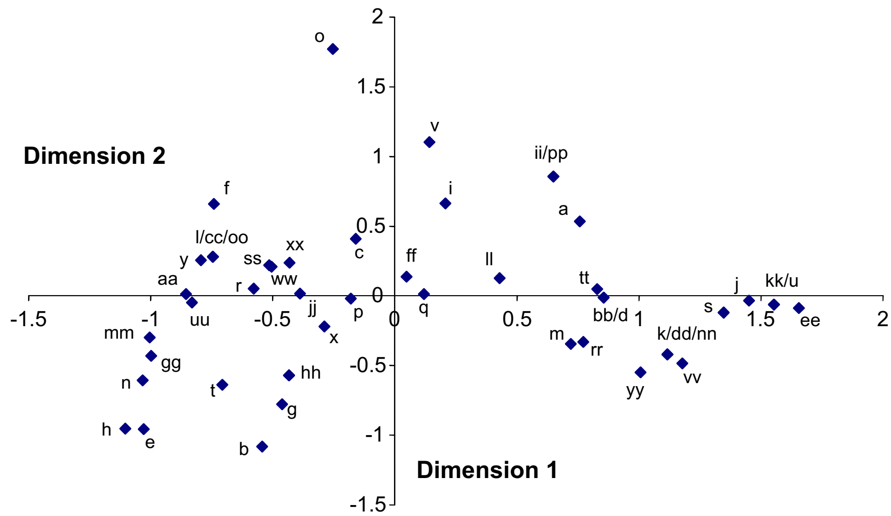

Fig. 1. Factorial plane of the quantifications of the categories of variables.

were quantified and represented in the factorial plane in which the axes were the two dimensions of the model (Fig. 1). The quantifications of the categories were the average of the scores of the objects of the same category. Furthermore, to ascertain which category of each variable contributed best to each dimension, the model calculates the contributions of the dimension of the inertia of the point for each variable, which are explained below for the most significant variables of the model expressed in percentages.

For the variable *G*, the category that best explained the positive value of dimension 1 was a gross income of less than 1 million euros (m) (52.0%) and, for negative values, a gross income of 1 million euros (m) (52.0%) and for negative values an income of 1 and 2 million euros (n) (45.8). Meanwhile, for dimension 2, the best was a gross income of more than 1 euros (n) (15.7%) for negative ones, since they presented the contributions of the dimension to the inertia of the largest point.

For the variable *M*, the category that best explained the positive values of dimension 1 was to offer specific training on health and safety for the labourers during the work period (u) (60.3%) and for the negative values this was done prior to the beginning of the work (t) (50.0%), whereas for positive values of dimension 2 it was not to hire anyone without prior training (v) (52.1%) and for negative values to provide training prior to the beginning of the job (t) (40.6%). With regard to variable *C*, the category that best explained the positive values of dimension 1 were companies with less than 10 workers (d), which explained 73.3%, and for negative values companies of between 10 and 20 workers (e), which explained 26.4%. Meanwhile, for positive values of dimension 2 the best were companies with more than 20 workers (f), which explained 18.7% and for negative values companies with between 10 and 20 workers (e) that explained 22.9%. For the variable *E*, the category that best explained positive values of dimension 1 was that the number work teams were greater than 5 (k), which explained 83.2%, while for positive values of dimension 2 that the number of work teams should be greater than 5 (*l*) (11.8%) and for negative values that the number of work teams should be less than 5 (k) (11.8%).

For the variable *P*, the category that best explained positive values of dimension 1 was that there was no quadrant of checks of the work teams (dd), which explained 83.2%, while for negative values it was that there was a quadrant of checks for the work teams (cc) (11.8%) and for negative values that there was no such quadrant (dd) (11.8%).

In addition, the multiple correspondence model helped represent the objects (companies) on the factorial plane by scoring them in each of the two dimensions (Fig. 2). In this representation, it can be seen that the companies of the sample were grouped in three clusters of companies with homogeneous characteristics. Cluster

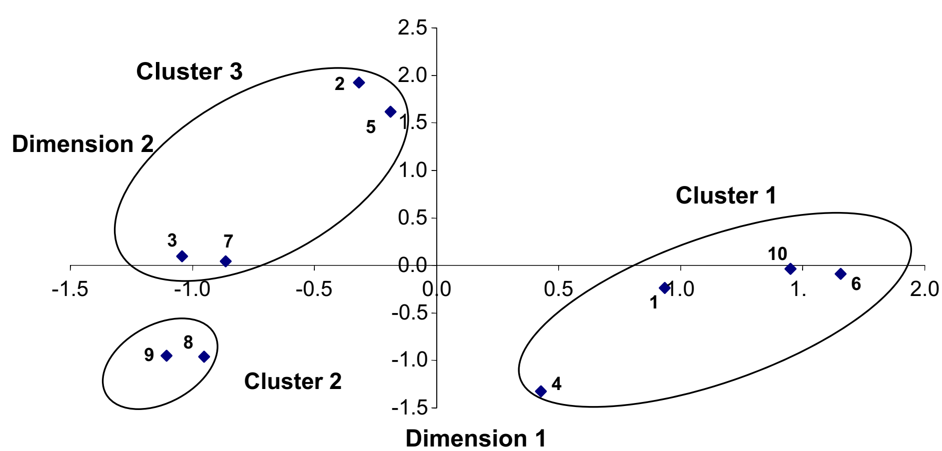

Fig. 2. Factorial plane of the scores of objects (companies).

1 presented positive scores in dimension 1 and negative ones in dimension 2, while cluster 2 presented negative scores both in dimension 1 as well as in 2, and finally cluster 3 presented negative scores in dimension 1 and positive ones in 2.

5. Discussion

5.1. Study limitations

For the characterization of the preventive activity of the greenhouse-construction industry of south-eastern Spain, a sample of 20% of the companies censused in Almería were considered, and thus the study constitutes an estimation, as other companies could differ from the sample analysed.

5.2. Descriptive analysis of the variables

5.2.1. General characteristics of the companies

Not all the greenhouse-construction companies specialized exclusively in construction, as some 60% were dedicated to greenhouse construction but the remaining 40% not only constructed greenhouses but also pursued other agriculture-related activities, such as the installation of irrigation systems or sales of agricultural machinery. The mean number of workers of the greenhouse-construction companies was 13.3, and thus the company size in terms of workers coincided practically with that of the annual agricultural report of Almería of 2005 (VV.AA., 2005) which quoted 13.46 workers per firm. Thus, 50.0% of the companies were micro-companies (less than 10 workers) and the rest were small companies (11–49 workers), and nevertheless for the entire construction sector of the region of Andalusia (Spain), micro-companies represent 14.0% of the businesses (Calderón, 2006). This low number of workers in the companies is indicative of a higher accident rate, given that for the construction industry in Spain for the period 1990–2000, Camino-López et al. (2008) put the percentage of mortal accidents 32.4% for companies of fewer than 10 works and at 74.2% for companies of fewer than 50 workers.

The mean annual gross income of the companies sampled was 1.56 million euros, some 50% less than one million euros, and 30% more than 2 million euros. However, for the greenhouse-construction companies as a whole in Andalusia (Spain), the highest percentage (29.0%) grossed 0.5 and 1 million euros (Calderón, 2006). From the results of the descriptive analysis of the variables as well as the univariate analysis of the variance, it was deduced that there was a correlation between the size of the company (i.e. the number of workers) and gross income, with variables of safety and prevention management in such a way that the larger companies adopted better measures to manage health and safety in the greenhouse-construction procedures, as reported by other researchers in the construction sector of other countries (Buskin and Paulozzi, 1987; Tam et al., 2004; Chia-Fen et al., 2005; Haslam et al., 2005; Zeng et al., 2008) and Spain (Benavides et al., 2003; Camino-López et al., 2008). In addition, the companies with more income evaluated labour risks according to existing mandatory legislation (BOE, 1997), as stated by other authors, who mentioned that the lack of resources in small companies resulted in a higher frequency of accidents (Suruda, 1992; Oleinick et al., 1995; Suruda and Wallace, 1996; Stevens, 1999; Beaver, 2003; Fabiano et al., 2004; Sorensen et al., 2007; Camino-López et al., 2008; Hasle et al., 2008).

Greenhouse construction of in south-eastern Spain is a seasonal activity, normally from May to September, so that the companies average about 6.5 months of work per year. This is because the builder adapts to the work season of the grower who needs a greenhouse (Soriano et al., 2004), and therefore the construction workers are often temporary and thus not always adequately trained (Ponce, 2005). Consequently, these companies have a higher accident rate, as reported by several authors (Banfield et al., 1996; Benavides et al., 2003; Guadalupe, 2003; Saha et al., 2004; Waehrer et al., 2007; Camino-López et al., 2008; Fabiano et al., 2008). Thus, Benavides et al. (2003), Guadalupe (2003), Camino-López et al. (2008) and Fabiano et al. (2008), indicates that the reasons for a higher incidence of accidents among temporary workers with respect to permanent workers is due to lack of specific knowledge, the absence of preventive training, and the work period. This period of annual activity of the greenhouse-construction companies coincides with the months with the highest accident rate in the Spanish construction sector, particularly July, which presented the highest rate (Camino-López et al., 2008). Similarly, in the United States, the construction sector presents higher accident rates in June, July, and August (Huang and Hinze, 2003).

In addition, it has been observed that the geographic zone where the construction activity is undertaken affects the rate of serious accidents. In Spain, Camino-López et al. (2008) have reported that in the north of the country, the rate of serious accidents is higher than in the areas of the Mediterranean region, where the present study was made. This trend was reported in other countries, such as Turkey, where lower mortal-accident rates were found in Kocaeli, situated in the south, than in the north (Colak et al., 2004), and in Portugal, where the northern region has higher accident rates than in the south (Macedo and Silva, 2005). In all cases, the northern regions are mountainous and rainy, while the south (Mediterranean) have smoother topography and are less rainy.

5.2.2. Characteristics of health and safety in construction procedures

A construction tool that helps prevent labour risks is the drafting of a technical plan for the construction project. However, some 70% of the companies sampled stated that there was no technical project for the greenhouses that they constructed, while the remaining 30% indicated that sometimes a project was prepared (a figure quite far from the 10% indicated by Calderón (2006), for construction in Andalusia, Spain). In addition, the majority practise of constructing greenhouses without a technical project goes counter to the new trends in construction to prevent labour risks by design, including preventive worker-safety measures, proposed by a wide variety of authors (Gambatese, 1996, 2000; Hecker et al., 2004; Behm, 2005; Weinstein et al., 2005; Rubio et al., 2005; Toole, 2005; Van Gorp, 2007; Gambatese et al., 2007; Toole and Gambatese, 2008). Some 80% of the companies sampled worked in construction both as contractors as well as subcontrac-tors, while the remaining 20% worked only as contractors. How-ever, in Andalusia (southern Spain), 36% of the construction companies work as contractors while 16% serve as both contractors and subcontractors (Calderón, 2006), and thus there is a higher in-dex of subcontracting in the greenhouse-construction industries. Thus, all the companies sampled claimed to use personal protec-tion for the workers as accident prevention in building green-houses, but none claimed to adopt measures of collective protection or use warning signs at the construction site. Of the workers, some 40% used gloves and safety footwear for protection, while the other 60% also used tinted safety goggles, but in no case was there any indication of the use of a hardhat, as reported by Tam et al. (2004) for the construction sector in China, where the workers sampled indicated that the hardhat was not compatible with many tasks. Thus, Chia-Fen et al. (2005), reported that the smallest construction companies in China presented a greater inci-dence of falls from heights among workers due to lack of experi-ence, training, and the generalized practice of not using personal or collective protection. In terms of work clothes, 40% of the com-panies claimed that workers used street clothes at work, while the remaining 60% used work clothes of the vest type and therefore do not use the appropriate clothes for the work being performed. All this leads to inadequate physical conditions at the jobsite, in agreement with several authors who state that small companies have worse physical working conditions and greater accident risks for the workers (Beaver, 2003; Fabiano et al., 2004; Sorensen et al., 2007; Camino-López et al., 2008; Hasle et al., 2008).

5.2.3. Characteristics of health and safety prevention and management

With respect to the organization of company resources for prevention, some 90% of the companies use outside prevention services while the remaining 10% assume their own prevention. In both cases, one or more workers are dedicated to prevention. None of the companies sampled had its own prevention service. In 10% of the companies, there was no formal naming of the preventive resource nor was it documented, 70% of the cases had formal naming but not documented, and 20% of the cases had naming as well as documentation. This latter fact coincides closely with the results reported by Mohamed (1999) for the construction industry in Australia, since only 25% of the companies studied consider the naming of safety personnel by the company to be adequate. In relation to the training for risk prevention, 60% had specific training, while 40% had none, the latter implying a lack of safety (Goldenhar et al., 2001; Gervais, 2003; Guadalupe, 2003; McCann, 2003; Tam et al., 2004). The company owner was obligated to make an initial risk evaluation as well as other periodic ones according to the circumstances, so that 70% of the companies sampled claimed to undertake labour-risk assessments while 30% did not.

In addition, the intermediate heads of the company considered the responsibility of company health and safety in 70% of the cases to be for everyone (i.e. directors, the outside prevention service, and the intermediate heads of the company) while 20% felt that it was exclusively for the intermediate heads, and 10% felt it was only for directors. In 40% of the companies, the workers felt that the adoption of company health and safety measures did not inter-fere with the work, while the other 60% indicated that at times it interfered, results that coincide quite well with those of other authors (Tam et al., 2004; Calderón, 2006). In terms of the rights of workers to medical checkups and training in health and safety, 70% of the companies assured that such checkups were made to validate worker fitness, a value lower than the 86% reported by Calderón (2006), whereas 30% indicated that checkups were not made. Furthermore, the companies sampled offered training in health and safety to the workers, but in markedly different ways. Some 50% indicated that they offered this training prior to the work, a percentage lower than the 62.5% of Calderón (2006), 20% during the period hired, and 30% offered no direct training but claimed not to hire workers without prior safety training. Therefore, some 50% (20 + 30) of companies do not train workers or do so inadequately, this being considered by many authors to be one cause of the high accident rates in the construction sector (Goldenhar et al., 2001; Gervais, 2003; Guadalupe, 2003; McCann, 2003; Tam et al., 2004; Camino-López et al., 2008). For example, for the construction sector in Spain, Guadalupe (2003) related worker training to the type of labour contract, confirming that workers with a temporary contract received less safety training than did permanent workers, due to a lower investment in human capital (among which training is included) for the former with respect to the latter type of worker. Also, it should be pointed out that the duration that the worker has stayed with the company is correlated with greater or lesser training, so that the less the time with the company, the less the training and the higher the number of accidents (Cattledge et al., 1996; Guadalupe, 2003; Benavides et al., 2003; Camino-López et al., 2008). Nevertheless, as indicated by Camino-López et al. (2008), the workers with more time in the company have greater self-confidence in their duties, increasing the accident rate. Thus, for the construction industry in Spain, those working 3–6 months in a company had the highest accident rate (17.5%), followed by those who had worked 6–12 months (16.4%), a trend that applies to serious accidents but is the reverse for mortal accidents, since for the period of 3–6 months the mortal accidents registered 14.0% while for 6–12 months the rate reached 15.9% (Camino-López et al., 2008). Also, 30% of the companies never verified that the worker was certified for the work desig-nated while another 30% indicated that this was done at times, and the remaining 40% claimed that it was always done. In con-trast, Calderón (2006) held that 22% of the companies did not make these verifications. In terms of keeping a list identifying work teams and a quadrant of checking on them, 50% of the companies had an identification list while 50% did not; meanwhile, 60%claimed to have a quadrant while 40% did not. The high percent-ages of companies that did not have and/or did not verify the lists, together with the low awareness among company heads in orga-nizing preventive resources, in providing medical checkups, etc. reflects the poor safety management of the company, which in turn results in a high accident rate. (Gun, 1993; Jaselskis and Recarte-Suazo, 1994; Tam et al., 2004; Haslam et al., 2005; Calde-rón, 2006; Hasle et al., 2008; Zeng et al., 2008). Thus, Hasle et al.(2008) indicates that the lack of a safety policy of companies implies that company managers do not conceive of job safety as a priority, this being characteristic of small companies.

As a result of the characteristics of the accident prevention and safety and health management of greenhouse-construction companies in south-eastern Spain, it can be stated that it is necessary to change the way companies approach safety, and that the mere existence of a safety guideline is not sufficient, but rather the policy and management of safety must be redesigned within the company. Many other researchers in Spain and other countries have reached the same conclusion, such as Dawson et al. (1988) and Blockley (1995) in the United Kingdom, Rowlinson and Matthews (1999) in Hong Kong, Mohamed (1999) in Australia, Guadalupe (2003), Benavides et al. (2003), Calderón (2006), and Camino-López et al. (2008) in Spain.

5.2.4. Characteristics of the coordination of activities by the company during the construction work

In Spain, as in most developed countries, construction work must be undertaken with a technical plan drawn up by a qualified architect, which involves a study of health and safety of the projected work, later to be materialized in a prevention plan that the contractor must propose to the supervisor and the health and safety coordinator. However, in the construction of greenhouses, none of the companies sampled drew up such a plan, nor named a health and safety coordinator, either in the phase of drawing up the project or in the execution of the work. These findings con-trast sharply with the results of Calderón (2006), who found that 83.3% of the companies named a health and safety coordinator dur-ing the phase of drawing up the plans while 94.4% did so during the execution of the work. In the present case, the data reflect a lack of safety, because of the hesitation by promoters, contractors, and subcontractors to have the safety coordinators enter the project (Hinze et al., 1998; Haslam et al., 2005; Calderón, 2006). All this is due to the lack of a safety policy of greenhouse-construction companies, supporting the statement by Hasle et al. (2008) that companies do not hold safety to be a priority.

5.3. Multiple correspondence analysis

From the interpretation of the factorial plane of Figs. 1 and 2, correspondences can be found between categories of variables and by extension the characteristics of each of the three clusters of certain companies. Thus, the companies of cluster 1 are characterized by presenting all the categories of the variables with positive quantifications in dimension 1, the most significant ones being that the company takes in less than a million euros (m), that the number of work teams is less than 5 (k), it constructs only greenhouses of the *Almería* type (a), it specializes in the general construction of buildings, single edifices, roofs and walls (i), it does not undertake initial or periodic work-risk assessments (yy), it does not contract any worker without prior training in health and safety at work (v), it does not offer specific preventive training (ii), company heads believe that the promoters do not value health and safety measures at the construction site when taking bids on the project (rr), it never oversee the contractor (vv), it does not have a quadrant of checks on work teams (dd), workers use only gloves and safety footwear for protection (nn), and workers wear street clothes to work (pp).

Cluster 2 of companies is characterized by presenting the categories of the variables with negative quantifications both in dimension 1 as well as 2, as reflected in Fig. 1, the most significant being that the company grosses between 1 and 2 million euros (n), it has between 10 and 20 workers (c), it constructs all types of greenhouses (b), it also raises crops and undertakes other activities related to agriculture (g), it manufactures metal structures and related parts (h), it offers specific training in prevention for health and safety (hh), it sometimes draws up technical projects for greenhouses that it constructs (mm), it sometimes verifies that workers are certified for certain tasks (x), and it formally names and documents the preventive resource and (gg).

Cluster 3 presents the categories of the variables with negative quantifications in dimension 1 and positive in dimension 2, as shown in Fig. 1, the most significant being that the company has a gross income of more than 2 million euros (o), it has more than 20 workers (f), it has more than 5 work teams (l), it constructs all types of greenhouses and also undertakes other activities (c), it makes an initial an periodic assessments of labour risks (xx), it believes that the promoters sometimes value health and security measures at the construction site when taking bids on the project (ss), it has a quadrant for checking on the work teams (cc), the workers use not only gloves and safety footwear for protection but also tinted safety goggles (oo), and always verify that the work is certified for certain tasks (y).

The characteristics described for the three clusters of greenhouse-construction companies clearly indicate that the larger companies adopt better preventive measures and have better health and safety procedures, in agreement with other researchers examining the construction sector in other countries (Buskin and Paulozzi, 1987; Tam et al., 2004; Chia-Fen et al., 2005; Haslam et al., 2005; Zeng et al., 2008) and in Spain (Guadalupe, 2003; Benavides et al., 2003; Calderón, 2006; Camino-López et al., 2008). Meanwhile, the smaller companies have poorer physical conditions at the jobsite and thus a higher accident risk among their workers (Beaver, 2003; Fabiano et al., 2004; Calderón, 2006; Sorensen et al., 2007; Camino-López et al., 2008; Hasle et al., 2008).

6. Conclusions

The greenhouse-construction companies of south-eastern Spain can be categorized as small businesses and most as micro-companies, with a mean of 13.3 workers and an annual gross income of 1.56 million euros. Their construction activity is markedly seasonal and it not usual to build from a technical plan. Also, no type of preventive coordination is undertaken in the construction work nor do the companies draw up a health and safety plan. Some 80% of the companies work in construction as contractors or subcontractors, and all claim to provide personal protection gear for the workers, but they also indicate that they adopt no measures for collective protection nor do they provide warning signs at work or work clothes in 40% of the cases. The risk-prevention management is very poor, given that the companies adopt no internationally recognized model of accident-prevention management, although the larger companies manage labour risks more adequately, adopting better safety measures than do small companies.

The overall sampling of companies can be grouped in three clusters: cluster 1 corresponds to the smallest size companies, with a lower gross annual income, a lower number of workers, fewer work teams, generally construct only Almería type greenhouses, and do not hire workers without specific training, and do not provide specific training in preventive health and safety measures. Cluster 2 corresponds to companies of medium size in the number of workers, teams, and income, and construct the Almería type greenhouse as well as the industrial type, and they provide specific preventive training in health and safety. Cluster 3 contains the largest companies in terms of number of workers, number of teams, and gross income, and also construct all types of green-houses in addition to performing other activities involving irriga-tion and sales of agricultural machinery, and they provide specific training in worker health and safety.

Finally, it should be indicated that the administration handling health and safety in the workplace should obligate companies in the sector studied to comply with existing legislation in this sense, since the study reflects the lack of preventive practice, indicating that in general the information and training of company owners, managers, and workers in health and safety in the workplace is insufficient.

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