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Determinants of success for biomedical researchers: a perception-based study in a health science research environment

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Abstract New institutions are coming to the fore as stakeholders in research, particularly hospitals and clinical departments involved in providing health care. As a result, new environments for research are gaining importance. This study aims to investigate how different individual characteristics, together with collective and contextual factors, affect the activity and performance of researchers in the particular setting of hospitals and research centres affiliated with the Spanish National Health System (NHS). We used a combination of quantitative science indicators and perception-based data obtained through a survey of researchers working at NHS hospitals and research centres. Inbreeding and involvement in clinical research is the combination of factors with the greatest influence on scientific productivity, because these factors are associated with increased scientific output both overall as well as in high-impact journals. Ultimately, however, satisfaction with human resources in research group combined with gender (linked in turn to leadership) is the combination of factors associated most clearly with the most relevant indicator of productivity success, i.e. the number of articles in high-impact journals as principal author. Researchers' competitiveness in obtaining research funding as principal investigator is associated with a combination of satisfaction with research autonomy and involvement in clinical research. Researchers' success is not significantly related with their age, seniority and international experience. The way health care institutions manage and combine the factors likely to influence research may be critical for the development and maintenance of research-conducive environments, and ultimately for the success of research carried out in hospitals and other settings within the national public health system.

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Introduction

Researchers' activity and performance are not only dependent on their individual characteristics, but are also associated with organizational context variables as well as interactions between the two (Bland and Ruffin 1992; Guzzo and Dickson 1996; Dundar and Lewis 1998; Bland et al. 2005). Some of these characteristics are gender (Mauleón et al. 2008; van Arensbergen et al. 2012), age (Bonaccorsi and Daraio 2003; Costas and Bordons 2011), family-related factors (Sax et al. 2002), level of specialization (Leahey 2006), academic rank (Bland et al. 2005) and scientists' background and career paths (Fox 1983; Corley 2005; Cruz-Castro and Sanz-Menéndez 2010). Among the collective, contextual, organizational or environmental factors that merit consideration are the organizational and social context (Fox and Mohapatra 2007; Salaran 2010), working environment (Bland and Ruffin 1992; Corley 2005), organizational climate (Louis et al. 2007), work group or department size and characteristics (Bauer et al. 2013), prestige of the institution or department of affiliation (Cole and Cole 1973; Allison and Long 1990), and the resources available for research (Bland and Ruffin 1992; Schuelke-Leech 2013). Other factors of both contextual and individual-psychological significance include researchers' social integration (Smith et al. 1994; Martín-Sempere et al. 2008), well-being at work (Torrisi 2013) and job satisfaction (Hermanowicz 2003; Torrisi 2013).

An in-depth review of the extensive literature and findings on the effects of different demographic, individual or personal characteristics is beyond the scope of this paper. Instead, we refer the reader to the many reviews that have been published (Andrews 1979; Long and Mcginnis 1981; Fox 1983; Bland and Schmitz 1986; Smith et al. 1994; Bland et al. 2005; Dundar and Lewis 1998; Von Tunzelman et al. 2003; Carayol and Matt 2004; Smeby and Try 2005; Rey-Rocha et al. 2006; Huang et al. 2011).

Most research on the determinants of researchers' activity and performance has been done in academic settings. Nevertheless, in recent years new institutions have come to the fore as research centres, thus new contexts and environments for researchers are receiving greater attention. Such is the case of hospitals and clinical departments involved in providing health care, which in some countries are developing as institutions that aim to fully incorporate research as the third element in their three-fold mission of health care provision, education and research (Weber-Main et al. 2013; Rey-Rocha and López-Navarro 2014). The ways in which these institutions manage and combine the factors likely to influence research may be critical for their ability to develop and maintain research-conducive environments, and ultimately for the success of hospital-based research and the overall health system on a nationwide level.

The availability of a supportive research infrastructure, a well-developed research culture and socialization have been identified as important factors for successful research in clinical contexts (Stange 1996; Hueston and Mainous 1996; Kruse et al. 2003). In empirical research of the associations between 11 characteristics of research support infrastructures and measures of research productivity in U.S. Family Practice Residency Programmes, Kruse et al. (2003) demonstrated that "research infrastructure in family medicine training programs" is positively associated with research productivity, but that

such infrastructure is inconsistent across programs and seemingly insufficient to develop the necessary research culture and socialization" (p. 54). This study also provided empirical evidence of the importance of research support professionals for successful research. The authors found that employment of these professionals was associated with first or second authorships and, in large programmes, with the number of manuscripts published in refereed journals, and with number of research proposals funded.

Furthermore, basic researchers working in clinical settings may benefit from interacting with clinical researchers and engaging in translational research. According to Hobin et al. (2012), in addition to improving human health (which can be considered the ultimate goal of translational biomedical research), participating in translational science "has more direct and immediate rewards for individual investigators and the institutions that support their work" (p. 2). For instance, involvement in translational research has been identified has providing benefits such as "gaining access to new funding streams supporting both institutional and individual projects" and "leveraging federal and nonfederal resources" (p. 5). The extent to which involvement in translational research benefits a scientist's academic career was also addressed by Bornstein and Licinio (2011). They reported that researchers who embark on translational projects obtain results that are presumably better suited to generating patents or intellectual property—a situation that drives them to "go beyond the cult of scientific articles in high-profile journals and cumulative impact factors" (p. 1568).

Bland and colleagues developed a model of research-productive organizations (Bland et al. 2005, p. 225) and applied it to their study of a strategy used in a primary care clinical department to increase its collective research productivity (Weber-Main et al. 2013). As drivers of success in the clinical context, they noted the importance of effective leadership, systemic culture change, and self-awareness in facilitating adaptation to changes in the research environment.

Most of these characteristics and factors cannot be measured directly, but only through different proxies and instrumental variables (Schuelke-Leech 2013). One possible approach to identifying these factors is to examine how scientists understand and perceive their environment (Bland and Ruffin 1992; Torrisi 2013; Weber-Main et al. 2013; Leahey and Cain 2013). Their perceptions and understandings can be considered in their own right, i.e. in their psychological dimension, but also as indicators of the quantity and quality of different elements that shape their research environment.

In most experimental research fields, obtaining funding for research projects and the publication of research articles are understood to be among researchers' most important—if not the most important—activities and targets. In fact, many evaluation agencies around the world use indicators based on research projects and articles published in international refereed journals to assess researchers' performance (Jiménez-Contreras et al. 2003; Patel et al. 2011)—even though the advantages and disadvantages of these indicators remain a matter of debate (Brumback 2009; Osuna et al. 2011; DORA 2012). Ultimately, research activity is guided not only by scientific principles, but also, to a great extent, by the evaluation criteria researchers are subjected to. Thus researchers are immersed in an imperative pursuit of the best scores on the particular set of indicators used to evaluate their work (Zamora-Bonilla 2012).

In Spain, substantial efforts are being made to enhance research activities at public hospitals and to turn them into scientific knowledge-generating institutions. One of the actions now being carried out is the Miguel Servet (MS) Research Contract Programme, aimed at incorporating full-time researchers with a mainly basic research background into Spanish National Health System (NHS) hospitals and their associated research centres

(Rey-Rocha and Martín-Sempere 2012). Researchers are supported with a 3-year contract which can be renewed for three more years if their work is evaluated favourably. At the end of this period their research activity and results are evaluated anew for those who wish to apply for a further 5-year contract through the Researcher Stabilization Programme. The recruitment of successful midcareer or senior, high-potential researchers has been identified as one way to increase research productivity in clinical and health care institutions (Weber-Main et al. 2013). The interrelationships of these researchers with the clinical setting are creating new working environments that affect the researchers themselves, clinicians and managers of these institutions. In addition, these novel sets of dynamics give rise to new situations and new challenges in the allocation of resources to research.

This study aims to investigate how different individual characteristics, along with collective and contextual factors, affect individual researchers' performance in the particular setting of hospitals and research centres affiliated with the Spanish NHS. In other words, we aim to identify some of the conditions that are associated with high research performance within the health care environment. The factors involved and the relationships among them can be analysed from different viewpoints. Here we report the findings obtained with a perception-based approach combined with traditional science indicators, and analyse how researchers' perceptions of their environment are related with their research performance. To this end, we address the following questions:

What individual characteristics are related with researchers' activity and performance at the Spanish NHS research centres and hospitals?
How do collective and contextual factors, as perceived by researchers, relate with research activity and performance?

Understanding the characteristics and factors that determine and enhance research activity and performance is of particular importance because it holds the potential to improve decision-making in science policy and R&D management. Once key factors are identified, those which are most likely to improve research activity and the outcomes achievable by individuals in specific settings and environments can be supported. Within this particular scenario, our results may help the Spanish NHS and the Carlos III Institute of Health (the main public institution responsible for funding, managing and carrying out biomedical research in Spain) to manage research resources more effectively, and to design and implement better R&D policies to promote research at NHS centres.

Methodology

Population, data collection and sample

The universe to be studied consisted of all researchers funded by the first eight calls for applications to the MS Programme (1998–2005). This population comprised 367 individuals (52.6 % men) who worked at 66 different hospitals and 22 research centres affiliated with the NHS. The complete list of researchers making up the population and their contact details were provided by the Carlos III Health Institute, which is the institution responsible for managing the MS Programme.

We used a web-based structured questionnaire to obtain data from the researchers. Owing to the size of the population studied, no sampling strategy was used and the whole population was surveyed. The overall response rate was 72.2 % (265 valid answers). The questionnaire, which was pretested in a selected group of scientists from the study

population, consisted of a set of mostly closed items grouped into the following sections: professional setting, type of activity, contribution to the creation of research groups, collaboration and multidisciplinarity, contribution to strengthening research capacity of the host group or department, research results, mobility, reasons for withdrawing from the programme before the end of funding period, and overall assessment of the programme. Researchers were invited to participate through a letter sent by postal mail explaining the reasons for the survey, the principles and objectives of the research, the affiliation of the research team, the funding source and the research strategy. The letter of invitation included a brief description of the research instrument, how the data were to be used and the confidentiality policy. Basic instructions on how to complete the online questionnaire were also provided, and additional information was given in the text introducing the online survey. A total of three reminders were sent to the surveyees. The questionnaire was available between September 2006 and January 2007 for researchers funded by the 1998–2001 calls, and during September and October 2011 for researchers funded by the 2002–2005 calls.

Biographical and research career data were obtained from the researchers' curricula vitae attached to their MS contract application. Data on research competitiveness (participation in and leadership of funded research projects) and scientific production (articles in refereed scientific journals) were obtained from the activity reports submitted by researchers at the end of their contracts.

To ensure a homogeneous sample, in this study we considered only survey respondents who had completed their full contract period and disregarded those who had not reached the end of their contract. The sample is thus constituted by 175 researchers who were employed with an MS programme contract awarded through the calls for applications issued between 1998 and 2005, whose contracts ended between 2005 and 2012, who had completed their 6-year contract, and who responded to the survey. These respondents worked at 46 NHS hospitals and 21 NHS research centres. Most of them held doctorates in biology (50.6 %), medicine and surgery (18.6 %) or pharmacy (12.2 %).

Variables

To obtain a positive evaluation of their 6-year research period, researchers must demonstrate (a) high productivity (in terms of authorship of articles published in high-impact journals) and (b) independence and leadership, which are assessed as: (b.1.) principal investigatorship of funded research projects and (b.2.) first and last authorship of published articles.[1] Accordingly, the activity of MS researchers is assumed to be oriented towards achieving high performance on these indicators. Consistent with these evaluation criteria, MS researchers' success is analysed here in terms of the indicators of productivity, competitiveness and leadership shown in Table 1 and explained below.

In this paper we define researchers' productivity as the number of authorships per researcher per time unit (the 6-year period of scientific activity analysed) in journals covered by the Thomson–Reuters Web of Science (WoS) database. Additionally, we

[1] Authorship position is increasingly used in research production assessment. In the experimental and biomedical sciences, the most widely accepted convention is that the most important positions in the list of authors are the first and the last ones (Savitz 1999; Tscharntke et al. 2007). The first-named author is usually responsible for the experimental work reported in the manuscript, and is often designated the corresponding author. The last-named author is usually assumed to be responsible for supervision and leadership of the research team, and this by-line position is often occupied by the most senior author (Moed 2000; Costas and Bordons 2011).

Table 1 Description of the variables and descriptive statistics

Dependent variables	Description	Descriptive statistics
Indicators of research productivity and competitiveness		Average ± standard deviation (range) median
Art-N	Number of articles per researcher in refereed journals with impact factor included in the Web of Science (WoS) during the 6-year contract period	14.1 ± 9.5 (0–53) 12 (Only one researcher reported no articles published)
Art-Q1	Number of articles per researcher in journals ranked in the first quartile of their subject category in Journal Citation Reports (JCR)	8.7 ± 6.0 (0–32) 7
Art-FL	Number of WoS articles per researcher as the first or last author	5.7 ± 5.3 (0-38) 4
Art-Q1-FL	Number of WoS articles per researcher in first-quartile journals as a first or last author	3.3 ± 3.0 (0-14) 3
Proj-N	Number of participations in funded research projects	8.9 ± 5.6 (1-54) 8
Proj-PR	Number of funded research projects as principal investigator	3.8 ± 3.5 (0-37) 3
Independent variables	**Description**	**Percentages**
Gender		Male 53.7 %/Female 46.3 %
Research career		
Seniority	Time since doctoral degree obtained	Years: 5.8 ± 3.2 (0-18) 5.5
Stays abroad	Academic stays abroad (predoctoral or postdoctoral) before obtaining an MS contract	Yes 78.2 %/No 21.8 %
Mobility to a different centre	Moving to a different centre upon obtaining an MS contract or remaining at the same centre	Yes 50.0 %/No 50.0 %
Previous work in the host group or unit (Inbred status)	Previous work in the host group or unit (predoctoral, postdoctoral or any other time)	Yes 63.2 %/No 36.8 %
Research activity		
Full-time researcher	Response to the question: During your MS contract, were you involved full-time in tasks related with your research? (including laboratory work, graduate training, writing articles, etc.) One of the following: Yes, I worked full-time in research No, I combined research with other tasks	Yes 74.3 %/No 25.7 %

Table 1 continued

Dependent variables	Description	Descriptive statistics
Type of research	Response to the question:	Basic (exclusively): 53.3 %
	Please describe the type of research you undertook during your MS contract, according to the following categories	Clinical (exclusively): 9.5 %
		Both: 37.3 %
	One or more options:	
	Basic; Clinical; Other	
Contextual factors		
Incorporation in a host group	Response to the question:	Yes 78.3 %/No 21.7 %
	Please indicate whether you joined a host group when you were hired as an MS researcher	
	One of the following:	
	Yes, I joined a group	
	No, I did not join a group	
Leadership of a research group	Response to the question:	Yes, leader of a new research group: 64.6 %
	Has your incorporation in the host department or centre led to the creation of new research groups?	No, member of a new or existing group : 35.4 %
	One of the following:	
	Yes, my incorporation has led to the creation of a new research group I lead	
	Yes, a new group has been created, of which I am a member	
	No, I stayed in an existing group	
Satisfaction with job conditions	Response to the question:	
	Please value your level of satisfaction with the following job conditions during your MS contract	
	Scale: 1 = very unsatisfied; 2 = fairly unsatisfied; 3 = neutral; 4 = fairly satisfied; 5 = very satisfied	%1+2/%3/%4+5
	Scientific quality of the host group	7.6/24.8/67.5
	Scientific quality of the host centre	12.3/33.3/54.4
	Research autonomy in developing your research line	5.7/12.0/82.3
	Decision-making capacity	6.9/14.9/78.3

Table 1 continued

Dependent variables	Description	Descriptive statistics
	Leadership	6.3/18.9/74.9
	Conditions of the available facilities	27.4/28.0/44.6
	Job stability expectations	24.1/30.0/45.9
Satisfaction with resources	Response to the question:	
	Please rate your level of satisfaction with the resources available to carry out your research activity during your MS contract	
	Scale: 1 = very unsatisfied; 2 = fairly unsatisfied; 3 = neutral; 4 = fairly satisfied; 5 = very satisfied	%1+2/%3/%4+5
	Human resources: technical and support staff	42.5/26.3/31.1
	Human resources: researchers in training	29.3/30.5/40.2
	Small inventoriable equipment: computer equipment, small devices	12.1/23.6/64.4
	Access to large scientific equipment and facilities	18.2/30.6/51.2
	Raw materials: reagents, etc.	10.5/22.7/66.9
	Facilities: animal facility, microscopy, etc.	21.0/31.8/47.1
	Research materials: animals, tissues, etc.	14.0/29.3/56.7
	Infrastructures: laboratories and similar areas	24.7/29.4/45.9
	Infrastructures: offices, meeting rooms, etc.	36.6/29.1/34.3
	Support and service units: computing service, library, statistics, etc.	30.6/35.8/33.5
	Economic resources	27.4/27.4/45.1

considered articles published in first-quartile (Q1) journals, i.e. journals listed in the top 25 % of their Thomson–Reuters Journal Citation Reports (JCR) subject category when ranked by their impact factor (IF). Most of the work done by these researchers is multidisciplinary, so a given research paper could not always be associated to a single JCR subject category. For papers published in journals that are included in two or more different subject categories with a different quartile for each category, the most favourable quartile was used (i.e. the first quartile instead of the second, and so on). We used quartiles instead of the IF because referring to quartiles "increases correct assessments and fair comparisons" (Bornmann and Marx 2013, p. 226). The problems and distortions arising from the use of the IF to evaluate individual researchers' work have been widely discussed in the literature (Garfield 2001; Alberts 2013). Although authorship of articles published in WoS journals and Q1-JCR journals does not measure the quality of articles, it does capture the researcher's capacity to conduct and publish peer-reviewed research and to publish it in highly ranked journals.

Competitiveness in scientific research can be understood and assessed in different ways. One approach is to consider success in the competition for funding as an indicator of researchers' capabilities, effort and competitiveness (García and Sanz-Menéndez 2005). In this study the indicators of competitiveness that we used were the number of funded research project MS researchers participated in, and the number of projects they led as principal investigator. This latter was also used as an indicator of leadership. As another way to address competitiveness, we considered researchers' success in their competition to publish in international refereed journals. Accordingly, indicators of scientific productivity noted above were also considered indicators of competitiveness.

Researchers were surveyed about different aspect of their research activity and their beliefs, perceptions, judgements and feelings about this activity and its organizational context. The questionnaire measured different aspects related to the work they performed and satisfaction with job conditions, resources available for research, relationships with colleagues, job identity and leadership. Additionally, curricula vitae attached to applications for an MS contract provided data on researchers' characteristics and career prior to their MS contract regarding seniority, stays abroad and previous job relationships with the host group or centre.

Scientific performance and academic achievement have been found to be associated with mobility, whereas inbreeding in academia is, in many countries, a less-favoured practice associated with negative consequences including decreased scientific production (for a review, see Cruz-Castro and Sanz-Menéndez 2010). Inbreeding is usually considered the recruitment of people from the same department or institution which trained them or awarded them their doctorate. Here we extend the concept of inbreeding and use two different indicators of inbreeding/mobility: the recruitment of researchers who (a) applied to the same centre they were already working in, or (b) had previously worked in the host group or unit (during predoctoral or postdoctoral work, or at any other time).

Researchers' autonomy and leadership were analysed through a single variable combining assessments of the level of satisfaction with research autonomy, decision-making capacity and leadership (see Table 1, variable 'satisfaction with job conditions', items 3, 4 and 5). This new variable was calculated by adding the scores of the three items that comprised the original variable, and then standardizing the resulting value by subtracting the mean and dividing it by the standard deviation of the distribution of the sum of variables. The resulting variable was recoded as one of the following: Values below 1 were assigned a score of 1 = unsatisfied; values between −1 and 1 were assigned a score of 2 = neutral, and values above 1 were assigned a score of 3 = satisfied.

The different categories for the item on satisfaction with available resources were described in terms of the following variables:

Human resources: technical and support staff and researchers in training (see Table 1, variable 'satisfaction with resources', items 1 and 2)
Material resources: equipment, facilities, infrastructures and research materials (items 3–9)
Support and service units (item 10)
Economic resources (item 11)

To calculate the value of the first two variables, we proceeded as with the previous variable. For variables with a single item, the "very unsatisfied" and "fairly unsatisfied" survey responses comprised the "unsatisfied" category, and the "very satisfied" and "fairly satisfied" responses comprised the "satisfied" category.

Basic descriptive statistics for all variables are provided in Table 1.

Data analysis

Descriptive statistical analyses were conducted to identify the basic indicators and determine the distribution of dependent and independent variables. Descriptive univariate tests were used to identify differences in research productivity and competitiveness associated with different values for the independent variables. In order to identify systematic differences between means values for paired samples, we used Student's t test with Bonferroni correction.

One-way between-subject analysis of variance (ANOVA) was conducted to compare the effects of independent variables on the dependent variables. The initial ANOVA included all independent variables that yielded significant differences in the univariate analysis; then less significant variables were removed in a step-wise manner in order to obtain a model in which all variables were significant. If this was not possible, the process is stopped when three independent variables remained in the model. All data were analysed with the Statistical Package for Social Sciences (SPSS) for Windows, version 21.0.

Results

Table 2 summarizes the results of the univariate analysis of differences between the means for paired samples. No significant differences were found in any of the characteristics of scientific success for the following independent variables: (a) seniority of MS researchers, (b) whether or not they had academic stays abroad prior to their MS contract, (c) whether or not they joined an existing group as an MS researcher, (d) whether they worked full-time on research during their contract or combined research with other tasks, and their satisfaction with (e) the conditions of the available facilities, (f) job stability expectations, (g) material resources at their disposal, (h) support and service units, and (i) economic resources.

Productivity in terms of WoS articles (art-N) was influenced by the extent to which individuals were able to follow a more or less mobile or an inbred employment path as an MS researcher. Although most MS researchers had a mobile career path thanks to their previous stays abroad, they followed different pathways regarding their relationship with the host group, unit or centre. Both researchers who obtained an MS contract for work at the same centre they were already working in and those who joined a group they had

Table 2 Summary of significant differences

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
		Average (*)					
Gender (n = 175)							
Male	81	15.0[a]	9.5[a]	6.5[a]	**3.9[b]**	9.5[a]	4.3[a]
Female	94	13.3[a]	8.1[a]	5.0[a]	**2.9[a]**	8.3[a]	3.4[a]
Seniority (n = 172)							
(Figures indicate Pearson correlation and significance)		−.1 (.3)	−.1 (.2)	.1 (.4)	.1 (.1)	−.05 (.5)	−.06 (.4)
Stays abroad (n = 165)							
Yes	129	13.1[a]	8.3[a]	5.3[a]	3.1[a]	8.5[a]	3.7[a]
No	36	16.5[a]	10.0[a]	6.3[a]	3.9[a]	10.4[a]	4.5[a]
Mobility to a different centre (n = 172)							
Yes	86	**11.4[a]**	**7.2[a]**	5.0[a]	3.0[a]	8.4[a]	3.6[a]
No	86	**17.0b**	**10.4[b]**	6.5[a]	3.7[a]	9.5[a]	4.0[a]
Previous work in the host group or unit (Inbred status) (n = 174)							
Yes	110	**15.6[b]**	**9.7[b]**	6.1[a]	3.5[a]	9.0[a]	3.8[a]
No	64	**11.5[a]**	**6.9[a]**	4.8[a]	2.9[a]	8.7[a]	3.8[a]
Full-time dedication to research (n = 175)							
Yes	130	14.1[a]	8.6[a]	6.0[a]	3.5[a]	8.8[a]	3.7[a]
No	45	14.2[a]	9.0[a]	4.8[a]	2.8[a]	9.0[a]	3.9[a]
Type of research (n = 169)							
Basic	90	**11.6[a]**	**7.4[a]**	4.9[a]	2.9[a]	**7.4[a]**	**3.3[a]**
Clinical	16	**19.4[b]**	**11.9[b]**	7.2[a]	4.0[a]	**12.5[b]**	**6.5[b]**
Both	63	**16.0[b]**	**9.6[b]**	6.0[a]	3.6[a]	**10.2[b]**	**3.8[a]**
Incorporation in a host group (n = 175)							
Yes	137	14.8[a]	9.0[a]	5.7[a]	3.3[a]	9.1[a]	3.7[a]
No	38	11.7[a]	7.8[a]	5.6[a]	3.5[a]	8.1[a]	4.2[a]

Table 2 continued

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
Satisfaction with job conditions							
Scientific quality of the host group (n = 157)							
Satisfied	21	**16.7**[b]	**10.27**[b]	**6.8**[b]	**3.9**[b]	9.4[a]	3.7[a]
Neutral	57	**10.3**[a]	**6.31**[a]	**3.7**[a]	**2.5**[a]	7.5[a]	3.4[a]
Unsatisfied	93	11.7[a,b]	6.42[a,b]	3.7[a,b]	2.1[a,b]	10.5[a]	4.5[a]
Scientific quality of the host centre (n = 171)							
Satisfied	12	15.8[a]	**10.1**[b]	**6.8**[b]	**4.1**[b]	9.2[a]	3.9[a]
Neutral	39	13.1[a]	**7.6**[a]	4.8[a,b]	**2.7**[a]	8.5[a]	3.5[a]
Unsatisfied	106	10.4[a]	**6.5**[a]	**3.2**[a]	**2.2**[a]	8.9[a]	4.1[a]
Research autonomy, decision-making capacity and leadership (n = 175)							
Satisfied	56	15.2[a]	9.2[a]	**7.4**[b]	**4.1**[b]	9.8[a]	**4.9**[b]
Neutral	96	13.9[a]	8.9[a]	**5.1**[a]	3.2[a,b]	8.5[a]	**3.4**[a]
Unsatisfied	23	12.2[a]	6.6[a]	**4.0**[a]	**2.3**[a]	8.2[a]	**2.6**[a]
Conditions of the facilities available (n = 175)							
Satisfied	48	14.0[a]	8.7[a]	6.1[a]	3.4[a]	8.7[a]	3.6[a]
Neutral	49	12.7[a]	7.9[a]	5.0[a]	3.1[a]	8.7[a]	4.0[a]
Unsatisfied	78	15.6[a]	9.6[a]	5.6[a]	3.6[a]	9.3[a]	3.9[a]
Job stability expectations (n = 170)							
Satisfied	41	14.5[a]	8.5[a]	5.9[a]	3.6[a]	9.1[a]	3.7[a]
Neutral	51	13.4[a]	8.1[a]	5.8[a]	3.3[a]	8.7[a]	3.3[a]
Unsatisfied	78	14.5[a]	9.4[a]	5.4[a]	3.1[a]	8.6[a]	4.1[a]
Satisfaction with resources							
Human resources: technical and support staff and researchers in training (n = 166)							
Satisfied	40	**17.4**[b]	**10.6**[b]	**7.9**[b]	**4.7**[b]	**10.3**[b]	4.5[a]
Neutral	105	**13.3**[a]	8.5[a,b]	**4.9**[a]	**3.1**[a]	8.8[a,b]	3.5[a]
Unsatisfied	21	**10.6**[a]	**6.1**[a]	**3.8**[a]	**1.9**[a]	**7.0**[a]	3.8[a]

Table 2 continued

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
Material resources: equipment, facilities, infrastructures and research materials (n = 146)							
Satisfied	17	12.7[a]	9.2[a]	5.1[a]	3.4[a]	8.2[a]	3.6[a,b]
Neutral	103	12.9[a]	8.0[a]	5.1[a]	2.9[a]	8.4[a]	**3.4[b]**
Unsatisfied	23	11.5[a]	7.1[a]	4.7[a]	3.0[a]	9.8[a]	**4.6a**
Support and service units (n = 173)							
Satisfied	7	14.1[a]	8.9[a]	4.9[a]	3.3[a]	11.9[a]	3.7[a]
Neutral	149	14.3[a]	8.8[a]	5.8[a]	3.4[a]	8.8[a]	3.8[a]
Unsatisfied	17	13.3[a]	8.5[a]	5.3[a]	3.3[a]	9.6[a]	4.1[a]
Economic resources (n = 175)							
Satisfied	14	13.3[a]	8.6[a]	6.1[a]	3.5[a]	9.0[a]	3.9[a]
Neutral	113	15.0[a]	9.4[a]	5.6[a]	3.3[a]	9.3[a]	3.7[a]
Unsatisfied	48	12.1[a]	7.3[a]	5.6[a]	3.4[a]	7.8[a]	3.8[a]
Leadership of a research group (n = 168)							
Yes. Leader of a new group	113	14.6[a]	9.1[a]	**6.7[a]**	**4.0[a]**	9.1[a]	**4.3[a]**
No. Member of a group	55	12.6[a]	7.5[a]	**3.8[b]**	**2.1[b]**	8.2[a]	**2.7[b]**

Mean values were compared with Student's *t* test and Bonferroni correction

Values in the same column and sub table not sharing the same superscript (a or b) are significantly different at $p < 0.05$ in the two-sided test of equality for column means, assuming equal variance

* Descriptive statistics [Average ± standard deviation (range) median] are shown in Table 4 in Appendix 1 section

Bold values indicate statistically significant differences

previously worked with published significantly more articles than mobile researchers, and a higher number of articles than those who joined a group they had not previously worked with. Productivity measured in terms of WoS articles was also associated with the type of research, such that clinical research, either alone or in combination with basic research, was associated with a higher number of papers. In addition, increased productivity was associated with researchers' satisfaction with the human resources available. Researchers' perception of the quality of their host group was also associated with scientific output, although there was no clear trend in terms of increased productivity. A similar pattern regarding satisfaction with the scientific quality of host group was observed in our analysis of the variables 'publication in highly-ranked first-quartile journals' (art-Q1), 'first or last authorship' (art-FL) and 'publication in first-quartile journals as first or last author' (art-Q1-FL).

Increased publication of articles in highly ranked first-quartile journals (art-Q1) was associated with a non-mobile (inbred) career path, clinical research and satisfaction with the human resources available as well as with the scientific quality of the host centre.

First or last authorship (art-FL) was associated with a satisfaction with i) the scientific quality of the host centre and ii) the human resources available. As expected, it was also closely associated with leadership, such that researchers who were group leaders and those who were satisfied with their research autonomy, decision-making capacity and leadership were first or last authors on a significantly higher number of articles.

The most highly valued publications were those published in first-quartile journals as the first or last author (art-Q1-FL). As expected, the number of these articles was associated with both indicators of leadership, i.e. leading a new research group and satisfaction with the degree of research autonomy, decision-making capacity and leadership. It was also related with gender, which in turn was found to be highly linked to leadership. Thus, men published a significantly higher number of art-Q1-FL than women, mainly because the former were more often independent research group leaders (79 % of men vs. 52.1 % of women; significant differences: Chi squared = 14.462, p value = 0.000). Moreover, satisfaction with the human resources available and with the quality of the host centre were also associated with increased art-Q1-FL productivity.

Participation in funded projects was positively associated with involvement in clinical research, and to some extent with satisfaction with the human resources. In addition, researchers' participation as principal investigator of a funded research project was also associated with clinical research, and (unsurprisingly) with autonomy and leadership.

Table 3 summarizes the results of the ANOVA for each of the dependent variables. These findings explained between 11 and 16 % (R-squared value) of the variance. Detailed ANOVA results for each of the dependent variables are shown in the Tables 5–10 in Appendix 2 section. As shown in Table 3, different variables were associated with increased scientific productivity, and with participation in and obtaining funding for research projects. Productivity was associated, to various extents, with the following independent variables depending on the productivity indicator considered: moving to a different centre, type of research, satisfaction with human resources, and gender. Most of these indicators did not appear to be associated with participation in research projects. The exception was type of research, which was the only independent variable associated with participation in research projects. Together with satisfaction with autonomy, decision-making capacity and leadership were the variables that had the largest positive associations with success in obtaining research funding as the principal investigator.

Regarding scientific productivity, inbreeding was associated with publication of a greater number of articles, both overall as well as in Q1 journals, and with increased first or

Table 3 Summary of ANOVA models

	Tests of between-subjects effects				
	Denominator df	Numerator df	F statistic	p value	R squared
Art-N (articles in WoS journals)					
Corrected model	153	5	5.9	.000	.16
Mobility to a different centre		1	8.4	.004	
Type of research		2	5.4	.005	
Satisfaction with human resources		2	3.4	.037	
Art-Q1 (articles in JCR first-quartile journals)					
Corrected model	161	4	6.1	.000	.13
Mobility to a different centre		1	9.4	.003	
Type of research		2	4.1	.019	
Gender		1	4.4	.038	
Art-FL (first and last authorships in WoS journals)					
Corrected model	160	4	5.0	.001	.11
Satisfaction with human resources		2	5.9	.003	
Mobility to a different centre		1	4.2	.042	
Gender		1	3.1	.078	
Art-Q1-FL (articles in first-quartile journals as first or last author)					
Corrected model	156	5	4.8	.000	.13
Satisfaction with human resources		2	3.8	.024	
Gender		1	4.8	.030	
Satisfaction with scientific quality of the host centre		2	2.0	.136	
Proj-N (participation in funded research projects)					
Corrected model	156	5	5.7	.000	.15
Type of research		2	10.0	.000	
Satisfaction with human resources		2	2.5	.082	
Gender		1	2.6	.111	
Proj-PR (research projects funded as principal investigator)					
Corrected model	163	5	5.8	.000	.15
Type of research		2	7.1	.001	
Satisfaction with autonomy, decision-making capacity and leadership		2	5.5	.005	
Gender		1	3.7	.057	

last authorship. Together with satisfaction with human resources, inbreeding was associated with increased first or last authorship. The combination of inbreeding, satisfaction with human resources and clinical research was associated with increased overall scientific output. Inbreeding combined with male gender and clinical research was associated with increased productivity in Q1 journals.

Researchers' gender and satisfaction with human resources were the factors with the strongest association with increased first or last authorship of articles in Q1 journals. Researchers who were less satisfied with human resources produced on average about 1 article less than those who were moderately satisfied ($\beta = -1.2$) and 2 articles less than those

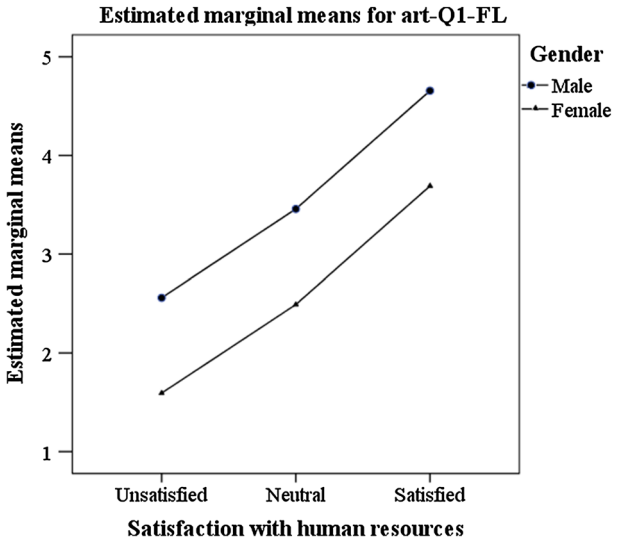

Fig. 1 Profile plot of the estimated marginal means for the variable art-Q1-FL

who were satisfied (β = −2.1) (see Table 8 in Appendix 2 section). This pattern was similar for both genders, bearing in mind that men published, on average, 1 art-Q1-FL more than women (β = 1.0). In summary, increased productivity of Q1 articles as the first or last author was favoured by male gender and satisfaction with the human resources available (Fig. 1).

Participation in a research project as part of the team, especially as the principal investigator, were both related with the type of research done during the contract period (Table 3). Compared to researchers involved in basic research only, those who combined basic and clinical research participated in almost three more projects, and those involved exclusively in clinical research participated in almost six more projects (1 per year) (β values: basic = −5.7; basic and clinical = −2.9; clinical = 0; see Table 9 in Appendix 2 section). Responsibility for projects as the principal investigator was positively associated with clinical research and satisfaction with research autonomy, decision-making capacity and leadership (Fig. 2). Compared to researchers who worked in clinical research only, those who combined clinical with basic research participated in about three fewer projects (β = − 2.8) and those who worked only in basic research participated in about three fewer projects (β = − 3.3). In comparison to researchers who were satisfied with their research autonomy, decision-making capacity and leadership, those who were unsatisfied were principal investigators for about two fewer projects (β = − 2.3) and those who were fairly satisfied were principal investigators for about 1.5 fewer projects (β = −1.6) (see Table 10 in Appendix 2 section).

Discussion and conclusions

In this paper we analyse, in the particular setting of health care and research centres of the Spanish NHS, how different individual characteristics combined with collective and contextual factors determine research achievement and success as measured in terms of competitiveness and productivity.

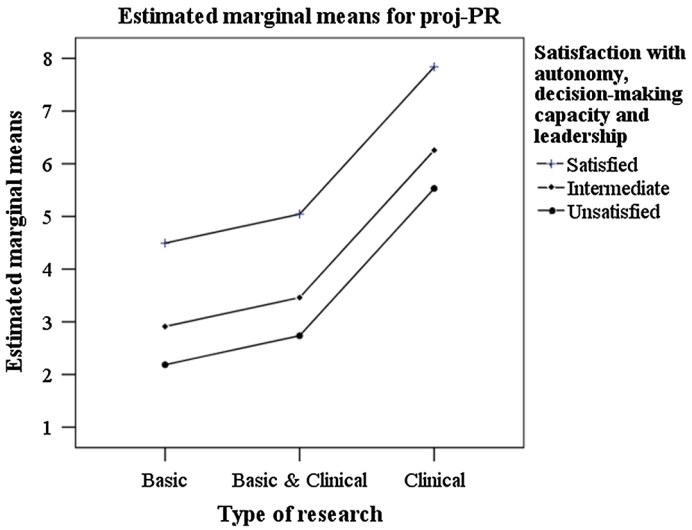

Fig. 2 Profile plot of the estimated marginal means for the variable proj-PR

Individual characteristics: gender

In the research reported here, individual characteristics of researchers were found to be less relevant than their environment. Neither seniority nor researchers' international experience had any statistically significant effect on their research success during their 6-year MS contract. Gender was the most relevant personal characteristic, showing some association with their research success. Gender differences in scientific productivity have been widely reported in the literature, although in some cases these differences appeared to be diluted in younger generations (Mauleón et al. 2008; van Arensbergen et al. 2012). Our results show that gender was a strong predictor of productivity in high-impact journals for principal (first or last) authors. This finding should be viewed from a more contextual or cultural perspective rather than as simply a characteristic of individual researchers. Many authors have noted gender differences in the social organization of science, as manifested by discriminatory mechanisms and differences in power, authority, income, selection and recruitment procedures, productivity, and grant allocation procedures (Xie and Shauman 2004; Mauleón et al. 2008; van Arensbergen et al. 2012). Therefore, our results in the Spanish setting may be interpreted within the framework of the inverse relationship between female gender and leadership. Our results show that the proportion of women who eventually become leaders of new research groups was smaller compared to men, so it is unsurprising that women were less likely than men to act as the first or last author of articles published in highly ranked journals.

Individual characteristics: mobility and inbreeding

Mobility and inbreeding (as well as gender and seniority) are characteristics inherent to candidates at the time they apply for an MS contract; in contrast, the rest of the variables relate to their situation during their employment under the contract. These "givens" can thus be considered as a priori predictors of research success. Although MS researchers were

embedded in a context of widespread mobility (most of them had spent time at foreign centres before applying for an MS contract), an unexpected finding was that time abroad did not seem to favour scientific productivity in MS researchers, at least not in the short term. This was surprising because stays abroad are expected to have a positive effect on the participants' research capacity and expertise, as well as on their linguistic proficiency with the use of English for academic purposes. These enhanced skills are assumed to facilitate writing papers for publication in English-medium scientific journals. Our results show that inbreeding was positively associated with productivity, such that employment at the same centre where the researcher was already working in increased the likelihood of being productive in terms of total number of articles, articles in first-quartile journals and first or last authorship. Nevertheless, recruitment inbreeding was not found to be a predictor of first or last authorship in highly ranked, first-quartile journals, or of obtaining project funding as principal investigator. Nevertheless, these results should be regarded with caution because they may disguise what may simply be delays in the increase in productivity of researchers with experience abroad. These delays may reflect the cost of certain environmental disadvantages borne by non-inbred researchers. In this regard, different authors have noted that the higher organizational transaction costs of non-inbred researchers make them less likely to be involved in previous work by the group and less likely to co-author papers produced by the group (Cruz-Castro and Sanz-Menéndez 2010). An additional consideration is the high cost incurred by efforts to reactivate professional networks once they return, along with the costs of becoming fully integrated in new networks and new groups (Musselin 2004). Moreover, returning researchers face difficulties in adapting to the Spanish R&D system, particularly if they previously worked in countries with systems characterized by (among other features) a more open labour market, easier mobility, greater participation of the private sector in R&D funding, and less bureaucratization than the Spanish R&D system (Gutiérrez-Fuentes and Puerta López-Cózar 2003; EC 2006; OECD 2007; Sanz-Menéndez and Cruz-Castro 2010).

The predominant role of environmental factors

Aside from individual characteristics, the characteristics of the environment, i.e. collective and contextual factors as perceived by researchers themselves, play an important role and interact to produce specific conditions under which research productivity and competitiveness are enhanced. This predominance of environmental factors over personal characteristics was reported by Bland and Ruffin (1992) in their review of the literature on research productivity, where they pointed out that "personal characteristics are essential but insufficient by themselves". In addition to having certain personal characteristics, researchers "must work in environments conductive to research" in order to be productive (p. 386). This was subsequently corroborated in several other studies (Louis et al. 2007, Heinze et al. 2009; Schuelke-Leech 2013).

The importance of human capital

For researchers, attaining sufficient human resources (in both qualitative and quantitative terms) within their group and unit is a cumbersome requisite for success. Previous research has supported the importance of human resources (including colleagues, graduate students, post-graduates, research assistants and support staff) for the effectiveness of research groups, units and individual researchers (Ziman 1989; Bland and Ruffin 1992; Johnston 1994; Rey-Rocha et al. 2006). Kruse et al. (2003) found employment of full-time research support professionals to be the only characteristic associated with research productivity in both large and small U.S. family practice residency programmes. The results reported here

are consistent with these previous studies, and also point to the importance of human capital not only for achieving high productivity, but for succeeding as the principal author of articles in highly ranked journals. Main authorship is more closely linked to the availability of technical and support staff and researchers-in-training than with the availability of economic and material resources, services and support units.

Leadership

Our results also show leadership to be related with productivity as principal author of articles in first-quartile journals, particularly in terms of competitiveness for research funds as principal investigator. Leadership has been acknowledged as "one of the most essential characteristics of research-productive organizations" (Weber-Main et al. 2013). In their literature review, Bland and Ruffin (1992) reported leadership to be the most influential organizational variable, and that some forms of leadership and governance were more likely than others to have a positive effect on research performance. Our results confirm leadership as a factor closely associated with competitiveness for research funds, if leadership is understood not only as being the leader of a research group, but also as the researcher's satisfaction with his or her autonomy, decision-making capacity and leadership.

Involvement in basic, clinical or translational research

Engagement in either basic or clinical research emerged as particularly relevant. As we have seen, a researcher's productivity (both overall and in highly ranked journals) and competition for research funds are related with the type of research (basic or clinical) they do. In this connection, our results show that researchers with a background mainly in basic research obtain opportunities to become more productive as a result of their participation in clinical research and collaboration with clinical researchers in the setting of NHS health care and research centres. Our data can thus be viewed as implicitly supporting the increasing relevance of translational research. One possible explanation for this situation is that clinical research in the NHS makes study material readily available, so that researchers need to spend less time and effort on fieldwork to collect and prepare samples and data, which in turn enables them to be more productive. In addition, relationships between basic and clinical researchers and health care professionals may generate favourable contexts for translational research (Hobin et al. 2012; Rey-Rocha and Martín-Sempere 2012), i.e. for the transfer of scientific knowledge from basic research to clinical practice; and the generation of biomedical research questions based on clinical practice—processes which benefit both researchers and research institutions (Rodés and Mayor 2003; Lander and Atkinson-Grosjean 2011). Although translational researchers have sometimes found it challenging to publish translational research and to be evaluated favourably by tenure and promotion committees (Bornstein and Licinio 2011; Hobin et al. 2012), in the health care environment studied here, clinical research (and probably also translational research) can be an incentive for researchers as it favours productivity and competitiveness.

Summary of results

In summary, scientific productivity in the researchers we surveyed is associated with a combination of different factors. The factors most clearly associated with increased numbers of publications are the combination of inbreeding, clinical research and belonging

to a research group that is well equipped in terms of human resources. However, the results of the multivariate analysis are ambiguous in terms of their ability to explain the influence of individual characteristics and other contextual factors on research success. The combination of inbreeding and clinical research shows the strongest association with productivity both in general and in terms of the number of publications in high-impact journals. Ultimately, however, the combination most clearly associated with scientific productivity is satisfaction with the human resources in the group together with gender (linked to leadership): together, these factors are clearly associated with increased numbers of publications in high-impact journals as the principal author.

Involvement in clinical research is related with increased participation in research projects, and the combination of clinical research with leadership (particularly with researcher satisfaction with his or her level of autonomy, decision-making capacity and leadership) gives rise to a contextual setting that increases the chances of successful competition for research funding.

Limitations

A few limitations of the study should be noted. First, the data collected and used for all analyses were self-reported, and external independent verification is lacking. Secondly, although our ANOVA models do not explain a high percentage of variance in the dependent variables and the coefficients are small, they nonetheless identify the main factors associated with researchers' enhanced productivity and competitiveness, and the relative contributions of these characteristics. It is important to consider that scientific research and scientific success are multidimensional phenomena that comprise and at the same time are influenced by many different factors—only some of which have been considered in this report. Accordingly, the effects of possible interactions among these factors may influence the results and their interpretation. Finally, particular caution is needed when interpreting the relationships between variables, as they are not necessarily causal.

Further research

Additional research with qualitative and mixed-methods approaches will help to identify the different factors, as well as their correlates and determinants, that influence scientific achievement and ultimately the researchers' success in the health care setting. Some factors that merit additional study are collaboration, novelty, originality, adaptability, and the usefulness and utility of results that are to be transferred to health care practise.

Implications for science policy

The results of this analysis suggest some recommendations for science policy which may be directly applicable to the MS programme, as well as to NHS hospitals and research centres that wish to develop or implement a research agenda. Experiences gained at such centres can serve as a reference for other programmes and institutions of similar characteristics. Investing in human resources for research, and favouring actions that allow researchers to have closer contact with clinical research and provide them with the required level of autonomy and leadership, are measures with potential to improve research competitiveness and productivity in health system environments. Our results suggest that it may therefore be advisable to implement measures aimed at encouraging the incorporation

of women as research group leaders, as a way to fight gender inequity in the access to positions of greater scientific responsibility. Finally, given that innovation and contributing to economic and social development have become part of the mission of many health care institutions (Rey-Rocha and López-Navarro 2014), it is imperative that policies to promote research at hospitals and health care centres do not simultaneously deter researchers' involvement with health care and clinical practise, and ultimately with translational research.

We should, however, not lose sight of the fact that efforts to enhance research per se together with research management strategies are necessarily context-dependent, and must be "informed by an assessment of local needs and environmental conditions likely to influence success" (Weber-Main et al. 2013). Furthermore, successful measures intended to facilitate research success must be dynamic and adaptive (Weber-Main et al. 2013), therefore it is important for management and policy actions to be developed and refined in the light of knowledge gained from evaluations. In this regard, the conclusions and recommendations of our study should be considered within the framework of its context specificity, and caution must be exercised in drawing generalizations and inferences for other researchers and other R&D frameworks.

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Appendix 1

See Table 4.

Appendix 2

See Tables 5, 6, 7, 8, 9, 10.

Table 4 Descriptive statistics

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
		Average ± standard deviation (range) median					
Gender (n = 175)							
Male	81	15.0 ± 10.2 (0–42) 12	9.5 ± 6.7 (0–32) 8	6.5 ± 6.6 (0–38) 4	3.9 ± 3.6 (0–14) 3	9.5 ± 6.8 (2–54) 9	4.3 ± 4.6 (0–37) 3
Female	94	13.3 ± 8.8 (1–53) 11	8.1 ± 5.4 (0–32) 7	5.0 ± 3.6 (0–18) 4	2.9 ± 2.1 (0–12) 3	8.3 ± 4.2 (1–18) 8	3.4 ± 2.1 (0–10) 3
Seniority (n = 172)							
(Figures indicate Pearson correlation and significance)		–.1 (.3)	–.1 (.2)	.1 (.4)	.1 (.1)	–.05 (.5)	–.06 (.4)
Stays abroad (n = 165)							
Yes	129	13.1 ± 8.7 (0–42) 11	8.3 ± 5.8 (0–32) 7	5.3 ± 5.0 (0–38) 4	3.1 ± 2.6 (0–14) 3	8.5 ± 4.6 (1–29) 8	3.7 ± 2.5 (0–12) 3
No	36	16.5 ± 11.4 (2–53) 12.5	10.0 ± 7.0 (1–32) 8.5	6.3 ± 5.3 (0–21) 4	3.9 ± 3.8 (0–14) 3	10.4 ± 8.3 (3–54) 9.5	4.5 ± 5.9 (1–37) 3
Mobility to a different centre (n = 172)							
Yes	86	11.4 ± 7.6 (1–42) 10	7.2 ± 4.4 (0–25) 6	5.0 ± 5.0 (0–38) 4	3.0 ± 2.7 (0-12) 3	8.4 ± 3.9 (2–22) 8	3.6 ± 2.1 (0–12) 3
No	86	17.0 ± 10.4 (2–53) 15.5	10.4 ± 7.0 (0–32) 9	6.5 ± 5.5 (0–27) 5	3.7 ± 3.2 (0–14) 3	9.5 ± 6.9 (1–54) 9	4.0 ± 4.5 (0–37) 3
Previous work in the host group or unit (Inbred status) (n = 174)							
Yes	110	15.6 ± 10.1 (2–53) 14	9.7 ± 6.7 (0–32) 8	6.1 ± 5.6 (0–38) 4	3.5 ± 3.1 (0–14) 3	9.0 ± 6.2 (1–54) 8	3.8 ± 4.0 (0–37) 3
No	64	11.5 ± 7.8 (0–35) 10	6.9 ± 4.3 (0–18) 6	4.8 ± 4.5 (0–27) 4	2.9 ± 2.6 (0–13) 2.5	8.7 ± 4.3 (2–22) 8	3.8 ± 2.2 (0–12) 3
Full–time dedication to research (n = 175)							
Yes	130	14.1 ± 8.9 (1–42) 12	8.6 ± 5.6 (0–32) 7	6.0 ± 5.6 (0–38) 4	3.5 ± 3.0 (0–14) 3	8.8 ± 6.0 (1–54) 8	3.7 ± 3.7 (0–37) 3
No	45	14.2 ± 11.2 (0–53) 10	9.0 ± 7.3 (0–32) 7	4.8 ± 4.1 (0–16) 3	2.8 ± 2.8 (0–12) 2	9.0 ± 4.4 (2–22) 8	3.9 ± 2.7 (0–11) 3
Type of research (n = 169)							
Basic	90	11.6 ± 7.8 (0–39) 9	7.4 ± 4.6 (0–22) 6	4.9 ± 4.3 (0–24) 4	2.9 ± 2.5 (0–14) 2	7.4 ± 4.0 (1–29) 7	3.3 ± 1.9 (0–9) 3
Clinical	16	19.4 ± 7.2 (10–34) 18.5	11.9 ± 5.6 (5–25) 11	7.2 ± 5.7 (0–21) 6.5	4.0 ± 3.6 (0–12) 3.5	12.5 ± 12.0 (2–54) 10	6.5 ± 8.8 (0–37) 4.5
Both	63	16.0 ± 10.9 (2–53) 13	9.6 ± 6.8 (0–32) 8	6.0 ± 5.9 (0–38) 5	3.6 ± 3.2 (0–14) 3	10.2 ± 4.3 (2–22) 10	3.8 ± 2.7 (0–11) 3
Incorporation in a host group (n = 175)							
Yes	137	14.8 ± 9.8 (1–53) 12	9.0 ± 6.3 (0–32) 7	5.7 ± 5.3 (0–38) 4	3.3 ± 2.9 (0–14) 3	9.1 ± 6.0 (1–54) 8	3.7 ± 3.7 (0–37) 3
No	38	11.7 ± 7.9 (0–35) 10	7.8 ± 5.0 (0–21) 7	5.6 ± 5.4 (0–27) 4	3.5 ± 3.3 (0–13) 2.5	8.1 ± 3.7 (2–16) 7.5	4.2 ± 2.4 (0–11) 4

Table 4 continued

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
Satisfaction with job conditions							
Scientific quality of the host group (n = 157)							
Satisfied	21	16.7 ± 10.0 (1–53) 15	10.27 ± 6.7 (0–32) 9	6.8 ± 6.0 (0–38) 5	3.9 ± 3.3 (0–14) 3	9.4 ± 6.0 (1–54) 9	3.7 ± 4.0 (0–37) 3
Neutral	57	10.3 ± 6.4 (2–26) 8	6.31 ± 4.0 (0–16) 6	3.7 ± 2.8 (0–10) 3	2.5 ± 1.9 (0–8) 2	7.5 ± 4.0 (2–16) 7	3.4 ± 2.2 (0–10) 3
Unsatisfied	93	11.7. ± 10.9 (2–39) 9	6.42. ± 4.2 (2–16) 5.5	3.7. ± 4.7 (0–17) 2	2.1 ± 3.3 (0–14) 3	10.5 ± 7.8 ((2–29) 9.5	4.5 ± 3.6 (0–12) 2.5
Scientific quality of the host centre (n = 171)							
Satisfied	12	15.8 ± 9.7 (0–42) 14	10.1 ± 6.7 (0–32) 9	6.8 ± 6.2 (0–38) 5	4.1 ± 3.4 (0–14) 3	9.2 ± 6.3 (1–54) 8	3.9 ± 4.2 (0–37) 3
Neutral	39	13.1 ± 9.8 (2–53) 11	7.6 ± 5.1 (0–24) 6	4.8. ± 3.7 (0–17) 4	2.7 ± 2.2 (0–8) 2	8.5 ± 4.9 (2–29) 8	3.5 ± 2.3 (0–11) 3
Unsatisfied	106	10.4 ± 6.6 (2–25) 9	6.5 ± 4.1 (2–19) 5	3.2 ± 2.7 (0–10) 2	2.2 ± 1.8 (0–7) 2	8.9 ± 4.2 (3–18) 9	4.1 ± 2.7 (1–12) 3
Research autonomy, decision-making capacity and leadership (n = 175)							
Satisfied	56	15.2 ± 10.8 (0–42) 12.5	9.2 ± 6.6 (0–32) 8	7.4 ± 7.1 (0–38) 5	4.1 ± 3.5 (0–14) 3	9.8 ± 7.3 (3–54) 9	4.9 ± 4.9 (0–37) 4
Neutral	96	13.9 ± 9.0 (2–53) 12	8.9 ± 6.1 (0–32) 7	5.1 ± 4.1 (0–24) 4	3.2 ± 2.8 (0–14) 3	8.5 ± 4.6 (1–29) 8	3.4 ± 2.4 (0–12) 3
Unsatisfied	23	12.2 ± 7.8 (2–30) 9	6.6 ± 3.4 (2–14) 6	4.0 ± 3.2 (0–10) 3	2.3 ± 1.7 (0–6) 2	8.2 ± 4.3 (2–16) 7	2.6 ± 2.0 (0–9) 2
Conditions of the facilities available (n = 175)							
Satisfied	48	14.0 ± 9.6 (0–42) 10	8.7 ± 6.6 (0–32) 6	6.1 ± 6.3 (0–38) 4	3.4 ± 3.1 (0–13) 3	8.7 ± 6.6 (1–54) 8	3.6 ± 4.4 (0–37) 3
Neutral	49	12.7 ± 7.9 (2–37) 12	7.9 ± 4.6 (1–24) 7	5.0 ± 3.3 (1–16)) 4	3.1 ± 2.1 (1–10) 3	8.7 ± 4.1 (3–22) 8	4.0 ± 2.5 (0–10) 3
Unsatisfied	78	15.6 ± 10.8 (2–53) 13.5	9.6 ± 6.4 (2–32) 8.5	5.6 ± 5.1 (0–24) 4	3.6 ± 3.5 (0–14) 3	9.3 ± 5.1 (2–29) 9	3.9 ± 2.5 (0–12) 3
Job stability expectations (n = 170)							
Satisfied	41	14.5 ± 10.9 (2–53) 10	8.5 ± 6.1 (0–23) 6	5.9 ± 4.5 (0–21) 4	3.6 ± 2.9 (0–14) 3	9.1 ± 6.5 (1–54) 8	3.7 ± 2.2 (0–10) 3
Neutral	51	13.4 ± 9.7 (2–42) 11	8.1 ± 5.7 (1–25) 6	5.8 ± 6.7 (0–38) 3	3.3 ± 3.1 (0–13) 2	8.7 ± 4.5 (2–22) 8	3.3 ± 2.3 (0–12) 3
Unsatisfied	78	14.5 ± 8.8 (0–40) 12	9.4 ± 6.3 (0–32) 8.5	5.4 ± 5.0 (0–24) 4	3.1 ± 3.0 (0–14) 3	8.6 ± 5.3 (2–29) 8	4.1 ± 4.5 (0–37) 3.5

Table 4 continued

	n	art-N	art-Q1	art-FL	art-Q1-FL	proj-N	proj-PR
Satisfaction with resources							
Human resources: technical and support staff and researchers in training (n = 166)							
Satisfied	40	17.4 ± 9.9 (1–42) 17.5	10.6 ± 6.7 (1–32) 9.5	7.9 ± 7.1 (0–38) 6.5	4.7 ± 3.5 (0–14) 3.5	10.3 ± 8.3 (3–54) 9.5	4.5 ± 5.7 (0–37) 4
Neutral	105	13.3 ± 9.4 (2–53) 11	8.5. ± 6.1 (0–32) 7	4.9 ± 4.0 (0–18) 4	3.1 ± 2.8 (0–14) 3	8.8. ± 4.7 (1–29) 8	3.5 ± 2.5 (0–12) 3
Unsatisfied	21	10.6 ± 7.4 (0–31) 9	6.1 ± 3.7 (0–16) 6	3.8 ± 3.7 (0–15) 3	1.9 ± 1.6 (0–6) 2	7.0 ± 3.2 (2–14) 6	3.8 ± 2.4 (1–10) 3
Material resources: equipment, facilities, infrastructures and research materials (n = 146)							
Satisfied	17	12.7 ± 8.5 (0–32) 14	9.2 ± 7.8 (0–32) 6	5.1 ± 3.8 (0–13) 4	3.4 ± 3.1 (0–9) 3	8.2 ± 4.8 (1–17) 7	3.6. ± 1.8 (1–7) 4
Neutral	103	12.9 ± 8.8 (2–53) 11	8.0 ± 5.3 (0–32) 7	5.1 ± 5.0 (0–38) 4	2.9 ± 2.6 (0–14) 2	8.4 ± 4.0 (2–22) 8.5	3.4 ± 2.3 (0–11) 3
Unsatisfied	23	11.5 ± 8.7 (2–39) 9	7.1 ± 5.0 (2–23) 6	4.7 ± 4.3 (0–17) 3	3.0 ± 2.6 (0–11) 2	9.8 ± 5.9 (3–29) 8	4.6 ± 2.7 (1–12) 5
Support and service units (n = 173)							
Satisfied	7	14.1 ± 8.0 (7–30) 15	8.9 ± 6.2 (2–19) 6	4.9 ± 3.6 (0–10) 5	3.3 ± 3.2 (0–9) 3	11.9 ± 3.6 (7–17) 11	3.7 ± 1.6 (1–6) 4
Neutral	149	14.3 ± 9.6 (0–53) 12	8.8 ± 6.0 (0–32) 7	5.8 ± 5.5 (0–38) 4	3.4 ± 3.0 (0–14) 3	8.8 ± 5.5 (1–54) 8	3.8 ± 3.6 (0–37) 3
Unsatisfied	17	13.3 ± 10.1 (2–39) 10	8.5 ± 6.9 (1–23) 6	5.3 ± 4.7 (0–17) 4	3.3 ± 3.1 (0–11) 2	9.6 ± 6.5 (2–29) 8	4.1 ± 3.0 (1–12) 3
Economic resources (n = 175)							
Satisfied	14	13.3 ± 9.1 (4–35) 10.5	8.6 ± 5.1 (2–18) 6.5	6.1 ± 6.8 (1–27) 4	3.5 ± 3.4 (1–13) 2.5	9.0 ± 4.5 (1–16) 10	3.9 ± 2.3 (0–8) 4
Neutral	113	15.0 ± 10.0 (1–53) 12	9.4 ± 6.3 (0–32) 8	5.6 ± 5.4 (0–38) 4	3.3 ± 2.8 (0–14) 3	9.3 ± 6.3 (2–54) 8	3.7 ± 4.0 (0–37) 3
Unsatisfied	48	12.1 ± 8.2 (0–33) 10	7.3 ± 5.5 (0–23) 6	5.6 ± 4.7 (0–24) 4.5	3.4 ± 3.2 (0–14) 3	7.8 ± 3.6 (3–16) 7	3.8 ± 2.3 (0–11) 3
Leadership of a research group (n = 168)							
Yes. Leader of a new group	113	14.6 ± 9.6 (0–42) 12	9.1 ± 5.9 (0–32) 8	6.7 ± 6.0 (0–38)) 5	4.0 ± 3.2 (0–14) 3	9.1 ± 6.0 (2–54) 9	4.3 ± 3.8 (0–37) 4
No. Member of a group	55	12.6 ± 9.4 (1–53) 10	7.5 ± 6.2 (0–32) 6	3.8 ± 3.1 (0–12) 4	2.1 ± 1.9 (0–8) 2	8.2 ± 4.8 (1–22) 7	2.7 ± 2.0 (0–10) 2

Table 5 ANOVA model for productivity in WoS journals (art-N)

Source	Tests of between-subject effects					Parameter estimates					
	Type III sum of squares	df	Mean square	F statistic	p value	β[c]	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	2320.4[a]	5	464.1	5.9	.000						
Intercept	17980.5	1	17980.5	230.1	.000	20.6	2.8	7.4	.000	15.1	26.1
Mobility to a different centre	659.3	1	659.3	8.4	.004						
0 = No						4.2	1.4	2.9	.004	1.3	7.0
1 = Yes						0[b]					
Type of research	845.6	2	422.8	5.4	.005						
1 = Basic						−7.5	2.5	−3.0	.003	−12.4	−2.5
2 = Basic and clinical						−4.3	2.6	−1.7	.099	−9.3	.8
3 = Clinical						0[b]					
Satisfaction with human resources	527.1	2	263.5	3.4	.037						
1 = Unsatisfied						−5.6	2.5	−2.3	.023	−10.5	−.8
2 = Neutral						−3.7	1.7	−2.2	.029	−7.1	−.4
3 = Satisfied						0[b]					
Error	11957.6	153	78.1								
Total	45807.0	159									
Corrected total	14277.9	158									

[a] R Squared = .16

[b] This parameter was set to zero because it is redundant

[c] β coefficients indicate the variation in the number of articles that moved from one category of the dependent variable to another. Thus, using the category with β = 0 as the referent, the remaining categories will have ± β articles

Table 6 ANOVA model for productivity in first-quartile JCR journals (art-Q1)

	Tests of between-subject effects					Parameter estimates					
Source	Type III sum of squares	df	Mean square	F statistic	p value	β	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	730.3[a]	4	182.6	6.1	.000						
Intercept	9356.2	1	9356.2	313.9	.000	9.6	1.5	6.4	.000	6.6	12.6
Mobility to a different centre	279.8	1	279.8	9.4	.003						
0 = No						2.6	.9	3.1	.003	.9	4.4
1 = Yes						0[b]					
Type of research	243.7	2	121.8	4.1	.019						
1 = Basic						−4.0	1.5	−2.7	.008	−6.9	−1.0
2 = Basic and clinical						−2.4	1.5	−1.6	.118	−5.4	.6
3 = Clinical						0[b]					
Gender	129.9	1	129.9	4.4	.038						
0 = Male						1.8	.8	2.1	.038	.1	3.5
1 = Female						0[b]					
Error	47987.0	161	29.8								
Total	18194.0	166									
Corrected total	5528.4	165									

[a] R squared = .13

[b] This parameter was set to zero because it is redundant

Table 7 ANOVA model for first/last-authorships in WoS journals (art-FL)

Source	Tests of between-subject effects					Parameter estimates					
	Type III sum of squares	df	Mean square	F statistic	p value	β	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	472.4[a]	4	118.1	5.0	.001						
Intercept	2833.4	1	2833.4	121.0	.000	7.6	.9	8.4	.000	5.8	9.4
Satisfaction with human resources	277.2	2	138.6	5.9	.003						
1 = Unsatisfied						−3.9	1.3	−3.0	.003	−6.5	−1.3
2 = Neutral						−2.7	.9	−3.0	.003	−4.5	−.9
3 = Satisfied						0[b]					
Mobility to a different centre	98.7	1	98.7	4.2	.042						
0 = No						−1.6	.8	−2.0	.042	−3.2	−.1
1 = Yes						0[b]					
Gender	73.7	1	73.7	3.1	.078						
0 = Male						1.3	.8	1.8	.078	−.15	2.8
1 = Female						0[b]					
Error	3746.6	160	23.4								
Total	9139.0	165									
Corrected total	4219.0	164									

[a] R squared = .11

[b] This parameter was set to zero because it is redundant

Table 8 ANOVA model for first/last-authorships in first-quartile JCR journals (art-Q1-FL)

Source	Tests of between-subject effects					Parameter estimates					
	Type III sum of squares	df	Mean square	F statistic	p value	β	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	184.9[a]	5	37.0	4.8	.000						
Intercept	798.2	1	798.2	103.2	.000	4.3	.5	8.5	.000	3.3	5.3
Satisfaction with human resources	59.0	2	29.5	3.8	.024						
1 = Unsatisfied						−2.1	.8	−2.5	.012	−3.7	−.5
2 = Neutral						−1.2	.5	−2.2	.027	−2.3	−.1
3 = Satisfied						0[b]					
Gender	37.1	1	37.1	4.8	.030						
0 = Male						1.0	.4	2.2	.030	.09	1.8
1 = Female						0[b]					
Satisfaction with scientific quality of the host centre	31.3	2	15.7	2.0	.136						
1 = Unsatisfied						−1.0	.8	−1.3	.195	−2.5	.5
2 = Neutral						−.9	.5	−1.8	.065	−1.9	.06
3 = Satisfied						0[b]					
Error	1207.0	156	7.7								
Total	3192.0	162									
Corrected total	1392.0	161									

[a] R squared = .13

[b] This parameter was set to zero because it is redundant

Table 9 ANOVA model for participation in research projects (proj-N)

Source	Tests of between-subject effects					Parameter estimates					
	Type III sum of squares	df	Mean square	F statistic	p value	β	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	796.9[a]	5	159.4	5.7	.000						
Intercept	7483.0	1	7483.0	266.8	.000	13.8	1.6	8.4	.000	10.5	17.0
Type of research	564.0	2	282.0	10.0	.000						
1 = Basic						−5.7	1.5	−3.8	.000	−8.6	−2.8
2 = Basic and clinical						−2.9	1.5	−1.9	.063	−5.9	.1
3 = Clinical						0[b]					
Satisfaction with human resources	142.6	2	71.3	2.5	.082						
1 = Unsatisfied						−3.2	1.4	−2.2	.029	−6.0	−.3
2 = Neutral						−1.5	1.0	−1.5	.126	−3.5	.4
3 = Satisfied						0[b]					
Gender	72.2	1	72.2	2.6	.111						
0 = Male						1.3	.8	1.6	.111	−.3	3.0
1 = Female						0[b]					
Error	4374.7	156	28.0								
Total	18025.0	162									
Corrected total	5171.6	161									

[a] R squared = .15

[b] This parameter was set to zero because it is redundant

Table 10 ANOVA model for participation in research projects as principal investigator (proj-PR)

Source	Tests of between-subject effects					Parameter estimates					
	Type III sum of squares	df	Mean square	F statistic	p value	β	Std. error	t	Sig.	95 % confidence interval	
										Lower bound	Upper bound
Corrected model	309.6[a]	5	61.9	5.8	.000						
Intercept	1641.3	1	1641.3	153.2	.000	7.3	.9	7.7	.000	5.5	9.2
Type of research	151.8	2	75.9	7.1	.001						
1 = Basic						−3.3	.9	−3.8	.000	−5.1	−1.6
2 = Basic and clinical						−2.8	.9	−3.0	.003	−4.6	−1.0
3 = Clinical						0[b]					
Satisfaction with autonomy, decision-making and leadership	117.1	2	58.5	5.5	.005						
1 = Unsatisfied						−2.3	.8	−2.8	.005	−3.9	−.7
2 = Neutral						−1.6	.6	−2.8	.006	−2.7	−.5
3 = Satisfied						0[b]					
Gender	39.5	1	39.5	3.7	.057						
0 = Male						1.0	.5	1.9	.057	−.03	2.0
1 = Female						0[b]					
Error	1746.1	163	10.7								
Total	4487.0	169									
Corrected total	2055.7	168									

[a] R squared = .15

[b] This parameter was set to zero because it is redundant

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