ORIGINAL ARTICLES

BIBLIOMETRICS

Interdisciplinarity of Spanish Cardiovascular Research Teams

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Objectives. The incidence of interdisciplinarity (ID) in Spanish cardiovascular research teams was analyzed and scientists' opinions about interdisciplinary relationships were examined.

Methods. The data analyzed were obtained in a survey sent in 1999 to a sample of 310 researchers. They were selected using bibliometric techniques and/or for being research project leaders in recent years.

Results. The response rate was 61%. Data were obtained from 130 research teams located mainly in Madrid and Catalonia. Teams doing clinical research (81%) and those working in hospitals (64%) predominated. Different facets of the interdisciplinary nature of the teams were analyzed: scientist training, team composition, behavior patterns, collaboration, and publication and reading habits. A high ID was observed in the area: more than 70% of the teams are interdisciplinary according to the training of scientists, around 80% make use of knowledge or techniques from other disciplines, and around 90% read and publish in journals outside their own disciplines. Basic research teams had a higher ID than clinical ones. A total of 37 highly interdisciplinary teams were identified. These teams had a greater tendency towards collaboration.

Conclusions. Interdisciplinary reading and publishing habits were the norm among Spanish researchers, even in single-discipline groups. The «scattered» nature of teams, their high rate of external collaborations, and the multidisciplinary context of centers enhance interdisciplinary relationships. Administrative barriers do not seem to be a major obstacle to establishing interdisciplinary contacts.

Key words: *Cardiovascular diseases. Cardiovascular system. Research personnel. Questionnaires. Interdisciplinarity.*

Full English text available at: www.revespcardiol.org

La interdisciplinariedad en los grupos españoles de investigación en el área cardiovascular

Objetivos. Se analiza la presencia de interdisciplinariedad (ID) en los grupos españoles de investigación en el área cardiovascular, así como las opiniones de los investigadores sobre las relaciones interdisciplinarias.

Métodos. Los datos analizados proceden de una encuesta enviada en 1999 a una muestra de 310 investigadores seleccionados por métodos bibliométricos o por haber dirigido proyectos de investigación dentro del área en los últimos años.

Resultados. La tasa de respuesta fue del 61%. Se obtienen datos de 130 grupos de investigación localizados sobre todo en Madrid y Cataluña. Predominan los grupos que realizan investigación clínica (81%) y los que están ubicados en hospitales (64%). El carácter interdisciplinario de los grupos se analiza en distintas facetas: formación de los investigadores, composición de los grupos, pautas de comportamiento, prácticas de colaboración y hábitos de publicación y lectura. Se observa una alta ID en el área: más del 70% de los grupos es interdisciplinario por la formación de sus investigadores, el 80% admite aplicar conocimientos o técnicas de otras disciplinas y cerca del 90% utiliza revistas de disciplinas distintas de la propia para la lectura y publicación de sus investigaciones. Los grupos básicos tienden a mostrar mayor ID que los clínicos. Se detectan 37 grupos muy interdisciplinarios, que muestran mayor tendencia a colaborar que los equipos restantes.

Conclusiones. Los hábitos de lectura y publicación interdisciplinarios son la norma entre los investigadores españoles, incluso en los grupos de composición unidisciplinaria. El carácter distribuido de los grupos, su alta tasa de colaboración externa y el ambiente multidisciplinario de los centros favorecen las relaciones entre disciplinas. Las delimitaciones administrativas no parecen ser un importante obstáculo para el desarrollo de contactos interdisciplinarios.

Palabras clave: *Enfermedades cardiovasculares. Sistema cardiovascular. Personal investigador. Encuestas. Interdisciplinariedad.*

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ABBREVIATIONS

FIS: Fondo de Investigaciones Sanitarias (Health Investigation Foundation).
I+D: investigation and development.
ISI: Institute for Scientific Information.
SCI: Science Citation Index.

INTRODUCTION

Current research is characterized by a growing interdisciplinarity (ID). Faced with the academic classification of knowledge which favors the separation and at times the isolation of disciplines for practical organizational purposes, there is currently a tendency to establish channels of communication between disciplines. This is due to the fact that an advance in a scientific field or area can depend to a great degree on its capacity to establish relationships with other areas, and to interpret and use knowledge from these areas (cross-fertilization). On the other hand, it is clear that some of the principal problems of society require multidisciplinary management and cannot be adequately treated by a single discipline.[1,2]

With the aim of favoring and promoting this type of contact, distinct initiatives are being developed in the more advanced countries. Among these is the creation of multidisciplinary centers or economic assistance aimed specifically at supporting interdisciplinary programs or projects.[3,4] With regard to Spain, the call for assistance for achieving investigative and developmental projects (I+D) of the Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica 2000-2003 (National Plan for Scientific Investigación, Development, and Technological Innovation) includes the development of multidisciplinary research in its objectives with the aim of «mobilizing the complementary knowledge of diverse scientific fields suited to solving society´s problems.» In certain organizations and centers, programs also exist that are specifically oriented toward stimulating and encouraging interdisciplinary contact. In a similar manner, there has been a proliferation in all countries of studies based on the analysis of scientific ID from various angles and perspectives.[6-12]

Interest in cardiovascular research is a result of the fact that it encompasses a series of illness with a high morbidity-mortality rate. From 1988 to 1995, the Fondo de Investigaciones Sanitarias (FIS) (Health Research Foundation) financed 482 cardiovascular projects (10% of all projects funded) which received total funding of nearly 10 million euros (an average of 21 000 euros per project, or 3.5 million pesetas per project).[13] The studies cited in the references show that cardiovascular research has undergone an important increase in Spain over the last decades. From 1990 to 1996, production of Spanish scientific documents in the cardiovascular field reached 1434 in the Science Citation Index (SCI), representing 3% of biomedical output in Spain, an 83% increase.[14] Not only has there been a quantitative increase in Spanish output collected by the Institute for Scientific Information (ISI) databases, but there has also been positive growth from a qualitative point of view-the researchers are increasingly able to publish their studies in high quality and widely distributed journals, meaning that their studies have successfully gone through the quality review process that precedes the acceptance of manuscripts for publication.

This study aims to evaluate research groups and comprises part of a previous, broader, study.[15] Along the same lines, the studies by Espinosa et al[16,17] collected information on groups by surveying the principal researchers of biomedical projects from 1989 to 1995. The objective of this study is to analyze the structural and behavioral characteristics of a sample of research groups in the cardiovascular field, as well as to find out the opinions of scientists with regard to ID in the practice of research. Questions such as the following were asked: what is the attitude of researchers with regard to ID? Are you open to the influences of other disciplines? What is your principal means of contact with other disciplines? Do you collaborate with investigators from other disciplines? Do you collaborate with researchers in other areas or incorporate said researchers into your groups? Do you read and publish your results in the journals of other disciplines?

METHODS

Data was obtained by using a questionnaire specifically created for this study and sent by mail in 1999 to a sample of researchers in the area. The questionnaire included 43 questions, divided into 4 different sections: *a)* characteristics of the research group; *b)* scientific collaboration; *c)* scientific context of reference, and *d)* socio-professional characterization of the interviewee. Parts *a)* and *b)* were specially designed to obtain information on research groups, since this is considered the environment in which research is habitually conducted in this area. On the other hand, the last 2 sections could be answered individually as they were designed to profile the interviewees and to obtain personal opinions.

In order to identify the researchers to be surveyed, we used 2 complementary methods. First, we identified those researchers who had participated as principal investigators in at least 1 research project financed during 1995-1997 by the Plan Nacional,

whose objective was to study cardiovascular diseases. This group was complemented by a reference search, adding a selection of authors who published studies between 1994 and 1996 in the cardiovascular journals listed in the SCI. Given that the questionnaire was directed to research groups, and with the aim of obtaining the broadest possible representation of the groups that are active in the field, these groups were identified by frequency of co-authorship (a method described in a previous publication[18]), and the most productive authors in each group were selected to receive the questionnaires. The final sample of researchers to be surveyed contained 178 project principal investigators, 109 authors who were very productive according to SCI publications, and 23 investigators who shared both characteristics. We sent out a total of 310 questionnaires.

From among the questionnaires received, we selected only 1 questionnaire per group, based on 2 criteria: we gave priority to the questionnaires that were answered by the group leader (if so indicated on the questionnaire) and to those questionnaires that were filled out most completely.

Statistical study of the data was performed via the SPSS statistical packet, version 9. Mean values of the variables were expressed as mean±standard deviation ($\bar{X}$±SD), including the median (Med) and range (minimum value-maximum value).

We used non-parametric variable tests to compare mean values, considering values of $P<.05$ to be statistically significant.

RESULTS

We received 190 complete questionnaires from a total of 310 mailed out (a response rate of 61%). Once a single questionnaire had been selected for each group, the sample was reduced to 155 questionnaires, and these were the object of this study. Twenty-five of the 155 individuals surveyed did not belong to a particular investigative group; therefore, the study of groups was performed on only the remaining 130 questionnaires (84% of the total).

The 155 questionnaires analyzed were filled out, for the most part, by male researchers (77% men vs 23% women). The mean age of the researchers was 47 years of age, with a minimum of 34 years and a maximum of 69 years of age.

The investigators surveyed came from 15 different autonomous communities, although we observed a greater concentration in a small number of communities: Madrid (28%), Catalonia (24%), and Andalusia (11%). The distribution of researchers by institutional sectors is shown in Table 1.

The 25 individuals surveyed who were not part of a research group were no different from the rest of the groups studied in regards to sex or age, but they did primarily belong to the hospital sector (Table 1) and spent an average of 55% of their time on health care, as opposed to 30% noted by the rest of the researchers who were surveyed.

General data on the groups

A total of 130 researchers stated that they were part of a research group. It is of interest that only 35 of them (27%) indicated that the group was an institutional I+D entity; in other words, with a department or an administrative I+D unit. In addition, 65 groups (42% of the total) were comprised of researchers from more than one center.

We asked the authors to describe the basic or clinical characteristics of the research conducted by their group, through the selection of as many responses as were applicable from a list of 4 categories. One hundred and twenty-five individuals responded to this question. We observed a preponderance of clinical research performed by the majority of the groups (101 groups, 81%), followed by basic applied research (76 groups, 61%) and, to a lesser extent, basic fundamental activity (37 groups, 30%) and technical development (28 groups, 22%) (non-exclusive responses). Various types of research co-existed within two-thirds of the groups, while the remaining third stated they specialized in a single type of activity, mainly clinical activity. Twenty-three percent of all groups performed clinical research, and this percentage was much lower in those groups dedicated only to applied basic research (5.6%), basic fundamental research (4%), and technological innovation (0.8%). The combination of basic applied research and clinical research occurred most frequently (44% of the groups).

A question regarding the scope of the groups was answered by 80% of individuals surveyed, although less than half answered the questionnaire completely including the number of people in specific personnel categories, as requested. This reduced the number of

TABLE 1. **Distribution of individuals surveyed by institutional sectors**

	Total		In a group		Not in a group	
	No.	%	No.	%	No.	%
Hospitals	99	63.9	78	60	21	84
University	26	16.8	25	19.2	1	4
Primary attention	11	7.1	10	7.7	1	4.3
Administration	7	4.5	7	5.4	0	0
CSIC	5	3.2	5	3.8	0	0
Investigative institutes	2	1.3	2	1.5	0	0
Other	1	0.6	1	0.8	0	0
NA	4	2.6	2	1.5	2	8
Total	155	100	130		25	

NA indicates not available

valid questionnaires to 53 (41% of the individuals surveyed who were with groups). The mean size described for these groups was 10 people (10.4±6; range 1 to 33), with 4 groups of more than 20 individuals standing out as outliers. As far as research staff was concerned, they represented an average of half of the team members, with a mean value of 6 investigators per group (5.6±3.9; range 0 to 20).

The groups were composed of full-time researchers (33%), contract researchers (12%), post-doctoral fellows (10%), pre-doctoral staff (25%), and technical personnel (20%). The size of the groups was the same or greater than 5 years previously in more than 90% of the groups, and the number of pre-doctoral personnel was the value which tended to increase the most in the majority of the groups (54%).

The research activity of the groups, measured by projects undertaken and the resulting publications, was greater than that of the previous 5 years in 59% of the groups, the same n 17%, and lower in 3% of the groups.

Data about funding of the groups was obtained for 117 teams. Average funding for the groups in 1998 went up to 10 million pesetas a year (60 000±90 000 euros; range, 1800 to 583 000 euros); however, we observed great variability in the amount of funding. Fifty percent of the groups indicated an annual estimate of less than 30 000 Euros (5 million pesetas), while only 10% noted numbers greater than 132 000 euros (22 million pesetas) (5 groups). We did not observe a clear relationship between the estimate made by the group and the size of the group, which can in part be attributed to the influence of other factors such as the type of research performed (basic or clinical) and variations in the amount of time dedicated by the group to the research, as many were dividing their time between other activities in addition to their research, such as teaching or health care.

Study of Interdisciplinarity in the field

The ID in the field was studied by using various indicators, including the training of the researchers, composition and the behavior guidelines of the groups, collaboration practices, reference journals, and publication journals.

TABLE 2. **Level of importance of various factors in obtaining specialization in research**

	Level of importance (%)			
Factors	**Very**	**Somewhat**	**Not very**	**Not at all**
University degree	14.2	20.0	41.9	22.6
Doctoral degree	30.3	34.2	25.8	8.4
Specialization courses	21.1	38.8	32.6	7.5
Daily work	80.0	20.0	0	0
Spending time abroad	49.7	24.2	18.1	8.1

Training of the investigators

The individuals surveyed were asked what their principal academic degrees were (up to 3) and in what discipline, in order to analyze the interdisciplinary character of their training. Eight-four percent of the researchers had a degree in medicine. A total of 134 researchers (86% of the total) had a doctoral degree, the majority in medicine (109 investigators, or 81% of the total); some had a degree in biology (11 investigators, 8%), and the rest in other disciplines. The title of specialist was listed by 64 researchers (41% of the total), and the specialties most frequently mentioned were cardiology (18, researchers, 28%), family and community medicine (10 researchers, 16%), internal medicine (6 investigators, 9%), and nephrology (6 investigators, 9%). Complementary certificates and diplomas were mentioned in 20 cases (13%), dispersed among various fields such as epidemiology, public health, and methodology in clinical research.

Table 2 shows the opinion of the individuals surveyed with regard to the importance of various factors related to training in order to become specialized in research. What stands out in this table is the importance of daily work (very important for 80% of the respondents) and of spending time in foreign medical centers (mentioned by 50% of respondents).

Composition of the groups

In order to study the unidisciplinary (researchers from a single discipline and specialty), or interdisciplinary (researchers from various disciplines and specialties) character of the groups, 2 complementary questions were asked. First, we asked the researchers a closed question, giving them several options and asking them to choose the response that best reflected their situation. A total of 24 groups proved to be unidisciplinary, while 20 groups (16%) included researchers from the same discipline but different specialties, and 80 groups (64%) contained researchers of the same and other disciplines and specialties. This information was provided by 24 of the 130 groups. We then asked the investigators to include the names of 5 members of their research group, indicating each member´s discipline and specialty. The areas of knowledge included in the Spanish academic curriculum, such as medicine, biology, or chemistry were called «disciplines.» The term «specialty» was applied to more specific areas, such as molecular biology or cardiology. The information regarding the composition of the groups was provided by 112 teams (86% of the groups). A total of 26 groups (23%) were clearly unidisciplinary (1 discipline, 1 specialty), while 86

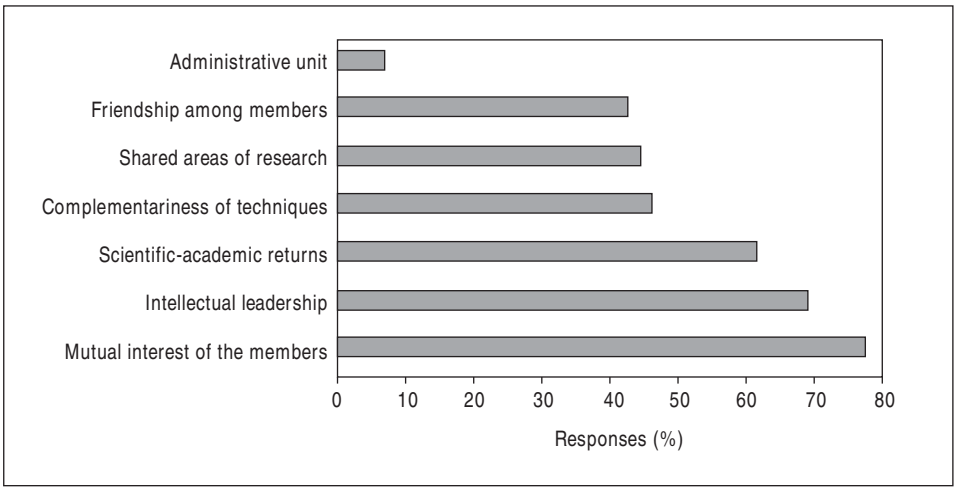

Fig. 1. Factors that were most influential in the cohesion of research groups.

groups (77%) could be defined as interdisciplinary. Twenty-seven groups had members of a single discipline but various distinct specialties; 10 groups had members of various disciplines although within the same specialties; and 49 groups included members from distinct disciplines and specialties.

Ninety percent of the groups had a physician among their members, and 35% had biologists, 15% had chemists, 8% had pharmacists, and 7% of the groups had mathematicians or engineers. Ninety-one percent of the groups of a single discipline were composed of physicians. The most frequent association among the interdisciplinary groups (more than 1 discipline) was that of physicians and biologists (26 groups, 23%).

Table 3 shows the mean number of different disciplines and specialties by group, which ranged from 1 to 5, as we requested this information for a maximum of 5 components per team. Given that the questionnaires did not always provide this data for 5 team members, the indicators for discipline diversity and specialty diversity were calculated for each group, to correlate the number of different disciplines and specialties with the total number of researchers supplied by the respondent; in other words, as a function of the size of the group. In both cases, we observed a greater variety of specialties than of disciplines.

When we limited the study to the 55 groups that performed a single type of research (basic or clinical), we observed a greater diversity of disciplines in the basic groups (diversity 0.6±0.2) than in the clinical groups (diversity 0.48±0.21; $P<.05$).

Group behavior patterns

We asked the researchers their opinions about some aspects of group dynamics, as a first attempt to determine the degree to which the groups were open to interdisciplinary influences. The opinions of the respondents (non-exclusive questions) with regard to the factors that most influence the cohesion of research groups are shown in Figure 1. The most influential factors indicated were mutual interest of the group members (77%), intellectual leadership (68%), and scientific-academic return (61%). Only 7% of the responders indicated that administrative unity was a decisive element in the cohesion of the group.

In order to find out the determining factors in the selection of the study objectives and investigative activities of the groups, we provided the respondents with a list of 7 factors and asked them to choose the 2 most important. The first factor chosen was continuity of areas of research that had already been initiated (68%), followed by the aim to solve social or economic problems (17%), and emergent topics in publications (10%) (Table 4).

Of interest, 80% of respondents admitted to using techniques or knowledge, or both, from fields different from their own. Nevertheless, there was little interest in responding to the question regarding whether or not they considered it of value to include researchers from other disciplines in the group—this question was only answered by 46 teams (35% of the total). Nevertheless, 85% of those who responded did so in the affirmative. Table 5 shows the greater use of knowledge and techniques from other disciplines on the part of groups performing basic research. It must be taken into account that more than half of the groups

TABLE 3. **Interdisciplinary composition of the groups**

	$\bar{X}$ ±SD	Med	Range
Number of different disciplines/group	1.79±0.91	2	1-5
Number of different specialties/group	2.34±1.21	2	1-5
Diversity of disciplines	0.48±0.25	0.45	0.2-1
Diversity of specialties	0.61±0.25	0.6	0.2-1

$\bar{X}$ ±SD indicates mean±standard deviation; Med, median.

TABLE 4. **Most important factors in the selection of objectives and research activities of the group**

	Responses (%)	
	First most important factor (n=107)	Second most important factor (n=105)
Continuity in areas of research	68.2	20
Solving social, economic, etc. problems	16.8	26.7
Emergent themes in publications	10.3	28.6
Subjects prioritized by funding agencies	1.9	8.6
International collaboration	0.9	7.6
Interests of the industrial sector	0.9	6.7
Others	0.9	1.9

TABLE 5. **Relationship between the use of knowledge and techniques from other disciplines and the basic or applied nature of the research**

	Use of knowledge and techniques from other disciplines		
	Yes	No	Total
Fundamental basic and/or applied	15 (83.3%)	3 (16.7%)	18
Clinical and/or technological development	23 (63.9%)	13 (36.1%)	36
Both types of research	62 (88.6%)	1 (11.4%)	70
Total	100	24	124

were performing basic and applied research simultaneously.

We also asked respondents to state what the importance was of various factors in the establishment of interdisciplinary relationships, and the greatest importance was attributed to personal contacts (61% of respondents stated that it was the most important), followed by the institution itself (maximum importance in 42%), and the body of publications (41%) (Figure 2).

Collaboration of investigators and groups

External collaboration or collaboration with researchers in other groups is common practice according to most of the respondents: 62.5% stated they collaborate frequently, and another 7% stated that they always collaborate. Twelve percent of all investigators indicated that they never collaborate with external colleagues, while 20% said they did occasionally. The environments in which collaboration occurred most frequently were in the setting of funded projects (44.3%) and informal collaborations (43.4%). Other collaboration mentioned was in the setting of institutional (5%) and contractual (3.3%) agreements.

Table 6 shows the opinions of the respondents with regard to various aspects of collaboration by investigators within research groups. The most supported opinions were that ID is necessary for the advancement of knowledge (85% of researchers considered this the first answer), followed by interest in ID to correct insufficient knowledge (64.5%), and for

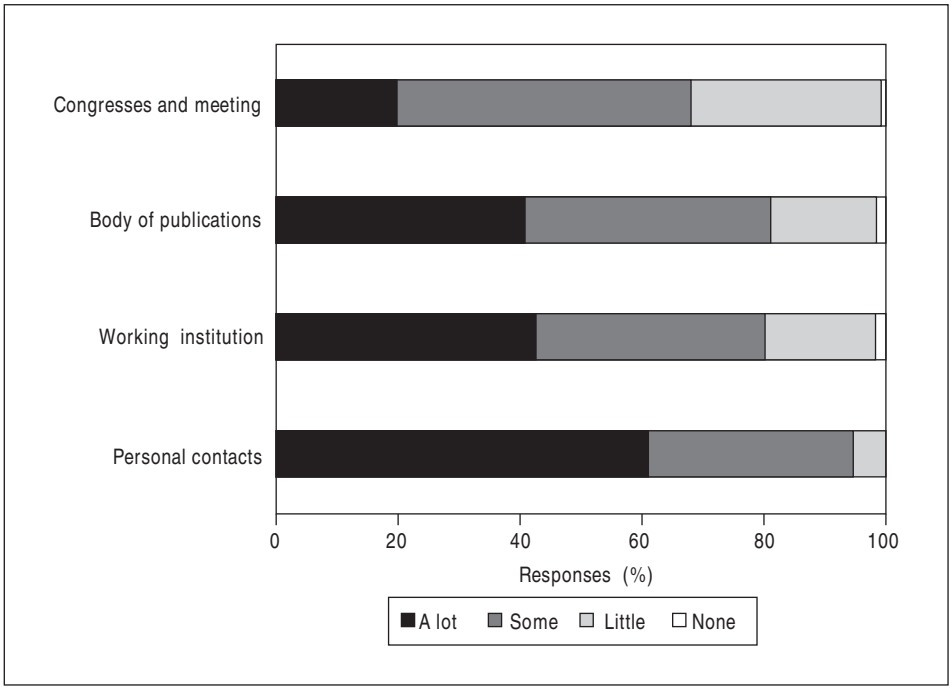

Fig. 2. Amount of importance placed on various factors in establishing interdisciplinary relationships.

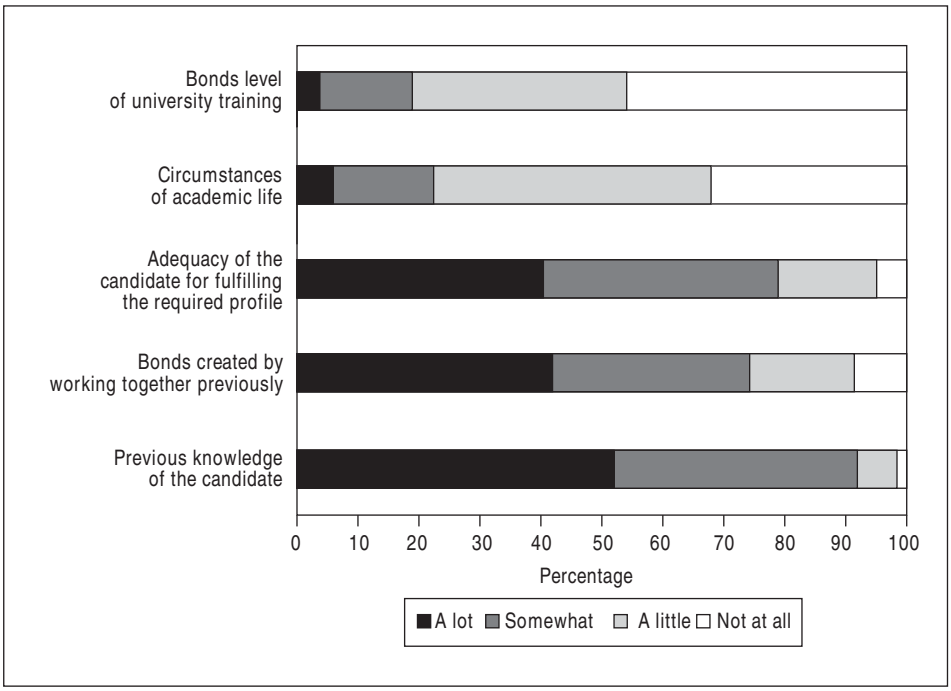

Fig. 3. Importance of various factors in establishing external collaboration.

the purpose of mutual learning.

The most valuable factors for collaborating with other groups was previous acquaintance with the potential collaborator (considered very important by 51% of respondents), the existence of bonds due to working together previously (42%), and whether the potential collaborator fulfilled the required profile (40%) (Figure 3).

Collaboration gives rise to study results that are disseminated conjointly in 95% of cases, and the most common way to do so is by means of scientific publications (99%). Other means reported are via protocols (24%), reports (20%), and patents (2%).

Reference and publication journals

With respect to the most important criteria for the selection of journals in which to publish results, we asked the responders to choose the 3 most relevant factors from a list of 7 factors, as is shown in Table 7. Taking into account only the first response of the researchers, the most relevant factor was the visibility and impact of the journal (46%), the appropriateness of its subject matter (16%), and its suitability for reaching the desired audience (16%).

On average, each group contributed to 4 publication journals and used 5 reference journals, 1 of each type belonging to the cardiovascular field, and, in total, up to 4 different disciplines. In order to categorize the journals by scientific discipline, we classified them according to the types listed by the ISI in Philadelphia.[19] We did not observe any significant differences between the diversity of disciplines for publication journals or for reference journals (Table 8). Considering only

TABLE 6. **Opinions regarding the importance of various factors in the collaboration between researchers from different disciplines and specialties within groups**

	Responses (%)		
	First opinion (n=125)	Second opinion (n=110)	Third opinion (n=107)
Need for the advancement of knowledge	84.8	0	0
Makes quality control of the investigation difficult	0.8	1.8	0
Useful to correct insufficiencies	11.2	64.5	0
Interesting for mutual learning purposes	1.6	31.8	25.2
Produces better results	0.8	0	72
No opinion	0	1.8	0.9
It is the trend	0	0	1.9
Total	99.2	99.9	100

TABLE 7. **Most important criteria for selecting the journal for publication of results**

	Responses (%)		
	First most important factor (n=99)	Second most important factor (n=101)	Third most important factor (n=105)
Journals in which we have always published results	3	1	11.4
Suitability according to subject	26.3	30.7	21
Those that allow the most rapid dissemination of results	1	10.9	14.3
Those most appropriate for reaching our audience	16.2	17.8	25.7
Those that facilitate publication of our type of study	5.1	13.9	20
Those with the greatest visibility or impact	46.5	23.8	6.7
Other	2	2	1

TABLE 8. **Interdisciplinarity in the reading and publication habits of the groups**

	Diversity of disciplines	
	Reference journals (n=150)	Publication journals (n=119)
Basic fundamental and/or applied investigation	0.97±0.45	1.05±0.28
Clinical investigation and/or technological development	0.77±0.23	0.80±0.52
Both types of investigation	0.85±0.26	0.91±0.34
Total	0.83±0.28	0.91±0.37

Data expressed as mean±standard deviation.

the 55 groups dedicated to a single type of research (basic or applied), we observed that the basic groups showed greater diversity of disciplines in their publication and reference journal choices than the clinical groups.

The principal findings with regard to the reference and publication journals are shown in Table 9. One hundred sixty-two reference journals and 196 publication journals are mentioned, and there is a greater consensus with regard to the reference journals, with an

TABLE 9. **Characteristics of the principal reference and publication journals**

	Reference journal	Publication journal
Responses (%)	95%	80%
Number of journal mentions	707	507
Number of different journals mentioned	162	196
Number of mentions per journal	4.4	2.6
Number of mentions of SCI journals	678 (95.9%)	455 (89.7%)
Number of different SCI journals mentioned	144 (88.9%)	161 (82.1%)
Number of mentions per journal	4.7	2.8
Number of mentions of Spanish journals	32 (4.5%)	54 (10.6%)
Number of different Spanish journals	11 (6.8%)	16 (8.2%)
Number of mentions per journal	2.9	3.4
Number of mentions of cardiovascular journals	224 (31.7%)	151 (29.8%)
Number of different journals	31(19.2%)	36 (18.4%)
Number of mentions per journal	7.2	4.2
Assigned theme of the journals		
Number of different SCI categories	43	49
Principal categories	CARD 21.6%	CARD 21.1%
	PERI 21.1%	PERI 16.4%
	HEM 14.5%	HEM 10.1%
	INTMED 13.7%	INTMED 7.7%
	BIOC 3.5%	BIOC 5%

SCI indicates Science Citation Index; CARD, Cardiovascular System; PERI, Peripheral vascular disease; HEM, Hematology; INTMED, Internal Medicine; BIOC, Biochemistry.

TABLE 10. **Principal reference and publication journals**

	Reference journals		Publication journals		SCI category	Position in the classification
	Frequency	%	Frequency	%		IF-1999
Circulation	81	11.5	35	6.9	CARD/HEM/PERI	1/65
New Engl J Med	54	7.6	8	1.6	INTMED	1/110
J Am Coll Cardiol	36	5.1	19	3.7	CARD	3/65
Lancet	33	4.7	12	2.4	INTMED	3/110
Circ Res	28	4.0	8	1.6	CARD/HEM/PERI	2/65
Hypertension	21	3.0	16	3.2	PERI	7/44
J Hypertens	21	3.0	10	2.0	PERI	10/44
Arterioscl Thromb Vasc	19	2.7	10	2.0	HEM/PERI	5/44
J Clin Invest*	17	2.4			MI	3/75
Am J Physiol	15	2.1	11	2.2	CARD/PERI/PHYSIOL	9/65
Eur Heart J	15	2.1	15	3.0	CARD	5/65
JAMA*	15	2.1			INTMED	2/110
Thromb Haemostasis	13	1.8	8	1.6	HEM/PERI	6/44
Nature*	12	1.7			MULTI	1/51
BMJ	11	1.6	13	2.6	INTMED	7/110
Atherosclerosis	11	1.6	13	2.6	PERI	12/44
Am J Cardiol	10	1.4	11	2.2	CARD	12/65
Blood	9	1.3	6	1.2	HEM	2/65
Aten Primaria	9	1.3	8	1.6		
Med Clin	9	1.3	12	2.4	INTMED	39/110
Rev Esp Cardiol			15	3.0	CARD	49/65
Br J Pharmacol*			9	1.8	PHARM/BIOC	16/175
Kidney Int*			7	1.4	UROL	2/45

*Journals frequently used in only 1 of the 2 categories: publication or reference. We did not include the number of mentions received in the other category. Spanish journals are shown in cursive type. SCI indicates Science Citation Index; IF, impact factor; CARD, cardiovascular system; HEM, hematology; PERI, peripheral vascular disease; INTMED, internal medicine; MI, medical investigation; PHYSIOL, physiology; MULTI, multidisciplinary; PHARM, pharmacology; BIOC, biochemistry; UROL, urology.

average of 4.4 mentions vs 2.6 mentions for the publication journals. The respondents showed a clear preference for journals recognized by the SCI. With regard to Spanish journals, they were mentioned in 5% of responses as reference journals and 11% of those mentioned as publication journals. Nearly 30% of the journals mentioned, whether as reference journals or as publication journals, were in the cardiovascular area, and the rest mentioned were distributed among other areas such as peripheral vascular disease, hematology, internal medicine, and biochemistry. We observed greater use of the internal medicine journals for consultation that for publication of results.

The 20 journals most frequently mentioned as being used for reference and publication are shown in Table 10. It should be pointed out that there was a great coincidence between the core list of reference journals and publication journals, as 16 titles appeared in both core lists, although with differences in how frequently they appeared. We observed a great consensus among researchers when they cited the reference journals, as the 20 titles indicated made up 62% of the mentions of reference journals vs 47% for publication journals. On the other hand, it must be pointed out that 3 journals that were cited as very important (*Circulation*, *New England Journal of Medicine*, and the *Journal of the American College of Cardiology*) are reference journals and consisted of 24% of the journals mentioned. In the 2 last columns of the table we show the subject matter of the journals listed, as well as the position they occupy with regard to other journals within their particular fields in decreasing order based on impact factor in 1999.[20] The principal category by subject is the cardiovascular system, followed by general medicine and peripheral vascular disease. The majority of the journals mentioned have high international visibility, as they have a high impact factor within their respective fields. Therefore, the journal *Circulation*, the one most frequently mentioned both for reading and for publication, is the journal with the greatest impact factor within the category of cardiovascular system (number 1 of the 65 journals included in the category).

The Spanish journals were mentioned more often as publication journals than as reference journals. A total of 18 journals were cited, receiving 32 mentions as reference journals and 54 as publication journals. The journals most often mentioned were *Atención Primaria*, *Medicina Clínica* and the *Revista Española de Cardiología* (Table 11). The journals *Atención Primaria* and *Medicina Clínica* appear in both core

TABLE 11. **Spanish journals mentioned as reference or publication journals**

	Reference journal		Publication journal	
	Frequency	%	Frequency	%
Atención Primaria	9	28.1	8	14.8
Medicina Clínica	7	21.9	12	22.2
Revista Española de Cardiología	5	15.6	15	27.8
Hipertensión	3	9.4	2	3.7
Medifam	2	6.2	1	1.8
Acta Pediátrica Española	1	3.1	1	1.8
Anales Españoles de Pediatría	1	3.1	3	5.6
Angiología	1	3.1	1	1.8
Nutrición Hospitalaria	1	3.1		
Revista Clínica Española	1	3.1		
Revista Española de Anestesiología	1	3.1	1	1.8
Anales de Medicina Interna			2	3.7
Clínica e Investigación de Arteriosclerosis			1	1.8
Gaceta Sanitaria			3	5.6
Medicina Intensiva			1	1.8
Revista Española de Pediatría			1	1.8
Revista de Neurología			1	1.8
Revista Sanitaria Higiene Pública			1	1.8
Total	32	100	54	100

lists, while the *Revista Española de Cardiología* appeared only in the core list of publication journals, where it was listed as 1 of the 5 journals used most frequently and ahead of the other 2 previously mentioned Spanish journals (Table 10).

Types of groups according to their interdisciplinary nature

The groups were classified into several types, with emphasis on 3 aspects of their unidisciplinary or interdisciplinarity quality: specialization of the group members, disciplines of the reference journals, and disciplines of the publication journals. With regard to the composition of the groups, we considered as interdisciplinary those groups in which various areas were represented (for example, medicine and biology) or various disciplines were represented (for example, cardiology and pediatrics) in their makeup.

This data was obtained for 100 groups. Seventy percent of the groups were composed of personnel from distinct areas or disciplines, and the journals used for reference or in which they published represented various scientific disciplines. Twenty-two percent were unidisciplinary according to the members making up the group, but they cited journals from distinct disciplines for both reference and publication. Seven percent of the groups were interdisciplinary, but mentioned journals from only 1 discipline as reference or publication journals. Only 1 group was clearly unidisciplinary, both with respect to the members of the group and the subject matter of the journals they use for reference and publication.

We did not observe a correlation between the ID composition of the groups and the diversity of subject matter of the journals they cited for reference or publication, or both, but the unidisciplinary groups (1 discipline and 1 single specialty) (n=24) were shown to be smaller than the remaining groups (n=88; 7.17±5.32 vs 10.54±8.51; $P<.06$) and less ID in their reading habits (3.56±1.04 vs 4.14±1.36 distinct areas for reference journals; $P<.05$) and in publication habits (3.25±1.51 vs 4.00±1.61 distinct areas for publication journals; $P<.04$).

On the other hand, we observed a certain relationship between the diversity of disciplines for reference journals and publication journals, such that 103 of the 104 groups that published in journals covering more than 1 discipline had an interdisciplinary pattern to their reading, while this pattern was only present in 7 out of 12 of the groups that published in unidisciplinary journals.

Finally, combining our data on group composition, reading habits, and reference habits, we identified 37 groups that were very interdisciplinary (defined as those with a high diversity in at least 2 of the 3 aspects analyzed): high diversity of disciplines or areas in the group, high variety of disciplines according to the publication journals, or high variety in the disciplines of

the reference journals. For each of these variables we considered as high those values above the 75 percentile.

The very interdisciplinary groups stated that they collaborated frequently in 70% of cases, vs 59% for the remaining groups. Twenty-two percent of the very interdisciplinary groups said that they never or rarely collaborated, vs 34% of the remaining groups.

DISCUSSION

The results show the presence of a high degree of ID in the cardiovascular field in Spain, in which groups of various types and specialty coexist with a predominance of staff with medical training (nearly 85% of the researchers were physicians), a preponderance of teams located in the hospital setting (64% of the groups surveyed), and a majority involved in clinical vs basic research.

We believe that the sample analyzed in this study is representative for Spain given the mixed method used for the selection of the researchers and the good response rate. The relatively low occurrence of physicians in the results who specialized in cardiology was notable: only 40% of the groups had a cardiologist and only 50% mentioned a cardiology journal among the 5 journals used for publication of their results, a percentage that increased to 65% with regard to reference journals.

The underlying factor at play is the great interrelational network that exists between the distinct medical specialties. Within the original limits of the area of study, cardiologists were identified, but so were researchers from other specialties, such as family medicine or internal medicine, who had proposed projects related to cardiovascular disease, with this being their principal area of study. In fact, in the study by Ricoy et al[13] of the projects funded by FIS between 1988 and 1995, it was observed that nearly 60% of those in the cardiovascular field were also assigned another area of study, which indicated the great ID of the field. We believe that the limits used in our study provide a broad overview of the field, including a central nucleus of researchers with a clear specialization in cardiology, as well as other researchers working in more peripheral areas of the field with diverse training and original disciplines. We believe that the latter are also relevant given the study results; this is supported by the fact that the researchers responded to the questionnaire, which was sent with the notation that this was a study being performed regsrding the field of cardiovascular medicine, showing they had «something to say» on the subject.

Our original presumption of treating the investigative group as the basic work unit in the area is supported by the study results. Eight-four percent of the respondents stated they were part of a team that in the majority of cases did not correspond to administrative units, and that in nearly 40% of cases even included members from various centers. This did not appear to be an obstacle to the function of the group, the cohesion of which was influenced more – in the opinion of the respondents – by mutual interest or intellectual leadership than by belonging to the same administrative unit.

Of note, the respondents who worked on their own (15%) primarily belonged to the hospital sector. We do not know if these researchers developed their activities along lines particularly well-suited to solitary work or if the situation indicated the lack of complete integration of these professionals into research areas. The difficulty of simultaneously performing health care and research activities in the hospital setting could cause many professionals to neglect this aspect of their activities, which becomes collateral and secondary and to which they only dedicate brief and isolated efforts.

With regard to the presence of ID in this field, it must be pointed out that more than 70% of the groups were interdisciplinary in the training of their researchers, while approximately 90% were interdisciplinary in their reading and publication habits, and 80% admitted applying knowledge or techniques from other disciplines to their work. ID appears to be more tied to basic groups than clinical groups, as basic groups indicated the use of knowledge or techniques from other disciplines with less frequency (83% vs 64%), showed less diversity of disciplines in the composition of their groups, and showed less diversity in their reading and publication habits. Nevertheless, we cannot forget that more than half of the groups who perform basic and clinical research simultaneously were not analyzed, thus substantially reducing the sample size.

With regard to the makeup of the research groups, 26 out of 112 (23%) contained professionals from a single discipline (usually medicine) and specialty disciplines (most frequently cardiology). The remaining 86 groups (77%) showed some level of ID; that is to say, they were made up of researchers from different areas or, above all, different specialties. On average, each group included researchers from 2 different disciplines and 2 different specialties. Ninety percent of the groups included a physician, but they also included biologists (in 35% of the groups), chemists (in 15%), pharmacists (9n 8%), and even mathematicians (in 7% of groups).

The ID that was observed with regard to publication and reference journals was greater than that identified for the training of the researchers. The journals noted for each group were distributed, on average, among 4 different categories. The groups that mentioned journals on a single subject were reduced in number to 5% in the case of reference journals and to 9% in the case of publication journals. Considering all the journals mentioned, only a third of them were in the field of the

cardiovascular system, and the rest were distributed among related disciplines (peripheral vascular disease, hematology), general disciplines (internal medicine), and others. The *Revista Española de Cardiología* was widely read and accepted by Spanish cardiologists,[21] was mentioned as a publication journal (the number 1 Spanish journal mentioned), and was mentioned as a reference journal, where it was a third behind *Atención Primaria* and *Medicina Clínica*. These data indicate the ID in the field, which is favored by the multidisciplinary environment of hospitals and driven by the need for global understanding of each patient´s reality. This last fact inspires collaboration between different specialties and explains the broad reading and publication patterns of the researchers (nearly 90% of the groups showed an interdisciplinary reading and publication pattern).

Nevertheless, it must be taken into account that according to the ISI classification, journals can be assigned to up to 4 different categories. We could have used another means of subject classification, but we thought that this same multi-assignment of journals in and of itself is an ID indicator[22] and therefore we wanted to apply it to our study.

The interdisciplinary composition of the groups does not appear to be an indispensable factor in guaranteeing the dissemination of results among various disciplines, as 22% of the groups were unidisciplinary in makeup while their reading and publication habits were not. Nevertheless, these groups showed less variety of disciplines in the journals they read and in which they published, which could be interpreted as their being less open to interdisciplinary influences.

Although scientific collaboration was considered a factor that favored ID, in this study we did not observe a clear positive correlation between these 2 characteristics. Nevertheless, it is certain that the more interdisciplinary groups (nearly 40% of the total), selected according to the extreme values of the 3 indicators used, showed a greater tendency toward collaboration with the rest of the teams, a fact that probably facilitates their contact with other disciplines.

Finally, with reference to the opinions of the respondents, more than 80% admitted that ID is necessary for the advancement of knowledge, but they showed little worry with regard to the lack of contact with other disciplines in daily practice. In fact, the researchers appeared to be satisfied regarding the curricular diversity of their groups. Our question as to whether they considered it of use to include researchers from other disciplines in their teams was answered affirmatively by 85% of those who responded, but only 35% of the groups polled answered the question, which we interpret as a lack of interest or concern with regard to the question. Nevertheless, the unidisciplinary groups showed greater awareness on this subject, as their response rate was 80% vs 22% for the rest of the groups.

It must be pointed out that the data obtained by the questionnaires did not allow us to detect individual ID. Analysis of the academic degrees of the researchers provided us with information regarding their professional progress toward a growing specialization, but showed scarce ID at an individual level. Very few researchers indicated that they possessed degrees in newly-created interdisciplinary areas or various degrees in distinct but complementary areas that could indicate interdisciplinary training. We did observe the presence of parity in some areas, as in the case of epidemiology, public health, and clinical research and methodology, which were mentioned by 13% of the respondents. In this sense, it appears that interdisciplinary training is not acquired academically; data that is supported by the low value attributed by the respondents to academic degrees in obtaining specialization, and the fact that the role of daily practice is considered very valuable.

In summary, ID is present in advanced research in the cardiovascular field, both in the area where groups of professionals with different training and specialties co-exist and within the groups themselves. The researchers are aware of the importance of ID for scientific progress, but they do not consider it to be a problem in the development of their research. The high percentage of groups without administrative correspondence indicates that contact can be established according to the needs of the projects or the specific areas of study, without administrative delimitations appearing to be a significant obstacle. It also appears that personal contact is important in establishing interdisciplinary relationships, in addition to other factors such as work environment or publications read.

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