FACTORS ASSOCIATED WITH PHYSICIANS' CLINICAL RESEARCH PRODUCTIVITY

CAN INFORMATICS RESOURCES IMPROVE THE CAPACITY FOR RESEARCH?

By

Vanina L. Taliercio

A THESIS

Presented to the Department of Medical Informatics and Clinical Epidemiology
and the Oregon Health & Science University
School of Medicine
in partial fulfillment of
the requirements for the degree of

Master of Science

March 2012

School of Medicine

Oregon Health & Science University

CERTIFICATE OF APPROVAL

This is to certify that the Master's thesis of

Vanina Taliercio

has been approved

Advisor

Member

Member

Table of Contents

Table of Tables

Table of Figures

Acknowledgments

I am very grateful to the following for providing guidance and support in carrying out this study.

My thesis committee, Drs. Judith Logan, Jayashree Kalpathy-Cramer, and Paula Otero, for all the time they found to discuss different aspects of my research project.

I also acknowledge the help of Dr. Diego Giunta of the research in internal medicine area at HIBA for his help in the analysis of the data, and my friends who supported me with the translation of this paper to English, Steven Bedrick, Damian Borbolla, Dian Chase, Lisa Vingara and Patty Yao.

Abstract

In Latin America, the number of researchers and the number of research projects and publications has been low in comparison with international standards. The purpose of this study was to identify the factors that most strongly influence whether a physician from Latin America will eventually attempt to perform research, with a particular focus on the role that information resources may play in the process. We believe this new knowledge will allow for the planning of interventions that might increase physicians' research productivity in these countries. **Methods:** All physicians enrolled in a medical web portal (IntraMed, www.intramed.net) could take an online survey after logging into the web page. The web survey was on the portal during the month of December, 2011. To assess whether there is a positive or negative relationship among predictor variables and research productivity, we first needed to group physicians based on their research activities using a cluster analysis and also to discover the principal components or themes inferred by the explicative variables include in the survey. Finally, we performed a Kruskal-Wallis test to evaluate differences among clusters in the median value of each of the components retained after the PCA analysis. **Results:** We found three clusters that seem to describe the levels of research productivity. Cluster one is the cluster with more research involvement and includes physicians with the highest number of conference presentations and publications. All physicians with publications in the last 3 years were also included in this cluster. In cluster three are physicians with no presentations or publications in a peer-reviewed journal. After performing a PCA analysis we found five principal components inferred by questions in the survey: environmental support, use of communication tools, computer knowledge, statistical analysis experience and use of computers for academic activities. We decided to add information resources as another explicative variable. All components were statistically significant when related with research productivity. Multivariable analysis showed us that these relationships are still significant after adjusting by possible confounders. **Conclusions**: As described in other settings, we found the same factors associated with physicians' research productivity. Informatics resources are another factor that might increase research productivity in Latin American physicians.

Introduction

Making an investment in research is important because research can lead to benefits in the current and future health of a population, and may also have a positive impact on the economic growth of a country.[1] Despite these well-described positive effects of research, there is limited investment in research in Latin America. Along with this low investment, the number of researchers and the number of research projects and publications have traditionally been low.[2,3]

It is necessary to have highly skilled researchers in order to develop research capacity.[2] Within Latin America, the countries of Argentina, Brazil, Uruguay and Chile rank within the top five countries for research involvement. Even so, based on their populations, far fewer researchers are available as compared with countries such as the United States, Japan, or Canada.[4,5] Figure 1 presents the number of researchers in all fields per thousand people in the labor force in selected countries in 2008.[5,6]

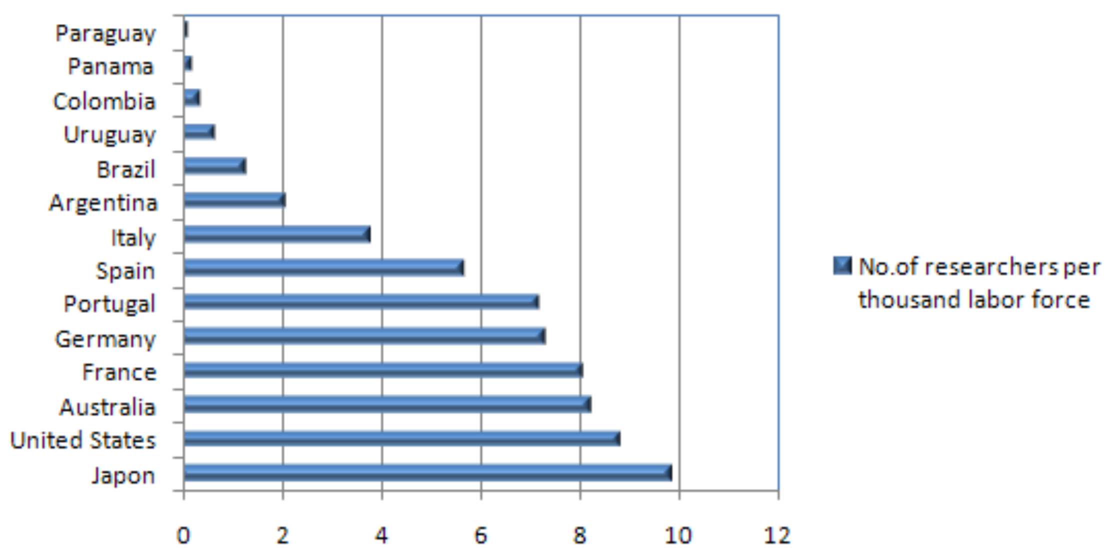

Figure 1:Researchers per thousand-labor force in selected countries, 2008

The expenditure on research in Argentina as well as in other Latin American countries is also relatively low when it is measured according to international standards.[5,6] For example, in 2008, Argentina's investment in research was 0.52% of its gross domestic product (GDP) and Brazil invested 1.19% of its GDP, while countries with higher investment in research like Japan, the United States and Germany spent about 2.5- 3.5 % of GDP.[5,6] Figure 2 presents the expenditure in research (measured as a percentage of its GDP) of selected countries in 2008.[5,6] This lack of adequate government funding is an obstacle to carrying out research, particularly in terms of retaining qualified researchers in the country.[2] As a result of the low level of government investment in research, a low number of projects are financed and published.[7]

This project seeks to identify the variables that most strongly influence whether a physician participates in clinical research, as well as the amount of variance in research

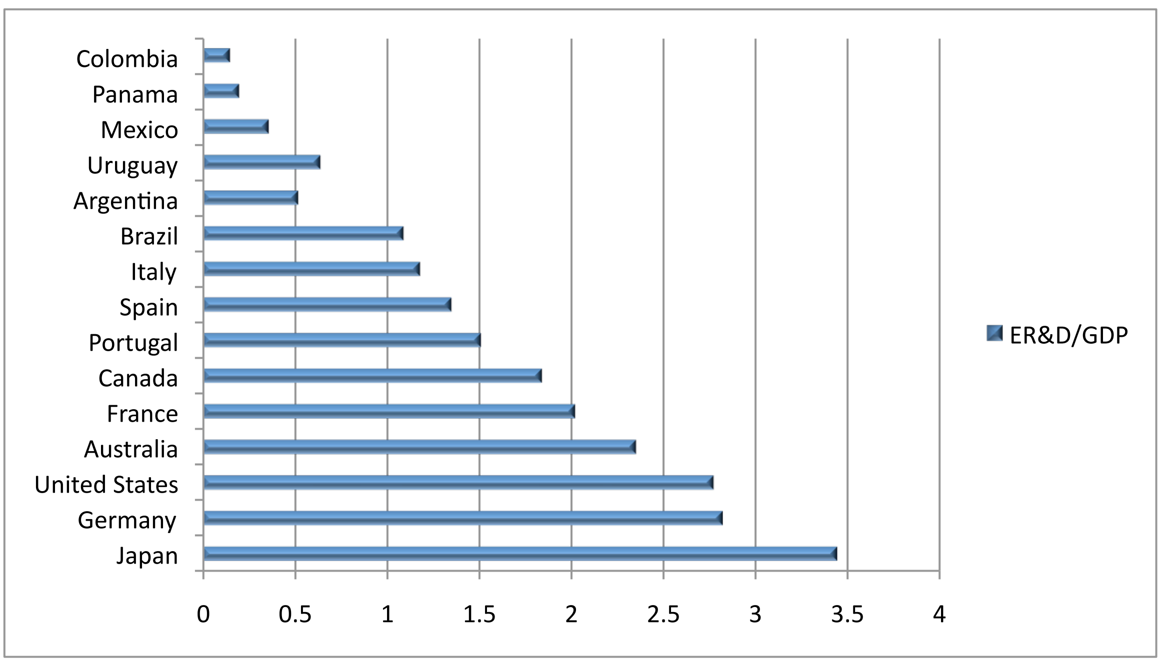

Figure 2: Percent of GDP available for research in selected countries

productivity each predictive variable explains; it has a special focus on informatics resources and competency. Discovering predictive variables will allow for the planning of interventions that might increase physicians' clinical research productivity.

Background

Previously published articles have shown a variety of factors to be related to the performance of clinical research, and have found the problem to be complex and multidimensional. Cooke's framework describes the necessity of acting at several different levels simultaneously in order to increase research activity.[8] An idea with its roots in the Social Ecological model, it is a framework that "examines the multiple effects and interrelatedness of social and physical elements in an environment".[9]

An individual with their own strengths (knowledge, skills, and desire to perform research) works in contact with others physicians, generally working for a specific institution or organization immersed in a specific community under the social and political norms of the country. All of these environmental layers influence an individual's decision and ability to be involved in research.

Physicians who think that information gained by conducting research is useful in the daily management of patients, and that evidence-based medicine improves the daily care of the patient, are more involved in research than physicians who do not think in this way.[10] Moreover, physicians who have the skills to perform research activities are more involved in research activities.[11,12,13] For example, Jowett's research in 2000 found that 50% of general physicians who had initiated original research did not have any research training compared to 74% who did have training, and this finding was statistically significant.[11]

Besides individual proficiency and experience, being part of a team has been recognized as being an important factor affecting research performance.[8,11] The interactions and interchanges promoted in group work help participants to generate different ideas as well as different perspectives about the same idea, both of which are essential for research activities.

In addition to team factors, Greenwood & Gray found that institutional factors affect their members' research behavior. They found that individuals at institutions or organizations that expect and reward scientific research were more likely to engage in research activities than were individuals working in less supportive environments.[14] The institution that values research will be more likely to have resources (staff, time, materials) available for use in performing research activities.[15] The presence of such resources can encourage other investigators in the environment to support appropriate learning, and fosters discussion of significant themes as potential projects. For example, an institution might designate specific administrative and support staff to help researchers in their activities, or might provide researchers with protected time to dedicate towards research activities as well as reimbursement for their research work.[11,15,16] The importance of protected time was demonstrated by Jowett and other authors, who found that the presence of institutionally-protected time varied significantly between physicians who had initiated research (24%) versus physicians who had not (13%).[11]

Institutional support may also increase researcher engagement by making available research courses and training programs, or by putting in place laboratories (e.g., statistics or clinical research support facilities) to help physicians develop and carry out research projects.[8,15] An institution that rewards research not only develops and provides resources for running research activities, but also disseminates its results as a way to share the new knowledge and translate the results to practice.[17,18] Another benefit of this type of dissemination is that it elevates the profiles of researchers within the institution, which supports and rewards researchers in a tangible way.[17]

Moving beyond institutional support, research has shown that governmental support can have strong effects on research productivity. If a country puts in place structures for supervision, supporting both public and private sectors, and creates a favorable legal framework for research, development and innovation are more likely to result from physicians who carry out research. In this way, there will be a budget planned, and optimization of resources with cooperation between program and projects. The intellectual property will be protected and will foment the exportation of innovations.[2,18]

Up to this point, we have discussed the role that various factors -- personal, organizational, governmental -- play in affecting research capacity. However, very little research has been conducted examining the role of information resources in explaining variance in research productivity.

It has been described that technology increases the productivity of workers. It is therefore expected that greater adoption of technology will have a positive effect on the growth of science.[2] Organizations having information resources will have data available for use in studies. The Electronic Health Record (EHR) can be used both as a source of data for secondary uses and as a tool for data collection. Researchers engaged in retrospective research benefit from EHR data in that it often contains a high volume of rich data representing a specific population that can be accessed at a relatively low cost. For prospective research, EHRs can help researchers establish the availability of subjects when preparing study proposals, and can assist in identification and management of study cohorts as well as identification and enrollment of subjects to include in the study.[19,20]

Researchers can also benefit from the use of administrative data. In healthcare, administrative data is the information used to manage daily operations such as billing of services provided to patients (as opposed to data directly related to the day-to-day care of patients), and scheduling appointments. Even when administrative data is not collected for research purposes, it is often used for observational research because of the little time and effort required to obtain data for large populations over a long time period.[21]

Potential research applications from administrative databases include quality improvement efforts, outcomes or treatment effectiveness studies, and cost analyses studies. Another type of information resource often found in hospitals is the patient registry. Registries are databases with information from a specific population, for example, patients with a specific disease or subjects treated with a specific drug. Registries are used mainly for observational studies.[22] Finally, clinical trials management systems can facilitate creation and management of study protocols, study event definitions, sites, users, and case report forms.[23]

Even when an informatics environment can facilitate the availability, recovery, and storage of data, computer skills are necessary for successful human computer interaction (HCI). HCI is involved in all stages of research, from looking for information to the diffusion of new knowledge over the internet.[23]

Instrument (Survey) Development

Stage 1: Development of the questionnaire. Upon reviewing the literature looking for factors that have previously been described as predictors of physician involvement in clinical research, we discovered the following themes: physicians' attitudes toward the use of scientific information, physicians' skills for doing research, and workplace readiness for research (including institutional support, financial reimbursement, etc.). We based our questionnaire especially on the works from Kagan and Sarre,[15,17] and also included questions about physicians' levels of computer experience[26] and workplace informatics resources.

Gill Sarre and Jo Cook in 2009[17] met a sample of experts in the field in order to develop indicators to measure the readiness for research in primary care organizations. They recognized indicators that measure infrastructure (e.g. posts with research responsibilities, protected time to do research), linkages and partnerships (e.g. mentorships, joint posts with universities), skill development, dissemination, research activity (e.g. number of principal investigators), proximity to practice, continuity and sustainability, leadership, and research culture. After this project they developed "The Organizational Support Tool for Research Capacity Development," a tool designed to measure the readiness for research in an organization. Because this tool was aimed towards management and administration, we reworded some questions so that it could be applied and understood by physicians.

Kagan in 2009[15] engaged a broad range of stakeholders to develop a framework for the evaluation of the international HIV/AIDS Clinical Trial Networks. This framework evaluates a number of factors including setting of biomedical objectives, collaborative communication within and between networks, operations and management, development of policies and procedures, resource utilization, community involvement, and relevance to participants. This framework was specific for this clinical trial network but because we considered some of the elements or ideas important, we borrowed many of the concepts.

A clinical research informatics expert reviewed the instrument to evaluate whether the instrument appeared to assess the desired qualities, and also whether the questions covered a representative sample of the domain to be measured.

We next performed several iterative cycles of pre-testing the questionnaire, in which we conducted several interviews with physicians. The aim of the pre-testing was to assess:

1. Meaning (i.e. whether or not each term has the same meaning for the respondent and the interviewer)
2. Ambiguity (i.e. whether or not the respondents felt that a term might have different meanings)
3. Comprehensibility of texts and of each survey item (i.e. ease of understanding)
4. Enhanced language options and appropriate synonyms
5. Restricted response ranges (i.e. determining whether a subject's lack of response to a specific item was because they did not understand the question, or because the subject felt that the instrument did not include an appropriate response)
6. Average time required to complete the survey

Stage 2: Measurement of survey properties. In the second stage, the feasibility of administering the questionnaire and the properties of the measurement itself (endorsement and intra-observer reliability) were assessed. To accomplish this, we conducted a limited test of the survey instrument using a convenience sample of 30 physicians in Argentina. Based on the following assessments, questions were eliminated.

Feasibility Analysis. As part of this validation study, we examined the question-by-question response rates as a way of assessing the feasibility of the questionnaire as a whole. We investigated the proportion of surveys that were returned, as well as the proportion of questions that were answered completely. The purpose of this was to identify potentially problematic questions; our evaluation outcomes for this phase were the proportion of non-responses (missing or otherwise) for each question as well as the overall proportion of questionnaires that were filled out completely (as opposed to being left partially completed).

Intra-observer reliability (test-retest reliability). We also measured the intra-observer reliability by administering the survey on two occasions separated by an interval of 15 days. We measured it using intra-class correlation coefficients (ICC).

Endorsement or ceiling effect. We analyzed the frequency of responses in each of the questions. We ruled out those questions whose responses where very similar across all of our pilot subjects, as these questions will not help us to discriminate between groups.

Stage 3: Determining the final survey instrument. Finally, at the request of IntraMed, which administered the survey, we eliminated all questions which were shown to be redundant. IntraMed had requested a survey with 20-25 questions only, while the final instrument contains 33 items.

Human Subjects Protection

Approval was obtained for this study from the Institutional Review Board of Oregon Health & Science University.

Methods

Aims

This research project addressed issues in the readiness for clinical research on a personal and environmental level. The specific aims of this research project were, as follows:

- Aim 1: Characterize the population of Latin American physicians based on their research experience.
- Aim 2: Evaluate which factors are associated with research involvement among Latin American physicians.
- Aim 3: Assess the relationship between information and technology resources and level of involvement in research.

Study design

This was a cross sectional study. The study collected information from a survey administered to physicians at a single point of time.

Setting

The study surveyed Latin American physicians, with particular focus on Argentina. All physicians enrolled in a medical web portal (IntraMed, www.intramed.net) could take the online survey after logging into the webpage. The portal contained an invitation to participate in the survey as well as consent language. The web survey was on the portal during the month of December, 2011. IntraMed is a medical network of science content with distribution in the geographic area of Latin America. It has over 250,000 subscribers and a frequency of use of approximately 50,000 different users per month. This portal has previously been used for surveys and the administrators agreed to host the current study.[24]

Eligibility criteria

All physicians in the web portal database were included in the sample. The survey was voluntary and no incentive was offered.

Sample size

To calculate the minimum number of physicians necessary for the study to have valid results, we followed the formula from Peduzzi et al. (1996).[25] Assuming that 29% of physicians in Latin America are engaged in clinical research, and considering an estimated number of 10 factors to include in the logistic regression equation, a minimum of 345 physicians needed to be recruited (N = 10*10/ 0.29 = 345). This number also covers those to be included for the PCA analysis using the rule subjects to variables, where the minimum number of observations is 10 times the number of variables included in the survey (33). After accounting for a 90% non-response rate, we arrived at a final minimum sample size of 3,450 physicians. The IntraMed portal, however, gave us access to many more physicians than this minimum sample size; low response rates, however, would be expected.

Instrument

The self-administered survey described above was designed to characterize physicians with respect to their level of involvement in research. In addition, IntraMed provided the investigators additional subject demographic data for each survey submitted, including age, specialty, country of residence, and gender. IntraMed did not provide any other identifiers to these investigators.

Statistical analysis

The participation rate was calculated as the ratio of physicians who agreed to participate compared to physicians who logged into the home survey page. The completion rate was calculated as the ratio of the number of physicians who finished the survey compared to those who agreed to participate. We described categorical data as a percentage and summarized it in a bar chart. Continuous data were expressed in median and range.

Aim 1: Characterize the population of physicians from Latin America based on research experience. By using the survey questions that address the subjects' level of experience in research, we performed a two-step cluster analysis using a log-likelihood criterion such as distance measured in SPSS. This method was selected since we have a large dataset. After performing pre-clustering on the data to reduce the matrix size, which contains distances between all possible pairs of cases, a hierarchical clustering algorithm on the pre-clusters was performed. The selection of the optimal number based on clusters was determined by the application of the Schwarz Bayesian Criterion. Bar charts were used to show the distribution of the variable within each cluster. Silhouette measures were used to address the internal quality of the clusters. The final clusters were used as variables that summarize the level of research involvement.

Aim 2: Evaluate which factors are associated with research involvement among Latin American physicians; and Aim 3: Assess the relationship between information and technology resources and research productivity. Principal component analysis was used to simplify and summarize the information revealed in the questionnaire by inferring the components that underlie these variables. These components are said to be non-correlated with each other and maintain the data variability. Data was standardized prior to the analysis. The analysis of the correlation matrix with Kaiser-Meyer-Olkin measure (KMO) and Bartlett test of sphericity was performed to test whether variables are correlated or not and, therefore, whether it is appropriate to perform PCA analysis.

In order to determine the number of components to be retained, we used the Kaiser rule that retains only eigenvectors with eigenvalues at least of one. A scree plot was performed to represent the eigenvalues. We excluded variables from the PCA analysis whose proportion of variance explained by the components was less than 0.30.

Having decided the number of components to retain and the variables to include in the analysis, we then determined the factor scores with varimax factor rotation. We considered a threshold of 0.4 for assigning a question to a specific component.

To evaluate differences among clusters in the median value of each of the components retained after the PCA analysis, the Kruskal-Wallis test was conducted. A profile chart was created in order to summarize the difference in the median of each component among clusters. Follow-up tests were performed to evaluate pairwise differences among the three groups on each of the components, controlling Type I error across tests by using the Bonferroni approach. We originally had $\alpha = 0.05$ as the overall level of significance. With $k = 3$ groups, there are $m = 3(3 - 1)/2 = 3$ pairwise comparisons, suggesting each test should be performed at the $\alpha' = 0.05/3 \approx 0.016$ level.

For a multivariate analysis, variables that were statistically significant (alpha 0.05%) in univariate analysis were included in a Generalized Ordered Regression Analysis by estimating the partial proportional odds model. Possible confounders were included in the model to assess whether the entire set of variables still has an impact after adjusting by confounders. Variables are presented with their regression coefficient b, standard error. For categorical variables included in the model, the female gender was chosen as the comparison group; clinical specialty was the comparison group for specialties and Argentina was also the comparison group for countries.

The analysis was performed by using the Statistical Package for the Social Sciences (SPSS) 17th version and STATA 12.

Results

Survey Development, Stage 1: Pretesting

After reviewing the literature, a first version of the survey was developed. A field expert validated this version. This first version had 74 questions. Figure 3 shows the flowchart for survey development.

From the months of June to August, 2011, we performed iterative pre-testing cycles of questionnaires by conducting several interviews with physicians. The first meeting was held in Argentina (Hospital Italiano). A convenience sample of physicians was asked to complete the survey. It took physicians an average of 15 minutes to complete the survey. After the meeting, we asked for feedback related to each question.

Suggestions included the following:

- In questions that address the physician's experience in research, we asked physicians to think about the number of conference presentations or publications that they have had.

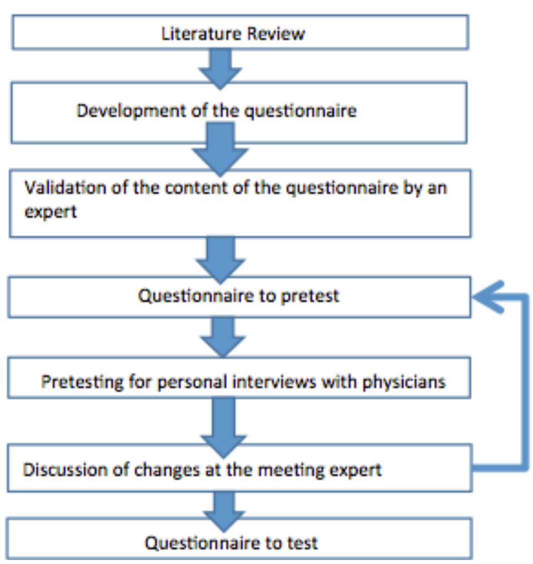

Figure 3: Survey Development Stage Flowchart.

The difficulty in remembering an exact number of publications or conference presentations was noted, especially for those people who have had a high number of conference presentations or peer-reviewed publications. Consequently, setting a range of options was suggested. The box below shows an example of how questions were modified based on this suggestion.

Initial question:

1.1 Since graduation from medical school, how many research presentations have you made at national or international conferences?

Revised question:

1.1 Since graduation from medical school, how many research presentations have you made at national or international conferences?
☐ 0
☐ 1-5
☐ 6-10
☐ 11-15
☐ >15

- We were also asked to replace specific words by appropriate synonyms, such as "impact" by "importance", since some physicians felt that "impact" could be interpreted differently by different people. The box below contains an example of changes that were made based on this suggestion.

Initial question:

What impact do you think that clinical research has in your clinical career?

Revised question:

Overall, how important are clinical research results to your practice?

- We were advised to change the options of some questions, for example, questions that addressed the training level, where more than one option might be appropriate. Physicians suggested changing the option in such a way that only one option is correct. The box below shows an example of changes of this type that were made.

Initial question:

If you have taken one or more courses, could you tell us what kind of training program you received those courses in? Please select all options that apply.

☐ Courses in statistics, epidemiology or clinical research taken outside of a degree program
☐ Masters degree in statistics, epidemiology or clinical research
☐ Masters degree in another field but with courses in statistics, epidemiology or clinical research
☐ PhD or doctoral degree in statistics, epidemiology or clinical research
☐ PhD or doctoral degree in another field but with courses in statistics epidemiology or clinical research
☐ Other (please explain)_______________

Revised question:

2.1 Select the highest level of training in statistics, epidemiology or clinical research that you have received:

☐ No courses since medical school in statistics, epidemiology or clinical research.
☐ At least one course covering <u>basic</u> concepts in statistics, epidemiology or clinical research.
☐ At least one course covering <u>advanced</u> concepts in statistics, epidemiology or clinical research.
☐ Masters degree in statistics, epidemiology or clinical research.
☐ PhD or other doctoral degree in statistics, epidemiology or clinical research.

- We also discovered that we needed to define some terms for people to understand them consistently. For example, we were asked to define the term “environment”. The box below illustrates changes that we made.

Initial question:

Please select your level of agreement regarding these statements about [topic] for research in your environment.

Revised question added:

Note: *Your "environment" may be your practice, the practices in your geographical area, a research or practice network, a hospital, or a research institution, i.e. wherever you do or might do research.*

Survey Development, Stage 2: Measurement of Survey Properties.

Figure 4 illustrates the responses to the pilot questionnaire.

Feasibility Analysis. A total of 30 surveys, 80 % (N 24) were returned, 95% (N 23) of them were fully answered. The only survey that was not fully answered had only one missing answer.

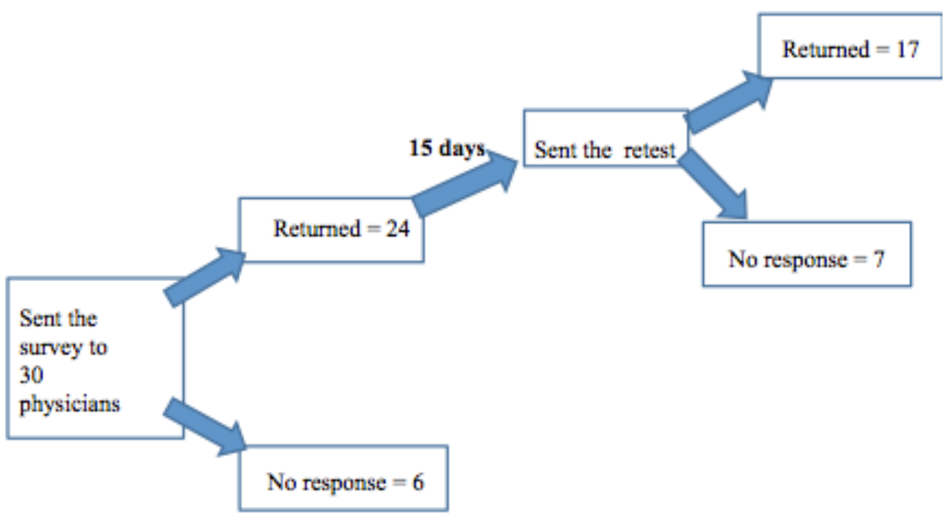

Figure 4. Flowchart of the pilot questionnaire

Intra-observer reliability (test-retest reliability). Intra-observer reliability refers to the ability of an instrument to measure attributes consistently. In our survey fourteen items had lower test-retest reliability with a cut-off point 0.65 (Appendix 2). These low values may indicate either that the scale is unreliable; that the test is reliable but the phenomenon changed over time, for example, with relatively quick changes; or that taking the test previously influenced physician's responses on the second survey administration.

Endorsement. None of the questions had an alternative option with more than 0.95 rate of response. However, we can see that there were some questions which had been answered in the same direction (Appendix 3).

Characteristics of the Population Under Study

During the period from November 25th to December 21st, 2011, 36,260 physicians from different Latin American countries logged into the IntraMed web portal. Of these, 49.2% (N 17,832) interacted with the first survey page. Only 26.5% (N 4745) agreed to participate in the survey (Figure 5).

Fifteen participants were excluded from the analysis for residing in other non-Latin American countries like Spain or the United States. The web survey had a participation rate of 26.5% and a completion rate of 100%. All the participants completed all items in the questionnaire.

The demographic characteristics of the participants are summarized in Table 1. The distribution of participants per country is shown in Figure 6. We observed that Argentina

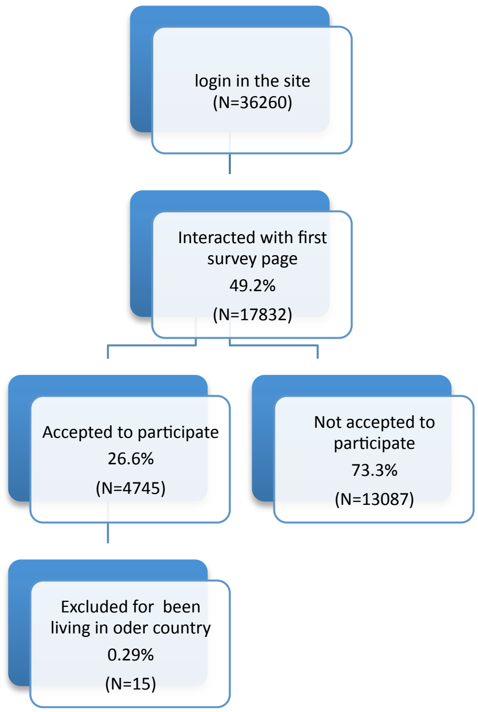

Figure 5. Study flowchart

was the country with the highest number of participants (80.99%). Figure 7 shows the percentage distribution of participants by specialty. Medical specialties were represented more often than surgical specialties (79.22% vs. 20.5%).

Gender	
Male	53.53 (2540)
Age*	45 (35-55)
Specialty	
Medical	79.22 (3747)
Surgical	20.5 (953)
Laboratory	0.63 (30)
Country	
Argentina	80.99 (3,831)
Mexico	5.88% (22)
Others	13.13 (877)

Table 1: Characteristics of the population under the study. All variables are expressed in percentage (number). except age * median (interquartile range)

Of all participants, only 32.29% (N 1,520) reported having electronic health records (EHRs) in their work environment. 59.0% (N 2,778) stated they have admissions and/or scheduling systems, 56.11% (N 2,654) have access to patient or disease registries. Very few of them reported access to clinical trial management systems (8.5%, N 403) or clinical decision support systems (5.25%, N 246).

Country	Percent	Freq.
Argentina	80.99	3,831
México	5.88	278
Ecuador	2.54	120
Cuba	2.43	115
Colombia	1.59	75
Perú	1.31	62
Venezuela	0.95	45
Uruguay	0.78	37
Guatemala	0.72	34
Bolivia	0.47	22
El Salvador	0.42	20
Dominican Republic	0.36	17
Chile	0.34	16
Nicaragua	0.34	16
Paraguay	0.32	15
Honduras	0.21	10
Panamá	0.17	8
Costa Rica	0.13	6
Brasil	0.06	3

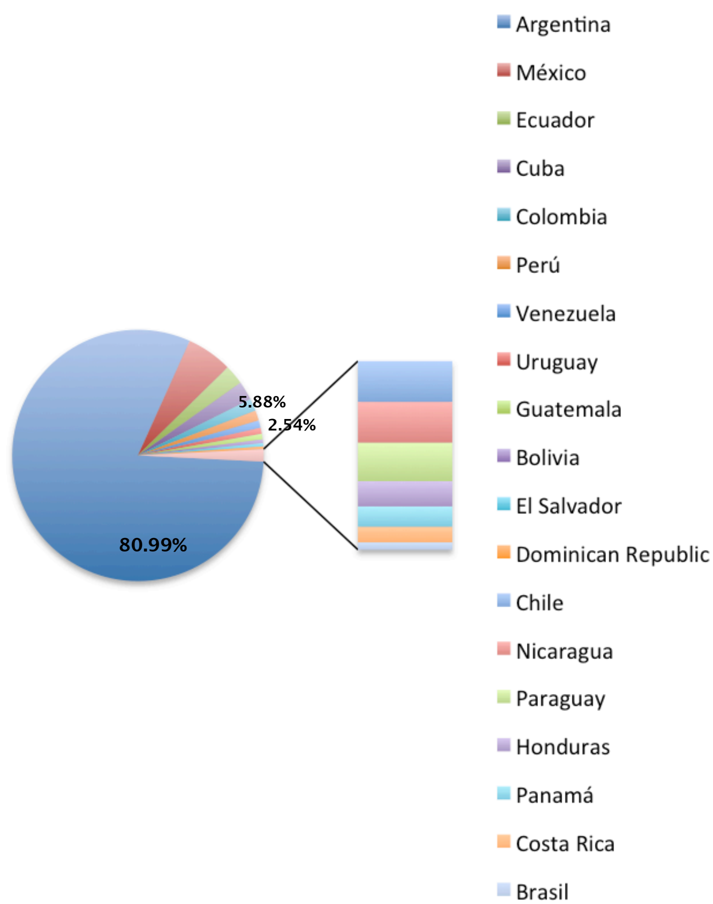

Figure 6: Count and percentage distribution of participating physicians by country.

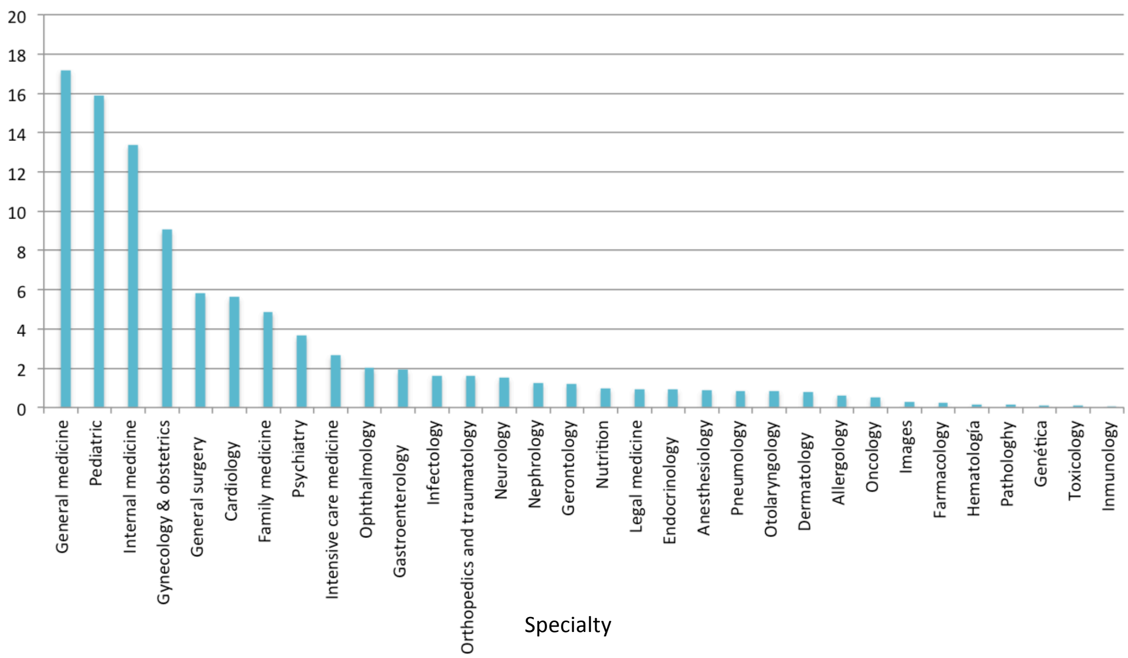

Figure 7: Percentage distribution of participating physicians by specialty

Classification of Physicians - Cluster Analysis

There appear to be three clusters that summarize the level of involvement in research after clustering participants according to the 5 questions related to research experience. Table 2 shows the number of subjects which belong to each of the final clusters.

The largest cluster contains 35.8% of the participants, whereas the smallest includes 29.3%. Figure 8 shows the distribution of the variables in each cluster. Figure 9 shows the internal quality of the clusters using the Silhouette measure.

Cluster	Cluster Distribution		
		N	%
	1	1693	35.8%
	2	1652	34.9%
	3	1385	29.3%

Table 2: Final distribution of physicians in each of the clusters.

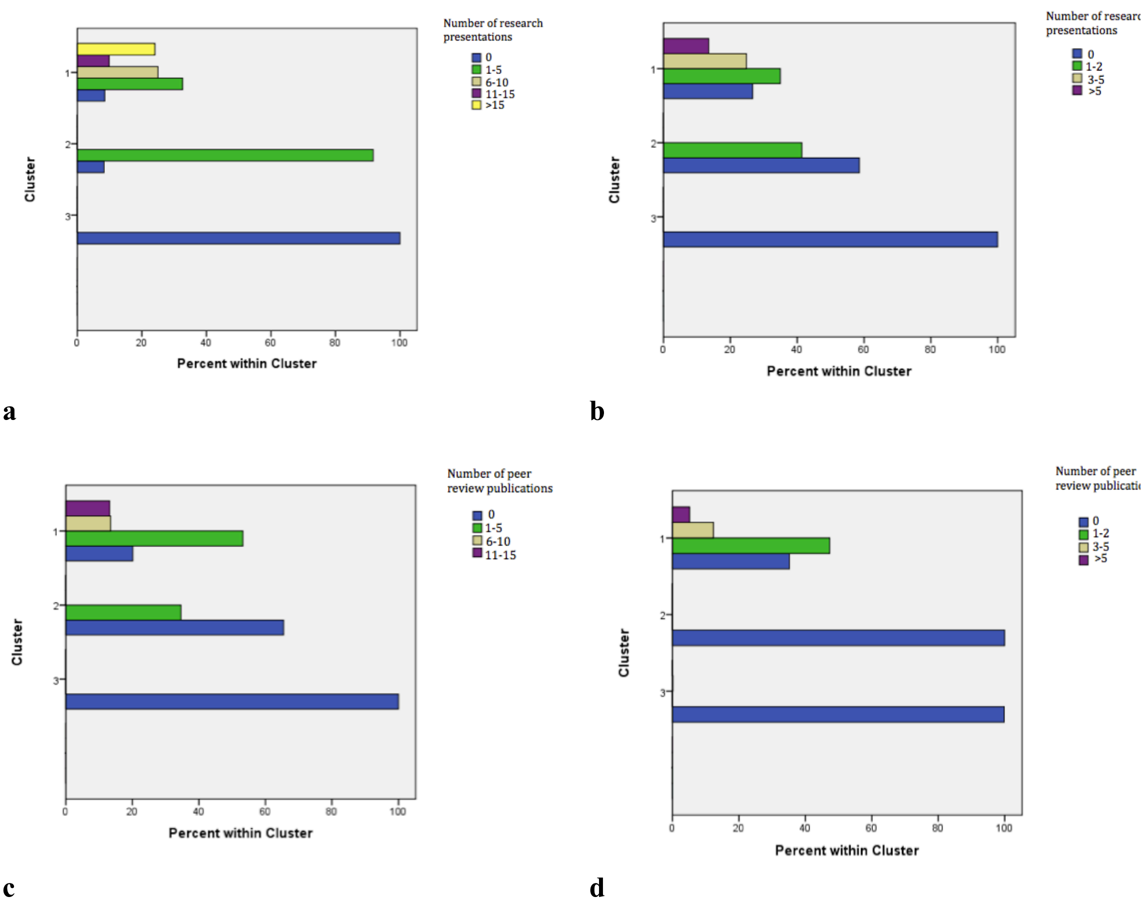

Figure 8. Cluster analysis results

a) Within-cluster percentage of participants' research presentations at national or international conferences.
b) Within-cluster percentage of participants' research presentations at national or international conferences in the last 3 years.
c) Within-cluster percentage of participants' peer-reviewed publications.
d) Within-cluster percentage of participants' peer-reviewed publications in the last 3 years.

.

Figure 9: Silhouette measure of cluster quality

Cluster 3 is the cluster with least involvement in research. Most physicians who have had no conference presentations or publications during their careers as physicians are included in this cluster. Cluster 2 seems to have some involvement in research with a history of presentations and publications during their careers as physicians. However, none of these participants reported having any publications in a peer-reviewed journal for the last 3 years.

Cluster 1 has the highest level of research involvement, considered to be a good level of involvement. This cluster includes physicians who have had a higher number of presentations and publications during their careers and all physicians who have submitted a publication in a peer-reviewed journal in the last 3 years.

Factors Associated with Clinical Research

Principal Component Analysis (PCA). Factors associated with research involvement among Latin American physicians and the relationship between information and technology resources and the level of involvement in research were evaluated using principal component analysis. Since the Kaiser-Meyer-Olkin test showed a high statistic (0.912) and the Bartlett $test_{378}$ was significant at 44835 ($p < 0.001$), it is suitable to use PCA analysis with this dataset.

Appendix 4 shows the commonalities of the variables. Most of the variables were represented well in the factorial structure except for “number of information resources” which is the sum of the information resources available in the participants' environments. This variable was therefore excluded from PCA and can be considered an independent variable.

After looking at the scree plot and, especially, after studying the variance explained by each component and its eigenvalues (Table 3), a factorial structure with 5 components

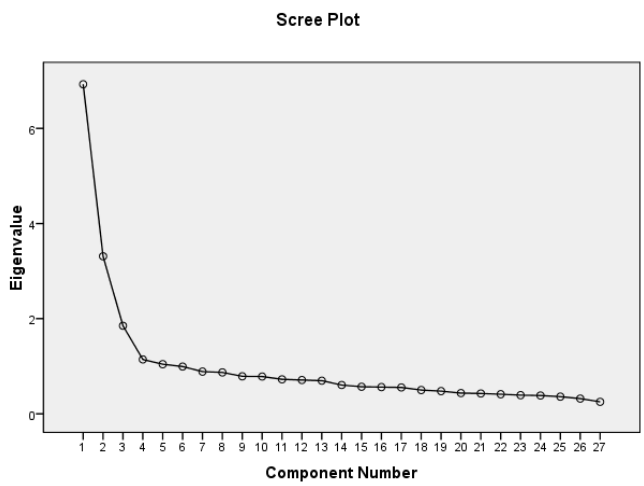

Figure 10: Scree plot: Eigenvalues by component

was selected. (Figure 10 and Appendix 5). These five components explain 54% of the variance within the population.

The component matrix (Appendix 6) shows the loading factors higher than 0.4 for each variable in each of the 5 components. Each question falls into a single component except for the questions "Performing statistical analysis on clinical research data" and "Obtaining advice on a specific patient's diagnosis or therapy", which fall into two components.

	Rotation Sums of Squared Loadings		
Component	**Eigenvalues**	**% of variance**	**Cumulative %**
1	5,819	22,400	22,400
2	3,110	11,972	34,372
3	2,621	10,089	44,460
4	1,356	5,221	49,682
5	1,183	4,552	54,234

Table 3: Eigenvalues retained and variance explained by the first 5 components

Environmental support	Use of communication tools	Computer use for academic activities	Computer knowledge	Knowledge in statistical analysis
My work environment facilitates and enables research supervision and mentorship.	Group calendaring (for example, Google calendar, Outlook group calendar).	Obtaining advice on a specific patient's diagnosis or therapy.	In a typical week, how many hours do you personally use a computer?	Performing statistical analysis on clinical research data.
My work environment facilitates or offers clinical research training through	Tools for coordinating meetings (for example, Doodle).	Writing (grants, research papers, teaching materials).	How would you rate your computer skills	the highest level of training in statistics, epidemiology or clinical research that you have received:
Investigators in my environment have adequate qualifications and experience to perform research.	Digital video for communication (for example, Skype).	Preparing presentations.		Obtaining advice on a specific patient's diagnosis or therapy.
Adequate protected time to do clinical research is provided in my environment .	Audio conferences.	Performing statistical analysis on clinical research data.		
Local scientific results are published and disseminated widely.	Discussion boards.	Searching medical literature.		
National institutions fund research projects in my environment.	Wikis or similar tools for collaborative online work (for example, Google Docs).	Teaching.		
International institutions fund research projects in my environment.				
The selection of a research topic follows national health priorities.				
There is good communication and collaboration in research between investigators in my environment.				
There is good communication and collaboration in research with other research				
There are good support services in my environment to help with clinical research, for example, statistics services or clinical research services.				

Table 4: Questions that belong to each component

On analysis of the matrix, the final components seem to have clear themes (Figures 11-15 and Table 4). The first component, called “Environmental support” combines the results of questions which reflect participants' perceptions of the readiness to research in the environment, while the second, “communication tools usage”, deals with the current use of technology for communication purposes. The third component, “Use of computers for academic activities”, refers to the use of computers for work and academic purposes rather than other available methods. The fourth component, “Computer knowledge”, includes the perception of participants' ability to use the computer as well as the weekly hours spent using a computer. The fifth component, called “knowledge in statistical analysis” includes the training level as well as the use of statistical software. Figures 11-15 show the weight of each variable belonging to each component.

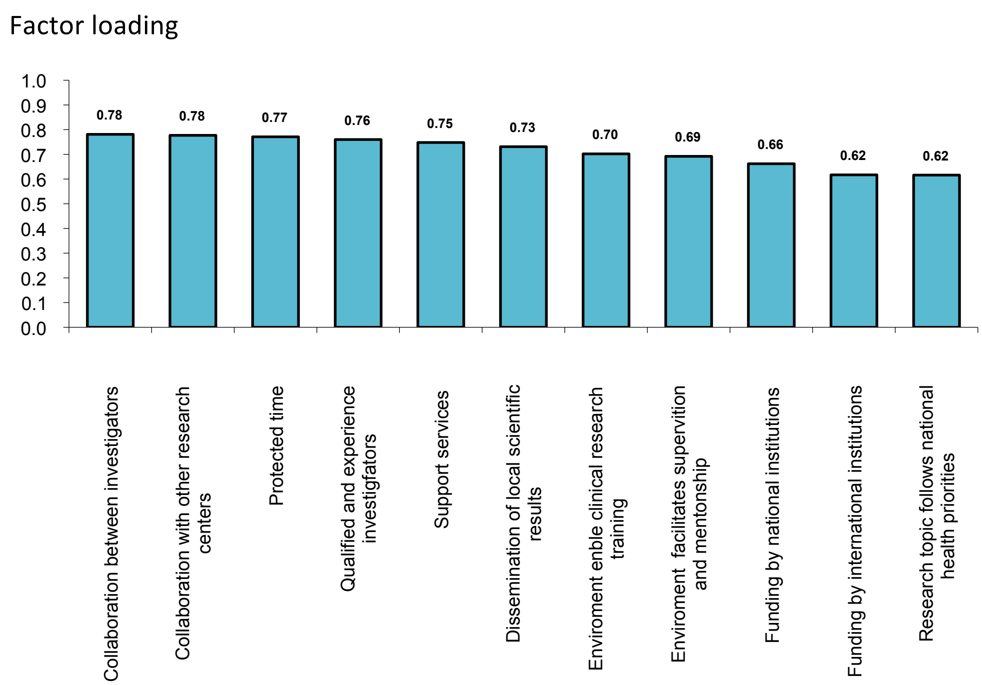

Figure 11: First component: “Environmental support”, main factor loadings

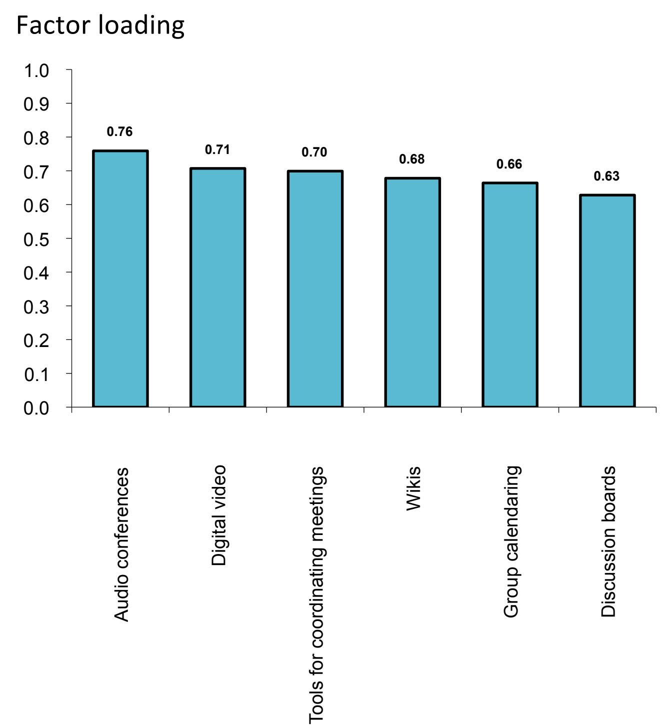

Figure 12: Second component: "Use of communication tools", main factor loadings

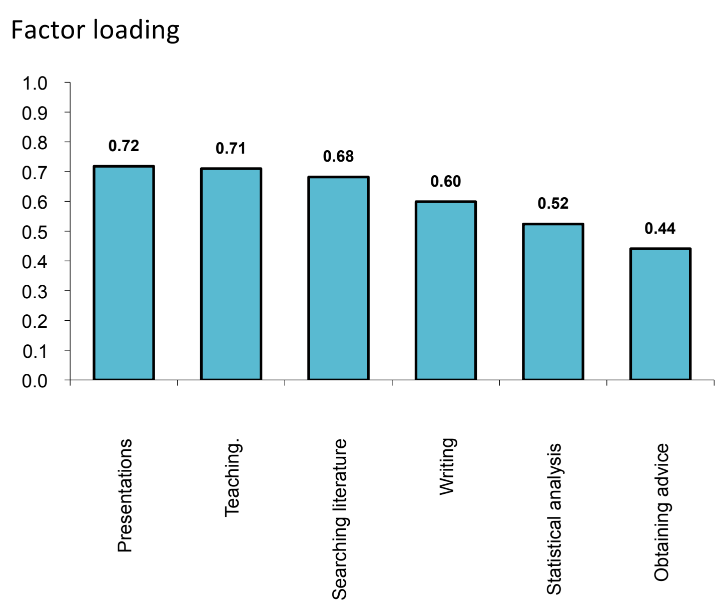

Figure 13: Third component: "Computer use for academic activities", main factor loadings

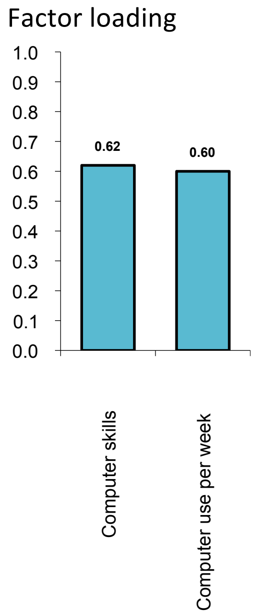

Figure 14: Fourth component: "Computer knowledge", main factor loadings

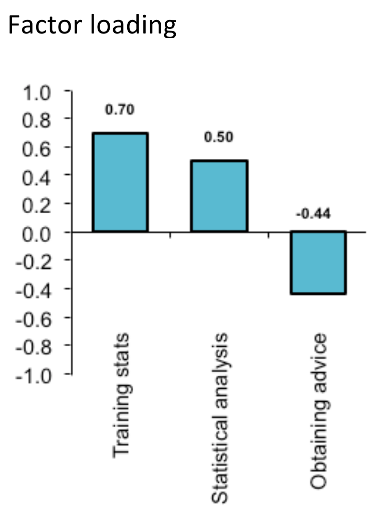

Figure 15: Fifth component: "Knowledge in statistical analysis", main factor loadings

Kruskal-Wallis and Pair-wise Comparison. To evaluate differences between clusters 1, 2 and 3 on median value of each of the components retained after PCA analysis, a Kruskal-Wallis test was conducted (Figure 16 and 17). The median of the each component is significantly different across clusters in all of the components ($p < 0.001$).

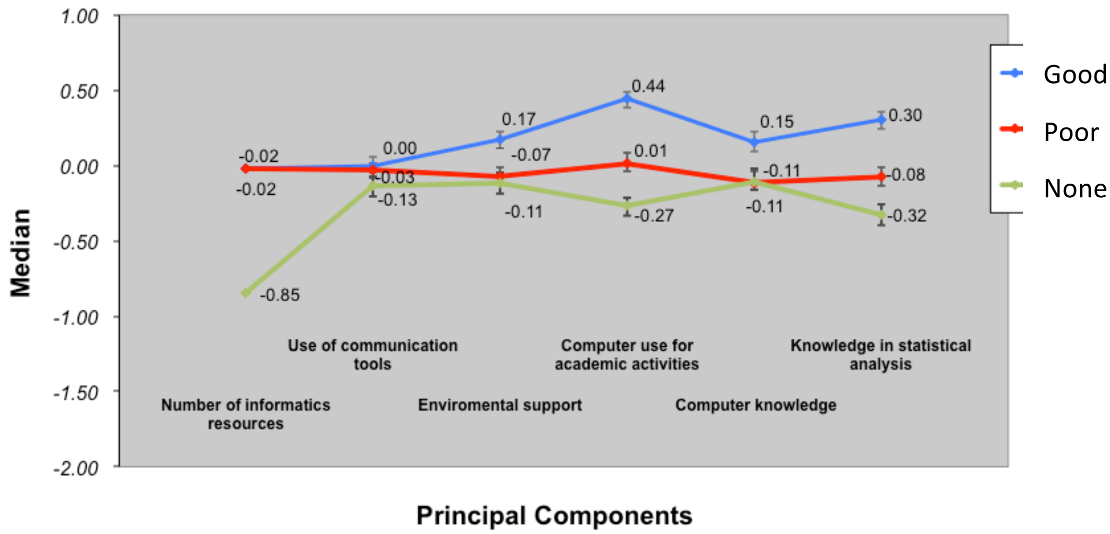

Figure 16: Median and 95% confidence interval for each component in each cluster

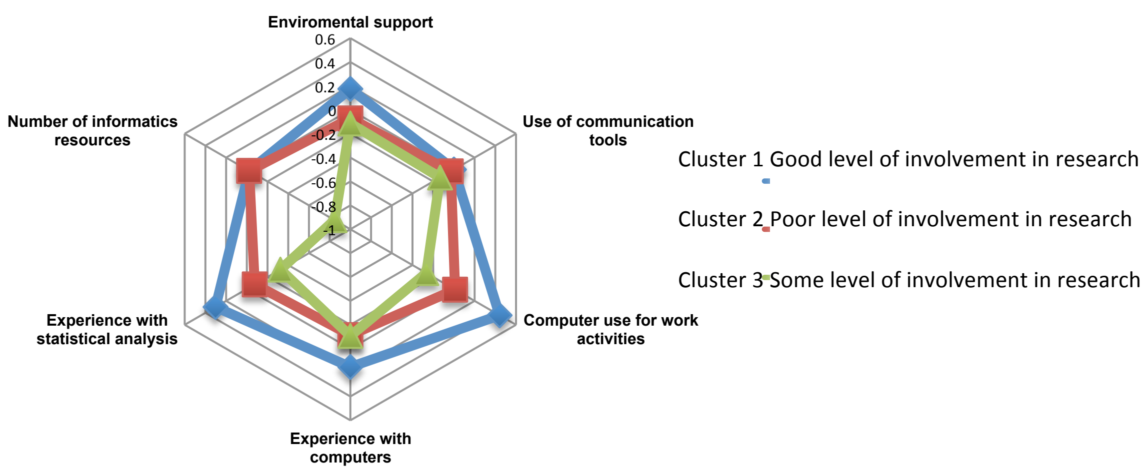

Figure 17: Radar chart: Median of each component by cluster

In this analysis we see that the cluster with no involvement in research (Cluster 3) was significantly less likely to have less information resources, less likely to use the computer for academic activities and had less knowledge of statistical analysis than the other 2 clusters. Additionally, this group showed less environmental support, less use of communication tools and less computer knowledge than the clusters that showed more involvement in research (Table 5-10)..

Cluster 2 showed a significant statistical difference only in the presence of information resources, the use of computer for work activities and knowledge of statistical analysis. Cluster 1, the cluster with highest involvement in research activities, had higher levels of support and information resources in their environment, showed higher use of the computer for work activities and had more experience with computer and statistical analysis (Table 5-10).

Environmental support Kruskal Wallis test [chi-squared 2 = 90,480= 0.0001]		
	Cluster 2	Cluster 3
Cluster 1	P value: <0.001	P value: <0.001
Cluster 2		P value:0.016

Post doc comparison test : Mann-Whitney U (Bonferroni correction)

Table 5: Differences in the median in terms of environmental support among 3 clusters (follow up test)

Use of communication tools Kruskal Wallis test [chi-squared 2 = 30,570= 0.0001]		
	Cluster 2	Cluster 3
Cluster 1	P value:0.082	P value: <0.001
Cluster 2		P value: <0.001

Post doc comparison test : Mann-Whitney U

Table 6: Differences in the median in terms of use of communication tools support among the three clusters (follow up test)

Use of computer for academic activities Kruskal Wallis test [chi-squared 2 = 340,091= 0.0001]		
	Cluster 2	Cluster 3
Cluster 1	P value: <0.001	P value: <0.001
Cluster 2		P value: <0.001

Post doc comparison test : Mann-Whitney U

Table 7: Differences in the median in terms of the use of computer for academic activities among the three clusters (follow up test)

Computer experience Kruskal Wallis test [chi-squared 2 = 48,757= 0.000]		
	Cluster 2	Cluster 3
Cluster 1	P value: <0.001	P value: <0.001
Cluster 2		P value: 0.355
Cluster 3		

Post doc comparison test : Mann-Whitney U

Table 8: Differences in the median in terms of the knowledge experience among the three clusters (follow up test)

Experience with statistical analysis Kruskal Wallis test [chi-squared 2 = 285,294= 0.0001]		
	Cluster 2	Cluster 3
Cluster 1	P value: <0.001	P value: <0.001
Cluster 2		P value: <0.001

Post doc comparison test : Mann-Whitney U

Table 9: Differences in the median in the knowledge of statistical analysis among the three clusters (follow up test)

Number of informatics resources Kruskal Wallis test [chi-squared 2 = 155,856= 0.0001]		
	Cluster 2	Cluster 3
Cluster 1	P value: <0.001	P value: <0.001
Cluster 2		P value: <0.001

Post doc comparison test : Mann-Whitney U

Table 10: Differences in the median in terms of number of information resources among the three clusters (follow up test)

1 none vs. (poor & good)			
Environmental support	0.2744899	0.0305223	0.000
Use of communication tools	0.1549498	0.0296815	0.000
Use of the computer for academic activities	0.5912699	0.035944	0.000
Computer experience	0.1326267	0.0355294	0.000
Experience with statistical analysis	0.484079	0.0305237	0.000
Number of informatics resources	0.1326778	0.0265557	0.000
Male	0.0624175	0.0603519	0.301
Surgical	0.6854519	0.1134891	0.000
Laboratory	-0.4746344	0.4505565	0.292
Clinical surgical	0.7751149	0.0906815	0.000
Other countries	-0.5275431	0.0883784	0.000
Age	0.0406633	0.002463	0.000
2 (none &poor) vs. good			
Environmental support	0.2744899	0.0305223	0.000
Use of communication tools	0.1549498	0.0296815	0.000
Use of the computer for academic activities	0.6967627	0.0380819	0.000
Computer experience	0.2539927	0.0347681	0.000
Experience with statistical analysis	0.484079	0.0305237	0.000
Number of informatics resources	0.1326778	0.0265557	0.000
Male	0.0624175	0.0603519	0.301
Surgical	0.6854519	0.1134891	0.000
Laboratory	0.5287694	0.4167502	0.205
clinical surgical	0.7751149	0.0906815	0.000
Other countries	-0.3227049	0.0886461	0.000
Age	0.0406633	0.002463	0.000

Table 11: Generalized ordinal regression (partial proportional odds model)

Multivariate Analysis. In the multivariate analysis, all variables that showed statistical significance in the univariate analysis as well as possible confounders such as age, specialty, and country were included. A statistically insignificant global Wald test indicates that the final model does not violate the parallel lines assumptions. As seen in Table 11, after adjusting other variables and possible confounders, participants tend to have a higher level of research involvement when they can count on more information resources in their environment and more environmental support as well as more experience in statistical analysis. Physicians who use communication tools for communicating with their colleagues and report more experience with computers also tend to be more involved in research activities. In these last two components, the effect is more likely to occur in people with a higher level of research involvement.

We also observed that physicians from surgical specialties tend to report a higher level of involvement in research than those in medical specialties. Responders from Argentina tend to report more research involvement than the other countries. Increasing age also increases the probability of having a higher level of research involvement.

Discussion

In this study we sought out the factors associated with clinical research in Latin America. We believe that these factors act at two structural levels: at the individual level and at an environmental level. Similar ideas are described in previous literature.[8] Urie Bronfenbrenner (1977, 1979)[9], for example, discussed the Ecological Systems Theory, which holds that "the person, the environment, and the continuous interaction of these two influence human behavior."

Factors described in the literature that facilitate involvement in research in developed countries are the same as those we found in our study of developing countries. We think this is an important finding given the cultural differences.

One of our findings suggests that at an individual level, having statistical analysis skills and use of computers increases the level of research involvement. We can assume that the use of the internet and computers is very important for research; for example, these might be helpful for reviewing the literature, for storage of data, and for performing data analyses. In Latin America, access to the internet has increased in the last decade. If this situation is maintained over time and statistical analysis skills can be provided to clinicians, we can presume that clinical research productivity will improve in the region.

In addition, involvement in academic activities was found to be related to research work performance.[11,13] However, as mentioned earlier, individuals are continuously interacting with their environments, which likely have an effect on the outcomes. An encouraging environment that promotes the acquisition of skills by means of courses and mentorship activities may influence physicians' abilities and opportunities to do research work.[8,17]

These factors were recognized by physicians with a good level of research involvement from our sample.

In the interplay between physicians and their environment, physicians might obtain some benefit from the available infrastructure.[8,11,16] Having protected time and other investigators in the environment, the presence of support services and funding were more commonly described in our study by physicians with more research involvement than by those less involved.[11,12,17,28] In addition to environmental support, the information systems factor seems to be important for increasing clinical research involvement.

In the literature, the possible benefits of having information resources for research have been discussed.[20,21,22,24] Despite this knowledge, no previous research project has investigated this relationship. We learned that the number of information resources available in the environment is directly associated with the level of research involvement. The presence of some type of electronic health record is related to a higher level of research involvement. Scheduling and admission systems, clinical decision support systems and patient or disease registries proved to be statistically different between the clusters. These findings agree with the literature in the sense that this association probably results from the availability of data for analysis and because of improved recruitment of patients in research projects. [20,21,22,24]

We learned that Argentina is more involved in research than other Latin American countries.[3,4]. Our results are consistent with other literature that rank Argentina as the leading Latin American country in number of publications. Other significant findings were that men are more involved in research than women, again in accordance with the findings described by others (Ferrero[29]), but these effects disappeared after including a variable for gender in the multivariate analysis. Age is also associated with research productivity. Our analysis suggests that physicians in surgical specialties are more involved in research than those in medical specialties. This finding has not previously been described to our knowledge. All physicians in specialties tend to report a higher level of research than physicians who work in primary care, including internal medicine and family medicine. This is likely due to the fact that physicians in hospital-based specialties need to demonstrate research capability if they want to advance in their careers, which might not be the case in primary care.[11]

In Latin American countries, it is not very common to find organizations or institutions that support and reward research activities. However, the situation is different in institutions that have medical residency programs that include research as part of their curriculum.[28] We can assume that the interest in research continues for these resident physicians after completion of their residency programs; the physicians in those programs have received skills that can promote their continued involvement in research.

We also believe that the incorporation of research activities as part of the expectations of employment can increase research productivity because of the availability of time for research and also because this research activity can then not be displaced by welfare activities.

Limitations

Given the characteristics of our survey, i.e. a web survey and voluntary participation, the sample may not represent the whole population of physicians in Latin America. Physicians interested in research may have been over-represented as well as physicians with higher levels of computer skills and access to the Internet. The cross-sectional design did not let us draw conclusions about the direction of the relationship between the 5 components and research activity. In addition, most of the responders were from Argentina. Non-native Spanish-speaking countries such as Brazil are not well represented, although this reflects the common users of this medical web portal.

We can see that most responders belong to clinical specialties; however, this is representative of the general population of physicians. It would be interesting to include some other factors, such as the physicians' academic success, since it is expected that with a higher level of academic success, more involvement in research would occur.

EHR, admission and other health information systems use was found to be high in this study; this might be evidence of a skew in data related to the voluntary nature of the survey and the use of an electronic survey, where only physicians with Internet access can participate. If we compare this data to data from the US[31] and other developed countries[32,] we find similar results; even when there is no information available related to the information level of health systems in Latin America, we forecast that the results are overestimated in the real situation.

Strengths

Cluster analysis allowed us to identify similar groups of physicians who, at the same time, are different from physicians of other groups based on their research activities. This grouping will help us in future studies of influences on research activities. The PCA analysis allowed us to discover something about the nature of the independent variables that affect them.

We had a large number of responders. The response rate was not dissimilar to others described in the literature for web surveys, 20 to 30%.[33] In addition, the survey had a 100% completion rate which may be due to the great care that was taken in designing the survey. This instrument will be reused in future studies, such as on the effects of altering specific environmental factors.

Conclusions

A higher level of research involvement can only be reached if changes occur at both individual and environmental levels. At an individual level, there is a need for the physicians who wish to do research to be directly involved in academic activities and to have skills in using tools that aid in conducting investigations, including informatics tools.

The environment should also encourage and stimulate individuals to investigate means of promoting training activities and mentorship programs that focus on clinical research fields. In order to achieve improved research involvement, it is important to promote human capital development as well as infrastructure investment in processes and information resources.

References

1. Frank C, Nason E. Health research: measuring the social, health and economic benefits. CMAJ. 2009 Mar 3;180(5):528-534.

2.Thorn K. Science, Technology and innovation in Argentina [Internet]. WB Working Paper; 2005. Available from: http://siteresources.worldbank.org/INTARGENTINA/Resources/ScienceTechnologyandInnovationinArgentina.pdf

3. Karlberg J. Biomedical Publication Trends by Geographic Area. Clinical Trial Magnifier. 2010.

4.Ministerio de Ciencia, Tecnología e Innovación Productiva [Internet]. [cited 2011 Aug 3];Available from: http://www2.mincyt.gob.ar/index.php?contenido=publicaciones

5 UNESCO Institute for Statistics [Internet]. [cited 2011 Jul 30];Available from: http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=198&IF_Language=eng

6. Comparativos [Internet]. [cited 2011 Jul 30];Available from: http://www.ricyt.edu.ar/index.php?option=com_content&view=article&id=149&Itemid=3

7. Man JP, Weinkauf JG, Tsang M, Sin DD. Why do some countries publish more than others? An international comparison of research funding, English proficiency and publication output in highly ranked general medical journals. Eur. J. Epidemiol. 2004;19(8):811–7.

8. Cooke J. A framework to evaluate research capacity building in health care. BMC Fam Pract. 2005 Oct 27;6:44.

9. Social ecological model - Wikipedia, the free encyclopedia [Internet]. [cited 2011 Jul 30];Available from: http://en.wikipedia.org/wiki/Social_ecological_model

10.Askew D, Schluter PJ, Claravino AM. Changing GPs' attitudes to research - do N of 1 trials hold the key? Aust Fam Physician. 2008 Jul;37(7):578-582.

11. Jowett SM, Macleod J, Wilson S, Hobbs FD. Research in primary care: extent of involvement and perceived determinants among practitioners from one English region. Br J Gen Pract. 2000 May;50(454):387-389.

12.Askew DA, Clavarino AM, Glasziou PP, Del Mar CB. General practice research: attitudes and involvement of Queensland general practitioners. Med. J. Aust. 2002 Jul 15;177(2):74-77.

13. Lester HE, Carter YH, Dassu D, Hobbs FD. Survey of research activity, training needs, departmental support, and career intentions of junior academic general practitioners. Br J Gen Pract. 1998 Jun;48(431):1322-1326.

14. Greenwood J, Gray G. Developing a nursing research culture in the university and health sectors in Western Sydney, Australia. Nurse Educ Today. 1998 Nov;18(8):642–8.

15. Kagan JM, Kane M, Quinlan KM, Rosas S, Trochim WMK. Developing a conceptual framework for an evaluation system for the NIAID HIV/AIDS clinical trials networks. Health Res Policy Syst. 2009;7:12.

16. Murillo H, Reece EA, Snyderman R, Sung NS. Meeting the challenges facing clinical research: solutions proposed by leaders of medical specialty and clinical research societies. Acad Med. 2006 Feb;81(2):107-112.

17. Sarre G, Cooke J. Developing indicators for measuring Research Capacity Development in primary care organizations: a consensus approach using a nominal group technique. Health Soc Care Community. 2009 May;17(3):244-253.

18. North American Primary Care Research Group Committee on Building Research Capacity; Academic Family Medicine Organizations Research Subcommittee. What does it mean to build research capacity? Fam Med. 2002 Oct;34(9):678-684.

19. Kahn MG, Kaplan D, Sokol RJ, DiLaura RP. Configuration challenges: implementing translational research policies in electronic medical records. Acad Med. 2007 Jul;82(7):661-669.

20. Murphy EC, Ferris FL 3rd, O'Donnell WR. An electronic medical records system for clinical research and the EMR EDC interface. Invest. Ophthalmol. Vis. Sci. 2007 Oct;48(10):4383-4389.

21. Roberts RJ, Stockwell DC, Slonim AD. Discrepancies in administrative databases: implications for practice and research. Crit. Care Med. 2007 Mar;35(3):949-950.

22. Gliklich R, United States. Registries for evaluating patient outcomes : a user's guide. Rockville MD: U.S. Dept. of Health and Human Services Public Health Service Agency for Healthcare Research and Quality; 2007. 17. Embi PJ, Payne PRO. Clinical research informatics: challenges, opportunities and definition for an emerging domain. J Am Med Inform Assoc. 2009 Jun;16(3):316-327.

23. Wang L, Chen Y, Shi J. Attitudes toward computers: a new attitudinal dimension. Cyberpsychol Behav. 2007 Oct;10(5):700-704

24. Flichtentri D, Braga F, Garcia D et al. Usefulness of the functionalies of an electronic medical record on a latinamerican medical web portal. Unpublished manuscript.

25. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol. 1996 Dec;49(12):1373–9.

26.Cork RD, Detmer WM, Friedman CP. Development and initial validation of an instrument to measure physicians' use of, knowledge about, and attitudes toward computers. J Am Med Inform Assoc. 1998 Apr;5(2):164–76.

28.Manjarin M, Cutri AM, Torres FA, Noguerol ME, Ossorio MF, Durán P, et al. [Evaluation of scientific production in a pediatric residency]. Arch Argent Pediatr. 2009 Feb;107(1):26–9.

29. Ferrero Fernando, Otero Paula. Participación de la mujer en publicaciones periódicas científicas: tendencias en la pediatría latinoamericana. Arch. argent. pediatr. [revista en la Internet]. 2007 Jun [citado 2012 Feb 17] ; 105(3): 244-247.

30. Pan American Health Organization (PAHO). Las residencias médicas en America Latina. Serie La renovación de la atención primaria de salud en las Américas Nº 60. Washington, D.C.: 2011

31. DesRoches CM, Campbell EG, Rao SR, Donelan K, Ferris TG, Jha A, et al. Electronic health records in ambulatory care--a national survey of physicians. N. Engl. J. Med. 2008 Jul 3;359(1):50–60.

32. Davis K, Doty MM, Shea K, Stremikis K. Health information technology and physician perceptions of quality of care and satisfaction. Health Policy. 2009 May;90(2-3):239–46.

Appendix 1: English Language Survey

Clinical Research in Latin America

We are asking for your cooperation in completing this survey about the current status of clinical research in your workplace. In the context of this study, we include as clinical research clinical trials, observational studies, and retrospective data analysis in patients and populations.

This research project is being performed as part of the Master's thesis in Medical Informatics of Dr. Vanina Taliercio at Oregon Health & Science University (OHSU). The Principle Investigator is Dr. Judith R. Logan and the study has been approved by the Institutional Review Board at OHSU, #7986. We believe that data from this research will be useful in understanding the current state of clinical research in Latin America and to characterize the relevant factors that promote the development of clinical research.

The data will be collected anonymously and used only for purposes of this research. Please do not leave any questions unanswered. The survey will take approximately 10 minutes to complete.

Thank you for your time and cooperation! *For comments or concerns please contact Dr. Taliercio at talierci@ohsu.edu.*

1. Research experience

1.1 Since graduation from medical school, how many research presentations have you made at national or international conferences?

☐ 0
☐ 1-5
☐ 6-10
☐ 11-15
☐ >15

1.2 How many research presentations have you made at national or international conferences in the last 3 years?

☐ 0
☐ 1-2
☐ 3-5
☐ >5

1.3 Since graduation from medical school, how many peer-reviewed publications have you had?

☐ 0
☐ 1-5
☐ 6-10
☐ 11-15
☐ >15

1.4 How many peer-reviewed publications have you had in the last 3 years?

☐ 0
☐ 1-2
☐ 3-5
☐ >5

1.5 Including all clinical research activities (e.g. protocol development, research conduct, data analysis, and presentation of findings), how many hours a month do you dedicate to clinical research?

____________________hours per month

2. Education in research

In this section we are asking about the development of appropriate skills for research through training and opportunities to apply those skills.

2.1 Select the highest level of training in statistics, epidemiology or clinical research that you have received:

☐ No courses since medical school in statistics, epidemiology or clinical research.
☐ At least one course covering basic concepts in statistics, epidemiology or clinical research.
☐ At least one course covering advanced concepts in statistics, epidemiology or clinical research.
☐ Masters degree in statistics, epidemiology or clinical research.
☐ PhD or other doctoral degree in statistics, epidemiology or clinical research.

2.2 Please select your level of agreement for each statement about the availability of educational resources in your environment.

2.2.1 My work environment facilitates and enables research supervision and mentorship.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

2.2.2 My work environment facilitates or offers clinical research training through scholarships, local graduate programs, or courses in statistics, epidemiology, or clinical research.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3. Environmental factors

Environmental factors include the structures and processes that are set up to enable the smooth and effective running of research projects and research-related activity

Note: *Your "environment" may be your practice, the practices in your geographical area, a research or practice network, a hospital, or a research institution, i.e. wherever you do or might do research.*

3.1 Policies and procedures

3.1.1 In your environment, is there a central Institutional Review Board?

☐ Yes
☐ No
☐ Do not know

3.2 Resource Utilization

Please select your level of agreement regarding these statements about the resource utilization in your environment.

3.2.1 Investigators in my environment have adequate qualifications and experience to perform research.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.2.2 Adequate protected time to do clinical research is provided in my environment.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.2.3 Local scientific results are published and disseminated widely.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.2.4 Research projects in my environment are funded by national institutions.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.2.5 Research projects in my environment are funded by international institutions.

☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.3 Scientific Agenda

Please select your level of agreement regarding these statements about the scientific agendas in your environment.

3.3.1 The selection of a research topic follows national health priorities.
☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.4 Collaboration and communication

Please select your level of agreement regarding these statements about collaboration and communication for research *in your environment*.

3.4.1 There is good communication and collaboration in research between investigators in my environment.
☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.4.2 There is good communication and collaboration in research with other research centers.
☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

3.4.3 There are good support services in my environment to help with clinical research, for example, statistics services or clinical research services.
☐strongly agree ☐agree ☐neutral/no opinion ☐disagree ☐strongly disagree

4. Computer experience

4.1 Please select the informatics tools available at your place of work:
☐ Electronic Health Records (EHRs)
☐ Admission and or scheduling system
☐ Patient or Disease Registries
☐ Clinical decision support system
☐ Clinical Trials Management System
☐ Statistics software like SPSS, Stata or Epinfo
☐Other: _______________

4.2 In a typical week, how many hours do you personally use a computer?
_______________hours per week.

4.3 How would you rate your computer skills?
☐ Unable to use computer
☐ Unskilled at using a computer
☐ Moderately skilled in using a computer
☐ Very skilled at using a computer
☐ Expert in using a computer

4.4 To what extent do you use a computer for each of the following professional tasks?

4.4.1 Obtaining advice on a specific patient's diagnosis or therapy.

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

4.4.2 Writing (grants, research papers, teaching materials).

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

4.4.3 Preparing presentations.

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

4.4.4 Performing statistical analysis on clinical research data.

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

4.4.5 Searching medical literature.

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

4.4.6 Teaching.

☐ Always use a computer for this task
☐ Often use a computer for this task
☐ Sometimes use a computer for this task
☐ Perform this task but never use a computer
☐ Never perform this task

5. Collaboration

5.1 To what extent do you use the following technologies for professional communication and collaboration?

5.1.1 Group calendaring (for example, Google calendar, Outlook group calendar).

☐ I use this tool daily or almost daily
☐ I frequently use this tool
☐ I use this tool sometimes
☐ I rarely use this tool
☐ I never use this tool

5.1.2 Tools for coordinating meetings (for example, Doodle).

☐ I use this tool daily or almost daily
☐ I frequently use this tool
☐ I use this tool sometimes
☐ I rarely use this tool
☐ I never use this tool

5.1.3 Digital video for communication (for example, Skype).

☐ I use this tool daily or almost daily
☐ I frequently use this tool
☐ I use this tool sometimes
☐ I rarely use this tool
☐ I never use this tool

5.1.4 Audio conferences.

☐ I use this tool daily or
☐ I frequently use
☐ I use this tool
☐ I rarely use this
☐ I never use

almost daily	this tool	sometimes	tool	this tool

5.1.5 Discussion boards.

☐ I use this tool daily or almost daily	☐ I frequently use this tool	☐ I use this tool sometimes	☐ I rarely use this tool	☐ I never use this tool

5.1.6 Wikis or similar tools for collaborative online work (for example, Google Docs).

☐ I use this tool daily or almost daily	☐ I frequently use this tool	☐ I use this tool sometimes	☐ I rarely use this tool	☐ I never use this tool

Appendix 2: Test-Retest Reliability of Each of the Questions in the Survey

Question	ICC	Ic 95%	
2.1 Since graduation from medical school, how many research presentations have you made at national or international conferences?	0.95461	0.91178	0.99744
2.2 How many research presentations have you made at national or international conferences in the last three years?	0.85820	0.73100	0.98540
2.3 Since graduation from medical school, how many peer-reviewed publications have you had?	0.75573	0.54869	0.96276
2.4 How many peer-reviewed publications have you had in the last three years?	0.94118	0.88605	0.99630
2.5 Including all clinical research activities (e.g. protocol development, research conduct, data analysis, and presentation of findings), how many hours a month do you dedicate to clinical research?	0.94942	0.90183	0.99702
Most types of research don't give me information that is useful in clinical practice.	0.70642	0.46459	0.94826
I make better decisions based on my clinical practice experience than on research information.	0.73613	0.51499	0.95728
I don't really have any incentives to use research information in my practice.	0.76296	0.56124	0.96469
When I have tried to use research information in the past, it has cost me too much time, money or commitment.	0.56968	0.24362	0.89575
The statistics in research papers make the results difficult to interpret and use.	1		
Research information is too academic and complicated.	0.80124	0.62842	0.97407
The culture in which I work is not supportive for using research information.	0.33981	0.00000	0.76680
3.2 Overall, how important are clinical research results to your practice?	0.81870	0.65615	0.98124
4.1 Select the highest level of training in statistics, epidemiology or clinical research that you have received:	0.90419	0.81612	0.99226
My work environment facilitates and enables research supervision and mentorship.	0.90123	0.81059	0.99188
My work environment facilitates or offers clinical research training through scholarships, local graduate programs, or courses in statistics, epidemiology, or clinical research.	0.96448	0.93080	0.99816
5.1.1 In your environment, is there a central Institutional Review Board?	1		
Policies are available in my environment regarding clinical research that reflect what is required for good science, protection of human subjects, and safety.	0.69231	0.44094	0.94367

Policies are available in my environment regarding clinical research that facilitate generic drug use.	0.70968	0.47007	0.94929
Investigators in my environment have adequate qualifications and experience to perform research.	0.75453	0.54663	0.96244
Adequate protected time to do clinical research is provided in my environment.	0.96350	0.92890	0.99810
Multidisciplinary teams are doing clinical research in my environment.	0.78349	0.59709	0.96989
Local scientific results are published and disseminated widely.	0.84375	0.70468	0.98282
National institutions fund research projects in my environment.	0.84275	0.70287	0.98263
International institutions fund research projects in my environment.	0.85841	0.73138	0.98543
Research information including funding and training and opportunities are widely disseminated.	0.80222	0.63016	0.97429
Research activities conducted in my environment are communicated so that other professionals can get involved.	0.80222	0.63016	0.97429
The dignity and human rights of participants are respected.	0.88927	0.78829	0.99026
Clinical trial protocols successfully meet recruitment and retention goals.	0.71631	0.48127	0.95135
Research is conducted acknowledging the culture, norms and values of the community.	0.86246	0.73881	0.98612
Appropriate and relevant community representation is included in conducting research.	0.79832	0.62324	0.97340
Research sites provide hours that make participation accessible to subjects.	0.48178	0.11110	0.85246
Community support, training and education are provided for research.	0.61905	0.32131	0.91679
The selection of a research topic follows national health priorities.	0.72881	0.50249	0.95513
The protocols are developed with attainable goals.	0.82796	0.67614	0.97977
The proposed scientific priorities and research plans are feasible.	0.65343	0.37681	0.93005
Scientific priorities are reassessed and reprioritized as the field evolves.	0.56463	0.23579	0.89346
To set research agendas, scientific input is obtained from a large group of clinical investigators.	0.93028	0.86532	0.99525
High impact research results get translated into practice.	0.84566	0.70815	0.98317
The questions to be addressed are relevant to the population in which studies are done.	0.60000	0.29105	0.90895
There is good communication and collaboration in research between investigators in my environment.	0.74156	0.52428	0.95883
There is good communication and collaboration in research with other research centers.	0.73554	0.51397	0.95710

There is good international communication and collaboration in research.	0.83539	0.68955	0.98123
There are good support services in my environment to help with clinical research, for example, statistics services or clinical research services.	0.80915	0.64247	0.97582
Research information, resources and materials are shared across a network.	0.60656	0.30143	0.91169
6.2 In a typical week, how many hours do you personally use a computer?	0.85600	0.72432	0.98768
6.3 How would you rate your computer skills?	0.93893	0.88177	0.99609
Documentation of patient information (history, physical exams, and progress notes).	0.96064	0.92339	0.99789
Accessing clinical data (laboratory data, EKG, radiology reports).	0.50889	0.15116	0.86661
Communication with colleagues.	0.54783	0.20997	0.88568
Obtaining advice on a specific patient's diagnosis or therapy.	0.46939	0.09301	0.84576
Writing (grants, research papers, teaching materials).	0.88510	0.78054	0.98966
Preparing presentations.	0.96078	0.92367	0.99790
Performing statistical analysis on clinical research data.	0.77663	0.58507	0.96820
Searching medical literature.	0.87302	0.75820	0.98783
Teaching.	0.72414	0.49454	0.95374
Editing documents (word processing or document markup).	0.62455	0.33011	0.91899
Organizing documents (using labels, tags, folders).	0.22526	0.00000	0.68350
7.1 How much experience do you have in collaborative research with other investigators, institutions or organizations?	0.68975	0.43668	0.94282
Data gathered for a research project should be openly shared with others investigators.	0.54930	0.21222	0.88637
Electronic mail.	0.54067	0.19905	0.88229
Group calendaring (for example, Google calendar, Outlook group calendar).	0.89715	0.80296	0.99134
Tools for coordinating meetings (for example, Doodle).	0.91225	0.83125	0.99325
Digital video for communication (for example, Skype).	0.87183	0.75602	0.98764
Audio conferences.	0.73926	0.52034	0.95818
Discussion boards.	0.71289	0.47548	0.95029

Wikis or similar tools for collaborative online work (for example, Google Docs). [Wiki]	0.86325	0.74025	0.98625

Appendix 3: Endorsement of Questions in the Survey

Question	Strongly disagree	Disagree	Neutral/ no opinion	Agree	Strongly agree
Most types of research don't give me information that is useful in clinical practice.	24%	48%	16%	12%	0%
I make better decisions based on my clinical practice experience than on research information.	12%	28%	16%	36%	8%
I don't really have any incentives to use research information in my practice.	32%	40%	20%	4%	4%
When I have tried to use research information in the past, it has cost me too much time, money or commitment.	16%	44%	24%	16%	0%
The statistics in research papers make the results difficult to interpret and use.	0%	60%	4%	24%	12%
Research information is too academic and complicated.	8%	60%	16%	16%	0%
The culture in which I work is not supportive for using research information.	16%	52%	20%	8%	4%
My work environment facilitates and enables research supervision and mentorship.	0%	28%	20%	44%	8%
My work environment facilitates or offers clinical research training through scholarships, local graduate programs, or courses in statistics, epidemiology, or clinical research.	4%	32%	20%	32%	12%
Policies are available in my environment regarding clinical research that reflect what is required for good science, protection of human subjects, and safety.	0%	0%	20%	36%	44%
Policies are available in my environment regarding clinical research that facilitate generic drug use.	0%	12%	48%	16%	24%
Investigators in my environment have adequate qualifications and experience to perform research.	0%	20%	16%	40%	24%
Adequate protected time to do clinical research is provided in my environment.	24%	40%	8%	16%	12%
Multidisciplinary teams are doing clinical research in my environment.	0%	32%	26%	32%	20%
Local scientific results are published and disseminated widely.	0%	16%	48%	32%	4%
Research projects in my environment are funded by national institutions.	12%	48%	20%	12%	8%
Research projects in my environment are funded by international institutions.	8%	36%	24%	16%	16%
Research information including funding and	12%	32%	28%	16%	12%

training and opportunities are widely disseminated.					
Research activities conducted in my environment are communicated so that other professionals can get involved.	4%	44%	16%	24%	12%
The dignity and human rights of participants are respected.	0%	0%	20%	44%	36%
Clinical trial protocols successfully meet recruitment and retention goals.	0%	0%	24%	56%	20%
Research is conducted acknowledging the culture, norms and values of the community.	0%	4%	40%	40%	16%
Appropriate and relevant community representation is included in conducting research.	4%	16%	40%	32%	8%
Research sites provide hours that make participation accessible to subjects.	8%	40%	24%	24%	4%
Community support, training and education are provided for research.	4%	60%	16%	20%	0%
The selection of a research topic follows national health priorities.	12%	48%	20%	20%	
The protocols are developed with attainable goals.	0%	8%	32%	60%	0%
The proposed scientific priorities and research plans are feasible.	0%	8%	36%	56%	0%
Scientific priorities are reassessed and reprioritized as the field evolves.	0%	20%	48%	28%	4%
To set research agendas, scientific input is obtained from a large group of clinical investigators.	0%	20%	36%	40%	4%
High impact research results get translated into practice.	0%	8%	16%	52%	4%
The questions to be addressed are relevant to the population in which studies are done.	0%	0%	24%	68%	8%
There is good communication and collaboration in research between investigators in my environment.	0%	20%	28%	40%	12%
There is good communication and collaboration in research with other research centers.	4%	28%	44%	24%	0%
There is good international communication and collaboration in research.	8%	32%	36%	20%	4%
There are good support services in my environment to help with clinical research, for example, statistics services or clinical research services.	0%	16%	28%	36%	20%
Research information, resources and materials are shared across a network.	0%	28%	28%	36%	8%
Data gathered for a research project should be openly shared with others investigators.	0%	4%	4%	40%	52%

	Extremely important	Moderately important	Important	Minimally important	Not important at all
Overall, how important are clinical research results to your practice?	33.3%	29.2%	37.5%	0%	0%

	No courses since medical school in statistics, epidemiology or clinical research.	At least one course covering basic concepts in statistics, epidemiology or clinical research	At least one course covering advanced concepts in statistics, epidemiology or clinical research.	Masters degree in statistics, epidemiology or clinical research.	PhD or other doctoral degree in statistics, epidemiology or clinical research.
Select the highest level of training in statistics, epidemiology or clinical research that you have received:	32%	36%	24%	8%	0%

Question	yes	Do not know	no
5.1.1 In your environment, is there a central Institutional Review Board?	80%	8%	12%

	Unable to use computer	Unskilled at using a computer	Moderately skilled in using a computer	Very skilled at using a computer	Expert in using a computer
6.3 How would you rate your computer skills?	0%	4%	56%	28%	12%

4 To what extent do you use a computer for each of the following professional tasks?	Never perform this task	Perform this task but never use a computer	Sometimes use a computer for this task	Often use a computer for this task	Always use a computer for this task

Documentation of patient information (history, physical exams, and progress notes).	0%	16%	12%	16%	56%
Accessing clinical data (laboratory data, EKG, radiology reports).	4%	12%	12%	36%	36%
Communication with colleagues.	4%	0%	40%	36%	20%
Obtaining advice on a specific patient's diagnosis or therapy.	4%	12%	40%	36%	20%
Writing (grants, research papers, teaching materials).	4%	20%	16%	16%	44%
Preparing presentations.	0%	4%	12%	8%	76%
Performing statistical analysis on clinical research data.	12%	28%	4%	8%	48%
Searching medical literature.	0%	0%	0%	36%	64%
Teaching.	0%	8%	20%	44%	28%
Editing documents (word processing or document markup).	0%	8%	24%	40%	28%
Organizing documents (using labels, tags, folders).	0%	8%	20%	28%	44%

How much experience do you have in collaborative research with other investigators, institutions or organizations?	No experience	A little experience	Some experience	A lot of experience
	20%	56%	20%	4%

3To what extent do you use the following technologies for professional communication and collaboration?	I use this tool daily or almost daily	I frequently use this tool	I use this tool sometimes	I rarely use this tool	I never use this tool
Email	0%	4%	12%	28%	56%

Groupal calendaring	32%	16%	12%	24%	16%
Tools for coordinate meetings	40%	32%	20%	8%	0%
Video communication	28%	16%	28%	24%	4%
Audioconferences2	28%	20%	28%	24%	4%
Discussion boards	28%	12%	40%	16%	4%
wikis	24%	28%	20%	16%	12%

Appendix 4: Proportion of Variance Explained by the Components for Each of the Variables (Communalities)

Communalities		
	Initial	Extraction
Training in statistics, epidemiology or clinical research	,997	,574
Environment facilitates research supervision and mentorship	,999	,558
Environment offers clinical research training	,999	,541
Investigators with adequate qualifications and experience	,998	,596
Adequate protected time	,999	,617
Dissemination of local scientific results	,999	,549
Research projects funded by national institutions.	,999	,461
Research projects funded by international institutions.	,999	,446
Research topics follow national health priorities.	,999	,408
Communication and collaboration between investigators	,999	,630
Communication and collaboration with other research centers	1,000	,622
Support services for research	1,000	,577
Hours week spent in the computer for personal use	,999	,521
Computer skills	,994	,408
Obtaining advice on a specific patient's diagnosis or therapy.	1,000	,454
Writing	,999	,515
Preparing presentations.	1,000	,597
Perming statistical analysis on clinical research data.	1,001	,615
Searching medical literature.	1,001	,562
Teaching	1,001	,560
Group calendaring	1,000	,517
Tools for coordinating meetings	,998	,568
Digital video for communication	1,000	,552
Audio conferences.	1,000	,605
Discussion boards.	,998	,464
Wikis	1,000	,489
Number of informatics resources	,996	,274
Extraction Method: Principal Component Analysis. Communalities		

Appendix 5: Covariance Matrix

Tools for coordinating meetings		,699			
Digital video for communication		,707			
Audio conferences.		,759			
Discussion boards.		,628			
Wikis		,678			
Training in statistics, epidemiology or clinical research					,698
Environment facilitates research supervision and mentorship	,692				
Environment offers clinical research training	,702				
Investigators with adequate qualifications and experience	,760				
Adequate protected time	,771				
Dissemination of local scientific results	,731				
Research projects funded by national institutions.	,662				
Research projects funded by international institutions.	,617				
Research topics follow national health priorities.	,616				
Communication and collaboration between investigators	,781				
Communication and collaboration with other research centers	,777				
Support services for research	,748				
Hours week spent in the computer for personal use				,660	
Computer skills				,620	
Obtaining advice on a specific patient's diagnosis or therapy.			,441		- ,436
Writing			,599		
Preparing presentations.			,718		
Perming statistical analysis on clinical research data.			,524		,500
Searching medical literature.			,682		
Teaching			,710		
Group calendaring		,664			