

Research Productivity Among Nations

Anthony DeMaria

Editor in Chief, Journal of the American College of Cardiology, San Diego, California, USA

I recently reviewed the paper “Cardiovascular Scientific Production in Spain and in the European and Global Context (2003-2007)” being published this month in *Revista Española de Cardiología*.¹ As is apparent from the title, the manuscript reported the research productivity of nations throughout the world relative to that of Spain, and was based upon a bibliometric analysis of published articles. The paper raises the issue of the state of the worldwide cardiovascular research enterprise, an issue of some interest to *JACC*. We have always received at least 60% of our submissions from outside of the United States, and have seen this grow to 70% in recent times. The new article stimulated this essay which is being jointly published in *JACC* and *Revista*.

The data in the paper demonstrated that the United States ranked first as a single country in the overall production of scientific cardiovascular publications, but scored second to the aggregate European Union (EU) countries in this category. However, for high quality articles, that is those published in the highest quartile of journals in the Cardiac & Cardiovascular Systems category under *Journal Citation Reports*, the United States produced more than all other countries as well as the EU cohort. Japan, China, and the English speaking countries of Australia and Canada also were among the leaders. Within the EU, the United Kingdom and Germany were most productive; Spain ranked sixth and

ninth worldwide (tenth if only first quartile journals are considered). The relative position of individual countries was altered when adjusted for population size or Gross Domestic Product, with Canada being particularly productive relative to these variables.

In assessing research productivity throughout the world, it must be acknowledged that bibliometric methods have a number of serious limitations. Firstly, they consider only published articles (as recorded in the *Science Citation Index Expanded*), and neglect other scholarly material such as patents, books, non-print venues, and training programs. It goes without saying that analyzing only the number and not the quality of articles is a severe failing. This particular article did not take into account papers published in the general medical literature or the variable number of national journals in individual countries. Many excellent cardiovascular manuscripts appear in the general medical journals such as the *New England Journal of Medicine*. Finally, in assessing high quality papers the article relied on the impact factor, which has obvious imperfections. Nevertheless, the paper in *Revista* does provide a gross picture of the international state of cardiovascular research.

A number of factors are capable of influencing the research productivity of any country. Most obvious and probably most important among these factors are the economic status, wealth and population size of the country. Wealthy nations can provide support for research from the government, foundations, or philanthropists. In addition, generous reimbursement for clinical services can supply sufficient funds to free up clinicians to perform investigation instead of clinical care. This has enabled a great deal of applied clinical research to be done in the United States without specific grant support. It is apparent that a greater population will yield a larger pool of individuals with interest and talent in scientific investigation, and a larger potential market for medical products with which to attract industrial support. It is not surprising, therefore, that the research output of nations can be related well to their gross domestic product.

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Correspondence: Dr A. DeMaria,
Editor-in-Chief,
Journal of the American College of Cardiology,
E-mail: ADEMARIA@ucsd.edu

The value of a national tradition of scientific research cannot be underestimated as a factor favoring productivity. This is well exemplified by the high research output of small nations with well developed and supported investigative enterprises such as the Netherlands, Sweden, Belgium, and Switzerland. Countries with a long tradition of research have the appropriate infrastructure in place, a critical mass of investigators, and the mindset of the importance of new discovery. Importantly, abundant role models will exist to attract and mentor the training of new investigators who are critical to both maintaining and expanding the research enterprise. There can be little doubt that "research begets research." This factor has widespread implications; it is incumbent upon the well established national research enterprises to assist developing countries in implementing similar programs.

I believe that an important factor in determining the research publications of any country is the role that such productivity plays in personal professional promotion and advancement. In many countries the major yardstick used in evaluating the performance of individuals is the number of publications they have authored, especially in high impact journals. As the cliché goes, "publish or perish." This stimulus to the number of publications is magnified by the necessity to show independence, an important criterion for promotion in many nations. Whether the emphasis upon publications as a criterion for promotion is misplaced can be debated. However, it is clear that it can be a major factor in producing papers in medical journals, and increasing the apparent research output of a country. Unfortunately, it often also leads to the splitting of data into multiple manuscripts and the well known minimal publishable unit (MPU).

As I discussed in a recent Editor's Page,² characteristics of the health care systems of many countries are advantageous to the acquisition of research opportunities and support and to the successful completion of clinical investigation, especially compared to the United States. The regionalization of health care usually present outside of the United States greatly facilitates the identification and enrollment of patients in clinical trials. A lower cost to perform experiments is another definite advantage in attracting studies for many countries, as is any reduced stringency in the rules of Institutional Review Boards for human research. Since the industrial sponsors of clinical investigation typically have many financial pressures, the ability to more rapidly acquire the CE mark in Europe as compared to FDA approval in the US holds great appeal in placing

studies. Of course, the location of the originators of new drugs/technology in a country would also favor the performance of clinical investigation with that invention in that nation. All these factors contribute to the ultimate research output of a nation.

Finally, several other characteristics may influence the cardiovascular research enterprise of a nation. It is obvious that funds, particularly from government, will be prioritized to the most prevalent diseases. Therefore, for countries in which infectious diseases are still the most common cause of death and disability, cardiovascular projects will be less well supported. In addition, for better or for worse, it is increasingly clear that English has become the language of medical science. Those countries in which fluency in English is lacking among the scientific community are at a substantial disadvantage in having papers accepted in medical journals, especially the most competitive journals. It is likely that these countries also lack manuscript presentation skills as well. Although presentation cannot salvage a flawed study, it can render a good study unacceptable.

It has long been clear that biomedical research can not only improve a country's health, but also serve as an engine to drive economic growth and development. Accordingly there has been a progressive increase in research productivity throughout the world. When my academic career began some 35 years ago, the United States was the unquestioned leader in cardiovascular investigation, and a clear gap existed between its output and that of the rest of the world. Over the years things have changed, and if any gap with other industrialized nations currently exists, it is trivial. Some of the increase in international research can be attributed to the greater support provided by industry, and the inherent advantages of health care systems outside the U.S. for clinical investigation. The increase in research output, however, has not been equal for all countries, as is evident in the paper in *Revista Española de Cardiología*. The heterogeneity, as is the case for the growth of international cardiovascular investigation itself, is almost certainly related to changes in the economic state of countries in Europe and Asia. However, the role of a tradition of research cannot be underestimated, with the infrastructure and critical mass it provides. In this regard, one of the most important developments has been the training of new young investigators, which is a requisite condition for the growth of a research enterprise. As time goes on I believe that we can look forward to enjoying the benefits

of augmented research from already successful international programs and new contributions from emerging worldwide investigative efforts. Hopefully governments will appreciate the many salutary effects of a strong research enterprise, and support the increasing pool of investigators and their innovative programs.

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