Original Article

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An Analysis of Global Research Trends in Cardiology Over the Last two Decades

Internal Medicine Section

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ABSTRACT

Introduction: Heart disease today is a major cause of morbidity and mortality plaguing mankind worldwide.

Aim: The present research was undertaken to ascertain global research trends in clinical trials in Cardiology involving human subjects over the last two decades.

Materials and Methods: Cross-sectional study. A detailed search strategy was employed in December 2013, using the PubMed database. All papers published in 1993–2013 were evaluated. The research trends of various cardiologic subspecialties in the United States and worldwide have been analysed and detailed statistical analysis was done.

Results: United States had maximum number of researches. Clinical trials involving infarction were maximum followed by coronary angiography and coronary angioplasty in that order. The year 2013 had the most researches. The United States was the top country and Boston was the top city. Author Christodoulos Stefanadis had the greatest number of researches in this field. American Journal of Cardiology was the most favored journal and Circulation was the journal with the highest impact factor. This effort may help funding agencies, prospective job seekers, fellowship applicants, policymakers and patients

Conclusion: The research output in cardiology has increased and improved significantly over past decade. The publication per diplomat is more in transplant cardiology, Also more clinical trials involving coronary restenosis have to be done to know in depth to add to current knowledge and database.

Keywords: Clinical trials, Cardiology subspecialties, Research output

INTRODUCTION

Today, heart disease is the most prevalent disease plaguing the world, leading to loss of work hours and enormous expenditure. According to the WHO, cardiovascular diseases killed nearly 17 million people in 2011; that is 3 in every 10 deaths [1]. Ischemic heart disease was the leading cause of death in the world in 2011 accounting for 7 million deaths [1]. In The United States alone; about 600,000 people die of heart disease every year [2].

Cardiology has evolved significantly as an academic field. In today's era; we speak of advancements such as alcohol septal ablation, aortic valve replacement, heart transplantation, and implantable pacemakers and defibrillators. Prognosis and 10y survival rate of patients have shown a concomitant dramatic rise. Multiple investigative modalities such as Electrocardiography (ECG), Echocardiography, Nuclear stress testing and Cardiac catheterization [3,4] have played significant roles in the diagnosis, management and follow up of patients.

The number of medical journals and publications has been increasing over the last decade and Cardiology research has played a significant role in developing new therapeutic and diagnostic procedures which have improved the longevity and quality of life of patients.

Today evidence-based medicine is on the rise, largely helped by clinical trials [5]. Clinical trials highlight the prominent role of Cardiology and the associated research trends in the conditions which affect morbidity and mortality among the general population. In our research, we analysed global trends and research output for clinical trials in the field of Cardiology over the last two decades from 1993 to 2013. This data is useful to fellows in training, funding agencies, research associates and coordinators, university administrators as well as patients.

MATERIALS AND METHODS

PubMed; the database of the US National Library of Medicine, is one of the most widely used online health databases in the world. The search for publications was performed in December 2013, using the PubMed database [6]. All papers published in 1993–2013 were evaluated. The search strategy was ((("adult"{MeSH Terms} OR "adult" {All Fields}) OR ("aged"{MeSH Terms} OR "aged"{All Fields} OR "elderly" {All Fields})) AND ("cardiology" {MeSH Terms} OR "cardiology" {All Fields})) OR ("heart"{MeSH Terms} OR "heart"{All Fields}) AND (Clinical Trial {ptyp} AND "humans" {MeSH Terms}).

To obtain data pertaining to adults; we put in a variety of search words, including adult/ aged/ elderly. The search terms Cardiology and Heart were put in. The detailed methodology also involved comparison of the clinical trials of the most important cardiac diseases affecting morbidity and mortality among the general population.

The command used to elucidate data for the specific period of time was ("1993/01/01"{PDAT}: "2013/12/07"{PDAT}). The search was done on 12/16/2013 at 9: 11 am 32 sec in New York. It is important to mention that a search conducted at a later date with the same filters might yield slightly different results given that some researches are in 'Ahead of print' mode.

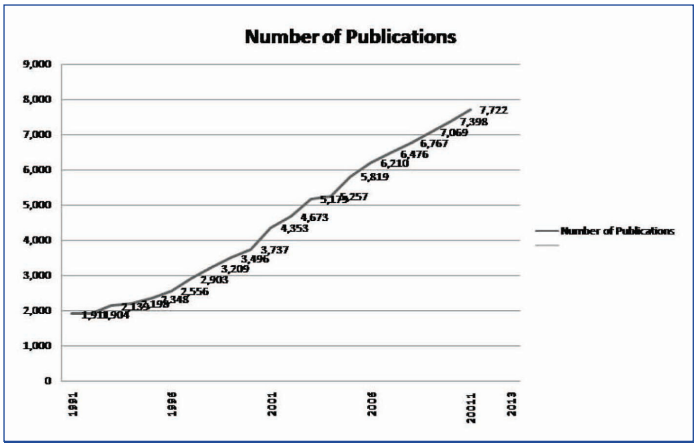
Research trends for various types of clinical trials conducted during the last two decades, including prospective studies, evaluation studies and treatment outcome studies were analysed.

We also analysed data for the number of clinical trials conducted in various cardiologic subspecialties; for example, Advanced Heart Failure/Transplant Cardiology, Interventional Cardiology, Cardiovascular disease and Clinical Cardiac Electrophysiology.

To obtain data in each of these four fields, the command was modified as follows:

A) Advanced Heart Failure /Transplant Cardiology

(((((("adult"{MeSH Terms} OR "adult"{All Fields}) OR ("aged"{MeSH Terms} OR "aged"{All Fields} OR "elderly"{All Fields})) AND ("cardiology"{MeSH Terms} OR "cardiology"{All Fields})) OR ("heart"{MeSH Terms} OR "heart"{All Fields}) AND (Clinical Trial{ptyp} AND "humans"{MeSH Terms})) AND (Advanced{All Fields} AND ("heart failure"{MeSH Terms} OR ("heart"{All Fields} AND "failure"{All Fields}) OR "heart failure"{All Fields}))) OR ((("transplants"{MeSH



[Table/Fig-1]: Publication trend across two decades

Rank	Country	Number of Publications
1	United States	23,144
2	Japan	7,283
3	Italy	6,357
4	Germany	6,269
5	United Kingdom	5,598
6	Turkey	5,232
7	Netherlands	4,680
8	China	4,658
9	Canada	2,757
10	France	2,507

[Table/Fig-2]: Publication Trend among top countries, for clinical cardiology worldwide

Rank	Top Cities	Publications
1	Boston	1,816
2	London	1,803
3	New York City	1,602
4	Athens	1,539
5	Ankara	1,423
6	Tokyo	1,364
7	Beijing	1,316
8	Istanbul	1,257
9	Seoul	1,001
10	Houston	988

[Table/Fig-3]: Publication Ranking across top cities globally

Terms} OR "transplants"{All Fields} OR "transplant"{All Fields} OR "transplantation"{MeSH Terms} OR "transplantation"{All Fields}) AND ("cardiology"{MeSH Terms} OR "cardiology"{All Fields})) AND ("1993/01/01"{PDAT}: "2013/12/07"{PDAT}).

B) Cardiovascular Disease

((((("adult"{MeSH Terms} OR "adult"{All Fields}) OR ("aged"{MeSH Terms} OR "aged"{All Fields} OR "elderly"{All Fields})) AND ("cardiology"{MeSH Terms} OR "cardiology"{All Fields})) OR ("heart"{MeSH Terms} OR "heart"{All Fields}) AND (Clinical Trial{ptyp} AND "humans"{MeSH Terms})) AND ("cardiovascular diseases"{MeSH Terms} OR ("cardiovascular"{All Fields} AND "diseases"{All Fields}) OR "cardiovascular diseases"{All Fields} OR ("cardiovascular"{All Fields} AND "disease"{All Fields}) OR "cardiovascular disease"{All Fields}).

C) Clinical Cardiac Electrophysiology

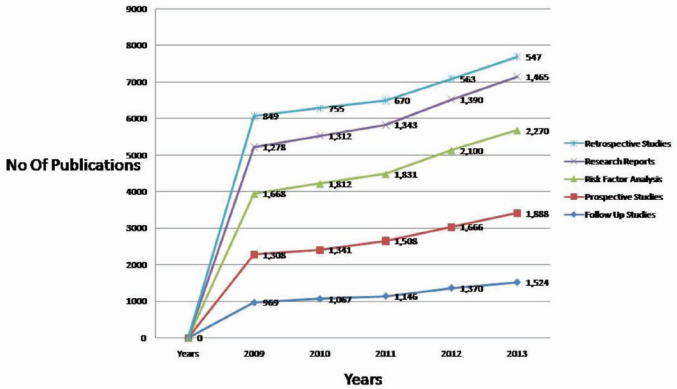
((((("adult"{MeSH Terms} OR "adult"{All Fields}) OR ("aged"{MeSH Terms} OR "aged"{All Fields} OR "elderly"{All Fields})) AND

Rank	Authors	Number of Publications
1	Christodoulosstefanadis	77
2	Kemal Aytemir	38
3	Jeroen J Bax	32
4	Hugo A Katus	28
5	M.J.Schalij	25
6	Barbara Mulder	25
7	Pieter Doevendans	25
8	Alec Vahanian	21
9	M.G.Kaya	20
10	Thomaslüscher	19

[Table/Fig-4]: List of top authors for clinical cardiology research output (*Database was analyzed for 1st 20,000 clinical trials due to limit of the search engine)

Rank	Name of Journal	Number of Publications	Impact Factor*(5year)
1	American Journal of Cardiology	718	3.408
2	Journal of American College of cardiology	540	13.710
3	International Journal of cardiology	511	4.125
4	Circulation	443	15.202(rank 1)
5	Plos One	357	4.6
6	European Heart Journal	342	14.097
7	Catheter CardiovascInterv	341	2.514
8	Circulation Journal - Japanese Circulation Society	321	3.578
9	EP-Europace	309	2.765
10	Echocardiography	289	1.261

[Table/Fig-5]: Top journals, according to number of publications, with their impact factors
**According to Journal Citation Report 2012*



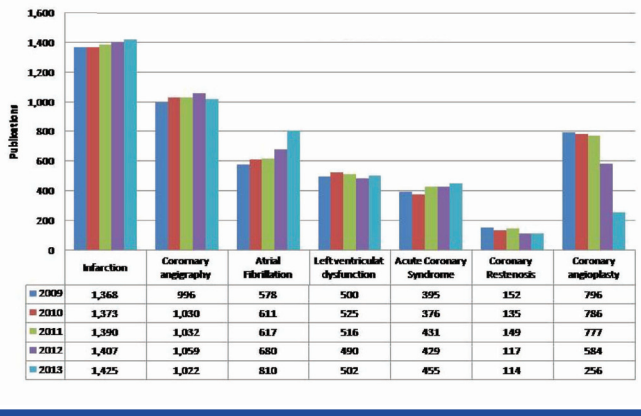
[Table/Fig-6]: Clinical trials study types in the last quartile

("cardiology"{MeSH Terms} OR "cardiology"{All Fields})) OR ("heart"{MeSH Terms} OR "heart"{All Fields}) AND (Clinical Trial{ptyp} AND "humans"{MeSH Terms})) AND (Clinical{All Fields} AND ("cardiac electrophysiology"{MeSH Terms} OR ("cardiac"{All Fields} AND "electrophysiology"{All Fields}) OR "cardiac electrophysiology"{All Fields})).

D) Interventional cardiology

((((("adult"{MeSH Terms} OR "adult"{All Fields}) OR ("aged"{MeSH Terms} OR "aged"{All Fields} OR "elderly"{All Fields})) AND ("cardiology" {MeSH Terms} OR "cardiology"{All Fields})) OR ("heart" {MeSH Terms} OR "heart"{All Fields}) AND (Clinical Trial {ptyp} AND "humans"{MeSH Terms}) AND ("1993/01/01" {PDAT}: "2013/12/07" {PDAT})) AND (Interventional{All Fields} AND ("cardiology"{MeSH Terms} OR "cardiology"{All Fields}))

The American Board of Internal Medicine (which was last updated on February 5, 2013) [7] lists the total number of American diplomats



	Infarction	Coronary angigraphy	Atrial Fibrillation	Left ventricular dysfunction	Acute Coronary Syndrome	Coronary Restenosis	Coronary angioplasty
2009	1,368	996	578	500	395	152	796
2010	1,373	1,030	611	525	376	135	786
2011	1,390	1,032	617	516	431	149	777
2012	1,407	1,059	680	490	429	117	584
2013	1,425	1,022	810	502	455	114	256

[Table/Fig-7]: Number of clinical trials in important clinical conditions and procedures

S. No.	Subspeciality	Number of American Diplomats	Number of Worldwide Publications	Number of American Publications	Publication Per Diplomat
1	Advanced Heart Transplamt/Transplant Cardiology	488	7682	2711	5.55533
2	Cardiovascular Disease	29249	99248	22636	0.77391
3	Clinical Cardiac Electrophysiology	2486	772	272	0.10941
4	Interventional Cardiology	289	4409	858	2.96

[Table/Fig-8]: Research output and ratio of clinical trials in the united states
**Note: There can be overlapping of data, and these are not mutually exclusive*

in each field of Internal Medicine. We used the data to obtain the total number of publications per diplomat within the United States.

A website called Gopubmed was also employed in our search strategy [8] which utilizes the data from Pubmed. Search results were consistent on both websites and were verified by several manual checks of the publication trends in each subgroup studied.

Top Year

Publication output of each year was analysed and an attempt was made to arrange the entire output in ascending order.

Top Authors

All authors of different publications were noted. A list of the most profilic top authors was made. Each author's name was considered by his/her last name; with up to two initials. One must also consider the fact that sometimes two different authors may have the same name; and efforts were made to correct this error as far as is possible [9].

Top Countries and Cities

A list of top countries was prepared; this was done by looking for the country of affiliation of each research article. Sometimes a particular research work was done as an international collaboration. To avoid ambiguity, the country of origin of the first author was considered in all cases. This was the country where the first author's university/ hospital/ program belonged. The list of top cities was prepared in a similar fashion.

Top Journals

Each journal was studied according to its impact factor and a table was made mentioning the number of publications in each journal publishing Cardiology academic endeavors. The impact factors of all journals were also obtained from the latest Journal Citation Report 2012 [10].

RESULTS

Our search yielded 62857 total human subject clinical trials in Cardiology over the last two decades. Abstracts were available for 61552 of these articles and free full texts were available for 17786 articles.

The greatest number of publications was reported in 2012 followed by 2007, 2011, 2008 and 2010 [Table/Fig-1]. Most Cardiology research fields have shown a steady increase in output over the last two decades. The maximum research output was 7722 in the year 2013 and the minimum was 1911 in the year 1993. The mean research output of these 20 y was 4444.

We found that The United States played a dominant role in Cardiology clinical trial research output. The United States topped the list with 23,144 publications followed by Japan at 7283 [Table/Fig-2]. United States, followed by Japan, Italy, Germany, and United Kingdom, comprised the top five countries respectively. Interestingly, Turkey and China are in the top 10, ahead of Canada and France. Boston, London, New York, Athens and Ankara are the top five cities with 1816, 1803, 1602, 1539 and 1423 publications respectively [Table/Fig-3].

Due to limitation of the search engine and lot of authors ;analysis of top 20,000 researches was conducted to look for the top author; Christodoulos stefanadis had the greatest number of publications among all authors, followed by Kemal Aytemir and Jeroen J Bax. [Table/Fig-4] demonstrates the list of top authors for Cardiology clinical trials in the last two decades. Among Cardiology journals; American Journal of cardiology and Circulation are the journals with the most publications observed [Table/Fig-5]. We also looked at the latest impact factor for these journals. The Circulation had the highest impact factor among the top 10 journals.

The number of clinical trials in Cardiology was further divided into four subtypes and finer details were analysed. The field of "Cardiovascular Disease" globally was on top with 99248 publications, followed by "Advanced Heart Failure or Transplant Cardiology" ranking second with 7682 clinical trials. This was followed by "Interventional Cardiology" at 4409 and "Clinical Cardiac Electrophysiology" at 772. These results were semantically analysed and were not mutually exclusive.

Data on the number of clinical trials in each disease was also gathered. The studies were further subdivided into followup studies (13,341), Prospective studies (16094), Risk factor analysis (18,327) and Research Reports (15.111), the respective quartiles have been shown in [Table/Fig-6]. [Table/Fig-7] represents the clinical trials done in myocardial infarction, coronary angiography, Atria Fibrillation, Left ventricular dysfunction ,acute coronary syndrome ,coronary restenosis and coronary angioplasty which were found to be 15461, 11152, 6815, 5844, 4044 and 1709 respectively. Again, these results were semantically analysed and were not mutually exclusive.

The number of board certified diplomats was found from the American Board of Internal Medicine [7] and publication per diplomat was analysed [Table/Fig-8]. This data helped us calculate the number of publications per diplomat in The United States.

The publication trends for the different types of clinical trials and clinical conditions have been represented in [Table/Fig-7]. It can be noted that there has been a steady rise in the number of studies involving clinical trials involving myocardial infarction, atrial fibrillation however little variability has been seen in the clinical trials conducted in coronary angiography, left ventricular dysfunction, acute coronary syndrome and coronary restenosis, A declining trend was observed in the field coronary angioplasty [Table/Fig-7].

DISCUSSION

Heart disease has the highest mortality worldwide among all other illnesses [1]. Coronary heart disease alone costs the United States $108.9 billion each year [11]. Approximately every 34 sec, one American has a coronary event and approximately every one minute, an American will die of one [12]. When looking at the situation for patients diagnosed with heart failure, it is again grim with 1 in 9

death certificates (274,601 deaths) in 2009 in the United States mentioning heart failure according to the AHA [10].

This study is an attempt to measure worldwide human subject Cardiology research output with a focus on clinical trials. The study clearly outlines the dominance of The United States in Cardiology research.

The quality of research cannot be ascertained from this study. Nevertheless, it demonstrates the volume of research output in clinical Cardiology and its various subdivisions, including Advanced Heart Failure/Transplant Cardiology, Cardiovascular Disease, Clinical Cardiac Electrophysiology and Interventional Cardiology.

Publication trends, in terms of top countries, top cities, top authors and top journals have been analysed.

Looking exclusively at the United States, utilizing the ABIM data; it was surprising that even with the low number of diplomats in the field of Transplant Cardiology; their clinical trials outnumbered the others. The number of publications per diplomat for the United States was analysed. This data reveals the miniscule number of researches being carried out per diplomat, a somewhat surprising fact for a country like The United States which has the highest number of clinical trials. However, the number of publications per diplomat was not analysed for other countries, representing a limitation of this study.

Another limitation of our study is that it analysed only publications in the Pubmed database. Publications in other databases, or research activities which did not produce a potential publication were excluded.

CONCLUSION

It is heartening that research output in Cardiology has increased and improved significantly over the past decade. Yet there is still much to be discovered and many miles to be covered to improve the diagnosis, survival and prognosis of cardiac patients. More clinical trials involving coronary restenosis have to be done to know in depth and add to current knowledge and database.

Therefore, it is necessary that research endeavors continue to be encouraged and the activities of all those involved - students, residents, fellows and cardiologists - merit continued incentives in the form of funds and grants to sustain the worthy academic activity which has cemented the foundation for society's ever-improving health.

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