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CARDIOVASCULAR MEDICINE AND SOCIETY

A Changing Landscape in Cardiovascular Research Publication Output

Bridging the Translational Gap

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ABSTRACT

The concern about predominance of basic discovery research and lack of translation into clinical medicine, and segregation between these research communities, led the authors to study these research communities through mapping networks of publications and cross-references. Cardiovascular research from 1993 to 2013 was published in 565 journals, including 104 new journals. Only 50% were published in core cardiovascular journals, such as the *Journal of the American College of Cardiology*, whereas one-half of cardiovascular publications were found in broader biomedical/multidisciplinary journals. The growth of the clinical journal community and merging into one broad journal community suggests a decreasing dichotomy between basic/preclinical and clinical research, potentially contributing to bridging the translational gap. (J Am Coll Cardiol 2018;71:1584–9)

The growth in cardiovascular research (1), with >50,000 cardiovascular publications in 2013, reflects major activity, in line with the societal burden of cardiovascular disease (2). Ensuring that investment in cardiovascular research results in improved cardiovascular health remains a challenge. Scientists, funders, and society have issued concerns about results from basic discovery research leading to novel clinical application (so-called "valley of death"). In 2002, the National Institutes of Health leadership recognized a widening gap between basic and clinical research with major spending in basic discovery; also, in Europe, leadership pointed to the disconnect between basic biology research and clinical needs (3). Funding in the United States and Europe has responded and encouraged "translational" research through specific funding schemes and strategic actions. Nevertheless, concerns about lack of communication persist.

Publications in peer-reviewed journals are an important means of science communication, especially in the biomedical sciences. By analyzing citation patterns, we can identify scientific communities that are connected by their intercommunication. As time progresses, these communities can split or merge to form more diverse or more well-connected communities. We have examined journals and networks based on cardiovascular research publications (1) and their citations to address whether the gap is widening between preclinical/basic and clinical communities in the cardiovascular field.

TOOLS TO ANALYZE NETWORKS

We investigated trends in journal initiation/development and publication output from 1993 to 2013. An annotated database with additional information can be found elsewhere (4). Based on the reference,

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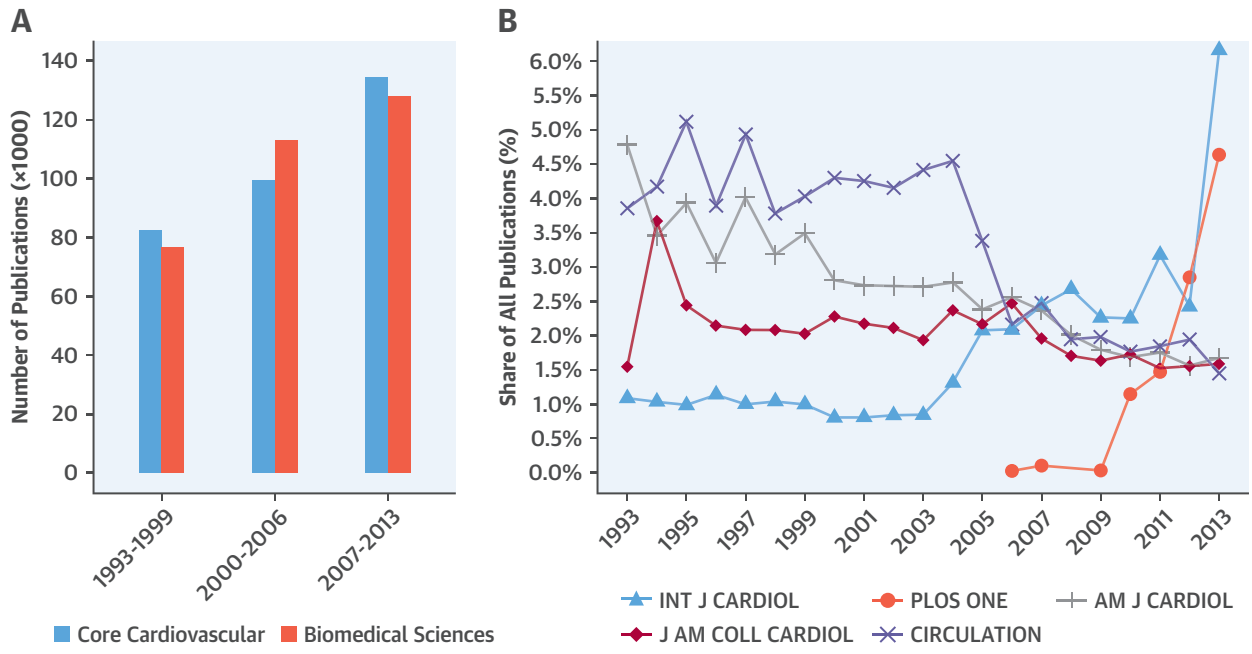
CENTRAL ILLUSTRATION **Evolution of Journals Publishing Cardiovascular Research**



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(A) Number of publications in each 7-year time period, according to journal field category. **(B)** Annual share of publications for the 5 journals with the largest change in share (4). Source: Clarivate Analytics Web of Science Core Collection.

abstract, and citation data for 804,152 cardiovascular publications in 5,984 journals (1), we included the most active and visible 565 journals according to rank, contributing the top 80% of all research output (n = 646,463 publications) and/or citations (n = 5,067,873) 2 full years after publication. Data were obtained from the Clarivate Analytics Web of Science Core Collection. All indicators were calculated yearly and for 7-year time periods: 1993 to 1999, 2000 to 2006, and 2007 to 2013. Each journal was also classified into 1 category: Core Cardiovascular; Broader Biomedical Science; Multidisciplinary; Natural Science; or Applied and Social Science. We compared the number/share of publications per journal, according to establishment and journal category. Statistically significant changes in proportions were evaluated by using the chi-square test, with p values <0.05.

We examined knowledge transfer and cardiovascular research communities through the flow of communication (cross-citations) between journals. The citation link strength (5) was calculated between individual journals based on the number of citations from Journal.A to Journal.B, standardized according to the total number of citing publications' references in Journal.A and citations received by cardiovascular publications in Journal.B. We then clustered the journals according to the citation link strength using Infomap (6). The statistical significance of journal community changes over time was tested by using the Infomap bootstrap networks method.

AN EXPANDING AND DIVERSE COMMUNITY IN CARDIOVASCULAR RESEARCH

Cardiovascular research is published widely, with an equal output of publications in traditional core cardiovascular journals and broader biomedical science journals (**Central Illustration, A**). Overall, 37 journals have a publication share >0.5% in 2007 to 2013 (4). One-half of all journals maintained a steady contribution over time. The *International Journal of Cardiology* experienced the largest growth, attaining the highest relative share at 6% of all cardiovascular publications in 2013 (**Central Illustration, B**) (4), surpassing *Circulation,* the *American Journal of Cardiology*, and the *Journal of the American College of Cardiology*. The

multidisciplinary journal *PLOS ONE* has a different editorial evaluation policy based on data accuracy, rather than novelty, and accepts many cardiovascular papers. Within 5 years of starting, *PLOS ONE* joined the top 5 journals ranked according to research output, contributing almost 5% of all cardiovascular publications in 2013.

Well-established journals account for the majority of publications, although there is also growth in the number of journals, from 389 in 1993 to 550 in 2013, including 104 newly established journals. Journal owners' and editorial policies have contributed to this change. The largest increase in new core cardiovascular journals occurred in 2008 to 2009 when the American College of Cardiology introduced subspecialty journals and the American Heart Association expanded the *Circulation* family with 6 new journals. This increase in the *Circulation* family may explain the large decrease in *Circulation* publications after 2008 (**Central Illustration, B**).

We further investigated the change in dissemination outside of core cardiovascular journals. Cardiovascular research continues to be published in highly visible journals, a potential indicator of continued innovation in the field. Of the most highly cited nondisciplinary journals, 12 had significant changes over time (4). The *Archives of Internal Medicine* had the largest proportion of cardiovascular publications at 31% of all papers in 2007 to 2013, whereas *Science* had the smallest proportion/significant change in cardiovascular publications from 2% to 1% over time. Of note, *JAMA* had the largest increase in proportion of cardiovascular publications (to 24% from 2007 to 2013); in contrast, the *Journal of Clinical Investigation* had the largest reduction in proportion of cardiovascular publications (to 16%).

CENTRAL JOURNALS WITH STRONG COMMUNICATION

We identified 18 central journals that received >50 citations from, and had standardized citation link strengths >0.01 with, at least 25 other journals in any time period (4). One-half of these central journals were core cardiovascular journals. The top 3 most strongly cited journals remained the same over time: *Circulation*, the *Journal of the American College of Cardiology,* and the *New England Journal of Medicine*. The *Journal of the American College of Cardiology* and the *European Heart Journal* experienced the largest increase in strong citation links over time, whereas the *Lancet* and the *Journal of Biological Chemistry* experienced the largest decrease.

CHANGING COMMUNITIES IN CARDIOVASCULAR RESEARCH

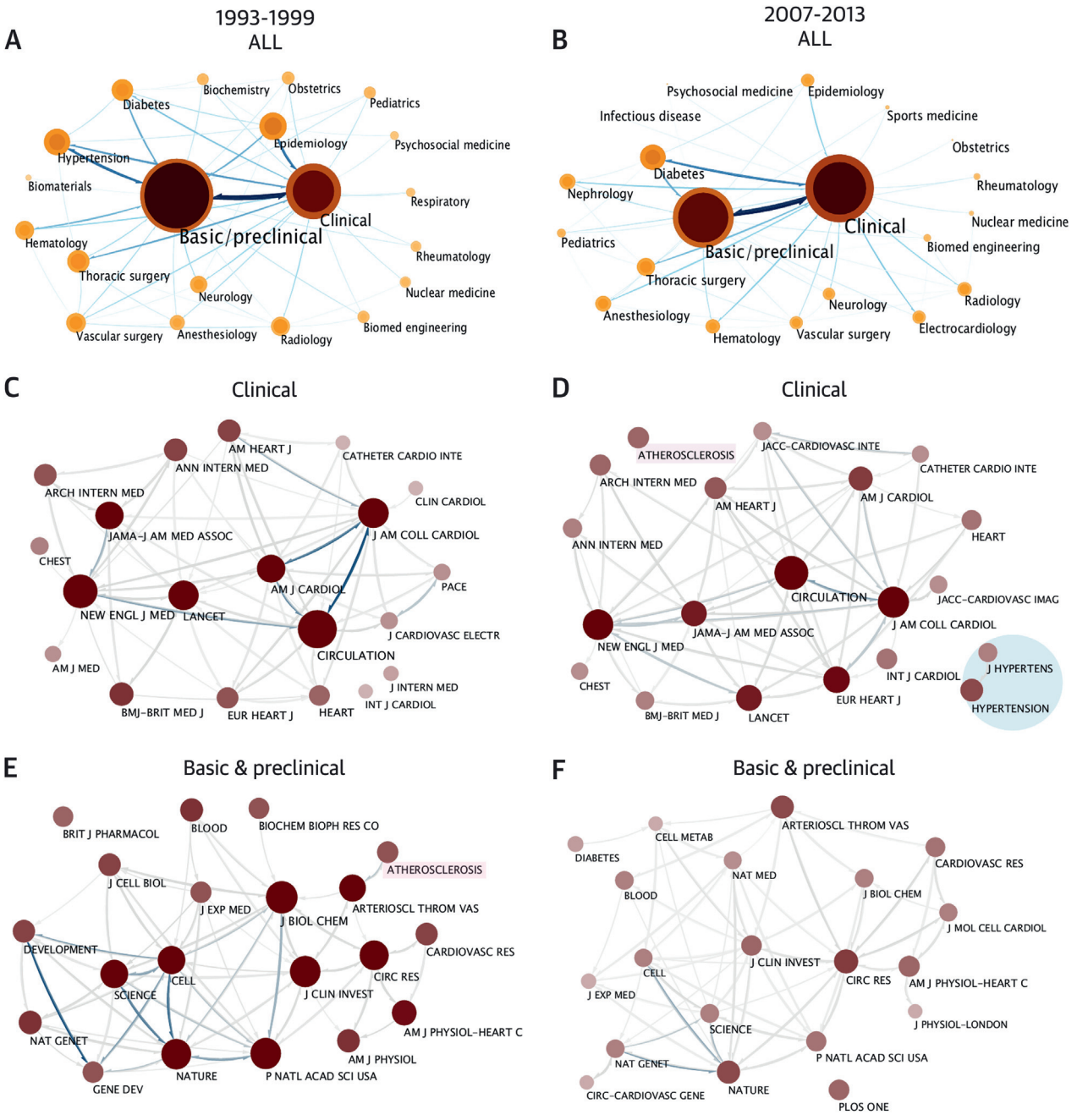
As with biological systems and social networks, the cross-talk between journals, through cross-citation of publications, contains community structure. We examined communities of journals having greater flow of communication through citations within a group of journals than with journals outside of the community, creating maps of journal groups that connect more densely together and have fewer connections with other journal communities (7).

There were 27 journal communities in 1993 to 1999, reduced to 25 in 2007 to 2013 (**Figures 1A and 1B**). Most notably, 2 central journal communities appear: one clinically focused and another focused on basic/preclinical research. Over time, the basic/preclinical community decreased its share, while the presence of the clinical community increased. In addition, the flow of communication between the basic/preclinical and clinical communities increased from 3% to 4%. Some communities changed over time, with the earlier hypertension, respiratory, and sleep communities becoming part of the core hub, more closely linked to the general clinical research community. In addition, 3 new communities were identified in 2007 to 2013: electrocardiology, sports medicine, and infectious disease. Many journal communities link strongly to core journals in distinct fields (e.g., surgery, radiology, engineering), meaning there is strong communication of cardiovascular research outside of the field.

Within the clinical journal community (**Figures 1C and 1D**), the 20 most influential journals remained relatively stable over time. *Circulation* maintained its central position. However, the journal *Atherosclerosis* changed its affiliation over time, moving from the basic/preclinical community to the clinical research community. In addition, 2 hypertension journals moved into the top 20 clinical journals in 2007 to 2013. Overall, the strongest links in each community were predominantly with core journals in specific fields or between/with American journals (4).

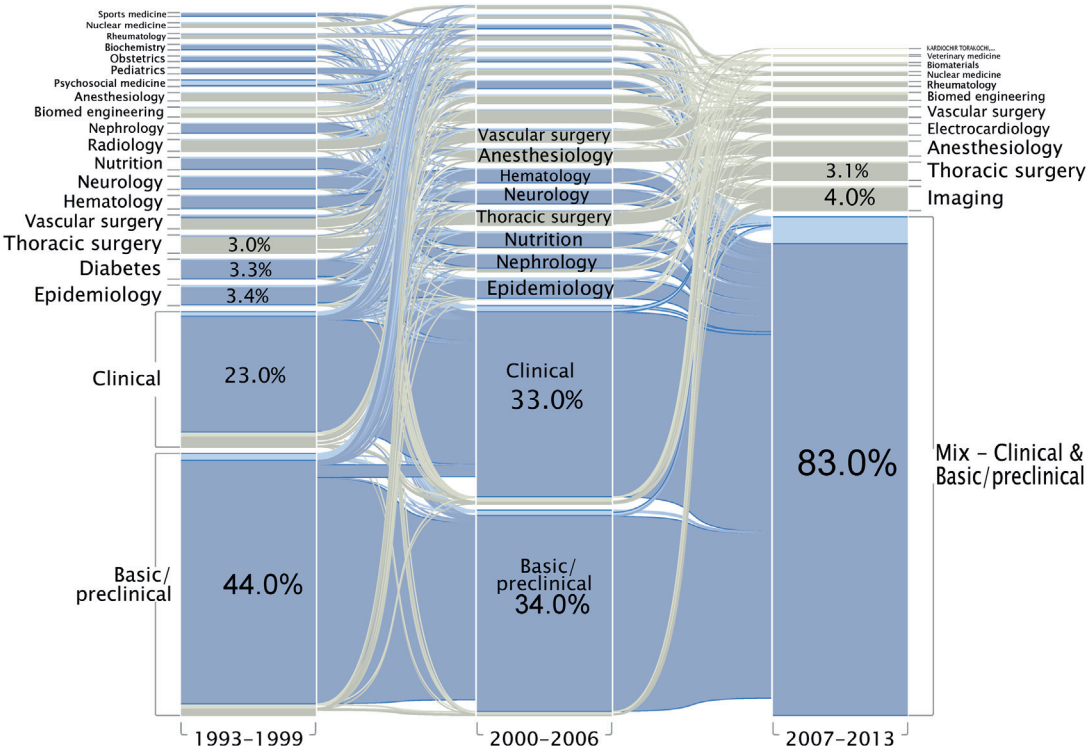
One of our unexpected findings is that over time, the strength of the clinical community surpassed the basic/preclinical journal community. This finding may indicate growing and advancing clinical research. Further support comes from quantifying the growth of journals and number of articles, both being larger in the clinical community (4). New core cardiovascular journals play a role in increasing the citations between clinical communities, creating their distinct communities but linking closely to the main clinical journals.

FIGURE 1 **Changing Journal Communities**



Graphical representation of communication flow based on the strength of the citation links between **(A, B)** the top 20 journal communities and the top 20 journals within **(C, D)** clinical and **(E, F)** basic/preclinical communities, with their strongest 100 links. The **outer-ring** of each community represents the share of communication flow with other communities; the **inner circle** represents the share of communication flow within the community. The **circle size/color intensity** represent the share of communication flow within that **(A, B)** community relative to other communities or **(C, D, E, F)** total communication flow for each journal relative to all other journals, increasing from **(A, B) light orange to dark brown** and **(C, D, E, F) transparent red to dark red**. **Lines:** The strength of communication flow between communities/journals increases from **light gray** to **dark blue**. **Arrows** point from citing to cited communities, following the flow of citations. The **circle positions** are based on the Force Directed Kamada-Kawai algorithm that reduces crossing of lines.

FIGURE 2 Decreased Fragmentation of Journal Communities



Alluvial plot presenting distinct journal communities' share of flow of communication, to and from cardiovascular research. The **blue** highlights the communities that merge significantly (90% confidence interval) to form the large mixed community in 2007 to 2013. The **light blue** denotes nonsignificant changes for journals moving between communities (4). Source: Clarivate Analytics Web of Science Core Collection.

DECREASING FRAGMENTATION OF COMMUNITIES SUPPORTING TRANSLATION

We further assessed the stability of the networks over time and examined whether the allocation of journals in each journal community was statistically significant by using re-iterative testing and bootstrap methods (4). The alluvial plot resulting from this analysis indicates decreased fragmentation of the flow of communication between clinical and basic/preclinical journals over time (Figure 2).

In 2007 to 2013, the separation of the clinical and basic/preclinical journal communities was no longer present at a statistically significant level because most journals were allocated to 1 combined community. The change from 2000-2006 to 2007-2013 is profound, with journals in the clinical, basic/preclinical, epidemiology, nephrology, nutrition, neurology, hematology, pediatrics, psychosocial medicine, and nuclear medicine communities merging into 1 large journal community. This merged community supports increased cohesion between basic/preclinical and clinical cardiovascular science and may indicate more translational activity. Another reason can be the changing nature of communication, with an increased number of journals and more citations. Increased ease of access to literature and a growing number of references per publication (4) likely also contribute to increasing flow and links bringing communities closer together.

DRIVERS FOR CHANGE IN CARDIOVASCULAR RESEARCH

Although the present study describes how publication output and citation patterns are changing, the data do not reveal why this change is occurring. Some mechanisms and drivers could be found in journals' and funders' policies.

Editorial policies may lead journals to increase their scope to publish both basic/preclinical and clinical research, such as for *Atherosclerosis* and recently for *Circulation Research,* and to encourage wider citing of research. Requesting reference to

relevant clinical guidelines and systematic reviews may also bridge clinical and basic/preclinical communities.

Funding policies have promoted translational and clinical research through strategic actions within the National Institutes of Health (8), the European Union framework programs, and others. The quality of information on funding sources is increasing, and linking publications to funding sources will be informative.

Finally, scientists' choices—in initiating research, in evaluating funding applications, and in writing manuscripts—remain important drivers in determining research directions and networks. Increased referencing of various types and topics of research by all communities may reflect genuine increase in cross-boundary research.

OUTLOOK FOR CARDIOVASCULAR RESEARCH

The current data indicate that cardiovascular research is published widely. Journal communities in basic discovery and clinical research have strong internal links as well as to other fields, emphasizing the multidisciplinary nature. Changes with time suggest that, at the level of publication and communication flow, the divide between basic and clinical research is decreasing. Translation into new medicines is not apparent at this time (9), but the time window from discovery to implementation is notoriously long. Monitoring of patents and other outputs deserves further study.

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REFERENCES

1. Gal D, Glänzel W, Sipido KR. Mapping cross-border collaboration and communication in cardiovascular research from 1992 to 2012. Eur Heart J 2017;38:1249–58.

2. Roth GA, Johnson C, Abajobir A, et al. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. J Am Coll Cardiol 2017;70:1–25.

3. Butler D. Translational research: crossing the valley of death. Nature 2008;453:840–2.

4. Gal D, Thijs B, Glänzel W, Sipido KR. Annotated database for "A changing landscape in cardiovascular research publication output: bridging the translational gap." Lirias Data Repository. KU Leuven 2018. Available at: https://lirias.kuleuven.be/handle/123456789/607264. Accessed January 11,2018.

5. Zhang L, Janssens F, Liang L, Glänzel W. Journal cross-citation analysis for validation and improvement of journal-based subject classification in bibliometric research. Scientometrics 2010;82:687–706.

6. Rosvall M, Bergstrom CT. Mapping change in large networks. PLoS One 2010;5:e8694.

7. Rosvall M, Bergstrom CT. Maps of random walks on complex networks reveal community structure. Proc Natl Acad Sci USA 2008;105:1118–23.

8. Galis ZS, Black JB, Skarlatos SI. National Heart, Lung, and Blood Institute and the translation of cardiovascular discoveries into therapeutic approaches. Circ Res 2013;112:1212–8.

9. Mullard A. 2016 FDA drug approvals. Nat Rev Drug Discov 2017;16:73–6.

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