Identifying Research-Active Specialists at an Academic Medical Center: A Case Study

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ABSTRACT

How might one identify, via publicly accessible web sites, research-active specialists at an academic medical center? As a case study, health informatics specialists were identified at two academic medical centers: University of Colorado, Anschutz Medical Campus and University of Maryland, Baltimore. Four types of data about researchers were sought: frequency of publication, frequency of citations, money from grants, and patents. Based on frequency of published papers, one center favored bioinformatics and cardiology, whereas the other produced more results in nursing and radiology. Interestingly, different patterns were found across different datasets. This bibliometric method was contrasted with the method of searching for active researchers via a web portal showing board certified specialists at a particular institution. This alternative approach was tried for informatics and sleep medicine, and the bibliometric method seemed to produce better recall and precision.

Keywords: health informatics; academic medical center; bibliometrics; grants; patents

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INTRODUCTION

In the 21st century, medical librarians at academic health centers are challenged to be health informaticists and to connect more intimately with their constituents to facilitate the use of information systems (1, 2). One approach is to identify clients who are receptive to being helped and then embed the librarian in the clients' projects, as has been done in a nursing class (3) and in a health science conference (4). More general approaches have looked at systems used across the academic health center with librarians embedded in the system, as with learning management systems (5) or electronic medical records systems (6), or focused on one discipline and making the library a key partner with researchers in that discipline, as illustrated in work with bioinformatics (7).

Identifying prominent researchers on a topic who might be receptive to working with librarians is not always a straightforward process. For topics such as cardiology or orthopedic surgery, an administrative entity in the health center may map in a straightforward way to that topic, or a directory of medical specialists might be queried for people within that specialty, and the librarian can thus begin to identify relevant faculty. However, for some topics, such as health informatics, the health center may lack a research department that focuses on that topic and specialists in the area might not be fully identified in a faculty directory. One approach to identifying prominent researchers in a particular area exploits bibliometric techniques.

For this case study, the author has chosen the topic of health informatics (HI). The choice is not arbitrary because, for health librarians, the topic of HI is at the core of what they do. Librarians at academic health centers have not only the opportunity to help health specialists use

information but have an obligation to help the health center develop and maintain policies of successful information practice (8).

LITERATURE REVIEW

Many different descriptions of HI have been offered. One bibliometric study covering publications from 2006 to 2017 concluded that literature on the topic of HI could be seen to cover: mobile health, organizational aspects of health information systems, electronic health records, and biomedical data analysis (9). The American Medical Informatics Association describes five main areas of health informatics (10): Translational Bioinformatics, Clinical Research Informatics, Clinical Informatics, Consumer Health Informatics, and Public Health Informatics (11). Health care informatics has been defined as the "study of how the diverse types of health information are researched and combined to result in decisions to optimize patient care quality (1)." However, for this paper, HI will only be implicitly defined via the queries on databases used to find people involved in HI.

To find HI researchers, one study began with the 100 top-cited HI articles (12) by first identifying all articles published in journals that the Web of Science classified as HI journals. An Australian paper analyzed health informatics in Australia through patterns in PubMed (13); the authors identified HI through a MeSH query and used the 'Affiliation' field of PubMed to identify papers by Australia authors. In a Latin American paper, the authors compared HI publication activity in MEDLINE versus LILACS (Latin American and Caribbean Literature on the Health Sciences) (14). Another paper took the journals identified by the National Library of Medicine as medical informatics journals and, from the abstracts of all the papers published in those journals, used natural language processing software to extract clusters of HI concepts. (15)

This paper draws from the preceding methods but also adapts others. When taking advantage of a MeSH query, the author relies heavily on the explode property (16) of a MEDLINE query. Four different types of database are used: a) PubMed, b) citation databases from Google and Microsoft, c) grants databases, and d) patent databases.

METHODS

The author first studied the HI researchers at the University of Colorado, Anschutz Medical Campus (CU Anschutz), which is the biggest academic health science center in the Rocky Mountain Region. CU Anschutz is part of a large state academic system but is also a dedicated health sciences campus without a connected general campus. To compare the results from CU Anschutz with another entity, the University of Maryland Baltimore (UMB) was chosen. Like CU Anschutz, UMB is dedicated campus without a connected general campus.

For each of CU Anschutz and UMB, 4 types of searches were done:

1. Frequency of authoring an article in PubMed,
2. Frequency of citation of articles,
3. Grants received from NIH, and
4. Patents granted by the US Patent and Trademark Office.

For each of those searches, the top 10 HI researchers are reported (i.e., the most frequently published, frequently cited, funded, and patented). The method is detailed next.

Authoring frequency

The PubMed query had two parts that were ANDed together:

- The affiliation [ad] search for CU Anschutz was '(Aurora[ad] NOT "Aurora Health"[ad])', and for UMB was '(Baltimore[ad] NOT Hopkins[ad] NOT "National Institutes of Health"[ad])'.

- For the topic part of the query, five MeSH terms were exploded and combined with OR: “Information Science", “Automation, Laboratory”, “Computational Biology”, “Management Information Systems”, and “Mathematical Concepts”. Furthermore, the MeSH term had to represent the main topic of the article, as reflected in "[major]" appended after the MeSH term in the query.

The affiliation query specified "Aurora" because CU Anschutz is in Aurora, CO. "Aurora Health" is in a different Aurora and not related to CU Anschutz. One might wonder why the term Anschutz was not used. Since 2008 CU Anschutz has been in the city of Aurora, and when authors give an address, they specify Aurora but might not refer to Anschutz. UMB is in Baltimore, but the query needs to exclude two other institutions with Baltimore addresses, namely Johns Hopkins and the National Institutes of Health (the National Institute of Aging, National Institute of Drug Abuse, and National Human Genome Research Institute are in Baltimore).

The term "Computational Biology" is included in the query, although "Computational Biology" is in the MeSH "Information Science" hierarchy and would be automatically included in the explode function. Exploding "Information Science" would seem to make adding "Computational Biology" redundant. However, "Computational Biology" occurs in both the "Information Science" and "Natural Science Disciplines" hierarchies. A query exploding "Computational Biology" will include MeSH terms more specific than "Computational Biology" in the "Natural Science Disciplines" hierarchy, (such as Genomics), whereas exploding "Information Science"' will omit articles indexed with Genomics (see Figure 1).

Figure 1: Anomaly of Query Explosion for MeSH Terms in more than one Hierarchy

<table>
<tr>
<td>Information Science [L01]
Informatics [L01.313]
Cheminformatics [L01.313.062]
Computational Biology [L01.313.124]
Consumer Health Informatics [L01.313.187]</td>
<td rowspan="2">"Computational Biology" occurs in both "Information Science [L01]" and "Natural Science Disciplines [H01]" which leads to the query "Information Science"[MeSH] getting different retrieval results than ("Information Science"[MeSH] OR "Computational Biology"[MeSH])</td>
</tr>
<tr>
<td>Natural Science Disciplines [H01]
Biological Science Disciplines [H01.158]
Biology [H01.158.273]
Botany [H01.158.273.118]
Cell Biology [H01.158.273.160]
Computational Biology [H01.158.273.180]
Genomics [H01.158.273.180.350]
Metabolomics [H01.158.273.180.599]
Phenomics [H01.158.273.180.700]
Systems Biology [H01.158.273.180.800]
Cryobiology [H01.158.273.195]</td>
</tr>
</table>

While this may seem an obscure point, the impact on the performance of a PubMed query is potentially substantial, and this author was unable to find any publicly accessible documentation to address this phenomenon. On October 12, 2021 the query on PubMed of ("Information Science"[MeSH]) retrieves 586,140 results, whereas the query ("Information Science"[MeSH] OR "Computational Biology"[MeSH]) retrieved 626,316 results -- a difference of more than 40,000 citations. This phenomenon of anomalous hierarchies is not unique to "Computational Biology". A search that explodes "Health Occupations" includes "Hospital Administration", where 'Hospital Administration' has no more specific terms. However, "Hospital Administration" is also included in the "Health Care Facilities, Manpower, and Services" tree where it has 13 more specific, MeSH terms.

The MEDLINE queries used in this paper have weaknesses, of which 3 are:

- Exploding "Information Science" includes concepts that might not indicate a HI paper.
- If a paper is not indexed with MeSH terms, then the MeSH query will not return those papers. Important papers might be in PubMed but not be indexed. Indexed papers are only in the MEDLINE subset of PubMed (28).
- The 'AD' field has changed over time. For instance, non-first author affiliations were not added until 2014.

However, as a first approximation the query is powerful.

Citations, Grants, and Patents

A more useful measure of impact than frequency of publication is frequency of being cited (17, 18). Given this paper's focus on freely, publicly accessible sources, Google Scholar and Microsoft Academic were sources for citation frequency data. However, in searching Google Scholar, difficulties exist to find informaticians at UMB. Fortunately, McCoy, et al. developed a tool they called the Google Scholar Scraper to create a Biomedical Informatics Researchers ranking website (19). They scraped Google Scholar to generate an interactive list (20) of prominent HI researchers with attributes including affiliation and frequency of being cited. For CU Anschutz, 10 highly cited researchers were obtained from the Biomedical Informatics Researchers ranking website. The website included only 2 UMB researchers. A further 8 HI researchers from UMB were found via Microsoft Academic in an ad hoc fashion.

The author went to the NIH Reporter (21) and retrieved all the active NIH grants for 2020 at CU Anschutz and UMB, respectively, that satisfied this query:

> app OR computational OR "computer-assisted" OR "decision making" OR "decision support" informatics OR "information management" OR "information systems" OR "medical records systems" OR "mobile health" OR telehealth.

The term "app" was included as a search term because trial queries showed that "app" was used in some NIH informatics grants that did not use the other query terms. The first-listed, principal investigators for the 10 largest grants from each of CU Anschutz and UMB were then collected.

The US Patent and Trademark Office makes its database of patents, the USPTO Patent Full-Text and Image database (PatFT), publicly accessible online. Google also provides a user-friendly interface to a massive patent database, Google Patents. Additionally, each academic health science center helps its faculty market patents, as the academic institution is typically the assignee for the patent. Patent web portals for CU Anschutz and UMB are available and classify the patents so that HI patents are readily identified. The patent holders for CU Anschutz were chosen from the CU Anschutz patent website as the first-listed patent holder from the ten, most-relevant patents (22) categorized under "software". The University of Maryland System maintains a patent directory and its category of "Software + Algorithm" lists 25 patents (23);

from those 25 were chosen the ten whose first-listed patent holder was based at UMB and whose patents were particularly relevant to HI.

RESULTS

The results are presented in the same order as the methods: authoring, citations, grants, and patents. Table 1 shows the data for the top 10 authors from CU Anschutz by frequency of publication. Of the most frequent co-authors, the top 3 are not in the list of most frequent first authors. Based on closer examination of the individual authors, one notices that people who lead large teams tend to be co-authors rather than first authors. Table 2 shows the data for UMB of the top 10 authors by frequency of publication. In both tables, the first 3 columns show frequency of being first author on a paper and the second 3 columns show being most frequent as a co-author.

Table 1: CU Anschutz Frequency (freq) of Publications.

1st Author			Co-Author		
Author	Freq	Discipline	Author	Freq	Discipline
Shore, James H	19	psychiatry	Masoudi, Frederick	52	cardiology
Ginde, Adit A	10	emergency med	Dellavalle, Robert	50	dermatology
Garg, Satish K	9	pediatrics	Hunter, Lawrence	50	bioinformatics
Allen, Larry A	8	cardiology	Allen, Larry A	37	cardiology
Barton, Amy J	8	nursing	Matlock, Daniel D	31	geriatrics
Cohen, Kevin B	8	bioinformatics	Shore, James H	29	psychiatry
D'Alessandro, Angelo	8	biochemistry	Cohen, Kevin B	26	bioinformatics
Morrato, Elaine H	8	public health	Hansen, Kirk C	25	biochemistry
Thompson, Darcy A	8	pediatrics	Kempe, Allison	25	pediatrics
Bull, Sheana S	7	public health	Glasgow, Russell E	23	family med

Table 2: UMB Frequency (freq) of Publications.

1st Author			Co-Author		
Author	Freq	Discipline	Author	Freq	Discipline
Reiner, Bruce	66	radiology	Siegel, Eliot L	96	radiology
Resnick, Barbara	29	nursing	Reiner, Bruce I	81	radiology
Siegel, Eliot	20	radiology	Resnick, Barbara	43	nursing
Nahm, Eun-Shim	16	nursing	Mullins, C Daniels	29	pharmacology
Mackenzie, Colin	9	anesthesiology	Magaziner, Jay	24	epidemiology
Shardell, Michelle	9	biostatistics	Mills, Mary Eta	24	nursing
Cross, Raymond C	7	gastroenterology	Yu, Cedric X	24	radiation oncology
Guerrero, Mariana	7	radiation oncology	Jeudy, Jean	23	radiology
Doshi, Peter	6	pharmacology	Langenberg, Pat	23	biostatistics
D'Souza, Warren	6	radiation oncology	Scalea, Timothy M	23	emergency med

The 10 most frequently cited HI researchers from CU Anschutz and UMB are shown in Table 3. In comparing the list of frequently cited researchers from CU Anschutz with the list of researchers who publish frequently, oddities appear. For instance, 'Dellavalle' is the 2nd most published author in the co-author list but does not appear on the Biomedical Informatics Researchers ranking website list of most cited authors. The Biomedical Informatics Researchers ranking website does not claim to be comprehensive.

Table 3: Frequency of being cited for top 10 HI researchers at CU Anschutz and UMB

CU Anschutz			UMB		
Name	Citations	Discipline	Name	Citations	Discipline
Lozupone, Catherine	91,311	bioinformatics	Lakowicz, Joseph	117,999	bioinformatics
Ghosh, Debashis	30,353	bioinformatics	Scalea, Thomas M	39,050	emergency medicine
Haendel, Melissa	10,459	bioinformatics	Christenson, Rob	30,292	cardiology
Hunter, Larry E	9,896	bioinformatics	Schriml, Lynn	28,044	bioinformatics
Kahn, Michael G	4,810	pediatrics	Kochunov, Peter	16,387	radiology
Lin, Chentan	2,718	internal medicine	Harris, Anthony	11,890	public health
Kao, David P	1,728	cardiology	Felix, Victor	10,536	bioinformatics
Saba, Laura	1,529	bioinformatics	Shulman, Lisa M	10,047	neurology
Wiley, Laura K	1,064	bioinformatics	Piscotty, Ronald	2,012	nursing
Ozkaynak, Mustafa	560	nursing	Gourab, Krishnaj	2,007	rehabilitation

As described in the Methods section, the NIH Reporter was used to identify active grants to each of CU Anschutz and UMB for HI research. Table 4 shows the 10 largest HI grants for CU Anschutz and Table 5, for UMB. At CU Anschutz, researchers from cardiology have two entries, which is consistent with the publication records. At UMB, researchers from psychiatry had the most entries which is, however, not consistent with the record of publication frequency for UMB. The variation in patterns across the tables suggests the diversity of activity and the imperfection in any given search.

Table 4: 10 largest HI Grants to CU Anschutz faculty (sorted by grant size)

Principal Investigator	$ million	Discipline	Topic
Sokol, Ronald	14.0	Pediatrics	Translational Sciences Institute
Restrepo, Diego	6.0	Biology	Novel methods brain recording
Kohrt, Wendy	3.0	Epidemiology	Molecular Physical Activity Consortium
Ho, Michael	1.4	Cardiology	Personalized patient data
Gignoux, Christopher	0.8	Bioinformatics	Genomic population health

Rosenberg, Michael A	0.8	Cardiology	Clinical decision support tools
Costello, James C	0.8	Pharmacology	Systems analysis of cancer pathology
Matlock, Daniel D	0.7	Geriatrics	Shared decision support intervention
Norman, Paul John	0.7	Bioinformatics	Diseases born from genomics
Scherer, Laura D.	0.7	Psychology	Affective processing of evidence

Table 5: 10 largest HI Grants to UMB faculty (sorted by grant size)

Principal Investigator	$ million	Discipline	Topic
Rasko, David	3.55	Microbiology	Genomic determinants of infectious disease
Morgan, Daniel	2.32	Public Health	Bayesian reasoning for decisions
Bennett, Melanie E.	1.49	Psychiatry	Psychosis and learning health system
Dunning Hotopp, Julie	1.45	Microbiology	Bacterial DNA in cancer
Marano, Christopher	0.73	Psychiatry	Brain bioenergetic function
Gruber-Baldini, Ann L	0.72	Public Health	Cognitive thresholds for responses
Gold, James M.	0.69	Psychiatry	Predictive coding for psychosis
Mas, Valeria Raquel	0.67	Surgery	Epigenome prompting pathways
Hertzano, Ronna	0.65	Otolaryngology	Data sharing for hearing research
Schriml, Lynn Marie	0.65	Public Health	The Disease Ontology Project

Table 6 lists ten HI patent holders extracted from the CU Anschutz and UMB patent web sites, with inventors' names and respective topics.

Table 6: Ten Patents for HI at CU Anschutz and UMB.

CU Anschutz		UMB	
Inventor	Topic	Inventor	Topic
Chen, James	Dynamic reconstruction of coronaries	Shulman, Lisa	Data visualization for clinical data
Bunik, Maya	App for support of breastfeeding	Polf, Jerimy	Imaging for proton range
Carroll, John	Rapid prototyping medical imaging	D'Souza, Warren	Real-time tumor monitoring
Chase, H Peter	On-off switch for insulin pump	Jarrell, Bruce	Decision-making through simulation
Jortberg, Bonnie	Patient Self Support System	Orwig, Denise	Medication management
Pace, Wilson	Patient Entered Electronic Record	Magaziner, Jay	Extremity gain scores
Schilling, Lisa	CU Record Linkage	Martin, Stuart	Inhibition of metastases
Alexeev, Timur	Suppressing artifacts in digital images	Barton, Joseph	Balanced reach control

Zylberberg, Joel	Sleep states from brain signals	Sandler, Anthony	Likelihood of appendicitis
Jeffres, Meghan	Educational game about infectious diseases	Isaiah, Amal	Monitoring sleep apnea

As one compares the patent holders with those who appeared in the other lists (authoring, citations, and grants), the lack of overlap is striking. No one on the patent list appears in any of the other lists. An arbitrary sample of patent holders and further investigation of their cases helps explain why. Many of the patent holders had publications retrieved by the MeSH query (such as the article by Coats, et al. (24)) but not enough to be in the top 10. A PubMed query for one of the patent holders ("Jortberg B") retrieved 7 citations which was fewer than the least-frequently cited co-author in Table 1 who had 23 citations. The MeSH encoding of one of those retrieved articles by Jortberg (25) reveals part of the problem. The major MeSH terms for that paper are Organizational Innovation, Patient-Centered Care, Patient Health Care, Primary Health Care, and Self-Management, none of which are within the hierarchies exploded by the MeSH query used in this paper. Yet, looking at the index terms and their sub-headings of "statistics & numerical data" one sees a pattern indicative of a HI project.

DISCUSSION

If the list of authors and their frequency of publication were extended to the lower limit of a single publication, then every author in the frequency of publication list would most likely also appear in the citation list and the grant list. That is because to be cited, an author must have, at least, one publication, and NIH encourages grant recipients to publish their work. However, for the top ten researchers in the different categories almost no overlap occurs.

For CU Anschutz no researcher appears in more than 2 lists and only 5 authors appear in 2 lists. One author (Hunter) appears on the co-author frequency list and the citation list, while another author (Matlock) appears on the co-author list and the grant list. If one explores the individuals more deeply, then one gets some insight for these patterns. For instance, Hunter came to CU Anschutz from NIH in the year 2000 and has received numerous NIH grants supporting Ph.D. students; he co-authors with these Ph.D. students, but the students are the first author. While at CU Anschutz, Hunter has only written one paper as first author, which was an essay about the future of his field (26). For UMB the patterns across lists resemble those for CU Anschutz, namely, no researcher appears in more than 2 of the 5 lists and only 6 researchers appear in 2 lists.

If one sorts the authors by discipline and looks for patterns in the disciplines, then for CU Anschutz, bioinformatics is the the top field followed by cardiology. For UMB the discipline results are completely different, as the most common discipline is radiology and second is nursing. This frequency of discipline information is consistent with what one can learn about the two different health science centers in terms of their reputations.

The methods of retrieving data from different sources led to varied results. Many explanations exist for this. By example, Ghosh is the second most cited HI author at CU Anschutz but does not appear on the list of authors with frequent publications in PubMed. Ghosh moved to CU Anschutz from Penn State, and many of his publications would not be retrieved by the PubMed query that required the author affiliation be CU Anschutz. Also, Ghosh publishes some papers that are included in PubMed but not in MEDLINE (see, for instance, his 2019

article in *Mathematical Biosciences and Engineering* (27)), i.e., those papers are not indexed with MeSH terms and would not be retrieved by the MeSH query used in this paper.

The bibliometric approach to identifying specialists is not necessarily superior to other approaches but can complement other approaches. For instance, with HI one could go the CU Anschutz website and find a portal for searching for specialists (28). Choosing the specialty of "Clinical Informatics", one retrieves 3 people who have earned Board Certification in Clinical Informatics. Board Certification is available in Clinical Informatics as a subspecialty of Pathology or Preventive Medicine (29). However, many HI researchers are not Board Certified in Clinical Informatics. In this instance, the bibliometric method has better recall as a search method.

As an example of alternative approaches and how they perform, a tiny case study of "Sleep Apnea" researchers at CU Anschutz was done. To find prominent sleep apnea researchers at CU Anschutz, one could go to the CU Anschutz specialty portal (28), chose the specialty of sleep medicine, and thus retrieve 19 individuals who on their profile have Sleep Medicine as a specialty. Many are pediatricians who focus on asthma in children. One gets little indication from this list as to the research activity of the sleep medicine specialists. By contrast, a PubMed query that explodes "Sleep Apnea Syndromes"[major] with an affiliation of CU Anschutz returns 62 citations written by a total of 280 co-authors. All these authors have demonstrated research productivity on the topic of Sleep Apnea. Of the 10 most prolific PubMed authors only one (Norman Friedman) appears on the UC Anschutz "Sleep Medicine" list. In this case, the bibliometric approach shows seemingly better recall and precision than the alternative approach of searching for board-certified specialists.

The goal of this paper was not to identify 10 best HI researchers at an academic medical center. Rather the goal was to identify researchers that might be contacted to pursue collaborations. As one would contact those researchers, pointers to other researchers would inevitably arise. A health science librarian might want to collaborate with these HI researchers to help the health science center coordinate and advance HI projects. Other purposes for identifying HI researchers can be imagined. For instance, someone may want to move as a student or a professional to a center that has a vibrant community of HI researchers, and the methods demonstrated in this paper could help that person identify that community. A different purpose might be held by an investor who wants to invest in HI efforts at a center and wants to find people in whom to invest. For whatever the purpose, the results of this paper would be a starting point and not an end point.

Having searched for and found approximately 50 HI researchers at a center, one might then begin to browse the web for further information about the individuals. At academic medical centers, faculty members typically have a profile that the centers make publicly available, and from that profile one can learn about the faculty members' educational credentials, professional interests, hobbies, and more. At some point, one would contact an HI researcher and begin the dialogue that might lead to collaboration.

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