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Engineering and Technology in the Allied Health Sciences. Sources for Research and Teaching.

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Abstract

Since the end of the 19th century, technological advances have played a major role not only in medicine but also in the development of new disciplines that have been included under the term allied health.

The purpose of our study was to investigate how the allied health disciplines were represented in two databases with a major emphasis on technology and engineering. We used the data-mining technique to find out what elements of these databases might be useful to researchers and students in their searches for information on science and technology contributions to health sciences, and especially allied health sciences. Therefore, our paper is not a guide to searching these two databases - *Inspec* and *Compendex* - but rather research into the structure and terminology, as they relate to some of the allied health disciplines.

Introduction

Allied health professions constitute an important part of the health science infrastructure. They provide services that include prevention, identification and evaluation of illnesses and disabilities, health promotion, and rehabilitation. Their functions often facilitate and/or complement the work of physicians, nurses, and other health care specialists.

Technological advances in medicine have played a major role in the development of allied health disciplines. The first tools used for physical diagnoses were invented only in the 19th century. Until that time, medicine resisted using technology for learning about diseases of the human body. The invention of simple scopes, such as the laryngoscope and the gastroscope, started the trend towards using actual instruments for diagnosis of illnesses. By the end of the 19th century, other complex instruments for diagnoses, such as the microscope, the electro-cardiograph, and the X-ray, were developed and became a part of modern medicine.

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The use of these machines and instruments required a great deal of time, skill, and training for which medical practitioners could no longer devote their time and attention. As a result, a new brand of specialties, allied health professions, developed and became widespread in hospitals and diagnostic laboratories.

During the 20th century, technology became the main force producing a need for further specialization of these new fields of health care. According to a report of the National Commission on Allied Health Education[1] from 1980, by 1940 there were 27 new allied health occupations, by 1975 there were already 152, and the number has continued to grow. Technology has been responsible for creating allied health disciplines and continues to shape their future.

Also, with the growth of the elderly population, a need for developing more sophisticated assistive and rehabilitation technology as well as self-care technology will increase even more.

There are many areas of allied health that use sophisticated equipment for diagnosis and treatment in their daily routine, e.g., diagnostic medical sonography, radiography, radiation therapy, NMR, etc. In all of these areas, engineering design, innovation, and technological ingenuity are needed in order to find better solutions in delivering health care for treatment of illnesses and for assisting in disabilities.

At this time of growing research in medicine and other health sciences, it is impossible to ignore the contributions of technology to these areas. And yet, a person not experienced in searching databases would probably not look for health related information in technological databases.

A review of literature showed a few bibliometric studies related to allied health, but none of them dealt with technological databases. In 1994, Watson and Perrin[2] studied the coverage in the Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Medline of the literature for four allied health areas: medical technology, medical records, radiologic technology, and respiratory therapy. In 1999, Siebers[3] studied the error rate of references in the New Zealand Journal of Laboratory Science, and in 2003 Delwiche[4] provided a citation analysis of the literature of clinical laboratory sciences. Clearly, it was impossible in our preliminary study to cover all areas of allied health sciences. We selected two examples, physical therapy (relatively low-tech) and ultrasound / sonography (high-tech) in order to determine the coverage of these two areas in major technological and engineering databases.

According to guidelines published by the American Physical Therapy Association, physical therapy is defined as “the examination, treatment and instruction of persons in order to detect, assess, prevent, correct, alleviate and limit physical disability and bodily malfunction.”[5] The use of physical measures, activities, and devices for preventative and therapeutic purposes is included in the definition.

Ultrasonography is “a radiologic technique in which deep structures of the body are visualized by recording the reflections (echoes) of ultrasonic waves directed into the tissues.”[6]

The two obvious major engineering and technology databases selected for this project were Inspec and Compendex. Inspec, produced by the Institution of Engineering Technology (IET), is the world's leading bibliographic database providing comprehensive global coverage of scientific and technical literature in the fields of physics, electrical engineering, electronics, and computer science. Inspec contains over 8 million records dating from 1969 and draws upon 3,000 scientific and technical journals and 2,000 conference proceedings for coverage.

Compendex (an online version of the former Engineering Index, published by Elsevier) is a comprehensive bibliographic database of engineering research literature covering 5,000 engineering journals and professional conferences in applied science. Subject areas treated include chemical and process engineering, applied physics, computers, data processing, electronics, and communication. Combined searches of Inspec with the Compendex database ensure the most complete coverage of published engineering literature possible.

Since there is always a need for more research to develop new technology and update older technologies, there is also a need for information about where this kind of research is conducted and where the results are being published. Our paper will attempt to respond to the need for this kind of information.

The authors would like to present this survey also as a teaching and learning experience. By exposing students to this type of literature survey the following lifelong learning goals can be achieved: 1. The students will learn how to select appropriate databases for their area of study and research; 2. They will learn different techniques for searching relevant data; 3. They will find out about different document types, such as monographs, journal articles, conference proceedings, technical reports, etc.; 4. They will learn about the limitations imposed by search engines and web interfaces; and finally, we hope, 5. They will also learn how to evaluate the information that they find in databases and elsewhere. The project is not about how to research databases for finding specific information about a *narrowly defined* topic. We were interested in looking at *the big picture*. By using the technique that information scientists call "mapping," they attempted to discover the subject components of the selected fields of research.

Methodology

In our study we analyzed Inspec and Compendex for publications dealing with use of technology in allied health disciplines.

Inspec and Compendex were searched simultaneously using Engineering Village[7] (a product of Elsevier), a technical literature portal providing access to several databases.

We used standard searching techniques beginning with several preliminary keyword searches using terms related to the two subject areas being considered: physical therapy and sonography / ultrasonic. The preliminary results and their completed records were analyzed. The large number of subject terms generated by this search were then selected for a second round of searches. This data-mining method is similar to the one used by Schaible[8] who used it in order to identify new trends in physics.

Method 1. For the topic of physical therapy we found eight controlled vocabulary terms and one classification code that best reflected the areas under consideration and were included in the "Expert Search" as follows: (({Physical Therapy}) WN CV) OR (({Human Rehabilitation Engineering }) WN CV) OR (({Human Rehabilitation Equipment}) WN CV) OR (({Patient Rehabilitation}) WN CV) OR (({Neuromuscular Rehabilitation }) WN CV) OR (({Orthopedics}) WN CV) OR (({Exercise Equipment}) WN CV) OR (({Walking Aids}) WN CV) OR (({461.5}) WN CL). All these terms were limited to the controlled vocabulary fields of Compendex and Inspec. This search, limited to the period of 1995 to 2007, produced 13,236 records.

Method 2. Our second topic dealt with the use of sonography or ultrasound technologies in allied health sciences. After running several preliminary searches and analyzing their results, it was determined that a better approach for collecting data in this case was using keyword terms in the "Quick Search" as follows: (((Sonograph* OR Ultrasound) WN All fields) AND ((Diagnos* OR Therap* OR Medic* OR Health) WN All fields)). These keywords or their truncated equivalents were searched in all fields of both databases. The search, limited to the period from 1995 to 2007, produced 19,174 records. The citations obtained are listed in descending order based on their relevance. The sorting of the results done by the Engineering Village interface is based on an algorithm that takes into account several parameters related to the location and frequency of the terms.[9]

Once the successful search was performed, the Engineering Village interface automatically produced the following reports by: Database, Author, Author affiliation, Controlled Vocabulary, Classification Code, Country, Language, Year and Publisher. A brief description of these reports follows:

Database: lists all databases used and the number of documents obtained from each one of them.
Authors: provides a list of the authors most frequently found in a search.
Author affiliation: shows the institutions most frequently listed as corresponding to the first author of each document.
Controlled Vocabulary: gives a list of most common terms assigned to each document.
Classification Code: provides a list of most common numerical codes representing subject topics assigned to each document.
Country: a list of most frequent countries related to the Author affiliation field.
Language: shows in which language the original documents were published.
Year: a report of the distribution of documents by their year of publication.
Publisher: shows the most productive publishers found.

In addition, two more reports were created by the authors of this paper based on the data produced by each of the searches mentioned above: Journals and Conference Proceedings. These two reports were developed by examining the citations of the first two most relevant citations and determining which journal titles and which conference proceedings were cited. Furthermore, in the case of journals, the list of titles obtained was then searched against the results of the subject searches done. This means each of the two topical searches mentioned above were limited by each one of the corresponding set of journals. This approach gave us the number of

times each journal was found for each of the two sets of resulting citations (physical therapy and sonography / ultrasound).

Results – Physical therapy

Databases

In the case of physical therapy, Compendex is the dominant database with the 89.69 percent of the records

Table 1. Databases – Physical Therapy

Compendex: 11,871 citations.	Inspec: 1,365 citations.

Authors and their affiliation

The top 19 authors with 20 or more citations are included in Table 2. In total, 40 authors with at least 15 citations were found. This report shows that while the majority of authors had 20 or more citations, one of them (Cooper) had 76. In addition to the USA, other countries with institutions represented were: Italy, Slovenia, Japan, Switzerland, Taiwan, and Denmark. An asterisk (*) indicates that the institution is one of the top 56 found; see Table 3.

Table 2. Authors and their Affiliation – Physical Therapy

Cooper, Rory A. (76), Univ. of Pittsburgh, Pittsburgh, PA (*)
Enderle, John D. (48), Univ. of Connecticut, Storrs, CT (*)
Boninger, Michael L. (45), Dept. of Physical Medicine and Rehabilitation, Univ. of Pittsburgh, PA (*)
Reinkensmeyer, D. J. (35), Univ. of California, Irvine, CA (*)
Pruehsner, William (34), Univ. of Connecticut, Biomed. Eng., Storrs, CT (*)
Harris, G. F. (29), Dept. of Biomed. Eng., Marquette Univ.., Milwaukee, WI (*)
Dario, P. (24), ARTS Lab., Scuola Superiore Sant'Anna, Pisa, Italy
Bajd, T. (24), Fac. of Electr. Eng., Ljubljana Univ., Slovenia (*)
Tamura, T. (24), Dept. of Biomed. Eng., Chiba Univ., Japan
Webster, Thomas J. (23), Weldon Sch. of Biomed. Eng., School of Materials Eng., Purdue Univ., W. L., IN
Riener, Robert (23), Automatic Control Lab., Spinal Cord Injury Center, Univ. Hospital Balgrist, Switzerland
Higashi, Y. (22), Fac. of Eng., Kanazawa Univ., Japan
Durand, Dominique M. (22), Case Western Reserve Univ., Biomed. Eng. (*)
Winters, J. M. (22), Marquette Univ., Milwaukee, WI (*)
Triolo, Ronald J. (21), Motion Study Lab. Dept. Vet. Aff. Med. Ctr., Cleveland, OH
Rymer, W. Z. (21), Rehabilitation Inst. of Chicago, Northwestern Univ. Feinberg Sch.. of Med., IL (*)
Hogan, N. (21), Newman Lab. for Biomech. & Human Rehabilitation, MIT, Cambridge, MA (*)
Kuo, Te Son (20), Dept. of Electr. Eng., National Taiwan Univ., Taiwan
Sinkjaer, Thomas (20), Aalborg Univ., Denmark (*)

Author affiliation

Fifty-six institutions with at least 10 citations were obtained. Table 3 shows the top institutions with 20 or more citations. These top institutions have produced 736 documents related to the topic under discussion; this number is only 5.56 percent of the total (13,326). This is an indication that research and development on technological aspects of physical therapy are

conducted in a diverse number of institutions. Other countries beside the USA shown in this table are: Canada, Slovenia, Netherlands, Japan, Denmark, and Taiwan.

Table 3. Author Affiliation – Physical Therapy

Case Western Reserve Univ. (88)
Univ. of Pittsburgh (76)
Marquette Univ. (15); Dept. of Biomed. Eng., Marquette Univ., (36): (51)
Univ. of Connecticut (44)
Univ. of California (43)
Univ. of Alberta (37)
Univ. of Ljubljana, Slovenia (25); Fac. of Electr. Eng., Univ. of. Ljubljana (12): (37)
Univ. of Twente, Netherlands (36)
Massachusetts Inst of Technology (34)
Univ. of Michigan (33)
Univ. of Tokyo (32)
Ohio State Univ. (31)
Univ. of Washington (29)
Aalborg Univ., Denmark (28)
National Taiwan Univ. (28)
Ecole Polytechnique De Montreal (24)
Northwestern Univ. (23)
Johns Hopkins Univ. (22)
Catholic Univ. of America (10); Dept. of Biomed. Eng., Catholic Univ. of America, (10): (20)
Univ. of Minnesota (20)

Subject terms

As was mentioned in the Methodology section of this article, the search engine report produced two kinds of listings for subject terms: Controlled Vocabulary and Classification Code terms.

Table 4. Subject Terms – Physical Therapy

Subject Terms by Control Vocabulary	Subject Terms by Classification Code
Biomechanics (1,886)	Medicine (5,290)
Handicapped Persons (1,428)	Biomechanics (3,968)
Bone (1,249)	Biological Materials (3,596)
Muscle (1,224)	Biomedical Engineering (2,781)
Functional Electric Stimulation (1,005)	Computer Applications (1,986)
Computer Simulation (951)	Biomedical Equipment, General (1,753)
Mathematical Models (921)	Prosthetics (1691)
Patient Treatment (902)	Human Engineering (1,656)
Joints (Anatomy) (885)	Health Care (1,104)
Implants (Surgical) (869)	Control Systems (1,039)
Wheelchairs (748)	Computer Peripheral Equipment (903)
Neurology (741)	Mechanics (895)
Diseases (735)	Applied Mathematics (855)
Biomedical Engineering (726)	Data Processing (825)
Functional Neural Stimulation (717)	Robotics (794)
Neurophysiology (637)	Patient care and treatment (793)
Gait Analysis (629)	Numerical Methods (772)
Health Care (623)	Physical Properties of Gases, Liquids & Solids (674)
Functional Assessment (623)	Mathematical Statistics (661)
Surgery (599)	Computer Software, Data Handling and Applications (639)

The report produced by the search engine included a total of 52 Controlled Vocabulary terms and 71 Classification Code terms. The first 20 of both categories are listed in Table 4. Usually each citation included several of these subject related terms, therefore it is important to notice that this table shows those subject terms found more frequently, but independent of their relevance. In general, it is possible to say that terms such as biomechanics, handicapped persons, bones, muscles, electric stimulation, and computer simulation are the terms most often mentioned in the literature. Extracting this data from a literature survey could be of interest. Researchers may need this information when planning for external funding or looking for potential collaboration.

Country

Thirty-nine countries were found to be the most productive. Table 5 shows those contributing with at least 100 documents. Besides the USA (with 38.28 percent of all documents), the 17 other countries listed in this table contribute 44.70 percent; the table shows the top producing countries with a total output of 82.98 percent.

Other countries in descending order of output are: Hong Kong, Austria, Slovenia, India, Brazil, Turkey, Finland, Belgium, Ireland, Singapore, Mexico, Greece, Poland, Portugal, Hungary, New Zealand, Norway, Iran, South Africa, Ukraine, and Croatia. Finally, all major geographical areas of the world are represented, which implies that opportunities for technological advances in physical therapy are abundant.

Table 5. Distribution by Countries - Physical Therapy

United States (4,935) Japan (1,112) United Kingdom (806) Canada (611) Germany (447) Italy (414) Netherlands (312) Taiwan (298) China (275)	Australia (268) France (248) Korea, Republic of (211) Russia (210) Sweden (161) Switzerland (151) Spain (147) Israel (127) Denmark (119)

Document Type

According to Table 6, the two predominant types of documents in the technical literature of physical therapy are articles in scholarly journals and articles in conference proceedings. The table shows that there is a lack of dissertations in this field. It is unclear whether this figure is due to inadequate coverage for this type of publications by Compendex and Inspec or whether there are not many dissertations produced in their areas.

Table 6. Document Types - Physical Therapy

Journal article (8,708) Conference article (4,402) Conference proceeding (114) Report chapter (0)	Report review (7) Monograph chapter (3) Monograph review (2) Dissertation (0)

Language

The predominant language of the published literature on the topic of Physical Therapy is English (96.01 percent of publications). This result supports the widely held conjecture that English has become the language of the sciences. However, we must remind ourselves that the two selected databases, Inspec and Compendex, are both produced in English speaking countries (USA and UK). Other languages reported in the results are: Japanese, Portuguese, Turkish, Korean, Russian, and Spanish.

Table 7. Distribution by Language - Physical Therapy

English (12,708) Russian (217) Japanese (115) Chinese (88)	German (75) French (10) Polish (5)

Year

Since this search was conducted at the beginning of January 2007, there will be only a few documents captured by the databases for this year. Also, the figure for 2006 is lower that 2005 because it takes several months after the end of a year for the documents to appear in the databases. In general, with the exception of 2001, a trend of increased production of documents on this subject was found. For example, the number of documents in 2005 was more than double compared to 10 years earlier.

Table 8. Distribution by Year of publication – Physical Therapy

2007 (12) 2006 (1197) 2005 (1468) 2004 (1594) 2003 (1379)	2002 (1245) 2001 (949) 2000 (1150) 1999 (1014)	1998 (790) 1997 (899) 1996 (903) 1995 (636)

Publishers

Publishers are a very important component in the creation and distribution of technical information. The 18 publishers listed in Table 9 are producers of 58.91 percent of the literature. The Institute of Electrical and Electronics Engineers (the number one publisher) contributes 25.51 percent. A total of 47 main publishers were found. This table shows those with at least 100 documents.

Table 9. Publishers - Physical Therapy

Institute of Electrical and Electronics Engineers Inc. (3,377)
Elsevier Science Ltd (947)
Lippincott Williams and Wilkins (853)
Institute of Electrical and Electronics Engineers, Computer Society (328)
Rehabilitation Research and Development Service (250)
Springer Verlag (221)
American Society of Mechanical Engineers (207)
Association for Computing Machinery (193)
Veterans Administration (175)
John Wiley & Sons Inc. (165)
Raven Press Ltd (164)
SPIE - The International Society for Optical Engineering (158)
Kluwer Academic Publishers (148)
ASME (144)
American Institute of Physics Inc. (126)
Resna Press (121)
Chapman & Hall Ltd (113)
Institution of Electrical Engineers (108)

Journals

It was reported previously that articles in journals account for nearly two-thirds of all documents found and that this list of journals was selected from the first 200 most relevant citations. The total number of journals found was 47; they included 4,406 citations of the total 8,708 of articles or 51 percent. Table 10 shows those journals with more than 10 articles published. The top 12 journals produced 39.90 percent of all articles published. The top 30 (shown on Table 5) produced 50.09 percent of all articles published. Note that the top four journals in the table are not usually considered engineering journals.

Table 10. Journals - Physical Therapy

American Journal of Physical Medicine & Rehabilitation (678)	Medical and Biological Engineering and Computing (52)
Journal of Orthopaedic Research (555)	Biomedical Engineering - Applications, Basis and Communications (50)
Journal of Rehabilitation Research and Development (464)	IEEE Engineering in Medicine and Biology Magazine (50)
International Journal of Rehabilitation Research (332)	Journal of Applied Biomechanics (41)
IEEE Transactions on Neural Systems and Rehabilitation Engineering (216)	Critical Reviews in Biomedical Engineering (39)
IEEE Transactions on Rehabilitation Engineering (263)	Nippon Kikai Gakkai Ronbunshu, C Hen/Transactions of the Japan Society of Mechanical Engineers, Part C (35)
Clinical Biomechanics (220)	Biomedizinische Technik/Biomedical Engineering (26)
Optometry and Vision Science (189)	Advanced Robotics (24)
Journal of Biomechanics (170)	IEEE Transactions on Information Technology in Biomedicine (20)
AAC: Augmentative and Alternative Communication (150)	Robotica (20)
Medical Engineering and Physics (122)	Biological Cybernetics (19)
Assistive Technology (116)	New Scientist (19)
Meditsinskaya Tekhnika (82)	Journal of Intelligent and Robotic Systems: Theory and Applications (18)
Annals of Biomedical Engineering (76)	Advanced Materials and Processes (14)
IEE Colloquium (Digest) (75)	IEEE/ASME Transactions on Mechatronics (13)
Meditsina Truda I Promyshlennaya Ekologiya (70)	IEEE Spectrum (13)
Journal of the Acoustical Society of America (62)	Tissue Engineering (13)
Biomedical Sciences Instrumentation (56)	

Conference Proceedings

Table 11 is a representative list of some of the most relevant conference proceedings related to this topic. They are listed in alphabetical order and were taken from the first 200 most relevant citations. Proceedings of the conferences listed in this table were found, but specific years are not included in the table.

Table 11. Conference Proceedings - Physical Therapy

Annual International Conference of the IEEE Engineering in Medicine and Biology – Proceedings, 2004,2003, 2002, 2000, 1997, 1996, 1995.
ASEE Annual Conference Proceedings, 1997.
Bioengineering, Proceedings of the Northeast Conference, 2004, 2001.
Conference on Human Factors in Computing Systems - Proceedings, 1996, 1995.
IEEE International Conference on Intelligent Robots and Systems, 2002.
IEEE International Workshop on Medical Measurement and Applications, MeMeA, 2006.
IEEE Pacific RIM Conference on Communications, Computers, and Signal Processing – Proceedings, 2003.
IEEE Engineering in Medicine and Biology Society and Conference of the Biomedical Engineering Society of India. An International Meeting, 1995.
IEEE International Conference on Robotics and Automation, 2004, 2002, 2000, 1996.
IEEE International Workshop on Robot and Human Interactive Communication, RO-MAN, 2004.
IEEE Symposium on Computer-Based Medical Systems, 2006.
Conference on Universal Usability, 2000.
IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechatronics, 2006.
Triennial Congress of the International Ergonomics Association and 44th Annual Meeting of the Human Factors and Ergonomics Association, 2000.
Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, 1999.
IASTED International Conference on Biomechanics, 2004.
IEEE International Conference on Rehabilitation Robotics, ICORR, 2005.
Southern Biomedical Engineering Conference, 1997.
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2004.
International Conference on Electrical and Electronics Engineering, ICEEE, 2004.
IEEE Networking, Sensing and Control, ICNSC2005.
Wescon Conference Record, 1998.

Duplication between Compendex and Inspec

There is a portion of documents duplicated in both of the databases. The search engine allows for deletion of duplicated items only for the first 1,000 records. Therefore, there is a "duplication error" included in the reports produced by the Engineering Village interface. One way of determining the level of duplication is done by taking samples on a year-by-year basis and then estimating the total level of duplication. For the physical therapy topic the level of duplication was 3.27 percent, a relatively low percentage. On this basis, we consider the figures presented in Tables 2 to 11 to be fairly accurate.

Table 12. Level of duplication. Compendex and Inspec - Physical Therapy

Year	Total	Duplicate/1,000	Non-duplicate	Percentage Dupl
2006	1197	26	974	2.6
2005	1468	37	963	3.7
2004	1594	26	974	2.6
2003	1379	72	928	7.2
2002	1245	53	947	5.3
2001	949	29	920	2.9
2000	1150	47	953	4.7
1999	1014	53	947	5.3
1998	790	10	780	12.7

1997 1996 1995	899 903 636	13 0 0	876 903 636	14.5 0.0 0.0

Total number of documents = 13,236
Sample total = 11,177 – Percentage of the total number of documents = 84.44
Duplicates in the sample = 366
Percentage of duplicates in the sample = 3.27

Part 2: Sonography / Ultrasonic

For the topic of sonography or ultrasound technologies in the allied health sciences, we used a more simplistic search strategy to generate the data. After preliminary searches did not yield meaningful controlled vocabulary terms, method 2 (see Methodology) was found to be a better strategy. The search was limited to the period from 1995 to 2007 and it produced 19,174 records. Also as mentioned before, Engineering Village search results are listed in descending order based on their relevance which is measured by a proprietary algorithm of the database producer.

Databases

For our second topic (sonography / ultrasound), the number of citations were higher in Compendex, but Inspec came out with a substantial portion of the results, as well. Both databases need to be searched in order to get a comprehensive bibliography.

Table 13. Databases - Sonography / Ultrasound

Compendex: (11,089) citations	Inspec: (8,085) citations

Top Authors and their Affiliation

The search report produced by the Engineering Village interface included a list of the top 60 authors. Table 14 shows the top 20 most productive authors who published 1,643 documents. Two researchers, Hynynen, K. and Fenster, A., each have a significant number of published documents as compared to the others in the list. The authors listed in this table are affiliated with institutions located in the USA, Canada, United Kingdom, Germany, Netherlands, France, and Denmark. An asterisk (*) indicates the institution is one of the top 41 institutions found.

Table 14. Authors and their Affiliation - Sonography / Ultrasound

Hynynen, K. (243), Dept. of Radiol., Harvard Med. Sch., Boston, MA (*)
Fenster, A. (176), John P. Robarts Res. Inst., London, Ont., Canada
Van Der Steen, A. F. W. (93), Biomed. Eng. Dept., Erasmus Med. Centre, Rotterdam, Netherlands (*)
O'Donnell, M. (85), Dept. of Biomed. Eng., Michigan Univ., Ann Arbor, MI (*)
Ophir, J. (80), Med. Sch., Texas Univ., Houston, TX
Forsberg, F. (78), Dept. of Radiol., Thomas Jefferson Univ. Hosp., Philadelphia., PA
Fowlkes, J. B. (75), Dept. of Biomed. Eng., Michigan Univ., Ann Arbor, MI (*)
Foster, F. S. (74), Dept. of Med. Biophys., Toronto Univ., Ont., Canada

McDicken, W. N. (73), Dept. of Med. Phys. & Med. Eng., Edinburgh Univ., UK (*)
Ermert, H. (72), Dept. of Electr. Eng., Ruhr-Univ., Bochum, Germany
Sonka, M. (68), Dept. of Electr. & Comput. Eng., Iowa Univ., Iowa City, IA (*)
Greenleaf, J. F. (67), Dept. of Physiol. & Biophy., Mayo Clinic Coll. of Medicine, Rochester, MN
Shung, K. K. (66), Dept. of Biomed. Eng., Univ. of Southern California, Los Angeles, CA
De, Jong N. (65), Dept. of Cardiol. & Exp. Echocardiog, Erasmus Univ., Rotterdam, Netherlands (*)
Chapelon, J. Y. (61), Inserm, Lyon, France (*)
Jensen, J. A. (56), Center for Fast Ultrasound Imaging, Tech. Univ. Denmark, Lyngby, Denmark (*)
Varghese, T. (54), Dept. of Medical Phys., Wisconsin Univ., Madison, WI (*)
Cathignol, D. (53), Inserm, Lyon, France (*)
Crum, L. A. (52), Center for Ind. & Med. Ultrasound, Washington Univ., Seattle, WA (*)
Carson, P. L. (52), Dept. of Radiol., Univ. of Michigan Health Syst., Ann Arbor, MI(*)

Author Affiliation

Table 15 includes a list of 41 institutions where research and development in sonography / ultrasonic is being conducted. These top institutions have produced 8.7 percent of all documents. As in the case of physical therapy, it appears that a large number of institutions from several different countries are involved in research and development activities related to the use of sonography / ultrasound in the allied health sciences. Countries represented are the USA, Taiwan, France, Germany, China, Brazil, Denmark, and the United Kingdom.

Table 15. Author Affiliation - Sonography / Ultrasound

Univ. of Michigan, Ann Arbor, MI (37); Dept. of Biomed. Eng., Univ. of Michigan, Ann Arbor, MI (58); Dept. of Radiol., Univ. of Michigan (31); Dept. of Electr. Eng. Comput. Sci., Univ. of Michigan (27): (153)	Dept. of Electr. Comput. Eng., Univ.of Illinois, Urbana, IL(26)
Harvard Medical Sch, MA (22); Dept. of Radiol., Harvard Medical Sch., (102); Brigham and Women's Hospital, Harvard Medical Sch. (18): (142)	Univ. of Sao Paulo, Brazil (25)
Univ. of Washington, WA (54); Dept. of Electr. Eng., Univ. of Washington, (23); Appl. Phys. Lab., Univ. Washington, (20); Dept. of Bioeng., Univ. of Washington, (19): (116)	Riverside Res. Inst., New York, NY (25)
Duke Univ. (31); Dept. of Biomed. Eng., Duke Univ., NC (82): (113)	Dept. of Eng., Cambridge Univ. (25)
National Taiwan Univ. (23); Dept. of Electr. Eng., Nat. Taiwan Univ., (72); Nat. Taiwan Univ. Hospital (18): (113)	Dept. of Biomed. Eng., Cleveland Clinic Foundation., OH (25)
Inserm, l'Institut National de la Santé et de la Recherche Médicale, Lyon (88)	Dept. of Radiat. Oncology, California Univ., San Francisco, CA (23)
Univ. of Rochester (45); Dept. of Electr. Eng., Univ. of Rochester (20): (65)	Center For Fast Ultrasound Imaging, Tech. Univ. Denmark, Lyngby (23)
Dept. of Med. Biophys., Toronto Univ., Ont. (51)	Dept. of Med. Phys., Wisconsin Univ., Madison, WI (22)
Erasmus Univ. Rotterdam, Netherlands (48)	Dept. of Biomed. Eng., California Univ., Davis, CA (21)
Undefined (Univ. Hospital) (43)	Dept. of Eng. Sci., Oxford Univ. (21)
Univ. of Toronto (39)	Pennsylvania State Univ. (20)
Dept. of Electr. Comput. Eng., Iowa Univ., Iowa City, IA (36)	Drexel Univ. (20)
Univ. of California (35)	Dept. of Biomed. Eng., Univ. of Virginia (20)
Dept. of Biomed. Eng., Virginia Univ., Charlottesville, VA (31)	Riverside Research Inst. (19)
Thomas Jefferson Univ. (30)	Univ. of Edinburgh, UK (19)
Dept. of Electr. Comput. Eng., Drexel Univ., Philadelphia, PA (28)	Cleveland Clinic Foundation (19)
Univ. of Texas Medical Sch. (27)	Thoraxcentre, Erasmus Univ., Rotterdam, Netherlands (19)
Dept. of Electron. Eng., Fudan Univ., Shanghai (26)	Washington Univ., Sch. of Medicine (19)
	Imaging Res. Labs., Robarts Res. Inst., London, Ont. (19)
	Optical Imaging Laboratory, Dept. of Biomed. Eng., Texas A&M Univ. (19)
	Institute of Laser Life Science, South China Normal Univ. (18)
	Univ. of Iowa (18)
	Hong Kong Polytechnic Univ. (18)

Subject Terms

The top 15 Controlled Vocabulary terms and 18 Classification Code terms are included in Table 16. Based on the data reported in this table it is possible to assume that some of the most active areas in research and development are biomedical ultrasonics, sonic and ultrasonic radiation, medical imaging, blood vessels, tissues, diagnostic technology, and biological and medical computing.

Table 16. Subject Terms - Sonography / Ultrasound

Subject Terms by Controlled Vocabulary	Subject Terms by Classification Code
Biomedical Ultrasonics (6308) Ultrasonic Imaging (5006) Medical Imaging (4320) Medical Image Processing (2874) Ultrasonics (2678) Blood Vessels (2124) Tissue (1838) Diseases (1699) Diagnosis (1618) Doppler Effect (1336) Patient Treatment (1215) Ultrasonic Transducers (1200) Surgery (1125) Echocardiography (1056) Image Segmentation (1007)	Sonic and ultrasonic radiation (medical uses) (6527) Medicine (6081) Biomedical Engineering (5854) Biological Materials (5016) Ultrasonic Waves (4926) Sonic and ultrasonic applications (4766) Patient diagnostic methods and instrumentation (4624) Sonic and ultrasonic radiation (biomedical imaging/measurement) (4521) Ultrasonic Applications (4180) Biology and medical computing (3109) Computer vision and image processing techniques (2625) Optical, image and video signal processing (1995) Data Processing (1821) Computer Applications (1781) Light/Optics (1482) Light, Optics and Optical Devices (1251) Acoustic Waves (1191) Haemodynamics, pneumodynamics (1064)

Country

The 14 countries listed in Table 17 produced 78.15 percent of the literature on this topic. The USA is the leading country with 36.31 percent. Nevertheless, the table shows evidence that research and development on the application of sonography and ultrasound to the allied health sciences is an active field in countries from all parts of the world: Austria, Norway, Denmark, Spain, Australia, Poland, Brazil, Sweden, India, Hong Kong, Belgium, Greece, Switzerland, Finland, Singapore, Argentina, Egypt, Hungary, Portugal, Czech Republic, Croatia, Romania, Mexico, Lithuania, Slovenia, Iran, New Zealand, Ukraine, Chile, Yugoslavia, Thailand, Bulgaria, Cyprus, South Africa, Malaysia, Venezuela, Ireland, Slovakia, Macedonia, Belarus, Lebanon, Saudi Arabia, Iceland, and Uruguay.

Table 17. Distrubution by Country - Sonography / Ultrasound

United States (6,600) United Kingdom (1,171) Japan (1,054) Germany (955) Canada (857) China (840) France (773)	Italy (605) Netherlands (569) Taiwan (560) Israel (274) Korea, Republic of (262) Turkey (262) Russia (203)

Document Type

As in the case of physical therapy, articles in journals and conference articles are the predominant forms of documents produced. The lack of dissertations reported for this topic is also a concern. See our previous comments in the physical therapy section.

Table 18. Document Type - Sonography / Ultrasound

Journal article (12,893) Conference article (6,086) Conference proceeding (177) Report chapter (0)	Report review (9) Monograph chapter (6) Monograph review (3) Dissertation (0)

Language

Table 19 shows that English is also the predominant language for this topic. Other languages reported are: Korean, Lithuanian, Romanian, Danish, Turkish, Finnish, Persian, and Ukrainian.

Table 19. Language - Sonography / Ultrasound

English (18,502) Chinese (419) Russian (101)	Japanese (81) German (42) French (12)

Year

Table 20 shows that this field is also growing. The number of citations for 2005 is more than double of the ones cited 10 years earlier.

Table 20. Distribution by Year - Sonography / Ultrasound

2007 (21) 2006 (1,756) 2005 (1,940) 2004 (2,084) 2003 (1,811)	2002 (1,749) 2001 (1,565) 2000 (2,170) 1999 (1,193)	1998 (1,219) 1997 (1,758) 1996 (1,002) 1995 (906)

Publishers

Table 21 shows that the top four publishers produced 11,778 documents which is 61.42 percent of the total of documents found (19,174). Two publishers (Elsevier Science Ltd, and the Institute of Electrical and Electronics Engineers Inc.) produced 47.92 percent of the total output. The total number of most productive publishers is 39. Those with 2000 or more documents are listed in this table.

Table 21. Publishers - Sonography / Ultrasound

Elsevier Science Ltd (5,100)
Institute of Electrical and Electronics Engineers Inc. (4,090)
American Institute of Ultrasound In Medicine (1,090)
SPIE - The International Society For Optical Engineering (1,498)
American Institute of Ultrasound in Medicine, AIUM (661)
American Institute of Physics Inc. (453)
Society of Photo-Optical Instrumentation Engineers (361)
Institute of Physics Publishing (327)
Institute of Electrical and Electronics Engineers, Computer Society (269)
Springer-Verlag (237)
Elsevier Science Ireland Ltd (235)
Pergamon Press Ltd (230)
Chinese J. Med. Imaging Technol. Editorial Board (219)

Journals

This list was obtained from the first 200 most relevant citations. The 34 journals found include 6,454 articles from a total of 12,893, or 50 percent.

The five top journals account for 6,061 journal articles which is 93.91 percent of the sample and 47.01 percent of the total journal articles. Ultrasound in Medicine and Biology appears to be the most important publication in this field. This table lists the top 12 journals.

Table 22. Journals - Sonography / Ultrasound

Ultrasound in Medicine and Biology (4,913)
IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control (532)
Physics in Medicine and Biology (285)
Chinese Journal of Medical Imaging Technology (219)
Japanese Journal of Applied Physics, Part 1: Regular Papers & Short Notes & Review Papers (112)
Ultrasonic Imaging (64)
Ultrasonics Sonochemistry (47)
British Journal of Radiology (43)
Annals of Biomedical Engineering (38)
International Journal of Hyperthermia (32)
Journal of Telemedicine and Telecare (22)
Ultragarsas (20)

Conference proceedings

The conference proceedings listed in Table 23 were obtained from the first 200 most relevant citations. This is an alphabetical list and shows the conferences found; the years are not included. This list shows that conferences of professional societies such as AIP and IEEE play an important role in dissemination of new technologies and scientific research.

Table 23. Conference Proceedings - Sonography / Ultrasound

AIP Conference Proceedings, 2005.
AIP Conference Proceedings, 2006.
Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2006.
Annual International Conference of the IEEE Engineering in Medicine and Biology - Proceedings, 2003.
Computers in Cardiology 1997.
Computers in Cardiology, 2004.
Conference Proceedings - 1st Transdisciplinary Conference on Distributed Diagnosis and Home Healthcare, D2H2 2006.
8th International Congress on Acoustics, 2004.
The 8th World Multi-Conference on Systemics, Cybernetics and Informatics, 2004.
International Conference on Information & Communication Technologies: from Theory to Applications, 2006.
Medical Image Computing and Computer-Assisted Intervention, MICCAI 2006 - 9th International Conference, Proceedings, 2006.
1999 IEEE Ultrasonics Symposium. Proceedings. International Symposium. 1999.
Proceedings of the First Regional Conference, IEEE Engineering in Medicine and Biology Society and 14th Conference of the Biomedical Engineering Society of India. An International Meet, 1995.
Proceedings of the IASTED International Conference on Biomedical Engineering, 2003.
Proceedings of SPIE - The International Society for Optical Engineering, v 6176, Nondestructive Evaluation and Health Monitoring of Aerospace Materials, Composites, and Civil Infrastructure V, 2006.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5768, Health Monitoring and Smart Nondestructive Evaluation of Structural and Biological Systems IV, 2005.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5750. Progress in Biomedical Optics and Imaging , Medical Imaging 2005 - Ultrasonic Imaging and Signal Processing, 2005.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5721. Progress in Biomedical Optics and Imaging - MOEMS Display and Imaging Systems III, 2005.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5630. Progress in Biomedical Optics and Imaging - II, Optics in Health Care and Biomedical Optics: Diagnostics and Treatment II, 2005.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5698, 2005.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5391, 2004.
Proceedings of the SPIE - The International Society for Optical Engineering, v 5046, 2003.
Proceedings of the SPIE - The International Society for Optical Engineering, v l 5029, 2003.
Proceedings of the SPIE - The International Society for Optical Engineering, v 4037, 2000.
Proceedings of the SPIE - The International Society for Optical Engineering, v 4323, 2001.
Proceedings of the SPIE - The International Society for Optical Engineering, v 2711, 1996.
Proceedings. 6th International Workshop on Enterprise Networking and Computing in Healthcare Industry – Healthcom, 2004.
Proceedings 2000 IEEE EMBS International Conference on Information Technology Applications in Biomedicine. ITAB-ITIS 2000. Joint Meeting Third IEEE EMBS International Conference on Information Technology Applications in Biomedicine (ITAB'00). Third Workshop of the International Telemedical Information Society, 2000.
Proceedings. 2006 Conference on International Robotics and Automation, 2006.
2005 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2005.
2003 IEEE Ultrasonics Symposium, 2003.
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Proceedings of the First Regional Conference, IEEE Engineering in Medicine and Biology Society and 14th Conference of the Biomedical Engineering Society of India. An International Meet, 1995.

Duplication between Compendex and Inspec

Table 24 shows a duplication level of the citations between Compendex and Inspec of nearly 21 percent. We cannot make the broad assumption that this error is evenly spread, therefore, the results shown in Tables 14 to 21 should only be considered as a fair representation of the survey. Eliminating this high level of duplication would require performing multiple searches that would not exceed the 1,000 result limit, exporting these results, making the appropriate conversion, and building a database.

Table 24. Duplication level. Compendex and Inspec – Sonography / Ultrasound

Year	Total	Duplicate/1,000	Non duplicate	Percentage Dupl
2006	1,756	151	849	15.1
2005	1,940	242	758	24.2
2004	2,084	152	842	15.2
2003	1,811	238	762	23.8
2002	1,749	233	767	23.3
2001	1,565	246	754	24.6
2000	2,170	199	801	19.9
1999	1,193	243	766	24.3
1998	1,219	232	768	23.2
1997	1,758	155	845	15.5
1996	1,002	215	785	21.5
1995	906	193	713	21.3

Total number of documents = 19,174
Sample total = 11,906 – Percentage of the total number of documents = 62.1
Duplicates in the sample = 2,499
Percentage of duplicates in the sample = 20.98

Conclusion

We have made an effort to present this project as a teaching and learning experience that would help researchers and students to properly use bibliographic databases as effective tools to survey the literature of a technological field. This is particularly important when working on a project or when exploring a new area of interest.

We have researched two technological databases: Compendex and Inspec. In determining the output for physical therapy, Compendex was found to be the best source. In the case of sonography / utrasound both databases were equally useful.

We have found that using controlled vocabulary terms was the best way to search the literature of physical therapy, but in the case of sonography / ultrasound using keyword terms and truncations was a better strategy.

The two areas of allied health sciences presented have produced a wealth of information that can be replicated for individual projects.

The use of the Engineering Village interface proved to be an efficient way of creating numerous reports but its capability of deleting duplicated records between databases was found to be limited when doing extensive literature surveys. The automatically produced reports also need significant editing in order to have a reliable data set (e.g., an institution is listed under different departments) and consistency in the format (e.g. abbreviations).

Finally, we hope to have given reason for using specialized technological databases for searching allied health subjects. Although this paper is not exactly a guide to searching, the results of the study should serve scholars and students in allied health disciplines to discover that Inspec and Compendex can be valuable research resources.

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