

25 years of telepathology and virtual microscopy: a bibliometric analysis

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Outline

- Telepathology and virtual (digital) microscopy
- Bibliometrics
- Methods
- Results
- Discussion



Telepathology

- First appearance of term in scientific papers:
 - Weinstein RS: **Prospects for telepathology**. *Hum Pathol*. 1986 May;17(5):433-4.
 - research grew up developing different subfields, including **static** and **dynamic telepathology**, and more recently also **virtual/digital microscopy**.
- niche area of research in the wider pathology field
 - Contributions from medical informatics and biomedical engineering areas



It is also a subspecialty of telemedicine

Highly interdisciplinary

Bibliometrics

• *Bibliometrics is a type of research method used in library and information science. It utilizes quantitative analysis and statistics to describe patterns of publication within a given field or body of literature.*

(R.A.Palmquist)

- Among bibliometric measures, you know citations number, Impact Factor, and perhaps H-index
- It is becoming a tool for research evaluation and management



• although many criticisms on unwanted consequences have been made

Investigating research trends

- Another application of **bibliometrics** is the analysis of research trends,
- offering insights on research developments in a specific field over time,
- by assuming that publications represent, at a specific time, the output of research efforts in the immediately preceding years.



Bibliometrics in Pathology

• Bibliometric analysis has been rarely applied to pathology research,

• Although some report exists on the overall scientific production

• Fritzsche FR, Oelrich B, Dietel M, Jung K, Kristiansen G: European and US publications in the 50 highest ranking pathology journals from 2000 to 2006. *J Clin Pathol.* 2008;61:474-81.

• and on specific areas

• Donato HM, De Oliveira CF: [Breast pathology: evaluation of the Portuguese scientific activity based on bibliometric indicators]. *Acta Med Port.* 2006;19:225-34.



• Wierzbicki AS, Reynolds TM: Total research productivity in a pathology discipline. *J Clin Pathol.* 2002;55:495-8.

Bibliometrics in Telemedicine

- Also telemedicine has been the subject of bibliometric analyses in few studies
 - Moser PL, Hauffe H, Lorenz IH, Hager M, Tiefenthaler W, Lorenz HM, Mikuz G, Soegner P, Kolbitsch C: Publication output in telemedicine during the period January 1964 to July 2003. *J Telemed Telecare*. 2004;10:72-7.
 - Demiris G, Tao D: An analysis of the specialized literature in the field of telemedicine. *J Telemed Telecare*. 2005;11:316-9.
 - Gonzalez F, Castro AF: Publication output in telemedicine in Spain. *J Telemed Telecare*. 2005;11:23-8.



After 25 years from the appearance of telepathology term in scientific literature, the present work attempts an analysis of research in this field, starting from the techniques provided by bibliometrics.



Questions

- How telepathology and virtual microscopy developed during years?
 - how many papers per year?
- How many researchers involved?
- From which countries?
- On which Journals?



Methods: source of data and software

- Data of scientific articles related to telepathology and virtual microscopy have been extracted from PubMed,
- by means of semiautomated procedures:
 - A generic script (**MedMine**) developed in PHP,
 - That accesses PubMed Entrez Utilities,
 - Providing a query for extracting information,
 - And receiving back XML files containing the results
 - XML is processed to extract data, exported in CSV format
- Graphs are then produced with Excel, charts with Geocommons



Methods: search strategy

- Looking for telepathology papers, including variants like telecytology,
- ...and for virtual microscopy papers, including digital microscopy and Whole slide imaging
- Also Pathology, Medical Informatics and Biomedical Engineering Journals have been extracted from PubMed Journals database
 - With suitable queries



Methods: the query

"telepathology"[MeSH Terms] OR
 "telepathology"[All Fields]
 OR "telecytology"[All Fields]
 OR "virtual microscopy"[All Fields] OR "virtual
 microscope"[All Fields]
 OR "digital slides"[All Fields] OR "digital
 microscopy"[All Fields]
 OR "digital slide"[All Fields]
 OR ("whole slide"[All fields] AND
 ("imaging"[All Fields] OR "images"[All Fields]
 OR "scanning"[All Fields]))



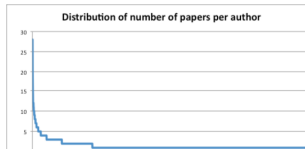
Methods: data

- Article data were used to extract **Authors, journal, publication date and type, MeSH keywords, and country** of the corresponding Author when available.
- From such data, further processing was done to identify the **distribution of papers in time, by authors, by country, by journal**, and also **keyword frequency**.
- Additional data included the **number of Authors per paper**, and the **journal area** when among Pathology, Medical Informatics or Biomedical Engineering.



Results/1

- 967 papers related to telepathology and virtual microscopy have been retrieved,
- which involved 2904 Authors.
 - 2213 co-authored just one paper, 312 co-authored two papers. They can be considered **occasional** telepathology authors
- The average number of authors per paper was 4.47



Results/2

- Corresponding Authors, as recorded in the Affiliation field of PubMed data, were from 37 different countries.
 - However, for 217 papers (22.4%) it was not possible to identify country of affiliation

country	papers
United states of America	310
Germany	81
Italy	46
United Kingdom	40
Japan	37
France	23
Australia	21
Canada	18
Austria	17
Switzerland	17
Norway	16
Spain	14
Poland	13
Hungary	13
Sweden	12
Netherlands	10



Results/3

- Papers were published on 344 different journals,
 - of which only 52 from the Pathology field (accounting for 372 papers), out of 171 active Journals in Pathology (30.4%)
 - 24 from Medical Informatics field (163 papers),
 - and 8 from Biomedical Engineering (18 papers).
- Other journals include some generalist publication, and many journals of fields that can be interested in telepathology results, including oncology, dermatology, ophthalmology
- **Only 18 papers (1.9%)** were related to **clinical trials** as stated in the publication record by the publication type field.



Most telepathological journals

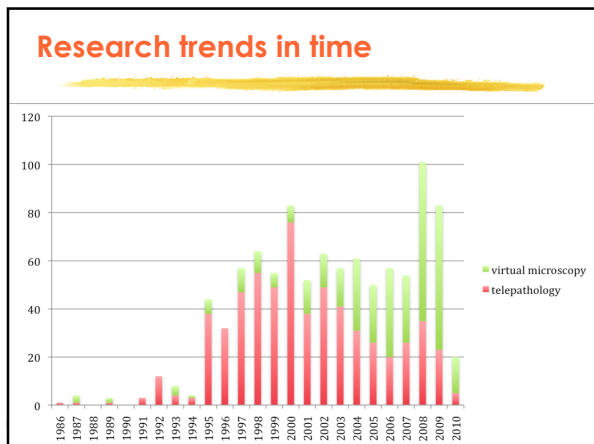
Journal	n. of papers	Category
J Telemed Telecare	71	Medical Informatics
Hum Pathol	65	Pathology
Telemed J	27	Medical Informatics
Stud Health Technol Inform	24	Medical Informatics
Diagn Pathol	23	Pathology
Anal Cell Pathol	23	Pathology
Adv Clin Path	22	Pathology
Arch Anat Cytol Pathol	22	Pathology
Arch Pathol Lab Med	18	Pathology
Am J Clin Pathol	17	Pathology
Pathologie	16	Pathology
J Clin Pathol	15	Pathology
Histopathology	11	Pathology
Tidsskr Nor Laegeforen	10	General medicine
Zentralbl Pathol	10	Pathology



Results/4

- An analysis of papers per year has been also attempted, that demonstrates **variable research output in time**
 - bi-annual European Congress of Telepathology
 - birth and diffusion of virtual microscopy techniques starting from 1997
 - papers referring to digital microscopy term before 1997 are in fact not related to what is currently called in that way
- Virtual microscopy research **overcome** traditional telepathology in 2006, according to number of published papers.





Results/5

- MeSH keywords used to index articles have been examined to understand the topics dealt with by articles.
 - TP has been applied mostly but not exclusively to **human** pathology
 - Technical topics related to TP are **image processing**, software, interfaces, and networks.
 - Two main applications: remote consultation and frozen sections.
 - Many studies related to the **quality of the process**, expressed in terms of reproducibility, sensitivity and specificity, and interobserver variation.



Discussion/1

- telepathology seems to have been studied, in time, by a relatively **small core community** of about 400 researchers, with occasional participation of many other people.
 - If, from one side, this may seem to circumscribe research to a small number of passionates,
 - on the other side the involvement of about 2500 occasional co-authors might be interpreted as a **good dissemination activity** towards physicians involved in clinical practice and/or other research.



Discussion/2

- USA contributes with just less than one third of the total number of published papers; summed up, papers from European countries reach a **similar amount**.
 - (no evaluation of transnational research)
- Although the number of involved countries seems low, it is in line with the 42 countries involved in telemedicine up to 2003 (Moser et al).
 - In respect to its parent specialty telemedicine, telepathology accounts for 5.3% of papers.



Anecdotes

- The most prolific Authors have been, unsurprisingly, the two "fathers" of telepathology: **Ronald Weinstein** and **Klaus Kayser**.
 - 28 papers each for the birth and growth of telepathology (plus many more on related areas)
- Interestingly, while analysing the literature, the term "digital microscopy" have been found in the title of a 1984 paper by Bartels et al
 - Bartels PH, Layton J, Shoemaker RL. Digital microscopy. *Monogr Clin Cytol.* 1984;9:28-61.



Study limitations

- The query used might have retrieved also some papers related to image analysis,
 - wide meaning given to the terms included in the query
- some article did not present complete affiliation data
 - and method used also does not allow to recognize transnational research
- Some surnames were written with variants, typos, or wrong abbreviation
 - individual contribution of some Authors is underestimated
- No evaluation of citation data has been attempted
 - because the aim of the work was to describe research efforts more than impact.



Conclusion

- Finally, the number of telepathology clinical trials is very low (1.9% of total publications).
- The higher but still low 4.7% figure for telemedicine (Demiris et al) has been the reason for a call for more randomized studies
 - because the lack of clinical trials limits the application of evidence-based telemedicine.
- This is the case for telepathology (and related techniques) too: **evidence-based telepathology will be the enabling factor for safely translating research into practice.**





COST Action IC0604 "Eurotelepath" looking at the future of telepathology

THANKS