Measuring Publication Rates of Randomized Controlled Trials and Meta-Analyses Among Medical and Surgical Subspecialties: How Does Orthopaedic Surgery Compare?

**Sharat K. Kusuma, M.D, M.B.A. James R. Eiszner, B.A.
Samuel B. Adams, Jr. M.D., Kingsley R. Chin, M.D.**

Abstract

Recently, the number of meta-analyses has increased rapidly. Published reports of their quality and citation rates provide limited insight into the current state of orthopaedic research. Comparing publication rates of meta-analyses and randomized clinical trials (RCT's) across medical and surgical specialties may provide further insight. We hypothesize that medical specialties publish meta-analyses at a faster time-dependent rate than surgical specialties, including orthopaedic surgery, but that orthopaedic surgery compares favorably with other surgical specialties. We performed a computerized Medline search and documented all meta-analyses published from 1980-2003. For each meta-analysis, the publishing academic department was placed into a specialty category identified as "medical", "surgical", or "other." To gather insight into the quality of the studies available for generating meta-analyses, we identified 46 journals from 23 specialties that had high Science Citation Index impact factors for their respective specialties and documented the number of RCT's published between 1989-2003. We compared rates of publication of RCT's and meta-analyses across medical and surgical subspecialties, and performed linear regression analysis of the effects of time and RCT publication on meta-analysis publication for medical and surgical specialties. 7273 total meta-analyses were identified that met eligibility criteria for the study period. Only two meta-analyses were identified from 1980-1989. Medical specialties produced 2016 (27.7%) meta-analyses, surgical specialties produced 498 (6.9%), and orthopaedic surgery produced 72 (1.0%). The average annual growth rate in publication of meta-analyses was 12% from 1990-2003. The regression coefficients for both time and RCT were significantly higher for medical specialties than for surgical specialties. The average number of RCT's/year that appeared in medical journals was 34.9 compared to 14.2 for surgical journals (p=.00001). The average ISI impact factor was 9.07 for medical journals and 2.77 for surgical journals (p=.007). Publication rates of RCT's and meta-analyses increased for all specialties since 1990. The rate of meta-analysis production is much more responsive to the RCT publication rate and occurs more rapidly for medical specialties than for surgical specialties. Medical journals are more effectively and more rapidly disseminating the data from RCT's to their readers than are surgical specialties. The quality of meta-analyses within the medical literature is higher than that for surgical specialties. Orthopaedic surgery, like other surgical specialties, should focus its resources on the production of more RCT's.

Address Correspondence to:
Sharat K. Kusuma, MD, MBA
MIS Hip and Knee Replacement Surgeon
Minimally Invasive Orthopedics, Inc
500 East Main Street, Suite 240
Columbus, Ohio 43215
614-566-8570 (office)
614-566-8548 (fax)
Email: sharat.kusuma@owen.vanderbilt.edu>

Sharat Kusuma is an attending surgeon MIS Orthopaedics in Ohio
James Eiszner is an anesthesia resident at Jefferson Medical College in Philadelphia
Samuel Adams is a resident in orthopaedic surgery at Duke University
Kingsley Chin is an attending surgeon at the Institute for MIS Spine surgery in West Palm Beach Fla

Introduction

Currently, there is a movement in healthcare towards the practice of evidence-based medicine (EBM). EBM is the idea that physicians should use their traditional, formal modes of training (i.e. medical school, residency training) in conjunction with the best available "evidence" in the medical literature to make better and more cost-effective treatment decisions. There is widespread agreement that studies such as randomized controlled trials (RCT's) and meta-analyses comprise a majority of this best evidence[1-5]. Many experts argue that meta-analyses occupy the highest position of all currently proposed hierarchies of evidence[1-3]. Meta-analyses have the ability to combine the results of several randomized controlled trials and provide stronger, more scientifically rigorous evidence than individual randomized control trials[4]. However, the scientific value of a meta-analysis is determined by several factors, the most critical of which is the quality of the studies that are pooled to comprise the meta-analysis; evidence demonstrates that meta-analyses that pool the results of RCT's are of the highest quality[6]. Previous reports have also shown that meta-analyses in the surgical literature and orthopaedic literature are of lower quality because they combine data from nonrandomized trials. Conversely, medical journals publish higher quality meta-analyses because of stricter pooling of data from RCT's only[6].

Based on this knowledge, it would seem that journals representing all medical and surgical subspecialties could provide more scientifically rigorous clinical information to their readers if they published more RCT's and meta-analyses, especially if these meta-analyses pool data exclusively from RCT's[2]. Previous reports suggest that journals might improve their impact factors by publishing a higher number of high quality systematic reviews and/or meta-analyses[6]. Although some attempts have been made to assess the quality of systematic review articles in the orthopaedic literature few reports have compared the rates of publication of RCT's and meta-analyses across medical and surgical specialties[6]. Such extensive analysis can provide a broader perspective of the state of orthopaedic research in comparison to other surgical and medical specialties. Our study makes the first attempt to quantitatively and qualitatively analyze the entire current body of medical literature to compare the rates of publication of meta-analyses and RCT's across all major medical and surgical specialties, with a special focus on how the field of orthopaedic surgery compares.

JOURNAL TITLE	SPECIALTY	IMPACT FACTOR
"OTHER" SPECIALTIES		
RADIOLOGY	RADIOLOGY	4.8
J NUCL MED		4.9
PAIN	ANESTHESIOLOGY	4.6
ANESTHESIOLOGY		3.5
ACAD EMERG MED	EMERG MED	1.8
ANN EMERG MED		2.6
ARCH GEN PSYCHIAT	PSYCHIATRY	10.5
AM J PSYCHIAT		7.2
ARCH DERMATOL	DERMATOLOGY	3.5
J AM ACAD DERMATOL		3.0
J PEDIATR	PEDIATRICS	2.9
PEDIATRICS		3.8
BRAIN	NEUROLOGY	8.0
ANN NEUROL		7.7
AVERAGE		**4.9**
MEDICINE SPECIALTIES		
J ALLERGY CLIN IMMUN	ALLERGY/IMMUNOLOGY	6.8
ALLERGY		3.2
RHEUMATOLOGY	RHEUMATOLOGY	3.8
ANN RHEUM DIS		3.8
CIRCULATION	HEMATOLOGY	11.2
BLOOD		10.1
CLIN CANCER RES	ONCOLOGY	6.5
J CLIN ONCOL		10.9
J AM COLL CARDIOL	CARDIOLOGY	7.6
CIRC RES		10.1
J INFECT DIS	INFECT DIS	4.5
CLIN INFECT DIS		5.4
DIABETES	ENDOCRINOLOGY	8.3
DIABETES CARE		7.5
GASTROENTEROLOGY	GASTROENTEROLOGY	12.7
HEPATOLOGY		9.5
AM J KIDNEY DIS	NEPHROLOGY	3.9
J AM SOC NEPHROL		7.5
LANCET	GENERAL MEDICINE	18.3
NEW ENGL J MED		34.8
AMER J RESP CRIT CARE MED	PULMONOLOGY	8.9
THORAX		4.2
AVERAGE		**9.1**
SURGERY SPECIALTIES		
ANN SURG	GENERAL SURGERY	5.9
BRIT J SURG		3.8
SPINE	ORTHOPAEDICS	2.7
J BONE JOINT SURG AM		1.9
ARCH OTOLARYNGOL	OTORHINOLARYNGOLOGY	1.2
LARYNGOSCOPE		1.4
J UROL	UROLOGY	3.3
UROLOGY		2.8
J NEUROSURG	NEUROSURGERY	2.3
NEUROSURGERY		2.3
AVERAGE		**2.8**

Table 1 - Grouping of specialties into medicine, surgery or "other" specialties. Journals chosen for randomized clinical trial (RCT) identification for each subspecialty, along with ISI ratings for journals are also given.

We hypothesize that medical specialties are producing meta-analyses at a faster annual rate than surgical specialties. Additionally, we hypothesize that if it is indeed true that meta-analyses within medical journals are of higher quality because of more strict RCT inclusion criteria, then this higher quality will be manifested by a higher correlation between the publication rate of RCT's and meta-analyses by medical specialties in comparison to surgical specialties. Finally, we hypothesize that the field of orthopaedic surgery will compare favorably with other surgical specialties with regard to both of these parameters.

Materials and Methods

Study design

Our overall study design and strategy was to survey the entire body of medical literature to determine the annual publication of meta-analyses by all different medical and surgical specialties. Such a comprehensive survey would allow us to determine and compare the annual, time-dependent rate of publication of meta-analyses between medical and surgical specialties. Our second task was to determine how the rates of publication of these meta-analyses in medical and surgical specialties were correlated with the publication rate of RCT's within medical and surgical specialties. This also required an efficient method by which to survey the entire body of medical literature to determine the rates of publication of RCT's by medical and surgical specialties. Once we had determined the publication rates of meta-analyses and RCT's, we could utilize linear regression models to quantitatively examine and compare these rates of publication within medical and surgical specialties.

Meta-Analysis Study Identification

To identify all meta-analyses published within the medical literature, we conducted a computerized Medline search utilizing the popular medical database Pub Med for the years 1980 to 2003 inclusive. The search was limited to studies published in English and studies that related to humans. The publication type was limited to "meta-analysis". The accuracy of computerized Medline searches for identifying all published meta-analyses has previously been documented to be between 96% and 99%[7]. However, in order to further validate our search, we performed an extensive manual computerized search using the terms "meta-analysis" OR "meta-anal" OR "systematic review" OR "quantitative review." Additionally, we performed a manual hand search of selected journals for these same search terms and time periods and found a 99% correlation rate between our manual computer search, manual hand search, and our original computerized Medline search. Finally, the authors also repeated manual Medline and manual hand searches of journals for the terms "systematic reviews", "reviews", and "overviews." We were unable to find any instances where these search terms were able to identify articles that were not also identified through the use of only the term "meta-analysis" for articles that analyzed pooled data. However, we did identify instances where the term "systematic review" was used interchangeably and along with meta-analysis. In every such case, all these same articles were also identified by the use of only the term "meta-analysis." In order provide even further validation of the sensitivity of our computerized Medline search for identifying meta-analyses, we contacted the administrators of the National Library of Medicine, which oversees the Pub Med search engine, to determine how studies are categorized as meta-analyses within this search engine. It was determined that Pub Med and Medline define meta-analyses as "works consisting of studies using a quantitative method of combining the results of independent studies (usually drawn from the published literature) and synthesizing summaries and conclusions which may be used to evaluate therapeutic effectiveness, plan new studies, etc. It is often an overview of clinical trials. It is usually called a meta-analysis by the author or sponsoring body and should be differentiated from reviews of literature."[8] Overall, the methods we used to search would constitute an exhaustive search strategy for someone who is looking for a particular meta-analysis or RCT on a particular subject within a particular specialty. For each year within the 1980-2003 time period, all such abstracts were reviewed and the medical or surgical specialty of the investigating department that performed the meta-analysis was documented. In those rare cases where the investigating department was indeterminable or not listed, the abstracts were placed in an "unclassifiable/no department" category. For the purposes of this focused analysis, investigating departments were placed into two broad categories, namely "medicine" and "surgery." Medical investigating departments were categorized as "general" medical departments or were placed into specific subspecialty departments such as gastroenterology, nephrology, or cardiology.

Within the "surgery" departments' category, we placed investigating departments into a category of "general" surgical departments or "subspecialty" departments. The "general" category included colorectal/gastrointestinal, oncology, pediatric, trauma, vascular, transplant/visceral, and cardiothoracic. Again, this categorization was used because most such departments most often maintain divisions under the broader umbrella of general surgery departments. Additionally, each of these departments normally requires fellowship training after the completion of general surgery training. The subspecialty investigating department category again included those departments that maintain residencies that are distinct from general surgery training, and included the specialties of orthopaedic surgery, urology, neurosurgery, and otorhinolaryngology.

Finally, in order to maintain focus within our analysis, we established a third category of specialty investigating departments designated as "other." This category included those specialties that did not fall under the umbrella of "medicine" or "surgery" departments. General characteristics of investigating departments specified as "other" included those specialties that normally maintain their own academic departments and residency training programs that are distinct from departments of "surgery" and "medicine." This category included investigating departments such as radiology/nuclear medicine, ophthalmology, neurology, anesthesiology, pediatrics, psychiatry, dermatology, and emergency medicine. A full detail of the categorization of investigating departments is found in Table 1.

The specialties of obstetrics/gynecology and dental/oral-maxillofacial surgery were excluded from the analysis, as both specialties were viewed as a combination of medical and surgical specialties. They were therefore excluded to avoid incorrectly skewing the data towards either medical or surgical subspecialties.

Identification of Randomized Controlled Trials

Because the quality of meta-analyses depends on the quality of the pooled studies, we proceeded to examine the number and rate of RCT's published from 1989 to 2003 by the groups of specialties in our study. We chose this time period because it was during these 14 years that the medical literature experienced a dramatic increase in the numbers of meta-analyses published, and our goal was to determine the relationship between published RCT's and meta-analyses. Prior to the year 1989, only two meta-analyses were found in the Medline database.

We identified two journals in each medical and surgical subspecialty that corresponded exactly to the same subspecialty categories used for classification of our meta-analyses. We picked the two journals in each specialty that had the highest impact factor as determined by the ISI (Institute for Scientific Information) Journal Citation Reports, and which also had a focus on clinical research (isiknowledge.com) [6]. The ISI impact factor for a journal is a numerical value that indicates the scientific value of a journal. Journals with higher ISI ratings are thought to have higher status and therefore higher scientific value. The impact factor is calculated as the quotient of the number of times articles in a journal are cited in the previous two years and the number of total articles in that same journal during the same two year time period. Although this method of assessing the quality and scientific value of a journal is not perfect, previous reports have demonstrated that articles in journals with higher ISI ratings are more likely to be cited[9]. Additionally, other previous studies have demonstrated the significance of the citation of articles in the propagation of scientific knowledge [10,11].

The chosen journals and their corresponding ISI impact factors are highlighted in Table 1. We chose this strategy for identifying journals because previous reports have demonstrated that higher quality systematic reviews and clinical trials are published in journals with higher impact factors[6,9,12]. Therefore, by choosing the two highest impact clinical journals in a given subspecialty, we are likely to identify the highest quality RCT's published within that specialty for a given year. Finally, for completeness of our analysis, we also used the same criteria to choose two journals that corresponded to those subspecialties that were categorized as "other" in our meta-analysis classification system, and which had the highest rates of publication of meta-analyses during the study period. This process resulted in our identification of 46 total journals across 23 medical, surgical, and "other" subspecialties.

For each chosen journal, we recorded the total number of articles published within that journal for each year between 1999 and 2003 inclusive. We also recorded the ISI impact factor for each journal for the year 2003, as this was the latest available data in the ISI database.

We subsequently repeated the Medline search using the same Pub Med search engine that was utilized for our meta-analysis search. We queried the database using the terms "randomized controlled trial" OR "randomized clinical trial" OR "randomized trial" for each of the 46 designated journals. We also repeated the validation comparison with a manual computer and manual hand search of selected journals for selected years for RCT's. The procedure used for this validation comparison was identical to that used for validating the computerized search for meta-analyses, and demonstrated an accuracy of 98% of the computerized Medline search for identifying studies classified as "randomized controlled trials." This search yielded the numbers of RCT's published in the selected journals over the period from 1989 to 2003. Previous reports have demonstrated a 99% accuracy rate for the identification of RCT's using such a computer search[12] For each year in the study period every meta-analysis that met the inclusion criteria was placed in the appropriate specialty category. The total number of meta-analyses per year per specialty was calculated. This data was analyzed by comparing the number of meta-analyses across specialties, and the number produced by the different specialties as medical, surgical, or other. Additional analysis was made of trends in the number of meta-analyses found across all specialties on a year-to-year basis. Similar calculations were made for RCT's across the 46 selected subspecialty journals. The total number of RCT's was documented for each journal for each study year and compared between the journals. Averages and standard deviations of the numbers of meta-analyses and RCT's produced by all specialties were computed and comparisons between and within medical and surgical specialties were made by use of unpaired two-tailed Student's t-tests. Additionally, where appropriate, Student's t-tests for proportions were also utilized

Statistical Analysis of Data

In order to assess the effects of the two variables time and RCT publication rates upon the meta-analysis publication rate, we constructed two different categories of univariate linear regression models. The first model examined the effect of time on the production of meta-analyses for medical and surgical specialties. For this model, the number of meta-analyses published was the dependent, y-axis variable, while time (in years) was the independent explanatory variable. This model yielded coefficients for each specialty that indicated the effect of time on meta-analysis production.

The second univariate model we created examined the effect of annual RCT publication rate on the annual meta-analysis publication rate. Again for this linear regression model, the number of meta-analyses published on a yearly basis within each specialty was the y-axis dependent variable, while the percentage of RCT's published on a yearly basis per specialty was the independent, explanatory variable. Regression coefficients were computed for this model. Coefficients for both models were reported with 95% confidence intervals.

Statistical analyses were performed on the data using Microsoft Excel (Microsoft Corp., Redmond, Washington) and STATA (StataCorp LP, College Station, TX) software packages. For all statistical analyses, p values less than 0.05 were considered significant

Results

Meta-analyses

There were 7273 meta-analyses cited in Medline during the study period that met eligibility criteria. A broad review of the data demonstrated that the number of meta-analyses published has increased in a yearly and nearly linear fashion for medicine, surgery, and orthopaedic surgery during the time period studied (Figure 1). Between the years 1980 and 1989, there were only two meta-analyses that met eligibility criteria. However, this changed significantly in 1990, as 242 such studies appeared in Medline in that year alone. From 1990 moving forward, there continued to be a large incremental increase in the number of meta-analyses produced each year, with an average annual increase of 12.3%. Also within each category of medicine and also within several of the specialties in the "other" category, the number of meta-analyses increased nearly every year between 1990 and 2003 (Please see Appendix A online content). However, surgical departments were slow to match this trend, as the numbers of meta-analyses produced by surgical departments was nearly unchanged for the period 1990-1992, and then actually decreased in the year 1993, before increasing at a nearly steady rate from 1993 forward

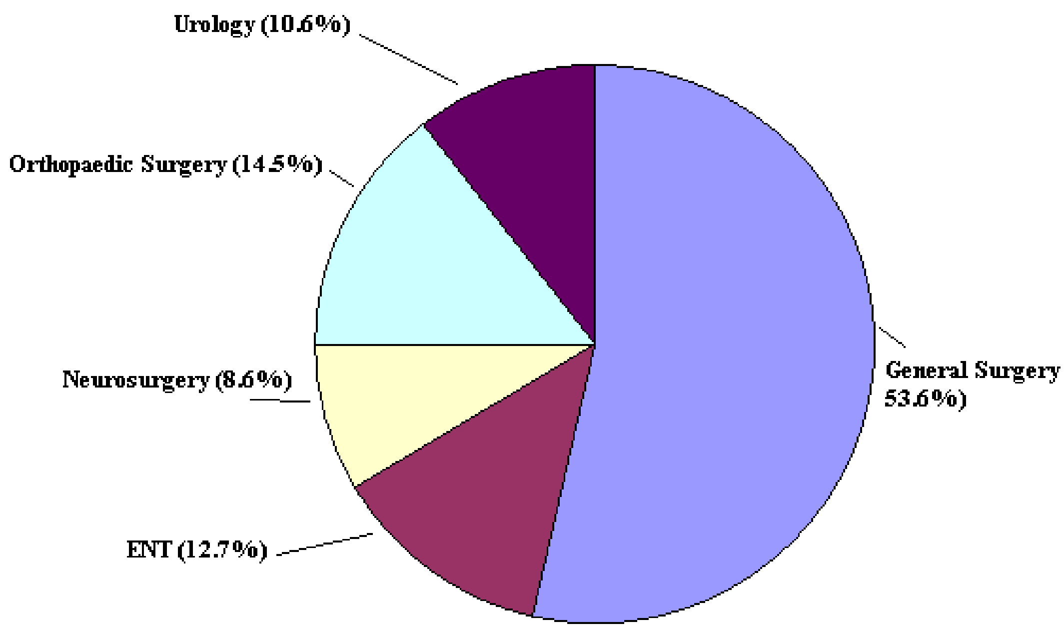


Figure 3 - Comparison of Meta-Analysis Production Between Surgical Specialties.-Pie chart demonstrating the percentage contribution of surgical specialties to overall total meta-analyses produced by all surgical specialties.

Of all the abstracts reviewed during the study period that met inclusion criteria, the departments categorized as "medicine" produced the largest number of meta-analyses, with a total of 2016 or 27.7% of the total number. All surgical departments combined produced only 498 meta-analyses or 6.9% of the total during the study period. Within the medicine category, the most active producers of meta-analyses were general internal medicine departments (11% of total), hematology/oncology departments (5.1% of total), and cardiology departments (4.4% of total). (Please see Online content Appendix B) Within the surgery category, general surgical departments were the most active producers, as they published 267 meta-analyses. This figure accounted for 53.6% of all meta-analyses categorized as "surgery" during the study period. Within the subspecialty surgery groups, orthopaedic departments were the most active producers, as they contributed 72 total meta-analyses or 14.5% of the surgery total. This data is highlighted in Figure 3. Several non-medical and non-surgical specialties in the "other" category contributed large numbers of meta-analyses to the literature. Specialty departments of note included those classified as departments of epidemiology/public health, which contributed 1186 meta-analyses (16.3). Additionally, psychiatry departments produced 450 or 6.2% of the total meta-analyses. There were 844 (11.6%) meta-analyses found in the literature that were placed in the "unclassifiable" category.

Specialty	Coefficient	R^2	Standard Error of Mean	P-value
Anesthesiology	1.57	0.90	0.14	**0.00001**
Pediatrics	2.51	0.68	0.48	**0.0001**
Psychiatry	4.15	0.82	0.54	**0.00001**
All Medicine	17.38	0.94	1.24	**0.00001**
Cardiology	3.44	0.82	0.44	**0.00001**
Heme/Onc	2.42	0.70	0.44	**0.0001**
Gastroenterology	1.99	0.90	0.18	**0.00001**
All Surgery	5.19	0.90	0.49	**0.00001**
Orthopaedics	0.86	0.88	0.09	**0.00001**
Urology	0.47	0.74	0.08	**0.00001**
Oto (ENT)	0.56	0.67	0.11	**0.0001**

Table 2 - Linear Regression Results of Year of Publication Versus Meta-analysis Production.

Randomized Controlled Trials

The average ISI impact factor was 9.07 for medical journals and 2.77 for surgical journals (p=.007). Using our RCT search criteria, we identified a total of 16798 eligible RCT's published between the years 1989 and 2003 in the forty-six journals that we chose. Sixty-three percent of these RCT's appeared in medical specialty journals, while 11.8% appeared in surgical specialty journals. In order to test the validity of our chosen sample of specialty journals we carried out extensive statistical analysis. The average number of articles per journal per year in our medical category was 466.2, while that for our chosen surgical journals was 398.4 (p=.10). The average number of RCT's/year that appeared in medicine journals was 34.9, while that for surgical journals was 14.2 (p=.00001). Therefore the annual percentage of articles in medical journals that were RCT's was 7.5%, while that for surgical journals was 3.56% (p=.01). For orthopaedic journals, the average articles/year was 352.7, and the average RCT's/year was 14.3. The average RCT publication rate for orthopaedic surgery was 4.05%, compared with 3.56% for all surgical journals (p=.75).

Analysis of Linear Regression Models for Meta-analyses and RCT's

Our linear regression models demonstrated several trends. Our first set of models examined the correlation between time (in years) and publication of meta-analyses across all specialties. The coefficients for time were 17.38 for all medical specialties, 5.19 for all surgical specialties (p=.0001). Within the medical specialties, the most active meta-analysis producing specialties, cardiology, hematology, general internal medicine, and gastroenterology demonstrated time coefficients of 3.44, 2.42, 5.81, and 1.99 respectively. Within the surgical specialties, the time coefficients were 2.91 for general surgery, and .47 for urology, and 0.86 for orthopaedic surgery. Several specialties within the "other" category also demonstrated high time-dependent rates of meta-analysis production, including psychiatry, pediatrics, and anesthesiology, which demonstrated coefficients of 4.15, 2.51, and 1.57 respectively. The summary data for the time versus meta-analysis production univariate model is detailed in Table 2. Overall, this time dependent model demonstrated that the entire body of medical specialties, individual medical subspecialties, and specialties such as pediatrics, anesthesiology, and psychiatry are producing meta-analyses at a much faster annual rate than their surgical counterparts.

Our second univariate linear regression model examined the effect of rate of RCT publication within subspecialty journals on the production of meta-analyses within the specialty corresponding to each particular journal. This model also demonstrated several trends across medical and surgical specialties. For all medical specialties, the coefficient of RCT publication versus meta-analyses production was 39.78, while that for all surgical journals was 18.54 (p=.018). The coefficients for the two most active medical meta-analysis producers, cardiology and hematology/oncology, were 4.02

and 5.47 respectively. The coefficient for orthopaedic surgery was 1.58, while that for urology and otolaryngology were 1.50 and 2.09 respectively. Overall, this univariate model demonstrated that there is a much higher correlation between rate of RCT production and meta-analysis production within medical subspecialties than within surgical subspecialties. The summarized data for this regression model is detailed in Table 3.

Specialty	Coefficient	R^2	Standard Error of the Mean	P-value
Heme/Onc	5.47	0.58	1.30	0.0005
Cardiology	4.02	0.60	0.92	0.0004
All Medicine	39.78	0.72	6.90	0.00001
All Surgery	18.54	0.65	3.79	0.0001
Orthopaedics	1.58	0.62	0.34	0.0002
Oto (ENT)	2.09	0.47	0.62	0.0020
Urology	1.50	0.49	0.43	0.0019

Table 3 - Linear Regression Results of Randomized Clinical Trial Production Versus Meta-analysis Production

Discussion

We performed an exhaustive survey of the entire body of the current medical literature to quantitatively and qualitatively assess the production of meta-analyses across various specialties. We also quantitatively analyzed those variables that are influencing the rate of publication of meta-analyses within various specialties. Overall, our data suggests several important trends. First, medical subspecialties journals, on average, have a higher percentage of articles that are RCT's within their highly rated journals than do surgical specialties. Second, medical specialties have produced, and continue to produce meta-analyses at a much faster rate than their surgical counterparts. However, other subspecialties that are not traditionally considered medical or surgical (psychiatry, anesthesiology, pediatrics) are also producing meta-analyses at a much faster rate than surgical specialties. Third, there was a much stronger correlation between the production of RCT's and meta-analyses within medical specialties than within surgical specialties. Fourth, the specialty of orthopaedic surgery was comparable to other surgical specialties with regard to all of these trends, with a low rate of meta-analysis production, a low rate of RCT production, and low correlation between these two variables.

The findings in our study are noteworthy because they not only demonstrate the higher rate of publication of meta-analyses within medical specialties, but they also suggest that the quality of these meta-analyses is higher for medical specialties in comparison to surgical specialties. The data demonstrated that on average, the percentage of articles within the highest ISI rated medical journals that are RCT's is higher than that for the highest rated surgical journals. Over the years, 1989-2003, the average percentage of articles within highly rated medical journals that were RCT's was 7.49%, compared to only 3.56% for surgical journals. For orthopaedic surgery, this percentage was 4.05%. Therefore, on average, medical journals dedicate nearly double the number of articles per journal to RCT's than do surgical or orthopaedic journals. This finding suggests that medical journals and medical specialties have at their disposal a much larger database of RCT's that may be utilized for meta-analysis production. Such a difference in RCT availability is likely to influence the rate of meta-analysis production. To compensate for this difference, orthopaedics, like other surgical fields, should focus on producing more RCT's relative to such publication types as review articles, small case series, and case reports.

The second major trend we identified is that there is a significantly higher correlation between RCT production and meta-analysis production for medical specialties than for surgical specialties. This indicates that the rate of meta-analysis production within medicine is much more sensitive to the rate of RCT production than it is for surgical specialties. The high correlation coefficient of RCT production upon meta-analysis production within medicine specialties suggests that the medicine literature is more effectively disseminating and assimilating the data from RCT's. Secondly, this higher correlation suggests that on average, medical meta-analyses are of higher quality than surgical meta-analyses. If the meta-analysis production rate is so highly dependent upon the RCT production rate, this indicates that those meta-analyses that are being published within medical journals and by medicine departments are a response to those RCT's that are published and available for meta-analysis pooling. Therefore, not only do medical specialties have at their disposal a larger database of RCT's from to pool data for meta-analyses, but they are also performing this function at a much faster rate than surgical specialties.

The lower average percentage of articles in surgical and orthopaedic literature that are RCT's indicates that these specialties have a smaller database of RCT's that may be pooled to produce meta-analyses. Secondly, the low correlation coefficient of RCT production versus meta-analysis production within surgical specialties suggests that meta-analysis production within surgical specialties is not very responsive to the publication rate of RCT's. Therefore, surgical meta-analysis production is likely more responsive to other variables. Previous literature has demonstrated that surgical meta-analyses often pool data from non-randomized trials and observational studies[6]. Therefore, further analysis would perhaps demonstrate a higher correlation between the publication of such observational studies and meta-analyses for surgical specialties. Overall, our findings lend support to the theory that meta-analyses in the surgical literature are less often based on RCT's, and are therefore in general of a lesser quality.

Our second regression model examined the effect of time on meta-analysis production. Again, the coefficients for this model were significantly higher for medicine specialties than for surgical specialties. This indicates that medicine specialties are also disseminating and assimilating the data from their RCT's at a faster rate to their readers in comparison to surgical specialties. For orthopaedic surgery, this time dependent coefficient compared favorably with the other surgical subspecialties examined.

Our data provides support for previous beliefs that the discrepancy between the best current evidence and clinical practice is highest in surgical subspecialties[2,4,14]. Our data also suggests that surgical subspecialties dedicate a smaller percentage of their journal space to RCT's, that meta-analyses within surgical specialties are less influenced by RCT's that are published within those specialties, and that the rate of publication of meta-analyses is relatively slow in surgical specialties. Orthopaedic surgery departments are similar to other surgical specialties in their low number and rates of publication of meta-analyses and RCT's. Therefore, the surgical literature contains less scientifically rigorous information, and the information that is available is of a lesser quality than that available in the medical literature, with regard to clinical studies.. In light of this information, it is no surprise that previous reports have shown large deviations between best evidence and clinical practice in surgical specialties[18].

There are likely other reasons why surgical specialties and orthopaedic specialties alike have been less effective in their production of meta-analyses. The first reason for this trend may be due to the historical orthopaedic literature which consisted of observational studies and case series; this tendency to utilize such scientifically non-rigorous research methods has persisted into the current orthopaedic literature[6,15-18]. In the seminal years of orthopaedics, the focus was primarily on the fixation of fractures and fixation methods were observed on a case-by-case basis to promote fracture healing in practice and thus were adopted as the standard of care[16]. Hurwitz offers the argument that orthopaedic surgery literature has primarily served as a forum for information exchange between academic researchers[18]. This is in contrast to other specialties of medicine, which use their respective literature to communicate rigorously tested data to practitioners. Another possible reason for the observed shortage of strong scientific evidence in surgical specialties is simply the great difficulty inherent in producing such evidence. The randomization and blinding processes that are an essential component of well-designed randomized control trials are very difficult to achieve for surgical treatments. Additionally, randomized control trials require long follow-up time to establish the efficacy or lack thereof for a particular surgical procedure.

Some might argue that surgical specialties will have further difficulty producing RCT's and high-quality meta-analyses because convincing patients to undergo a "random" surgical procedure may be difficult. After all, what type of patient would be willing to undergo a "random" invasive surgical procedure by a surgeon who is "indifferent" between two different treatment methods? Critics of our findings may posit that surgical specialties will always be hampered in their production of RCT's because patients are unwilling to be "randomized" to one of several different surgical treatment groups. However, our data would indicate otherwise. The specialties of cardiology, anesthesia, and gastroenterology, all of which are highly procedural in nature and which involve many different varieties of interventional treatments, all produce RCT's and meta-analyses at significantly higher rates than do surgical specialties.

On a more general level, our data also confirmed that the prevalence of meta-analyses and RCT's in the medical literature has grown rapidly since the early 1990's. Pettiti described a trend whereby meta-analysis first appeared in 1978 and was popularized in the biomedical literature in the late 1980's, when three widely read medical journals, the *New England Journal of Medicine*, *Lancet*, and the *Annals of Internal Medicine*, featured articles on the use and methodologies of meta-analysis[19-22]. Our data corroborated this assessment (Figure 1). We found that since 1990, the number of meta-analyses appearing in the medical literature grew at approximately 12% per year. At this rate, the number of meta-analyses will double nearly every six years.

The study possesses certain weaknesses. First, our study does not directly measure the quality of the individual meta-analyses and RCT's that were identified. However, in order to gather broad insight into the quality of identified publications, we utilized the highest quality rated journals across multiple specialties. Within these journals, we assessed the quantity and rate of publication of RCT's that comprised the available pool of studies from which each specialty could create meta-analyses. Our strategy of utilizing journals with high ISI ratings is an effective one for identifying RCT's in the most highly cited journals within each medical and surgical specialty. It is highly likely that RCT's in these journals represent the best quality such trials that are available within a certain medical or surgical specialty. The fact that we demonstrated such a strong correlation between the RCT's published in such highly rated medical journals and the publication of meta-analyses by medical specialties provides indirect qualitative and quantitative evidence of the higher quality of such studies within the medical literature.

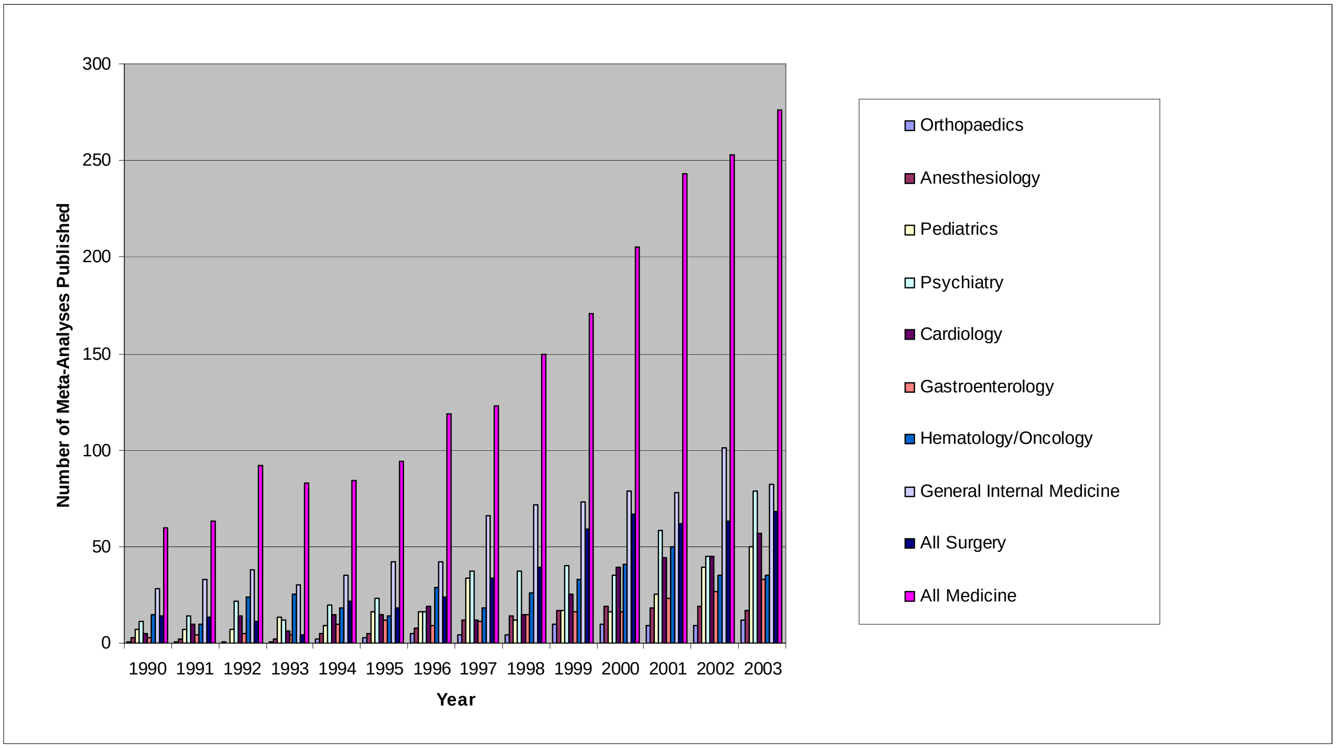
In conclusion, the current study provides a quantitative and qualitative view of the current medical research landscape by comparing research productivity and quality among various medical and surgical specialties. Increasing the number of high quality meta-analyses in the medical literature is important for several reasons. Well-designed, rigorous meta-analyses represent a very efficient method of combining results from several different studies on a given intervention or treatment. In an era of an increasing volume of scientific publications and limited time of clinicians to review this information, the publication of such efficient, systematic reviews of the literature will be important tools by which clinicians can practice evidence-based medicine.

References:

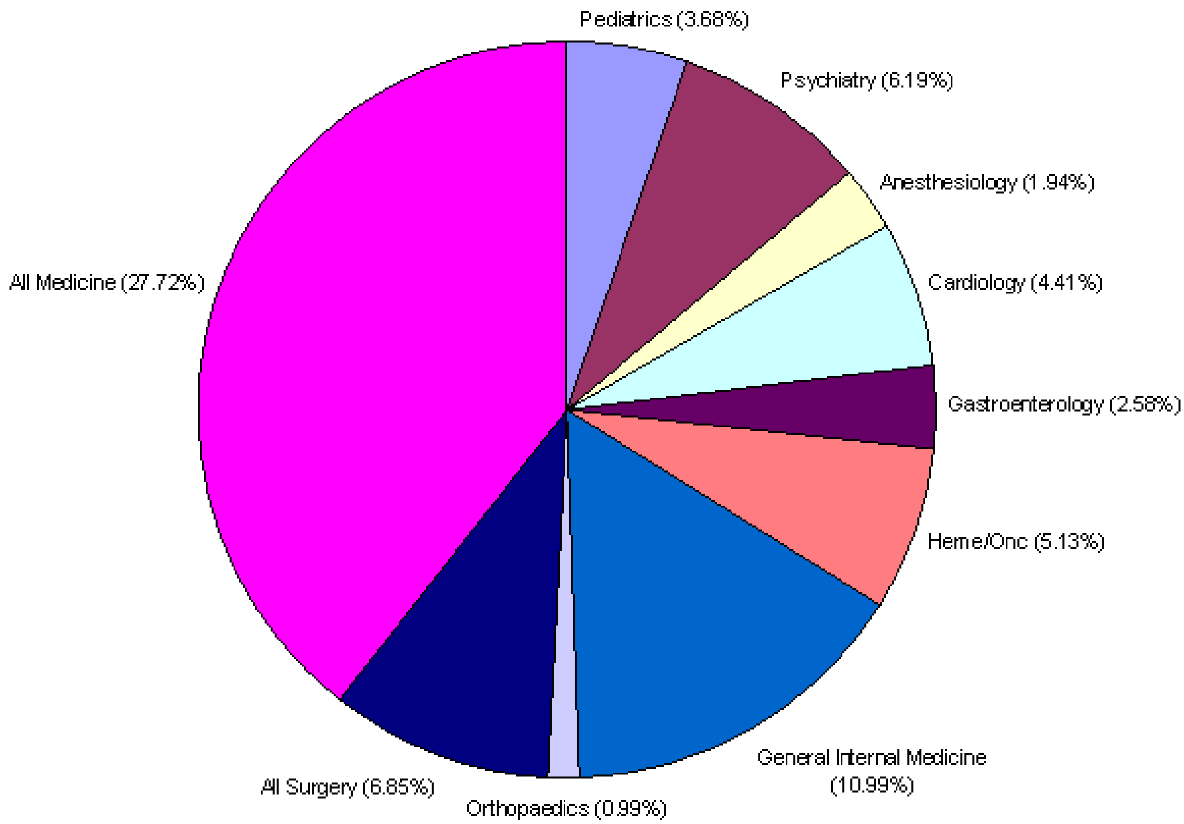
1. Barton S. Which clinical studies provide the best evidence? *BMJ.* 2000;321:255-6.
2. Bhandari M, Montori V, Devereaux P, Wilczynski NL, Morgan D, Haynes RB. Doubling the impact: publication of systematic review articles in orthopaedic journals. *J Bone Joint Surg Am.* 2004;86(5):1012-6.
3. Brown GC. Evidence-based medicine and cost-effectiveness. *J Health Care Finance.* 1999;26(2):14-23.
4. Kreder HJ. Evidence-based surgical practice: what is it and do we need it? *World J Surg.* 1999;23:1232-5.
5. Montori VM, Wilczynski NL, Morgan D, Haynes RB; Hedges Team. Systematic reviews: a cross-sectional study of location and citation counts. *BMC Med.* 2003 Nov 24;1(1):2.
6. Bhandari M, Morrow F, Kulkarni AV, Tornetta P 3rd. Meta-analyses in orthopaedic surgery. A systematic review of their methodologies. *J Bone Joint Surg Am*. 2001:83:15-24.
7. Montori VM, Wilczynski NL, Morgan D, Haynes RB. Optimal search strategies for retrieving systematic

reviews from Medline: analytical survey. *BMJ*. 2005;330:7482-8.

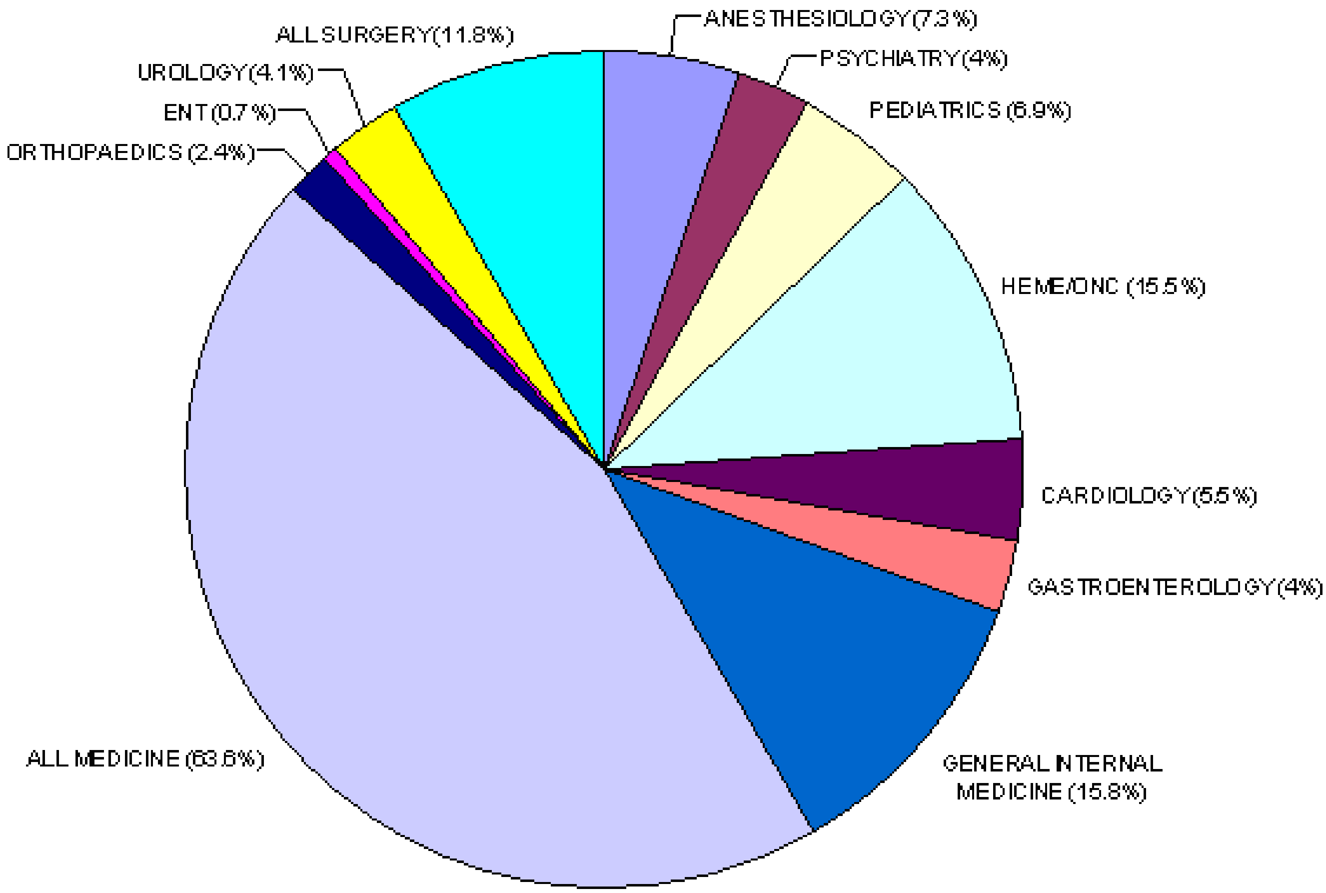
8. National Library of Medicine. Personal correspondence with authors. April 1, 2005.
9. Callaham M, Wears RL, Weber E. Journal prestige, publication bias, and other characteristics associated with citation of published studies in peer-reviewed journals. *JAMA.* 2002;287:2847-50.
10. Jadad AR, McQuay HJ. Meta-analyses to evaluate analgesic interventions: a systematic qualitative review of their methodology. *J Clin Epidemiology*. 1996;49:235-43.
11. Lankhorst GJ, Franchignoni F. The "impact factor" – an explanation and its application to rehabilitation journals. *Clin Rehabil*. 2001;15:115-8.
12. Lee KP, Schotland M, Bacchetti P, Bero LA. Association of journal quality indicators with methodological quality of clinical research articles. *JAMA*. 2002;287:2805-8.
13. Haynes RB ,Wilczynski N, McKibbon KA, Walker CJ, Sinclair JC. Developing Optimal Search Strategies for Detecting Clinically Sound Studies in MEDLINE. *J Am Med Inform Assoc*. 1994;1(6):447-58.
14. Morris RW. Evidence-based choice of hip prostheses. *J Bone Joint Surg Br*. 1996;78-B(5):691-3.
15. Evidence-Based Medicine Working Group. Evidence-based medicine: a new approach to teaching the practice of medicine. *JAMA.* 1992;268(17):2420-5.
16. Freedman KB, Bernstein J. Sample size and statistical power in clinical orthopaedic research. *J Bone Joint Surg* Am. 1999;81(10);1454-1460.
17. Hoelzer S. Confronting actual practice with practice guidelines in oncology. *Qual Assur*. 1999;7;163-71.
18. Hurwitz SR, Slawson D, Shaughnessy A. Orthopaedic information mastery: applying evidence-based information tools to improve patient outcomes while saving orthopaedists' time. *J Bone Joint Surg Am*. 2000;82(6):888-894.
19. Bulpitt CJ. Meta-analysis. *Lancet*. 1988;2(8602):93-4.
20. L'Abbe KA, Detsky AS, O'Rourke K. Meta-analysis in clinical research. *Ann Intern* Med. 1987;107:224-33.
21. Petitti DB. Introduction, Overview of the methods. In: Petitti DB. *Meta-analysis, decision analysis, and cost-effectiveness analysis: methods for quantitative synthesis in medicine*. New York: Oxford University Press; 2000:1-33.
22. Sacks HS, Berrier J, Reitman D, Ancona-Berk VA, Chalmers TC. Meta-analysis of randomized controlled trials. *N Engl J Med*. 1987;316:450-455.



Appendix A - Annual Meta-analysis Production for Medical, Surgical, and "Other" Specialties



Appendix B - Comparison of Meta-Analysis Production Between Various Specialties-Pie chart demonstrating the percentage contribution of representative medical, surgical, and "other" subspecialties to overall meta-analysis production.



Appendix C - Comparison of RCT Production Between Medical, Surgical, and "Other" Specialties- Pie chart demonstrating the percentage contribution of representative medical, surgical, and "other" subspecialties to overall RCT production.