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The identification of clinically important elements within medical journal abstracts: Patient–Population–Problem, Exposure–Intervention, Comparison, Outcome, Duration and Results (PECODR)

Martin Dawes*
Chair Family Medicine

Pierre Pluye*
Assistant Professor

Laura Shea*
Research Assistant

Roland Grad
Associate Professor

Department of Family Medicine, McGill University

Arlene Greenberg
Health Sciences Library, Sir Mortimer B Davis – Jewish General Hospital

Jian-Yun Nie
Département d'Informatique et de Recherche Opérationnelle, Université de Montréal

Montréal, Québec, Canada

* These authors contributed equally to this work

ABSTRACT

Background Information retrieval in primary care is becoming more difficult as the volume of medical information held in electronic databases expands. The lexical structure of this information might permit automatic indexing and improved retrieval.

Objective To determine the possibility of identifying the key elements of clinical studies, namely Patient–Population–Problem, Exposure–Intervention, Comparison, Outcome, Duration and Results (PECODR), from abstracts of medical journals.

Methods We used a convenience sample of 20 synopses from the journal *Evidence-Based Medicine* (*EBM*) and their matching original journal article abstracts obtained from PubMed. Three independent primary care professionals identified PECODR-related extracts of text. Rules were developed to define each PECODR element and the selection process of characters, words, phrases and sentences. From the extracts of text related to PECODR elements, potential lexical patterns that might help identify those elements were proposed and assessed using NVivo software.

Results A total of 835 PECODR-related text extracts containing 41 263 individual text characters were identified from 20 *EBM* journal synopses. There were 759 extracts in the corresponding PubMed abstracts containing 31 947 characters. PECODR elements were found in nearly all abstracts and synopses with the exception of duration. There was agreement on 86.6% of the extracts from the 20 *EBM* synopses and 85.0% on the corresponding PubMed abstracts. After consensus this rose to 98.4% and 96.9% respectively. We found potential text patterns in the Comparison, Outcome and Results elements of both *EBM* synopses and PubMed abstracts. Some phrases and words are used frequently and are specific for these elements in both synopses and abstracts.

Conclusions Results suggest a PECODR-related structure exists in medical abstracts and that there might be lexical patterns specific to these elements. More sophisticated computer-assisted lexical-semantic analysis might refine these results, and pave the way to automating PECODR indexing, and improve information retrieval in primary care.
Keywords: abstracting and indexing, information storage and retrieval, knowledge bases, medical subject headings (MeSH), Medline, primary care

Introduction

During the last century there has been an exponential growth of medical research and knowledge.[1–3] Electronic searching of this expanding evidence base was initiated by the National Library of Medicine (NLM) in 1966.[4] The Medline database from the NLM now contains more than 12 million bibliographic citations derived from over 4600 international biomedical journals. With the expansion of medical information, our knowledge should be greater and our practice should be more effective. Unfortunately this is too often not the case.[5] Indeed, primary care covers a variety of research areas and disciplines, and research-based information retrieval has often been perceived as impractical for primary care professionals.

Improvement in search engine design and function[6] and indexing of the medical literature using medical subject headings (MeSH) has increased the likelihood of successful information retrieval.[7] Primary care clinicians are increasingly using evidence from online databases,[8,9] but there remains frustration during the literature search.[10] Teaching search skills improves searching performance[11,12] and reduces this frustration.

One of the key search skills for successful information retrieval is to have the question defined as exactly as possible. An unstructured keyword expression is insufficient. A better expression can be created by structuring clinical queries so that the key elements of patient or problem (P), intervention (I), comparison if appropriate (C), and outcome (O) (PICO) are defined separately before starting the search.[13] Many undergraduate and postgraduate curricula now contain evidence-based practice teaching where students learn this process.[14,15]

However, although there are some search engines that prompt the user for these elements (askmedline.nlm.nih.gov/ask/pico.php), there is no system that has attempted to index the medical literature relevant to primary care using PICO-related terms. In order to build a structured index, the first step is to determine whether it is possible to identify these elements in abstracts. Our primary hypothesis was that it would be possible systematically to identify the key elements within the abstracts of papers describing various research findings. Secondly, we believed it would be possible to find phrases and words that would help identify the presence or absence of these elements.

Methods

To the four PICO elements suggested originally,[13] Time of study was recently added.[16] Results were one of the original items in the appraisal checklists from which the original PICO classification was generated.[17] The last two elements, Duration and Results, are important in terms of patient management and continue to appear in appraisal checklists in assessing effectiveness.[18–20] We changed the I to E for Exposure as this allows the inclusion of different types of study, such as case control studies and cohort studies, in addition to randomised controlled trials. We have changed the word Time to Duration of treatment and/or Duration until outcome was assessed, as this reflects the time interval of initiation of treatment to event. Our suggested changes result in the following six elements: Patient–Population–Problem, Exposure–Intervention, Comparison, Outcome, Duration and Results (PECODR; see Table 1 for an example).

Table 1 PECODR elements

PECODR elements		Example
P	Patient–Population –Problem	56-year-old man with hypertension
E	Exposure	Atenolol
C	Comparison	Placebo
O	Outcome	Cardiovascular event
D	Duration of exposure/follow-up	4.5 years
R	Results	Number needed to treat of 25

We used a convenience sample of 20 synopses from the June 2005 edition of the journal *Evidence-Based Medicine* (*EBM*) (2005; Volume 10, No. 3). This edition included synopses of randomised controlled trials (RCTs), systematic reviews, diagnostic tests, ætiology and a clinical prediction rule relevant to primary care physicians. This journal identifies PECODR elements of clinically important research articles, and acted as our gold standard for these elements. The abstracts of journal articles from which the *EBM* synopses were written were obtained from PubMed. Three health professionals independently reviewed the abstracts and synopses to identify PECODR elements. These professionals all have backgrounds in knowledge translation research and experience in healthcare research. Two are primary care physicians and one is a nurse, all with higher research degrees and all have worked using textual analysis, qualitative and quantitative research methods.

Each text extract (character, word, phrase or sentence) was assigned to one PECODR element by the reviewer (see example in Table 2). The sample size was chosen on the basis that we would probably be able to determine the feasibility of this approach as a crude assessment of the presence or absence of PECODR elements.

During this iterative process, rules were developed to define each PECODR element and the selection process of characters, words, phrases and sentences. These rules were developed by three authors over three meetings. Authors used each iteration of the rules to assess several papers prior to each consensus meeting and then brought the problems identified with the rules to each meeting. For instance, we did not assign

Table 2 Coding text discussion examples

Example 1	Examples of coding discussion	Example 2	Examples of coding discussion
<R> Despite major differences	*Code just 'major differences'?*	<P1> Forty patients with recurrent major depression who had been successfully treated with antidepressant drugs were randomly assigned	*Should we include the random allocation statement?*
<O> in blood pressure lowering,	*Remove word 'in'?*	<E2> to either cognitive behaviour treatment of residual symptoms (supplemented by lifestyle modification and well-being therapy)	*Include 'to either' or leave it in the text?*
<R> there were no		<C1> or clinical management.	
<O> outcome		<P2> In both groups, antidepressant drugs were tapered and discontinued.	*Include or exclude 'In both groups'?*
<R> differences		<D1> A 6-year follow-up was undertaken. During this period,	*Include phrase 'During this period' or not?*
<E> between atenolol	*Remove 'between'?*	<P3> no antidepressant drugs were used unless a relapse ensued.	
<C> and placebo in the four studies,			
<P> comprising 6825 patients,			
<D> who were followed up for a mean of 4.6 years.	*Include 'who were'?*		

orphan preposition or conjunction words, so that from the phrase 'Study selection and assessment: randomised controlled trials (RCTs) that compared', only the word 'compared' was coded to a comparison element and not the phrase 'that compared'. However, prepositions that did link nouns, pronouns or phrases to other words were integrated into the corresponding word-related extract. For example, 'with placebo' was coded as a Comparison from the phrase 'compared parenteral metoclopramide with placebo'.

Differences in identification, and allocation to PECODR elements of the extracts, were resolved by discussion between the three reviewers, and in the event of disagreement an arbitration committee of a librarian and another family physician made a final assignment.

Descriptive statistics on the assignment process were produced using NVivo software (www.qsrinternational.com). NVivo is one of the most frequently used software programs in social sciences for computer-assisted qualitative data analysis. While such software is not designed for complex lexical-semantic analysis and textual statistics, it was appropriate in our pilot study to enable researchers' coding in an inductive exploratory manner (researchers' assignment of extracts of data to categories – for example, themes). Using such software, texts are freely edited and coded. Then, Boolean searches by text and by categories, or both, permit more sophisticated analyses. We used version 2 of NVivo, which notably supports coding by multiple users, and permits comparison of user coding with reports by text, category or both. Results of combined searches are presented in matrices that are easily exported to statistical software (content of cell being the number of characters per category, for example). Chi-squared analysis using StatsDirect was used to determine differences in PECODR elements between PubMed and *EBM* abstracts.

For each PubMed abstract and *EBM* synopsis, one of us (PP) reviewed all the PECODR text extracts to identify potential text patterns that might be specific to that element. He identified 143 potential text patterns: six for P (for example, patients), 10 for E (for example, who), 17 for C (for example, placebo), 25 for O (for example, mortality), 16 for D (for example, month) and 69 for R (for example, odds ratio). Using the NVivo version 2 software function 'search text patterns', the frequency of these text patterns by element was identified. From the 143 potential text patterns, 44 were defined as 'likely' when 70% of the total number of text pattern occurrences in the whole document were found in the element-related extracts of text. The specificity of each text pattern was identified by comparing the frequency of the occurrences of the phrase within the PECODR element as a fraction of the total occurrences within the whole abstract or synopsis.

Results

A total of 1594 PECODR-related extracts containing 73 210 individual text characters were derived from all 20 PubMed abstracts and their corresponding *EBM* journal synopses. This was a significantly larger amount of extracts than was originally imagined. The initial finding when starting to code these elements was the complexity of the terminology used within abstracts. While this was expected for the primary journal abstracts, it was not expected within the secondary journal synopses. The commonest example of this was the use of different terms for the same meaning, such as 'quit rate' and 'smoking cessation' as two phrases for the same outcome.

The six PECODR elements were found in nearly all abstracts, with the exception of the component describing the duration, which was found in only 15 (75%) PubMed abstracts but 18 (90%) of *EBM* synopses (see Table 3), although this is not statistically significant.

If there was disagreement about the identification of an element between reviewers, this was resolved by consensus in most cases. Forty-one PECODR extracts from the PubMed abstracts and 46 extracts of the *EBM* synopses needed consensus discussion. Arbitration was needed for three of the PubMed abstracts and four of the *EBM* synopses. A total of 19 *EBM* synopses and 19 of the PubMed abstracts required consensus discussion. Reviewers reached initial agreement on 27 225 (85.0%) characters from a total of 32 052 individual characters in the PubMed abstracts and 35 716 (86.6%) characters out of a total of 41 263 characters in the *EBM* synopses (see Table 4). After consensus this rose to 96.9% agreement and after arbitration 99.7% in the PubMed abstracts.

Reviewers reached initial agreement in 86.6% of the individual characters of the *EBM* synopses and PECODR elements. After consensus this rose to 98.4% and after arbitration 100.0%. There was more disagreement concerning extracts of text assigned to Patient–Population–Problem than the other elements within the PubMed abstracts. There was less variation in selection of abstracts for elements for *EBM* synopses.

Text patterns were found within the PECODR element-related text extracts that might identify those element-related text extracts. For example, 'comparing', 'compared' and 'than' were three patterns seen frequently in the Comparison elements. The word 'comparing', which occurred twice, only occurred in text extracts identified as Comparison elements within PubMed abstracts, so was 100% specific. However, it occurred eight times in the *EBM* synopses, and only four of these occurrences were in Comparison element-related extracts, corresponding to a 50% specificity. In the PubMed abstracts, there were 19 occurrences of

Table 3 Number of PubMed abstracts of journal articles and their corresponding *Evidence-Based Medicine* journal synopses containing identifiable PECODR elements from a sample of 20, and the number of extracts relating to each element

Elements	PubMed abstracts		*EBM* synopses	
	No. of abstracts containing each element	No. of extracts found in those abstracts	No. of synopses containing each element	No. of extracts found in those synopses
Patient–Population–Problem	19	89	20	116
Exposure–Intervention	20	163	20	180
Comparison	18	92	19	120
Outcome	20	169	20	187
Duration	15	36	18	45
Results	20	210	20	187
Total	20	759	20	835

Table 4 Identification and agreement between reviewers of PECODR elements by number of individual characters within *Evidence-Based Medicine* journal synopses and PubMed abstracts

Elements	PubMed abstracts		*EBM* synopses	
	32 052 characters*		41 263 characters	
	No.	%	No.	%
Patient–Population–Problem	5450	17.0	13 104	31.8
Exposure–Intervention	7354	22.9	8168	19.8
Comparison	3426	10.7	4417	10.7
Outcome	6649	20.7	8751	21.2
Duration	1058	3.3	1473	3.6
Results	8010	25.0	5350	13.0
Not assigned to PECODR	105	0.3	0	0.0

* Including 105 characters corresponding to 'disagreement' (not assigned to a PECODR element)

the word 'compared', of which 16 (83%) were assigned to the Comparison element. However, the word 'than' occurred 42 times in PubMed abstracts, but only 67% of these occurrences were in text extracts assigned to the Comparison element (see Table 5).

We did not find such frequency patterns in Patient–Problem-related or Exposure-related extracts. For Comparison and Outcome elements, a cluster of four to five words was commonly found in both the journal abstracts and the *EBM* synopses.

The words 'differ', 'increase', 'significant' and 'difference' were used in both the abstracts and the *EBM* synopses that were specific for the Result element. We found nine words that only occurred occasionally in

Table 5 Potential text patterns that would help identify PECODR elements found in 20 journal abstracts and their *Evidence-Based Medicine* journal synopses: occurrence by document and theme-related extract sorted by percentage of occurrence in PECODR element-related extracts

Text patterns	PubMed abstracts		*EBM* synopses	
	No. of extracts in which the pattern occurs	Percentage of total occurrences found in element-related extracts*	No. of extracts in which the pattern occurs	Percentage of total occurrence found in element-related extracts
COMPARISON				
comparing	2	100	4	50
compared	19	83	20	86
placebo	47	83	20	84
standard	3	80	4	75
versus	2	71	5	100
than	42	67	18	81
OUTCOME				
end point	3	100	0	N/A
mortality	35	85	50	93
death	5	83	8	89
incidence	12	75	5	83
outcome	14	70	34	76
cause	10	56	34	89
adverse	2	33	12	92
admission	0	N/A	6	86
DURATION				
throughout	0	N/A	1	100
wk (shortened form of week)	0	N/A	4	80
long-term	6	86	0	N/A
RESULTS				
cast doubt	1	100	0	N/A
challenge	1	100	0	N/A
chance	1	100	0	N/A
closely	1	100	0	N/A
frequent	1	100	0	N/A
gradient	1	100	0	N/A
replicate	1	100	0	N/A
superiority	1	100	0	N/A
strongly	2	100	0	N/A
fewer	3	100	7	88
better	3	100	5	71
likely	1	100	2	67
decrease	3	100	2	50
correlated	1	100	2	100
differ	11	92	24	83
confidence interval	9	90	0	N/A
increase	8	89	13	76
significant	25	86	5	83
difference	6	86	6	75
odds ratio	5	83	1	100
occur	4	80	1	50
associated	7	78	5	83
greater	3	75	3	100
higher	5	71	2	67
ruling	0	N/A	1	100
highest	0	N/A	1	100
lowest	0	N/A	1	100

* Thus the word ‘comparing’ only occurred twice in all the 20 abstracts but in each case it was in a comparison element

the abstracts; these were highly specific for the Result element, but were not used at all in the *EBM* synopses. Conversely, we found three words that were infrequently used highly specific terms in the *EBM* synopses, but were not found in the journal abstracts. The term 'confidence interval' was not used at all in the *EBM* synopses and 'odds ratio' was only used once, but both were frequently used in journal abstracts and were highly specific for the Results element.

Discussion

Our results suggest that the majority of key elements of a structured question (Patient–Problem, Exposure, Comparison, Outcome, Duration and Results) might be available in most PubMed abstracts that describe RCTs, systematic reviews, diagnostic tests, ætiology and clinical prediction rules. In addition, we found what seem to be highly specific terms for several of the PECODR elements that would certainly assist automatic recognition of these elements. To our knowledge, this is the first time that anyone has systematically tried to identify these elements using both the abstracts and their related 'gold standard' *EBM* synopses.

There have been advances in indexing of trials by the National Library of Medicine, with new 'publication types' such as 'Controlled Clinical Trial' introduced in 1995, and their work to 'retag' reports of RCTs not already indexed with the appropriate 'Randomised Controlled Trial' or 'Clinical Controlled Trial' publication types that have led to highly sensitive search strategies.[21] The Unified Medical Language System (UMLS) might be the nearest approach we have to a complete glossary of the terminology required, and this has been used to try to index the medical literature automatically,[22,23] but has not been cross-matched to PECODR elements. The recommended structures for reporting randomised clinical trials produced by the CONSORT working group,[24] and diagnostic studies produced by the STARD group,[25] include many recommendations for the methods and the results sections of the text. However, for the abstract the CONSORT statement only recommends 'How participants were allocated to interventions (for example, "random allocation", "randomised", or "randomly assigned")' and the STARD statement only recommends 'Identify the article as a study of diagnostic accuracy (recommend MeSH heading "sensitivity and specificity")'.

Some terms and words are used frequently and are specific for the Comparison, Outcome and Results elements of both abstracts and synopses. However, the Patient–Problem and Exposure elements are not so easily defined by a generic set of terms. This is not surprising as they tend to be far more specific to each paper, and in a set of 20 papers we would not expect to find patterns of various exposures or patient description.

We found a difference in the lexical structure of phrases containing PECODR elements between PubMed abstracts and *EBM* synopses that could reflect the variation in abstract style of the publishers of the individual journals compared with the rigid structure of the synopses. The different frequency of statistical terminology found between the PubMed abstract and the *EBM* synopsis demonstrates how *EBM* synopses are tailored for a clinically oriented audience by limiting use of statistical terms.

Study limitations

This was a pilot study to explore feasibility of identifying PECODR elements within abstracts and *EBM* synopses. Only 20 abstracts and their synopses were analysed, by only three people. However, even within this limited number of abstracts, we retrieved 759 extracts relating to PECODR elements from the PubMed abstracts and 835 from the *EBM* synopses. The terms described in Table 4 that relate to the elements were identified manually using NVivo and not as part of a quantitative approach. This, combined with the small sample size, would explain why we did not find text patterns associated with Patient–Problem, Duration or Outcome. We would expect to find patterns with these elements using a quantitative approach in a much larger sample of abstracts. Future research now needs to be undertaken in this direction.

Conclusion

We could not find any search engines that have indexed medical articles using any of the key trial elements of Patient–Problem, Exposure, Comparison, Outcome, Duration and Results (PECODR) to improve the effectiveness of information retrieval. Our pilot work demonstrates that not only is this possible using purely the abstracts in many cases, but with the development of lexical rules based on this preliminary analysis, we believe it might be possible partly or possibly completely to automate this process. A program could be developed using lexical semantic rules of the sort we have identified retrospectively to identify and index the PECODR elements of large numbers of clinical trials. However, this software will take time to develop, so in the interim both primary and secondary care research journals should identify clearly within the abstract formats these specific elements to aid primary care professionals in retrieving information more effectively.

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CONFLICTS OF INTEREST

None.

ADDRESS FOR CORRESPONDENCE

Dr Martin Dawes
Chair, Family Medicine
McGill University
515 Pine Avenue West
Montreal, Quebec
Canada
Tel: +1 514 398 7375 x0469
Fax: +1 514 398 4202
Email: martin.dawes@mcgill.ca

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