EDUCATION

How to write and publish an original research article

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Most physicians have had little or no exposure to systematic teaching or training during the medical school and residency with respect to writing and publishing an original research article. The framework of every article should include the study objective(s), study design, results, and conclusion(s). The current "Clinical Opinion" article proposes a set of guidelines, based on the authors' experience, which can be useful to junior physicians who plan to publish their work. These guidelines should assist not only in the writing process of the initial manuscript but also in responding to reviews and in modifying the original manuscript.

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One of the most frequent, and often overlooked, issues today is the apprehension or fear of young physicians, residents, or fellows to write a peer-reviewed article. Many of these young physicians, despite their desire to pursue academic writing, become very reluctant because of perceived lack of time and/or mentorship. The current article provides writing guidelines to assist young authors in beginning this process. The skill to write and publish a paper is not necessarily "inherited"; it is often acquired but it requires strict adherence to certain principles. Because most young physicians are rarely exposed systematically to such training principles of "how to write and publish a paper" during their medical school or residency, it comes as little surprise that most hesitate to write and submit a paper for publication. One of the natural by-products of knowing "how to write and publish a paper" is the ability to also critically read or even "review" a paper for the journals. In our view, physicians who know how to write and publish a paper, also know how to critically read or review a paper (the converse is not true). Therefore, it is of paramount importance in academic medicine to teach and encourage young physicians on how to write and publish a paper. The purpose of this article is to outline a set of general guidelines (tips) that the authors have found to be useful, which young physicians may use as a guide to writing and eventually publishing a peer-reviewed article.

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Tips to consider while writing a paper

First, the author(s) should be aware of the specific reporting guidelines that many journals have adopted, such as the CONSORT for randomized controlled trials,[1] QUORUM for metaanalyses and systematic reviews of randomized controlled trials,[2] MOOSE for metaanalyses and systematic reviews of observational studies,[3] STARD for studies of diagnostic accuracy,[4] STROBE for observational studies,[5] STREGA for genetic association studies,[6] and other guidelines for reporting economic evaluation studies.[7] In addition, authors should consult the "Guidelines for Authors" and the specific requirements of the journal in which they intend to submit their manuscript.

A peer-reviewed article should be considered as a means of communication. As such, it should be simple with clear organization of the thought process. A presentation framework should be first established (Figure). This framework can be used for any peer-reviewed article and it should reflect the ideal flow of the paper after its completion with its connecting 4 main parts, including the study objective(s), study design, results, and conclusion(s). The conclusion(s) should be directly related or connected to the study objective(s). Critical readers or reviewers subconsciously form a "mental" image of the paper that they just reviewed by using a framework similar to the one described here. In general, a peer-reviewed article consists of the title, condensation (or précis or synopsis), abstract, introduction, material and methods (or patients and methods), results, comment (or discussion), and list of references.

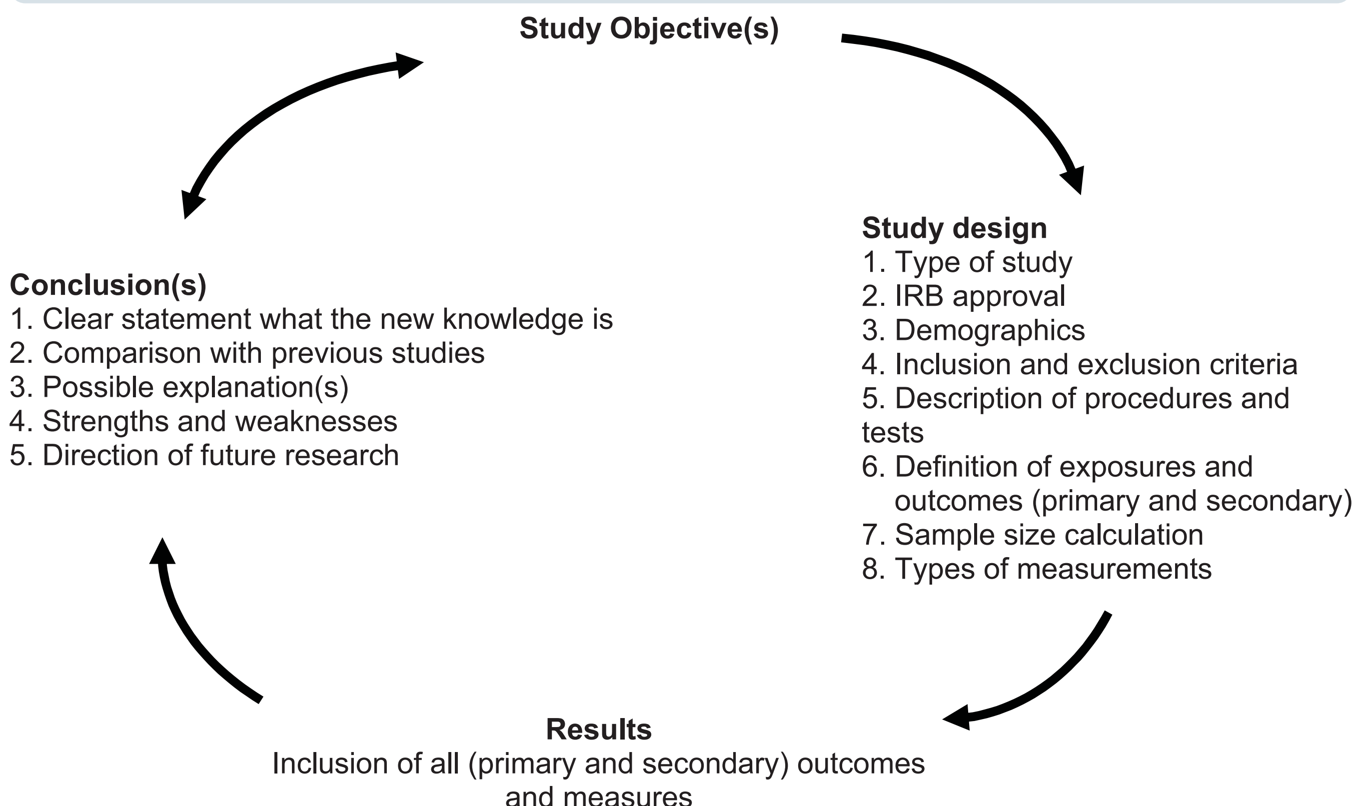
Title

The *title* should be relatively short and succinct. It should be easy to understand and at the same time intriguing enough to stimulate the interest of the reader. Long or confusing titles should be avoided because such titles may act as deterrents to further reading. Some journals may prefer to give the conclusion(s) in the title, whereas other journals require not to use concluding statements in the title. Some journals may not favor titles containing questions but we do because the question, as a title, usually describes the study objective and at the same time stimulates an interest to read further.

Condensation or précis or synopsis

The *condensation (or précis or synopsis)* should summarize the main conclusion or conclusions in 1 sentence containing no more than 25 words. The rule of thumb should be that this sentence should make sense and be understood by someone who has not read the article.

FIGURE
Framework of the peer-reviewed article reflecting the ideal flow of the paper and its connecting 4 main parts



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Many busy journal readers frequently read the condensation first even before deciding whether to read the abstract or the paper.

Abstract

The *abstract* is the "mirror" of the full manuscript. There is no doubt that the abstract is the most widely read part of the article by both those who peruse through the journal, as well as those who perform electronic literature searches. The abstract should be structured with specifically designed headings focusing the writer (and the reader) to the 4 main elements, namely, objective(s), study design, results, and conclusion(s). The author has the opportunity to use succinct language to summarize the paper by following 2 principles: (1) the abstract should be clear enough to be understood by a reader who may not read the rest of the article, and (2) the abstract should not be too long (word limitation varies from journal to journal).

Introduction

The *introduction* is 1 of the most critical parts of the article because it sets the tone for the reader and the reviewer. Ideally, the introduction should contain 2 components, preferably expressed in 2 paragraphs. The first paragraph should summarize the background information leading to a *rationale* for performing the study, justifying the *need* for the study, and clarifying the *new information* that the study aims to offer. The first paragraph should convince the reader that the study is not a "fishing expedition" but it is based on a solid background with respect to plausibility. The second paragraph should clearly state the study *objective* (or the hypothesis).

Materials and Methods (or Patients and Methods)

The *Materials and Methods (or Patients and Methods)* section should include descriptions of (1) study design; (2) documentation of institutional review board (IRB) approval and type of consent obtained, if applicable; (3) demographics of the study cohort, if applicable; (4) inclusion and/or exclusion criteria; (5) clear description of any procedures or tests; (6) clear definitions of exposures, and primary and secondary outcomes; (7) sample size calculation based on primary outcome; (8) types of measurements used; and (9) methods of statistical analysis and level of significance.

In our computerized age, there is widespread use of statistical software among young academic physicians and scientists. Some of the commonly used statistical software programs are SAS (http://www.sas.com/), SPSS (http://www.spss.com/), STATA (http://www.stata.com/), R (http://www.r-project.org/), SPlus (http://www.splus.com/), and MINITAB (http://www.minitab.com/). Tables 1 and 2 can serve as a quick reference to the choice of the appropriate

TABLE 1
Appropriate statistical tests for continuous, ordinal, and categorical data

Comparison	Continuous data	Ordinal data	Categorical data
2 groups of different subjects	Unpaired *t* test[a] or Z-test[a]	Mann-Whitney rank sum test[b]	χ^2 or Fisher's exact test[b]
≥3 groups of different subjects	ANOVA[a]	Kruskal-Wallis test[b]	χ^2 or Fisher's exact test[b]
Same subjects (before/after treatment)	Paired (matched) *t* test[a]	Wilcoxon-signed rank test[b]	McNemar's χ^2 test[b]
Same subjects (≥3 treatments)	Repeated measures ANOVA[a]	Friedman test[b]	Cochrane Q test[b]
Association between 2 variables	Linear regression/correlation[a]	Spearman correlation[a]	Contingency coefficient[b]

ANOVA, analysis of variance.

[a] Indicates test for parametric data; [b] indicates test for nonparametric data.

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statistical test(s) according to the type of the data to be analyzed and compared.

The descriptive statistics and methods of statistical analysis should be carefully determined based on the type of data to be analyzed. Data can be continuous (interval or linear), ordinal, or categorical. In descriptive statistics, continuous data that are assumed to follow a normal distribution are often expressed as "mean and standard deviation," continuous data without normal distribution or ordinal data are expressed as "median and interquartiles or ranges" and categorical data are expressed as proportions (percent).

Unfortunately, peer-reviewed articles frequently use inappropriate descriptive statistics. For instance, it is not infrequent for obstetric articles to use Apgar scores or parity (or gravidity) as continuous variables and express them as "mean" Apgar scores (or mean parity/gravidity). Examples include a mean 1-minute Apgar score of 7.5 or parity 1.5. However, Apgar scores, as well as parity (or gravidity) are often not normally distributed. In addition, in real life, Apgar scores or parity/gravidity are not expressed with decimals. Therefore, it is more appropriate to describe such variables by using median and ranges.

One of the most frequently used statistical methods with respect to the accuracy of a diagnostic test is the determination of its sensitivity, specificity, and positive and negative predictive values. The thorough and clear understanding of these terms is an absolute necessity for both the author, as well as the reader of a peer-reviewed article. It is axiomatic that to establish the accuracy of a test there should be a phase of observation (natural history) without an intervention that can alter the outcome. If there is an intervention as a result of an abnormal test result, which possibly can alter the outcome of interest, then the accuracy of the test cannot be established. The classical example of this scenario is our inability to truly establish the accuracy of intrapartum fetal heart rate monitoring because in real life, for ethical reasons, an "abnormal" fetal heart rate pattern will most likely lead to intervention (ie, instrumental or cesarean delivery), which may have prevented the "bad" outcome. Nevertheless, in such cases, the fetal heart rate monitoring "abnormality" may be erroneously perceived by some as a "false-positive test." Another area that authors and readers should be aware of is the effect that "prevalence" of disease has on the diagnostic accuracy of a test. The traditional teaching is that the sensitivity and specificity of the "disease" are not influenced by the prevalence of the disease and that only positive and negative predictive values are influenced by the prevalence of the disease. However, this principle is true only if the test conditions are "fixed" and the results are reproducible. If the test conditions are not fixed or if the results of the test are subjective, then sensitivity and specificity are definitely influenced by the prevalence of disease. Here, the classical example is the performance of an obstetric ultrasound to rule out fetal anomalies. If the *a priori* risk for a fetal anomaly is high (high prevalence of disease), the examiner will most likely pay much higher attention and spend more time to visualize completely all fetal structures. On the contrary, in a routine sonogram on women with low *a priori* risk (low prevalence of disease), it is expected that the ultrasound examiner may not exercise the same degree of scrutiny in the ultrasound examinaton. Thus, in the first case (high prevalence of disease), the sensitiv-

TABLE 2
Appropriate regression analyses according to the type of data

Data	Type of regression analysis
Dependent (Y) variable (outcome) is continuous	Linear regression
Powers of independent (X) variables	Polynomial regression
≥2 independent (X) variables	Multiple regression
Selection of best set of independent (X) variables	Stepwise regression
Dependent (Y) variable (outcome) has 2 categories	Logistic regression
Dependent (Y) variable (outcome) has ≥3 categories	Polytomous logistic regression or discriminant analysis

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ity of the (ultrasound) test to identify fetal anomalies is higher as compared with the second case (low prevalence of disease). Thus, it appears that the conditions of the (ultrasound) test are not fixed because there is intraobserver variation in the accuracy of the test depending on the prevalence of the sought disease (*a priori* risk). In addition, there is interobserver (subjective) variation in the accuracy of ultrasound as a test depending on the skill of the ultrasound examiner.

Another issue to be considered is that case-control studies can provide estimates of positive and negative likelihood ratios but not positive or negative predictive values. In addition, case-control studies do not allow determination of population prevalence or incidence of a disease.

Another consideration in this section pertains to articles in which a relatively new methodology is used where those details have been previously published in another report. In such instances, it is preferable to describe, briefly, that particular methodology again rather than referring the reader to those previously published reports. This shows respect for the reader's time.

Results

In the r*esults* section the author(s) should be prepared to give "results" for all outcome measures that are described under "Materials and Methods." The converse is also true. The paper should not contain results that are not mentioned under "Materials and Methods." The results may include text, tables, figures, or any combination of the above. Results should be given for all outcome measures (primary and secondary) that are described under "Materials and Methods." Here, the opportunity exists for reporting all the raw data. However, the editorial space should be respected by the judicious use of tables and/or figures, which have the purpose of saving editorial space and at the same time make it easier for the reader to understand or interpret the results. Each table or figure should stand on its own and be self-explanatory. In deciding the exact format and data to be depicted in each table or figure, it is a good idea to consider that each table or figure is a candidate for reproduction by another author for another publication. The text and tables should not contain raw numbers without percentages or percentages without the raw numbers. The numbers should be internally consistent and in agreement between the tables and the text. Any internal discrepancies in the numbers put in jeopardy the credibility of the author(s) and severely compromise the chances for publication. Confidence intervals provide more accurate indication of the strength of the associations and therefore, provide better information than *P* values; thus, in conjunction with the effect measure, confidence intervals should be used liberally.

The text should include a brief description and analysis of the findings and it should follow the order that tables and figures appear. The important findings should be highlighted that may or may not be statistically significant. Again, the editorial space should be respected and detailed description or repetition of all the information depicted in the tables or figures should be avoided.

Comment (or discussion)

The c*omment (or discussion)* section should include the following: (1) clear statement of what the principal findings were, as well as the *new knowledge* that the current study offered; (2) strengths and weaknesses of the study; (3) comparison of the findings of the current study with those of previous studies; (4) clarification regarding the similarities and differences with the findings of previous studies; (5) possible explanation(s) for the different findings; (6) clear and concise conclusion of the meaning of the study as it relates to clinical practice or future research; and (7) proposal for future research.

References

The *references* list may be one of the most important parts of the paper with respect to the chances for publication. The reason for this is because editors frequently use as reviewers those included as authors in the reference list. This is only natural because some of the references have authors who have completed similar work and therefore, they are considered experts.

At this point, it should be emphasized that for studies requiring IRB submission and approval, and almost all studies do, the introduction, materials and methods, a significant portion of the discussion, and the references are already most likely included in the IRB application. Thus, most of the hard work in regard to the writing of the paper is already done.

Tips to consider before submitting the manuscript for publication

Before submitting the paper for publication, all coauthors should have the opportunity to review the manuscript and provide suggestions. In addition, consideration should be given to the following: (1) ask someone with experience in writing or reviewing peer-review articles to review the paper. It would be preferable that this senior reviewer is not very familiar with the study details, so that he/she can be a neutral barometer regarding the quality of the paper; (2) the paper should not contain any contradictions; (3) the paper should be understood by a reader with average knowledge; and (4) avoid errors.

As per the authors' experience as peer reviewers, the most frequent errors are as follows: (1) inappropriate conclusion(s), for example, conclusions that are applied to populations different than the one used in the study or conclusions implying cause-and-effect relationship based on inappropriate study designs; (2) lack of power analysis; (3) inadequate sample size; (4) too much confidence in negative results from small samples; (5) improper use of statistics; (6) when multiple comparisons are made true clinical significance should not be assumed if 1 or few comparisons turn out to be statistically significant because this can happen by chance alone; (7) incorrect use of statistical terminology with the terms "multivariable" vs "multivariate." Unfortunately, these 2 terms are being used interchangeably. However, the term "multivariable" refers to situations when a response or disease status is measured once (ie, as in case-control studies), and

the association between an exposure and an outcome is assessed after adjustment for confounders. In contrast, the term "multivariate" refers to situations when the response is measured repeatedly on the same subject, thereby yielding a "vector" of responses for each subject, and hence "multivariate"; (8) inappropriate reporting of "rates of proportions" without any reference to the numerators and denominators. It is not good practice to present (or interpret) relative measures (ie, relative risk) without examining absolute measures (ie, absolute risk); (9) possible retrospective manipulation of the study objective according to the (positive) findings; and (10) misspelling of the authors' names that are cited in the references. If an authors' name is misspelled, and that author is one of the assigned reviewers, the reviewer may be "turned off."

Tips to consider after receiving the editor's response

A few weeks after submission of the paper, it is expected that the editor's response, along with the reviewers' comments, should be received. Based on the editor's letter and the reviewers' comments, the presumed disposition of the paper can be in 1 of 4 categories: (1) acceptance without revisions, as is (extremely rare); (2) possible acceptance after minor revisions; (3) possible acceptance after major revisions; and (4) rejection. Each 1 of these 4 initial dispositions requires a different course of action to maximize the chances for publication.

If the paper is accepted without revisions, we suspect this is a very rare occurrence, the only challenge is to correct the galley proofs very carefully. This task should not be taken lightly because "what goes in print, stays in print forever." The quality of the galley proofs varies from journal to journal. Sometimes, editors or publishers may change the meaning of the article in their attempt to improve it by substituting certain words with others. If the error is substantial and it is caught late, it may be acknowledged as an "erratum" in a subsequent edition of the journal; but, it is almost certain that most of the audience will be unwilling to go back and read the original article again to obtain the complete picture. In other words, the damage may be irreparable. There have been instances that typographic errors were not caught until months or years later when a particular table or figure was reproduced for another publication in another journal. This is clearly an avoidable situation for which particular attention has to be given, especially by busy physicians.

If the paper needs revisions, we suspect most papers do, the revisions can be minor or major. It is a good policy to follow all minor revisions assuming that the clarity or quality of the paper will not be compromised. In such cases, the acceptance for publication is almost certain. However, the situation is quite different when major revisions are required. Major revisions can be categorized in 4 categories (each requiring a different action): (1) those that improve the quality of the paper, when revised (it is strongly advisable to implement the suggested revisions); (2) those that have no effect on the quality of the paper (it is advisable to implement those changes to the extent possible); (3) those that may diminish the quality or clarity of the paper (it is advisable to not follow those suggestions); and (4) those that are impossible to do (they cannot be done). The rule of thumb is that if all or most suggested major revisions are followed, the acceptance is almost certain, whereas if several of the suggested revisions are rebut the acceptance remains uncertain. The chances are that the paper most likely will not be accepted if all suggested major revisions are refuted.

When the paper needs to be revised, especially when major revisions are needed, the most critical factor that will determine the fate of the paper is the cover letter to the editor. This letter should address each revision separately. Here, the author has the opportunity to "communicate" directly with the individual who has the ultimate power in deciding the fate of his/her paper. Editors read a large number of manuscripts and cover letters every day. Therefore, the cover letter has to be clear and concise addressing each criticism and need not be lengthy. If a suggested revision was followed, it is good practice to state in the cover letter: "the revision was followed" and indicate its exact location in the revised manuscript. All revisions should be highlighted in the revised manuscript. If a suggested revision was not followed, it is imperative to explain why. If the rebut is not convincing to the editor and it involves several revisions, then the editor may send the revised manuscript back to the reviewer who suggested the particular revisions in the first place and that may decrease the chances for publication dramatically. Thus, it is of paramount importance to put forward an extremely logical and concise rebut in your cover letter to the editor, so he/she does not send your revised manuscript back to the reviewers.

The fourth possibility, which is quite frequent, is that the paper is rejected from publication. This can be extremely disappointing, even heartbreaking, especially for young investigators who may take the criticisms personally. Fortunately, many editors use language to indicate that their decision was very much influenced by the high volume of papers that they receive and that this does not necessarily mean that the paper has no value. In case of rejection, it is advisable to try to improve the paper, before submitting it to a second journal, by addressing all the issues raised by the reviewers. This is recommended for 2 reasons: (1) some journals may ask if this is the first submission. If it is not, they may want to see how the criticisms of previous reviewers have been addressed; and (2) quite frequently the same reviewers may be asked by the editor(s) of the second journal to review that same paper. If none of their criticisms have been addressed it is natural, and quite justifiable, to feel insulted, it is certain that the paper will be rejected again. The same process should be carried out in the event of more submissions to more journals. However, one should be mindful that the paper does not lose clarity or focus in its final form after multiple revisions.

The last piece of advice for those young investigators who are apprehensive or fearful about writing and submit-

ting a paper for publication has to do with the realization that there is a very large number of obstetrics and gynecology journals, both in the United States and abroad, which are available and willing to consider publishing their work. In our view, adherence to the guidelines described previously will most likely increase the chances for publication. ■

REFERENCES

1. Moher D, Schulz KF, Altman D. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. JAMA 2001;285:1987-91. Available at: http://www.consort-statement.org. Accessed May 7, 2009.

2. Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF. Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement: quality of reporting of meta-analyses. Lancet 1999; 354:1896-900. Available at: http://www.consort-statement.org/index.aspx?o=1347. Accessed May 7, 2009.

3. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting, meta-analysis of observational studies in epidemiology (MOOSE) group. JAMA 2000;283:2008-12. Available at: http://www.consort-statement.org/index.aspx?o=1346. Accessed May 7, 2009.

4. Bossuyt PM, Reitsma JB, Bruns DE, et al. Towards complete and accurate reporting of studies of diagnostic accuracy: the STARD Initiative. Ann Intern Med 2003;138:40-4. Available at: http://www.stard-statement.org. Accessed May 7, 2009.

5. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007;370:1453-7. Available at: http://strobe-statement.org/index.php?id=checklist. Accessed May 7, 2009.

6. Little J, Higgins JP, Ioannidis JP, et al. Strengthening the reporting of genetic association studies (STREGA): an extension of the STROBE Statement. Hum Genet 2009;125: 131-51. Available at: http://hum-molgen.org/NewsGen/03-2009/000015.html. Accessed May 7, 2009.

7. Vintzileos AM, Beazoglou T. Design, execution, interpretation, and reporting of economic evaluation studies in obstetrics. Am J Obstet Gynecol 2004;191:1070-6. Available at: http://www.elsevier.com/framework_products/promis_misc/ajoghealth.pdf. Accessed May 7, 2009.