Judges' Commentary: The Outstanding Healthcare Papers

Sarah Root
Dept. of Industrial Engineering
University of Arkansas
Fayetteville, AR

Rodney Sturdivant
Frank Wattenberg
Dept. of Mathematical Sciences
U.S. Military Academy
West Point, NY

Introduction

The Interdisciplinary Contest in Modeling (ICM) is a vehicle for students in teams to develop a model to address a problem posed to them, over a four-day weekend. The contest challenges not only students' creativity and modeling prowess, but also their ability to work together in a time-constrained environment. Many of these teams' modeling effort and analysis is truly impressive. In early April, eight judges gathered to read, compare, and contrast the submissions to the contest. Like many of the teams, the judges were an interdisciplinary group with backgrounds in mathematics, statistics, healthcare administration, industrial engineering, and operations research.

The Problem

Teams faced the problem of developing a model to compare many of the world's healthcare systems. This is a timely and relevant issue, particularly in the U.S. with the upcoming presidential election. Although per capita the U.S. spends the most on healthcare, several countries have vastly better health outcomes. In addition, many point to inequities in the U.S. system, resulting

The UMAP Journal 29 (2) (2008) 169–174.

from a substantial percentage of the population that is either uninsured or underinsured, as evidence that the U.S. system could be improved.

The problem required teams to look at issues faced by countries around the world, including developing a model to help compare the countries' healthcare systems across these issues. The problem tasks fell into four main categories:

- **Metric Identification and Selection.** The teams had to identify metrics for efficiency and effectiveness of healthcare systems and then specify where such data could be obtained. Teams needed to incorporate at least three metrics into their models and justify the importance of the metrics selected.
- **Model Development.** After identifying the metrics, teams had to developing a methodology or model to use these data to compare healthcare systems.
- **Analysis and Comparison of Healthcare Systems.** Teams were to exercise their model to perform at least two comparisons: one to compare the U.S. to a country considered to have a good healthcare system, and a second to compare the U.S. to a country with a poor healthcare system.
- **Recommendations to Restructure a Healthcare System.** After performing the comparisons, teams were to select a country and use their model to suggest changes to restructure its healthcare system. They were either to adapt their existing model or to construct new models to suggest to what degree various changes would improve the system, as measured by the metrics that they had selected.

Overall, the judges were impressed both by the strength of many of the submissions and by the variety of approaches used.

Judging Criteria

To structure the judges' thinking and to ensure consistency across judges, we developed a rubric to evaluate submissions. Its framework encompassed:

- **Executive Summary:** It was important that a team succinctly and clearly explain the highlights of their submission. The executive summary needed to include the metrics selected, modeling approach(es) used, results from comparisons, and recommendations to restructure a healthcare system. Most teams did this. What distinguished the Outstanding papers was the clarity with which the authors connected these topics and conveyed substantial information in the executive summary.
- **Scientific Knowledge and Application:** This task required that teams either have or develop some knowledge about healthcare systems and mechanisms by which effectiveness can be measured. The majority of teams did this relatively well, selecting relevant metrics to use in their analyses. The teams that excelled in this area went beyond traditionally available metrics. For example, some teams combined readily-available metrics into new ones

that would more accurately assess a healthcare system's efficiency or fairness. Others arranged their metrics into groups that would shed light on the analysis. Another way in which teams distinguished themselves in this area was by exploring the tradeoffs between metrics and their limitations. For example, one team noted that although the lifespan of the population was an important metric, various interventions to improve the population's health would take a long time to impact the overall lifespan of the population.

- **Modeling and Assumptions:** The most effective papers made their assumptions explicitly from the scientific foundation that they developed in order to build their models. Models ranged widely in complexity, with factor analysis the most popular approach to synthesizing metrics. It was important that the modeling process was well formulated and robust; but unfortunately, some papers had wonderful models that offered little explanation of how the model functioned or provided little use of the results in the analysis. The ability to use the model to make conclusions and recommendations about healthcare systems distinguished the Outstanding papers regardless of model choice.

- **Analysis/Reflection:** Successful papers discussed how their models addressed issues and tasks of improving the healthcare system in a country. The later requirements of the project were often not addressed, or only superficially. As an example, teams often used models to produce scores to compare countries and conclude that the healthcare system of one was better than another. However, they did not delve into why one country scored higher or to address whether the result was meaningful. In some cases, the final task of restructuring a healthcare system was given very little attention. The best papers used the results of their model to support their recommendations for changes in a healthcare system.

- **Communication:** The ability to communicate effectively really distinguished the best papers from the others. In some cases, the mathematical model was presented with little or no explanation; so, while the work appeared promising, judges could not follow the exposition or determine how the model was used to address the issues. The judges noted several very specific things that made papers stand out, including presenting the work clearly and concisely and effectively connecting the science to the modeling process. Some papers described the healthcare system and issues well but then lost that thread as they began the modeling process. Additionally, some papers were disjointed, possibly because different team members wrote the various sections without ensuring continuity throughout the document.

Discussion of the Outstanding Papers

The Outstanding papers demonstrated true understanding of the difficulties and complexities of healthcare systems, included well-formulated models, and used this work to make thoughtful and interesting suggestions for improving healthcare. While the time constraint of a single weekend meant these papers were not perfect, each team produced work with distinguishing features.

- The Beijing University of Posts and Telecommunications submission (pp. 113–134) is notable for the impressive array of modeling techniques utilized in attacking the problems. There were other papers with a similar level of modeling, but this group not only describes the modeling process clearly but connects the models coherently to the problem at hand. To improve healthcare in the U.S. they propose, among other things, increasing "the ratio of general government expenditure on health to private expenditure" while "decreasing total expenditure on health as a percentage of GDP."
- The paper from the National University of Defense Technology (pp. 155–168) includes perhaps the most comprehensive review of healthcare systems, metrics, and issues among all submissions. The paper is also notable for the sensitivity analysis of its models. Further, this team continues to tie their scientific knowledge throughout the paper, resulting in exceptional comparisons and evaluation of healthcare systems based on their models. They recommend a "medical insurance voucher" to "increase the insurance coverage and reduce the unfairness" in the U.S. healthcare system.
- The Harvey Mudd College submission (pp. 135–154) was among the most clearly and concisely written papers. The team uses "meta-metrics" to map scores on various healthcare metrics into three areas. These then feed into a stochastic model to analyze various changes to a healthcare system. The result is a very strong set of well-supported recommendations for healthcare change in the U.S., such as "emphasis on the prevention of illness," as well as a "shift towards a more centralized healthcare system in order to make care more accessible to lower- and middle-class individuals."

Two other papers, not designated Outstanding and not published in this issue, stood out for the judges.

- The first of these considers healthcare through the eyes and life of "Simon," "an entity who currently does not exist" but "is equally likely to be any person in the world." This paper is not only incredibly clever and creative but demonstrates an outstanding understanding of particularly the economic side of the healthcare debate. The abstract concludes, "Simon says the United States needs healthcare reform now. As we have been told since childhood, it is always good to do what Simon says." Hear, hear.
- The second paper considers the healthcare system through "the lives of John and Jane Doe" and builds a "Virtual Life Model" from first principles. Again,

a very creative and interesting paper! This team notes improvement in the U.S. system but could improve through changes to "prevention, treatment, and access" components of healthcare.

Conclusion

The judges extend their congratulations to all who participated in the contest. The submissions represented not only a variety of approaches that teams used to model the problem, but also a variety of approaches to analyzing the results obtained by the model. Reading your submissions was an enjoyable activity. As judges, we will be excited to see both the types of problems that you approach and the creativity that you use as interdisciplinary modelers after you complete your studies.

Recommendations for Future Participants

- When ideas, assumptions, modeling concepts, and other aspects of the problem are clearly explained, it is easier to separate work that is outstanding from work that is just good. Aim to communicate your ideas clearly and concisely.
- Address all aspects of the problem that are asked. Omitting questions that are asked in the problem statement will not result in a submission that is competitive.
- Simple explanations are usually better than complicated ones. Both clarity and brevity in explanations are preferred to explanations that are long, rambling, and sometimes confusing.
- It is important to cite precise sources for work or words that are not your own. Material taken from other sources must be thoroughly documented and placed in quotation marks.
- The selection of an appropriate modeling approach is critical, but using the model to analyze the problem and present recommendations is often more important than the model itself. Teams should spend time not only in developing the model but in using it to obtain recommendations, analyze different scenarios, and perform sensitivity analysis.
- The recommendations that you make to decision-makers should stem from your model. They should not simply be the result of Internet research or other sources that are independent of your model.
- Team members should work to integrate their final submissions. The judges should not be able to distinguish clear breaks in communication or—worse—identify contradicting information in portions of the paper that were written by different team members.

About the Authors

Sarah Root is an Assistant Professor of Industrial Engineering at the University of Arkansas, where she teaches courses in operations research and service systems engineering. Her research interests are primarily in modeling and solving large-scale optimization problems, particularly those arising in logistics and healthcare systems.

Rod Sturdivant is an associate professor at the United States Military Academy in West Point, NY. He earned a Ph.D. in biostatistics at the University of Massachusetts—Amherst and is currently program director for the probability and statistics course at West Point. He is also founder and director of the Center for Data Analysis and Statistics within the Department of Mathematical Sciences. His research interests are largely in applied statistics with an emphasis on hierarchical logistic regression models.

Frank Wattenberg is a professor in the Department of Mathematical Sciences at the United States Military Academy (USMA), West Point. He is particularly interested in modeling and simulation and in the use of technology for simulation and for education across the undergraduate curriculum. He is currently leading a team at the USMA that is developing *Modeling in a Real and Complex World* to be published as part of the MAA Online Book Project. He is also working with colleagues at USMA and elsewhere to develop rich immersive environments for modeling and simulation. This project will produce environments with both virtual and hands-on components that students will revisit from middle school through college and from many different subject areas and levels. The architecture will support collaborative modeling and simulation based in part on the ideas of multiplayer games.