Editorial

Big Data and Behavioral Economics in Infectious Diseases

In our modern-day world, so much of our day-to-day life is heavily influenced by "big data" and "behavioral economics." Retailers mine vast amounts of data about our prior purchases and browsing history to suggest other products that we should buy. Pricing and comparison strategies are meant to influence our decision-making in such a way to facilitate buying a particular product at a particular time to meet our perceived need. According to Oxford Languages, "big data" is defined as "extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions." "Behavioral economics" is defined as "a method of economic analysis that applies psychological insights into human behavior to explain economic decision-making." One can easily see how these principles have applications well beyond buying widgets, and many have tried to apply them to improving health care. The coronavirus disease 2019 (COVID-19) pandemic has placed a magnifying

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glass on how individuals in our society make decisions that affect themselves, their immediate family and friends, and the general public. Both big data and behavioral economics have played an enormous role in how pandemic care and vaccines have been implemented across the country. In this Specialty Update, we have organized a collection of articles to examine how these principles apply to the field of infectious diseases.
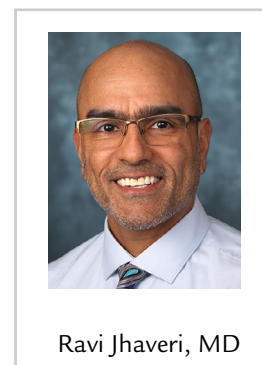
In the first article, Richards and Linder[1] review the role of behavioral economics in antimicrobial stewardship. They highlight that so much about antimicrobial prescribing is dictated by individual human behavior, and thus stewardship efforts have focused a great deal of attention on trying to get providers to make better decisions when it comes time to prescribe or not prescribe antibiotics. They frame their review in this way:

> "*Viewing inappropriate ambulatory antibiotic prescribing as an undesirable behavior allows the application of behavioral economics and nudges to change prescriber behavior. …. Nudges to improve ambulatory antibiotic prescribing could address context, attitudes, cognitive frames, or social implications to make doing the right thing easy or motivating.*"

Their article is a comprehensive review of antimicrobial stewardship efforts in this arena, but it also provides robust foundational knowledge for anyone interested in the topic.

The second article takes the discussion one step further about applications of behavioral economics to antimicrobial stewardship. Parzen-Johnson et al[2] review how the electronic health record (EHR) systems are a powerful tool that can be used to influence provider decision-making to promote antimicrobial stewardship. They briefly summarize the power of EHRs to achieve this end in their introduction:

> "*As EHRs have become increasingly complex, they have acquired a range of functionalities to affect antimicrobial prescribing behavior…In some cases, display of information or order entry is deliberately constructed to 'nudge' providers towards judicious prescribing. Interventions like these can have significant impact on prescribing patterns while requiring minimal up-front cost or effort.*"

In this review, the authors highlight some of their real-world experiences successfully using these strategies via the EHR, and they also offer some tips for those interested in implementing some of these strategies at their institutions.

Vaccination has the power to protect both individuals and society, and thus the decision to vaccinate has been scrutinized for ways to get patients and parents more comfortable with accepting recommendations. One communication tool that has been well studied is use of the "Affirmative Approach" to communication about vaccines.[3] In this issue, Dr. Rachel Caskey reviews how various behavioral economics strategies have been used or could be applied to promoting immunization[4]. In 2021, this topic is in the news every day as public health officials

grapple with large portions of populations who remain unvaccinated against severe acute respiratory syndrome coronavirus 2.[5,6] Dr. Caskey highlights one common strategy of "changing the default option":

> *"Changing the default behavior (in this case, declining a vaccine) can influence behavior. Most adult activities require opting-in to a behavior, leaving the default as no action. However, changing the default to an opt-out model has been shown to impact multiple individual behaviors including increase retirement savings and organ donor rates; as well as vaccination rates......Similarly, changing the choice architecture for clinicians also changes behavior."*

Given the ongoing discussions about convincing many more people to get vaccinated against COVID-19, this commentary offers a great overview of what has been attempted before and what has worked well to promote vaccination.

Big data in clinical research have long been promised as the panacea for all the limitations of traditional clinical trials. The power to harness the "real-world" experience to answer questions such as "What risk factors are associated with worse outcomes?" or "Which treatment works better for which patients?" is within the realm of possibility. My colleagues Marc Rosenman, Jordan John and I review some of the fundamental principles of EHR-based research, discuss some of the most common sources of big data, and offer a guideline for getting started in EHR research.[7] We highlight the potential advantages using the example of the relatively rare infection of mucormycosis:

> *"Because this infection is a rare event, randomized clinical trials are virtually impossible. However, the collective number of patients seen across most of the United States may be significant with different institutions having slightly different practices…The clinical information for all patients in such a database would be standardized so data could be pooled easily and analyzed across institutions."*

The COVID-19 pandemic offers many examples of how EHR-based research has offered us tremendous insights into how to better identify those patients at risk of the worst outcomes, and the pandemic has helped accelerate the penetration of EHR-based research into infectious diseases.

Lastly, if one wants to use large data sets for research, then one needs to have the proper statistical tools to analyze these data. Weltz et al[8] review reinforcement learning methods in infectious diseases and public health. Unlike static models of disease dynamics, reinforcement learning models allow for the uncertainties that are associated with public health situations and can be updated as new information is obtained about a particular disease entity. The authors share in their introduction to the topic:

> *"A central idea in [reinforcement learning] is learning from experience so that models and intervention decisions are continually improved as data are collected…. Optimal RL strategies seek to experiment only if and when the value of information generated by experimentation outweighs the cost of deviating from the estimated optimal decision; in this way, they maximize cumulative utility over the duration of the decision process."*

The authors offer several real-world examples that illustrate the statistical and mathematical principles discussed.

I would like to conclude by thanking all of the contributing authors for sharing their expertise with our readers. We value their efforts in helping bring this Specialty Update together. Because this is our annual update in infectious diseases, I would also take the opportunity to salute my fellow health care workers across the United States for their ongoing professionalism and dedication during this COVID-19 pandemic to a population that is still grappling with their obligation to their fellow citizens. It is tempting to become cynical and dispirited in this environment, but it is important to remember that there are multitudes of people who have benefited from our efforts, and that we in the health care community appreciate each other.

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