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Predictive Medicine

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Introduction

Healthcare in the United States primarily is based on diagnosing the presence of disease and subsequently treating the disease if it is present. Consider several of the most prominent medical advances of the past century: [0][0]

- Antibiotics to treat various infections
- Cardiac catheterization to treat the obstructed coronary vessel(s)
- Beta blockers to treat high blood pressure

Though widely accepted to result in better outcomes at lower cost, preventative medicine has received far less fanfare. One issue is that preventative medicine is less profitable. Another is that our understanding of individual risk for individual diseases is poor. For example, while we know that risk factors such as smoking and pollution increase a population's rate of lung cancer, we cannot reliably predict the risk of lung cancer in a given individual even if smoking and pollution status is known; after all, not every person who smokes or lives next to a freeway will develop lung cancer. As a result, our current approach to preventative medicine is to universally apply a one-fits-all intervention; seatbelts, vaccinations, diet, and exercise are prime examples.

However, when considering additional preventative measures, there is limited to no understanding of individual risk for a disease. If new interventions were applied universally, huge amounts of resources would be wasted on implementing those measures on individuals who were never at risk for that outcome in the first place. Consider the waste, complications, and moral implications in a hypothetical scenario of performing universal mastectomies to prevent breast cancer.

Function

Predictive medicine is a relatively new subspecialty in healthcare, but the concept is not novel. In the most basic terms, predictive medicine utilizes specific laboratory and genetic tests to determine the probability if an individual will develop a disease. The use of biomarkers has been common in the field on oncology to predict recurrence of cancer, but now the aim is to increase the use of similar biomarkers to predict the more common clinical disorders in everyday life.

Issues of Concern

Predictive Medicine

Ideally, we would calculate a person's individual risk for breast cancer or any other disease and intervene appropriately. This is the goal of predictive medicine, the practice of obtaining and cataloging characteristics about individual patients, analyzing that data to predict the patient's individual risk for an outcome of interest, predicting which treatment in which individual will be most effective, and then intervening before the outcome occurs.Traditionally, predictive medicine was exclusively confined to the realm of genetics. It was once thought that genetics would revolutionize medicine and, in fact, genetics and genomics have improved our ability to predict individual risk for some diseases (e.g., the BRCA gene and breast cancer) and predict which treatment will be more effective in a given individual (e.g., therapy directed at a molecular target in cancer). However, genetics-based risk prediction has proven of limited benefit for reasons including (1) Whole genome sequencing is still relatively expensive and not currently covered by insurance, and (2) the majority of diseases afflicting the population today is multifactorial. Heart disease, for example, is influenced not only by genetics, but also by age, diet, exercise, and stress levels. Collecting and organizing this data for analysis is invaluable.

The Big Data Revolution [0]

Though never formally quantified, healthcare data already has been collected on a titanic scale; every vital sign, medical chart, and radiology image from every clinic, pharmacy, and hospital collectively represent only a tiny fraction of data points available for analysis. Social media data, billing data, census data, and more also include information that contributes to healthcare outcomes. The amount of data increases exponentially as the price of data collection, storage, and processing decrease. All this data, coupled with newer computer-based analytic techniques, such as machine-learning, make up the so-called "Big Data Revolution." With big data, predictive medicine may soon be able to quantify individual risk for a variety of healthcare outcomes and determine optimal, personalized treatment options. Other industries already have taken advantage of this revolution and are continuing to refine their predictive applications: banks can predict a customer’s individual risk for defaulting on a loan, social media websites predict the type of advertisement to which a user is most likely to respond, and insurance companies predict how likely an individual is to file a claim. Most importantly, these industries have been able to develop the software and workflow infrastructure needed to deploy these analyses in real-time on the front lines of their operations.

Clinical Significance

To achieve its goals, predictive medicine must similarly not only provide applicable insights about outcomes that have not yet occurred, but also deliver these personalized insights to frontline healthcare providers such as physicians, mid-level practitioners, and nurses at the point of patient contact. Otherwise, the potential of predictive medicine will be reduced to an academic novelty: compelling in theory but impractical for the reality of clinical practice.

Effective adoption and implementation will require significant efforts to not only purchase, develop, and refine the necessary IT infrastructure, but to also advocate for this next generation of data-based medicine. Success will require the alignment of incentives across all stakeholders—from the medical software companies who develop these tools, to the medical center administration that invests in the infrastructure, to the healthcare providers that are ultimately responsible for using these tools appropriately.   Assuming full adoption, predictive medicine will face additional new challenges. With the unprecedented acquisition and utilization of healthcare and healthcare-related data, HIPAA and data security will become an even more prominent issue. Philosophically, there will likely be ongoing debates about the use and overuse of these technologies and its effect on clinical acumen and medical practice just as there is ongoing criticism regarding the overuse of CTs and other imaging modalities.None of these challenges are insurmountable and the potential benefits at this time appear to be worth the effort. With the Affordable Care Act's shift from quantity-based healthcare payment reimbursement to value-based reimbursement system, stakeholders should be even more compelled to closely examine the cost savings and quality improvements afforded by predictive medicine and big data. Only time will tell if predictive medicine will live up to its potential. [4][5]

Other Issues

The biggest problem with predictive medicine is the validity of the available test. There is no test that is 100% sensitive and 100% specific. Hence, both false positives and false negatives are to be expected when applying any test to predict disease. When it comes to genetic testing to predict disease, cost and ethics are also of major concern. when applying genetic tests to predict disease, one can never negate the role of the environment or lifestyle. Plus, the reliability of genetic testing is not 100%. With cost containment, a priority in healthcare, empirical ordering of predictive tests may not be practical or realistic for the entire population.

While the results of big data have helped yield valuable clinical variables that are potentially associated with patient clinical outcomes of interest, one must appreciate the limitations of big data. Indeed, there have been several reports regarding the potential miscoding and/or incorrect diagnostic coding that ultimately can result in inconclusive or potentially incorrect statistical conclusions.

To mitigate these limitations, several authors have proposed utilizing big data results and its statistically and clinically relevant variables as a "flashlight" to highlight larger groups of relvant variables to be applied at the institutional level as part of more customized statistically relevant analyses. [6][7]

Questions

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