



# Predicting a Pandemic

*Expert opinion can forecast the spread of infectious disease outbreaks*

*Traders logged onto the Internet last spring to place trades not on oil futures, but on the spread of a frightening virus.*

*The traders, in this case experts on infectious diseases, very quickly sized up the severity of the problem. And they predicted the virus would spread widely but would not turn into a devastating killer.*

This is not the plot of a medical thriller, but the true story of a prediction market launched by the University of Iowa in 2009 to quickly assess the emerging threat posed by a new strain of influenza now known to all as H1N1.

The H1N1 flu prediction market is just one of several health prediction markets operated by the University of Iowa to gather expert opinion and then use it to forecast the timing, severity and course of disease outbreaks. These markets are experimental now, but if they prove effective, public health officials could consult them to help assess risk and then take steps to protect the public from disasters that range from an isolated outbreak of an infectious disease like mumps to a killer pandemic of unknown origin like severe acute respiratory syndrome or SARS.

The first prediction market was developed by researchers at the University of Iowa in 1988, and is still in operation today. Since that time, researchers here and elsewhere have run markets for stock options, election results, currency prices and the sales trends for popular items such as the *Harry Potter* series. They are used by companies such as Hewlett-Packard to forecast future sales of computer printers and other products, and by Best Buy to predict emerging trends in home electronics sales. The Hollywood Stock Exchange uses such a market to predict Oscar nominees.

And in the 2008 U.S. presidential election, the Iowa prediction market forecast a Democratic victory long before Barack Obama was even declared the party's candidate. In fact, such markets have been used for years now in presidential elections, and research shows they are highly accurate. For example, in forecasting presidential elections, the prediction error margin across six elections was less than 1.5 percent compared to an error margin of about 2.5 percent in opinion polls for those same elections.

## Using Prediction Markets to Protect Public Health

Economist Forrest Nelson, infectious disease specialist Philip Polgreen and their colleagues at the University of Iowa believe that the power of these prediction markets can be harnessed to identify an emerging threat to public health, such as a contagious virus that spreads through the air. They have created and are testing such markets to predict and plan for outbreaks of seasonal influenza, avian flu, syphilis and even quickly emerging diseases such as the H1N1 flu virus. The Iowa Health Prediction Markets are funded by the Robert Wood Johnson Foundation's Pioneer Portfolio, which supports innovative ideas that may lead to significant breakthroughs in the future of health and health care.

Such markets are particularly valuable because public health experts have limited ability to predict the spread, timing or severity of infectious diseases such as the flu in real time. The federal Centers for Disease Control and Prevention (CDC) collects information on the number of seasonal flu cases in each state, and then puts that data online in a color-coded map. But the map is based on data that are at least two weeks old. So while state and local health officials can view the map and get an idea of the severity of the outbreak in their region, that surveillance data offers, at best, a snapshot of the flu outbreak as it existed in the past.

A static map cannot show that the flu or some other infectious disease has started to spread rapidly in recent days and is posing

## Anatomy of a Prediction Market

Prediction markets are based on the real-money futures markets in Chicago and New York. In both prediction markets and futures markets, market managers define a contract and specify the value it will have contingent on the future event they're trying to track or predict. For example, the University of Iowa prediction market managers might say, "This contract will be worth \$1.00 if H1N1 becomes the dominant flu strain by March 1; otherwise it will be worth nothing." Then, the operators of the market stand behind the contract and let traders begin buying and selling.

According to financial theory, the expected value of a \$1.00/\$0.00 contract (such as the H1N1 example above) to a trader should be equal to that trader's belief that the event will occur. A trader who thinks that the outcome is, say, 80 percent likely might be willing to make a small profit by paying perhaps 75 cents or even by selling one unit for 85 cents. If another trader who has different expectations accepts that first trader's offer, a trade takes place and a price, which in the case of this type of market is also a prediction, is established. Other traders enter the market with varying beliefs and thus buy

and sell at different prices, which could lead first traders to possibly revise their beliefs and re-enter the market to sell the contracts they bought earlier.

The equilibrium price that emerges is taken to be the consensus view of the market for the probability that H1N1 will become the dominant strain by March 1. Just as in the for-profit futures markets, traders in the health markets must have the cash to back their purchases (although the health markets use either virtual money or a small grant in the place of real money). To sell shares they do not have, traders can "sell short," effectively borrowing the shares from the system but posting a \$1.00 deposit to guarantee they will repay the system for the loan. When the outcome becomes known and the market closes (March 1 in this example), all contracts held by traders are liquidated at the promised values. Successful traders show a profit on their accounts; unsuccessful traders/predictors show a loss. The market is valuable because it provides a continuously evolving, advance, expert opinion of the prospect of a particular event—in this case, a very useful prediction about H1N1.

a growing threat. And surveillance data cannot tell public health officials that an outbreak has already peaked and that the number of cases will start to dwindle.

## Health Prediction Markets: How Do They Work?

The University of Iowa researchers recruit health professionals, such as doctors, epidemiologists, caseworkers, nurses, pharmacists, public health officials and others with specific, real-time knowledge about disease outbreaks. Traders in the seasonal flu market often have inside information about the flu, including the severity of the outbreak in a given region, nationally or even worldwide. For example, the researchers might recruit microbiologists who have noticed the first uptick in lab tests for the flu. In addition, they would enroll health professionals on the front lines, such as nurses who might notice the first wave of sick patients coming in with flu symptoms.

In a prediction market, traders make investments based on their knowledge and a belief of what might happen in the future (see sidebar on page 2). In the real world, traders bet big money on futures markets, like the price of oil six months from now. The health professionals recruited for the University of Iowa Health Prediction Markets get either a small grant of \$100 or an account with virtual money, depending on the particular market. Either way, they bet on the likelihood that a certain prediction will come to pass. A trader's account rises or falls based on the accuracy of his or her prediction. When a trader runs out of money, he or she has to stop trading—that is a good thing for the market, since losing all of his or her money indicates a trader's predictions have not been accurate.

Prediction markets do not need vast numbers of traders in order to size up a trend. However, markets with more informed traders have a better chance of predicting an outcome with a high degree of accuracy.

Once the University of Iowa research team establishes a prediction market for a specific disease or outbreak, information can be aggregated—and acted upon—quickly. If seasonal flu market traders predict an increase in the number of cases and a quick spread, for example, then public health officials might use that information to redistribute available vaccine supplies.

And if forecasts from traders in a prediction market for a new, unknown virus indicate that the virus threatens to become a serious pandemic, health officials might take even more aggressive action to stop the outbreak, such as curtailing air travel to and from an infected region. Or they might advise public officials to close schools or other crowded places where the disease can easily spread.

Prediction markets also can be used to forecast the spread of a sexually transmitted disease such as syphilis. One dose of penicillin cures this age-old disease, so the level of precise information that prediction markets can offer public health officials gives them the ability to target an at-risk neighborhood and curb the disease so that it does not continue to spread. If, for example, a prediction market indicated a sharp increase in the number of syphilis cases in a particular neighborhood, local health officials could use that information to more aggressively track down infected people and encourage them to get treated.

The key outcome from these health prediction markets is knowledge that comes soon enough to make the interventions effective. It may not be perfect knowledge, but if it is an improvement over other information it can help decision-makers make better choices.

No matter the disease, prediction markets offer health officials a very powerful tool, one that could potentially identify an emerging outbreak very early on—and stop it before it has a chance to explode into a much larger problem.

Furthermore, these markets could also be used to prevent unnecessary panic about emerging diseases. For example, early news reports about the H1N1 outbreak predicted that the virus would kill at a rapid clip. But traders in the University of Iowa H1N1 market knew better (see sidebar on page 4).

## A History Lesson: The 1976 Flu Debacle

If former President Gerald Ford could have consulted a flu predictions market in 1976, he might not have launched an ineffective and costly campaign to prevent what was thought to be the beginning of a deadly flu epidemic. The same H1N1 flu spreading today broke out back then, and according to an early report had killed a healthy 19-year-old soldier at Fort Dix, N.J. A few medical experts predicted that the strain would kill 20 million people worldwide and 1 million Americans. Ford listened to that early warning and persuaded Congress to allocate a massive \$135 million to vaccinate every man, woman and child in the United States.

But just as the vaccine program was gearing up, the consensus among the medical community changed. Most of the experts came to believe the flu strain was no serious threat after all. But the original hype prevailed and 40 million Americans lined up for a flu shot.

Would a prediction market have averted this expensive campaign?

No one can say for sure, but health prediction markets rely on a consensus of experts to predict the future of a disease outbreak.

## **Health Prediction Markets Case Study: H1N1 Market Predicts the Future**

On Friday, April 24, 2009, frightening reports of the H1N1 virus circulating in Mexico began to surface in U.S. newspapers. On Sunday, Forrest Nelson and Philip Polgreen, directors of the University of Iowa Health Prediction Markets, consulted with Michael Pentella, associate director of the Iowa State Hygienic Laboratory, to create a new prediction market, this one aimed at evaluating this fast-moving outbreak.

The team had already successfully designed and operated markets for seasonal and avian flu, so it was not too much of a stretch to get a market for the new strain off the ground. By Monday, the team was putting the finishing touches on the market, and they had started to recruit traders from an existing pool of microbiologists, epidemiologists, public health officials and others who had already been active in the flu markets. The researchers gave those experts \$100 in “funny money” (no real value) and asked them to start predicting the number of future H1N1 cases, the timeline for vaccine availability and the mortality rate for the new strain.

By Thursday afternoon (long before the CDC had posted publicly-available surveillance data), the market had established a prediction: Traders wagered that the disease would be seen in every state by the end of May 2009 and that the number of infections would be high, but that the mortality rate would stay low.

As it turned out, they were right: As of June 1, 2009, the CDC had reported 10,053 cases of H1N1 in all 50 states and the District of Columbia. The mortality rate was low; only 17 people had died of H1N1 at that time.

What is remarkable about the forecast is simply this: In late April and early May, news reports on H1N1 played up the danger, reporting that the virus was killing young, relatively healthy people in Mexico. The fear was that the H1N1 virus would spread rapidly and be a formidable killer.

But the traders bet on a future that resembled the course of H1N1 as it actually played out over time.

Market prices indicated that H1N1 would spread widely but would not prove as lethal as had been feared during the early days of the outbreak.

Will H1N1 turn into a more deadly virus in the near future?

That is anyone's guess right now. But the prediction market, which assembles the collective opinion of the experts, is still tracking this virus and if it takes a lethal turn, chances are the market will sound an early warning.

If a market had been used back in 1976, it is likely that a small number of traders betting on a widespread flu outbreak would have been outvoted by the larger number of traders predicting a more modest outbreak.

Chances are such a market would have predicted early on just what actually happened: No epidemic ever emerged, and the flu season was one of the mildest on record.

## **The Future of Health Prediction Markets**

Prediction markets are a popular way to identify trends in sales or pinpoint a product that is likely to take off in the near future. For example, drug companies and others have used such markets to figure out the experimental drug or product most likely to succeed. Once a company has spotted a successful product they simply ramp up production in order to boost sales—and profits.

Right now, health prediction markets like the ones operated by the University of Iowa are considered experimental and are not yet being used widely to inform public health or policy decisions. However, these tools can offer local, state and national public health officials and policy-makers a great advantage.

Advance notice—or even real-time information—about the spread of a virus or some other infection can be extremely valuable to public health officials, who are charged not with boosting sales but with saving lives. Quick and informed predictions about an epidemic or an emerging disease could help public health officials coping with an uncertain, and sometimes frightening, situation. For example, getting information that suggests a virus is likely to die down and not explode into a rapidly spreading threat would be a real benefit to public health officers who must decide whether to ramp up the response to an outbreak—or simply wait it out.

Health prediction markets are not designed to replace the surveillance methods used now by the CDC and other agencies that track diseases. They could, however, help public health officials improve the current methods of surveillance. In addition, if these markets prove effective, they could offer very valuable insight and information to officials trying to size up and deal with the next outbreak of an infectious disease.

To learn more about the Iowa Electronic Health Markets, visit <http://iehm.uiowa.edu/iehm/index.htm> or contact Forrest Nelson, professor of economics at the University of Iowa's Tippie College of Business and the director of the markets, at [forrest-nelson@uiowa.edu](mailto:forrest-nelson@uiowa.edu) or (319) 335-0854.

Support for this publication was provided by a grant from the Pioneer Portfolio of the Robert Wood Johnson Foundation.