2014
Certificate Authority Cup International Mathematical Contest Modleing
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PROBLEM C(ICM): Ebola Virus: Why Cannot Curb the Spread?

The deadly hemorrhagic fever Ebola was first discovered in 1976, and it has haunted the public imagination for twenty years, ever since the publication of Richard Preston's "The Hot Zone." Yet, in all that time, no drug has ever been approved to treat the disease. Since December 2013, an ongoing outbreak of Ebola in West Africahas infected at least 567 people in Guinea, Sierra Leone and Liberia, including 350 who died, according to the World Health Organization. The outbreak appears to be the largest in history, surpassing the 425 cases that occurred in an Ebola outbreak in Uganda in 2000. People with Ebola are treated with only general therapies meant to support the ill patient. They might be given fluids (Ebola patients are frequently dehydrated), or treatments aimed at maintaining blood pressure and oxygen levels, and treating infections if they develop, according to the Centers for Disease Control and Prevention. (Supplies of the experimental drug administered to two American patients have already run out.) The lack of an Ebola treatment is disturbing. But, given the way drug development is funded, it's also predictable.

When pharmaceutical companies are deciding where to direct their R & D money, they naturally assess the potential market for a drug candidate. That means that they have an incentive to target diseases that affect wealthier people (above all, people in the developed world), who can afford to pay a lot. They have an incentive to make drugs that many people will take. And they have an incentive to make drugs that people will take regularly for a long time—drugs like statins.

This system does a reasonable job of getting Westerners the drugs they want (albeit often at high prices). But it also leads to enormous underinvestment in certain kinds of diseases and certain categories of drugs. Diseases that mostly affect poor people in poor countries aren't a research priority, because it's unlikely that those markets will ever provide a decent return. So diseases like malaria and tuberculosis, which together kill two million people a year, have received less attention from pharmaceutical companies than high cholesterol. Then, there's what the World Health Organization calls "neglected tropical diseases," such as Chagas disease and dengue; they affect more than a billion people and kill as many as half a million a year. One study found that of the more than fifteen hundred drugs that came to market between 1975 and 2004 just ten were targeted at these maladies. And when a disease's victims are both poor and not very numerous that's a double whammy. On both scores, a drug for Ebola looks like a bad investment: so far, the disease has appeared only in poor countries and has affected a relatively small number of people.

It’s not just developing nations that the system disserves, however. In recent years, the rise of drug-resistant microbes has made the antibiotics we use less effective and has increased the risk that an infectious disease could get out of control. What people in the West need, health officials agree, is new drugs that we can keep in reserve against an outbreak that regular antibiotics can’t contain. Yet, over the past thirty years, the supply of new antibiotics has slowed to a trickle. “Antibiotic resistance really has the potential to make everything about the way we live different,” Kevin Outterson, a co-director of the Health Law program at Boston University and a founding member of the C.D.C.’s working group on antimicrobial resistance, told me. “So we need to stoke the pipeline.”

The trouble, again, is the business model. If a drug company did invent a powerful new antibiotic, we wouldn’t want it to be widely prescribed, because the goal would be to delay resistance. “Public-health officials would appropriately try to limit sales of the drug as much as possible,” Outterson says: a good public-health policy; a bad investment prospect.

So how can we get the drugs we need without magically transforming the industry that develops them? The key is to reward companies for creating substantial public-health benefits. And the simplest way to do this would be to offer prizes for new drugs. Outterson describes one scenario: “The government would make a payment or a stream of payments to the company, and in exchange the company would give up the right to sell the product.” The drug company would get paid, and would avoid all the expenses of trying to push a new product (which you don’t want with a last-resort antibiotic, anyway). Society would get a new drug, and public-health officials would be able to control how it was promoted and used.

Task #1: Choose the country you believe to be most critical in terms of Ebola in Africa. Build a model to approximate the expected rate of change in the number of Ebola infections for the country from 2006 to 2025, in the absence of any additional drugs. Fully explain your model and the assumptions that underlie your model. In addition, estimate the cost of US to deal with the crisis.

Task #2: Build a mathematical model to determine whether any new disease need to develop drugs during this time period in the area. If so, estimate the deadline and output of drug development process.

Task #3: Develop a “reward” policy for pharmaceutical companies to support drug R & D work. The approach that you develop should make use of public-health benefits and US Budget.

Task #4: Joint drug research conducted by multiple companies can effectively lower costs and risk. How to select some enterprises to establish cooperation is a thorny

issue. Your team can help the government to make a choice?

References:

More data are found from the link below and attachments :
http://www.fda.gov/Drugs/default.htm
http://www.nsf.gov/statistics/

***Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages.**