What if people use too much antibiotics?

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Abstract

Antibiotics are miraculous drugs that help us fight off bacterial infections. But sometimes bacteria evolve resistance against antibiotic treatment. Unnecessary use of antibiotics helps this *antibiotic resistance* spread faster. So it is important to study how much antibiotics people consume worldwide.

We analyzed antibiotic-use data from 76 countries between 2005 and 2015. We found that consumptions of these medications stayed constant in most high-income countries, but has increased rapidly in middle and low-income countries. (But *per capita* consumption there is still lower.)

Our analysis suggests that the main reason for this was the growth in income, which made the medications more accessible. But this also caused an increase in unnecessary use. Economists predict that income will continue to grow in the next 15 years. So we need new strategies to reduce unnecessary antibiotic consumption and resistance.

Introduction

Before people began using antibiotics to treat bacterial infections in the 1930s, even a small scratch could be deadly if it became infected. Nowadays, antibiotics save millions of lives. We use them to treat common bacterial infections (such as pneumonia and tuberculosis) and to make surgery safer.

A small proportion of bacteria know how to be resistant to antibiotics since many antibiotics are derived from fungi. (Fungi and bacteria have been locked into an arms race for billions of years.) When we use antibiotics, we selectively kill off bacteria that are sensitive to the medication. The bacteria that are resistant continue to reproduce freely. This is evolution in action.

With millions of people around the world taking antibiotics every day (including when they don't really need them), new strains of antibiotic-resistant bacteria evolve.
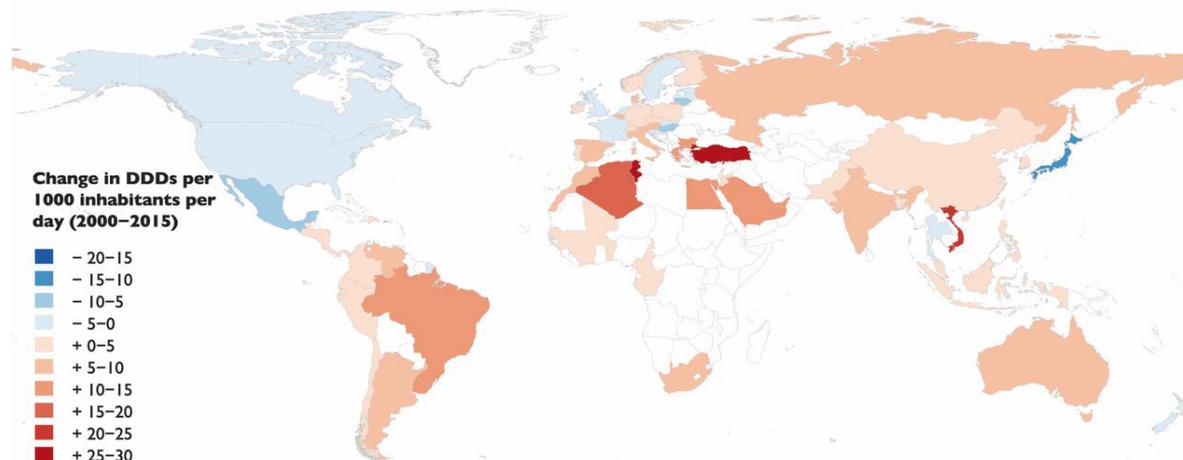

Figure 1:
We calculated the change in the amount of antibiotics used per 1,000 people per day for each of these countries (*defined daily dose or DDD*). Blue colors represent a negative change (a decrease), red colors represent a positive change (an increase). Has antibiotic use increased or decreased in most countries?.

Change in DDDs per 1000 inhabitants per day (2000-2015)

- − 20-15
- − 15-10
- − 10-5
- − 5-0
- + 0-5
- + 5-10
- + 10-15
- + 15-20
- + 20-25
- + 25-30

As they spread, antibiotics become less effective, which makes even common infections hard or impossible to treat. Some bacteria have adapted to every antibiotic we have developed.

Antibiotic resistance is not a problem of a single country. It is a major threat to global health because it can spread rapidly as people fly around the world. The first step in tackling this problem is to understand it better. To do this, we obtained data about antibiotic consumption from 76 countries from 2000 to 2015. We used the data to document global trends and to predict the future growth of global antibiotic consumption.

Methods

We obtained annual antibiotic consumption data for 76 countries from 2000 to 2015. But how should we compare all the different forms of antibiotics consumed (incl. pills and liquids in various amounts)? To do this, we converted all the different antibiotics (either pill or liquid) into a standard amount that a single individual takes in a day. This unit is called defined daily dose (or DDD). Then, we divided the total number of DDDs in a country by the total population to get DDDs per capita. This way, we could compare antibiotic consumption between different countries and see changes over time. Also, we looked at last-resort antibiotics - strong medications that should only be used when other drugs are no longer effective due to resistance.

We split the countries into groups based on income:

- high-income
- low-and-middle-income

Finally, we developed a mathematical model to predict the global consumption by 2030 for three different scenarios:

1. Baseline growth: all countries' per capita consumption remains at the current level (same DDD per person) but the countries' population increases (which will naturally lead to increased consumption).

2. Pessimistic scenario: no policies put in place to reduce global consumption. Consumption continues to increase at the same rate as from 2010 to 2015.

3. Optimistic scenario: consumption policies put in place. Countries either reduce consumption or slow growth in consumption so that all countries consume approximately the same amount as the median country by 2020.
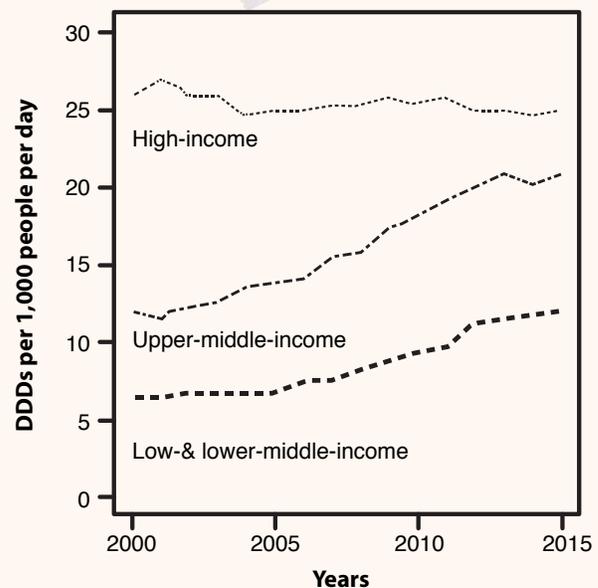
Results

- We estimated global antibiotic consumption at 42 billion DDD in 2015. This marked a 65% increase since 2000.

- Antibiotic consumption in low-and-middle-income countries more than doubled (Fig. 1). In most of these countries, consumption remained lower than in high-income countries, but they are rapidly closing this gap (Fig. 2).

- In lower-income countries, we found a link between economic growth and increases in DDDs.

- In high-income countries, overall consumption increased slightly but the per capita rate of consumption decreased by 4%. We didn't find a link between DDD and economic growth there.

- Consumption rates of last-resort antibiotics are increasing in all countries around the world.

- Figure 3 shows how we project global consumption will increase between 2015 and 2030.

Compare the DDDs of high and low-middle income countries. What is the trend in each group? If we extended the timeline to 2030, what would the graph look like?

Figure 2:
Antibiotic consumption rate in DDD (defined daily dose) - the amount of antibiotics used per 1,000 people per day - for each of the group of countries.

Discussion

We found that many poorer countries, which have lacked access to antibiotics in the past, do gain access as they get richer, which is good news. Still, inequities in access to medications persist. Many low-and-middle-income countries continue to deal with high rates of infectious diseases and low rates of antibiotic consumption. We need to make sure they have access to lifesaving drugs for patients who need them while preventing excessive and inappropriate usage. In high-income countries, however, the problem is not about access - it's about unnecessary use and overprescribing.

Another big concern is the rapid increase in the use of last-resort antibiotics in all countries worldwide. We may soon have more resistant bacteria that even the strongest antibiotics can't kill.

With antibiotic consumption increasing globally, the problem of antibiotic resistance is likely to get worse. We urgently need policies to:

- Reduce consumption and prevent unnecessary antibiotic use.

- Fight against infectious diseases in low-and-middle income countries by investing in improved sanitation, hygiene, vaccination, and access to proper health care.

If we are not careful enough, we may enter a post-antibiotic era where common bacterial infections cause deadly epidemics

Figure 3:
Estimated total global antibiotic consumption (in billions of DDDs) between 2010–2030 for the three scenarios.

Conclusion

You can help fight off antibiotic resistance. A big part of the problem is the unnecessary use of antibiotics. Remember that these medications do not work for all infections. For example, for most coughs and colds, antibiotics do not make you better.

Help prevent the spread of resistant infections by following some simple rules:

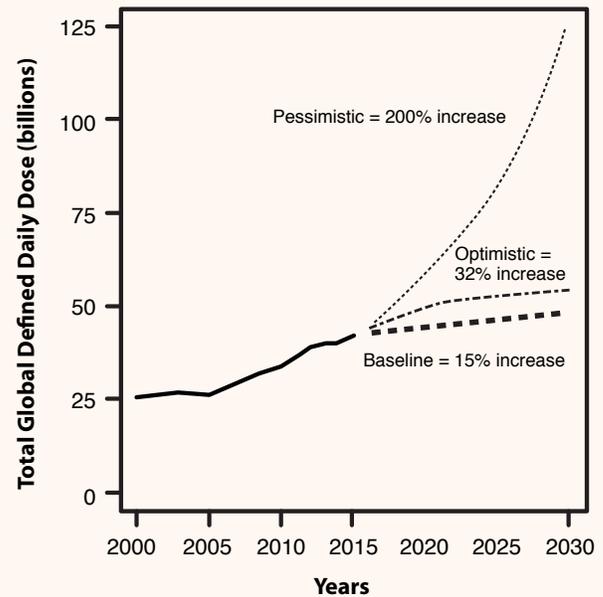- Wash your hands often, and clean your body regularly, especially after exercise.

- Cover and clean your wounds.

- Don't share personal items, such as razors and towels.

- Listen to your doctor if they say you have a virus and don't need antibiotics.

- Take antibiotics for as long as they were prescribed. Don't interrupt the treatment, even if you feel better.

REFERENCES

Eili Y. Klein, Thomas P. Van Boeckel, Elena M. Martinez, Suraj Pant, Sumanth Gandra, Simon A. Levin, Herman Goossens, and Ramanan Laxminarayan (2018) *Global Increase and Geographic Convergence in Antibiotic Consumption Between 2000 and 2015* **www.pnas.org/cgi/doi/10.1073/pnas.1717295115**

World Health Organization (WHO)
https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

Centers for Disease Control and Prevention
https://www.cdc.gov/drugresistance/about.html

Glossary of Key Terms

Antibiotics – a type of antimicrobial substance active against bacteria. Antibiotic medications are widely used in the treatment and prevention of bacterial infections. They may either kill or inhibit the growth of bacteria.

Antibiotic resistance – occurs when bacteria change in response to the use of these medicines. Bacteria, not humans or animals, become antibiotic-resistant. These bacteria may infect humans and animals, and the infections they cause are harder to treat than those caused by non-resistant bacteria.

Bacteria – a microscopic single-celled organism.

Defined daily dose (DDD) – standard amount of medication used by one person in one day.

Evolution – change in the genetic composition of a population over many generations. Bacteria evolve to be resistant to antibiotics.

Last-resort antibiotics – strong medications that should only be used when other drugs are no longer effective due to bacterial antibiotic resistance.

Mathematical (scientific) model – a computer program which uses our knowledge of real-world processes to make hypotheses and predict outcomes.

Median – in a numerical data set, the value in the middle when data are ordered least to greatest.

Per capita – per person. E.g. Per capita antibiotic consumption increased from 500 mg per person to 600 mg per person.

Check your understanding

1 Antibiotics are medicines that kill or slow down the reproduction of bacteria. But how do bacteria become resistant (develop antibiotic resistance) to these medicines?

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2 How does the excessive and improper usage of antibiotics speed up the spread of antibiotic resistance?

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3 Why does antibiotic resistance threaten global human health?

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4 Scientists found that antibiotic consumption rate is higher in low and middle-income countries than in high-income countries. They think that it is because of inappropriate use and overprescribing. What makes them think that way? Can they be sure?

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