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Climate change promotes the spreading of vibrios: IOW study reveals global distribution patterns

Vibrio vulnificus*, a bacterium that is potentially very dangerous to humans, is a natural component of marine plankton. The Leibniz Institute for Baltic Sea Research Warnemünde (IOW) has now presented the first comprehensive analysis of its global distribution. It shows that the pathogen occurs in almost all coastal regions of the world, but is more prevalent at comparatively high water temperatures, moderate salinity levels, and in decaying algal blooms. Published in Nature's journal "Communications Earth & Environment", the study also provides a predictive model that can be used to estimate future climate change-induced changes in the distribution of vibrios.*

The term "vibrios" refers to all bacteria of the genus *Vibrio*. They occur in the open sea and are also found in coastal, brackish, and freshwater environments, as well as in aquatic sediments. There are around 150 known species, of which around 10 % are pathogenic and cause infections in humans, fish, and shellfish. These include *Vibrio vulnificus*, which in the worst case can lead to fatal sepsis simply through contact with water.

To identify the environmental factors that determine the distribution patterns of *V. vulnificus*, an IOW research team around marine microbiologist Matthias Labrenz and bioinformatician Christiane Hassenrück analysed more than 70,000 environmental DNA data sets from coastal marine waters. These were obtained from water samples taken worldwide between 78° south and 83° north over the last 10 years and are freely available in public sequence data archives.

Vibrio hotspots and noticeable northward shift in occurrence

The analyses show that *Vibrio vulnificus* is found almost worldwide – from tropical coastal regions to the southern Baltic Sea. Hotspots with particularly high relative abundance are mainly located in the tropics, where 45% of all records were made. Hotspots were identified also on the US East Coast, in East Asia, and in the southern Baltic Sea. A shift towards higher latitudes is noticeable: Between 2013 and 2021, the number of detected cases in northern regions increased almost every year – an indication that rising sea water temperatures are accelerating a northward spread.

What influences the occurrence of Vibrio vulnificus and can it be predicted?

To analyse, which environmental factors have a significant influence on the occurrence of *V. vulnificus*, the IOW team combined sequence data analysis with satellite data on water temperature, salinity, currents and chlorophyll concentrations. Using machine learning methods capable of handling very large amounts of data, the researchers identified the following parameters as the most important factors influencing the relative abundance of the pathogen:

- Sea surface temperature proved to be the factor with the strongest statistically proven influence. *V. vulnificus* was detected almost exclusively in waters warmer than 15 °C (99%); higher temperatures favour increased occurrence.
- The occurrence of phytoplankton blooms and their decay proved to be an indirect enhancing factor, as the nutrients released in the decomposition process promote the growth of *V. vulnificus*.
- Salinity also plays an important role in the distribution of *V. vulnificus*: Although the bacteria occurred in a wide range between 4.3 and 39.8 ‰, they were particularly common at medium salinities of 5 – 20 ‰, which is typical for the Baltic Sea.
- Low current velocities (≤ 0.5 m/s) were associated with higher relative abundances of *V. vulnificus*, while fast currents (≥ 1 m/s) appeared to inhibit its occurrence.

Based on these factors, the researchers developed a model that can be used to predict increased occurrences of *V. vulnificus* and thus identify high-risk areas. To validate the model, the scientists used measurements from the Baltic Sea together with infection statistics from the countries bordering the

Baltic Sea. The model proved to be reliable, and especially the predicted high-risk areas corresponded very well with the documented cases of *Vibrio* infection in Sweden and Germany.

Climate and demographic change increase the risk of infection

Since *Vibrio vulnificus* is a natural component of marine plankton, humans regularly come into contact with the pathogen. It can enter the body while swimming through even the smallest of wounds and can also cause infections via contaminated seafood. As a rule, however, the immune system prevents serious illness, but particularly older people and those with weakened immune systems are at risk. If a spreading infection remains untreated, it often progresses rapidly and severely: Up to 50 % of those affected die, and one tenth can only be saved by amputation. However, if detected in time, the infection can be treated effectively with antibiotics.

"So far, *Vibrio* infections with fatal outcomes have been rare here at the Baltic Sea. With millions of tourists visiting the German Baltic region every year, there are barely more than one or two deaths," says Matthias Labrenz, one of the publication's two corresponding authors, who has been working on the topic of vibrios at the IOW for many years. "However, our study clearly shows that the effects of climate change, such as rising water temperatures, which, in addition to eutrophication, promote an increase in algal blooms, are enhancing the infection risk: Humans are increasingly exposed to *Vibrio* bacteria because the annual *Vibrio* season is getting longer, the pathogen concentrations in the water are higher and the distribution area is expanding northwards. In addition, the demographic developments will further increase the risk group of older people," says the marine microbiologist.

"This makes it all the more important to use our model, which also takes into account ecological factors such as the decay of phytoplankton blooms and regional marine currents, to create realistic risk scenarios and risk maps so that coastal regions and health authorities can be warned early on," adds Christiane Hassenrück, who is also a corresponding author for the publication. "The archiving of well-described, standardised data in long-term archives is essential for the detection of such ecological patterns," the bioinformatician continues. However, there are also limitations to the approach: Since only positive *Vibrio* records have been taken into account so far, areas without positive records cannot be conclusively excluded as potential distribution areas. In addition, the available infection data are documented very differently from region to region. The researchers therefore recommend placing greater emphasis on the systematic recording of infection cases in future and linking the models to current monitoring data.

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