Bird flu could be eradicated by editing the genes of chickens - our study shows how

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Recent advances in gene editing technology could potentially be used to create disease-resistant animals. This could curtail the spread of avian influenza, commonly known as bird flu.

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In a recent gene editing study, my colleagues and I showcased the potential of gene editing to protect chickens from the threat of bird flu. This disease is caused by an ever-evolving virus that gets around numerous biosecurity measures such as good hygiene, restricting bird movements, surveillance through appropriate testing, and selective elimination of infected birds.

A gene-editing breakthrough would stem the huge economic losses currently suffered as a result of bird flu outbreaks. It would also be a significant step in controlling a disease that can cause serious sickness and death in humans.

Why managing bird flu matters

Outbreaks of bird flu around the world cost billions of dollars in losses. The United States Department of Agriculture reported that up to 50 million birds died from bird flu in 2022. Recently, the South African Poultry Association said more than 7 million chickens were destroyed after outbreaks were detected in the first half of 2023.

Beyond the economic implications, bird flu outbreaks also pose a risk to human health.

Prior to the Covid-19 pandemic, bird flu was considered a possible trigger for a devastating human pandemic. This prompted international surveillance led by the World Organisation for Animal Health, the World Health Organization and the Food and Agricultural Organisation of the United Nations.

The fear is well-founded as the three flu pandemics of the 20th century – including the 1918 flu pandemic that claimed tens of millions of lives – originated from birds.

Vaccinations can only do so much

Vaccination is a primary method for preventing bird flu outbreaks in chickens.

However, the effectiveness of vaccines is limited because the bird flu virus rapidly evolves. This makes existing vaccines less effective over time. Also, there are multiple strains of the bird flu virus but a vaccine is effective against a specific strain only.

It's necessary to match a vaccine with the prevailing strain causing an outbreak. Using vaccines may also involve substantial costs and practical hurdles of distribution.

Gene editing to improve animal welfare

In contrast to vaccinations, gene editing targets a protein or proteins within chickens that are vital for all strains of bird flu, effectively stopping the virus in its tracks.

Gene editing refers to the process of making a precise change in a specific gene in an animal to introduce traits such as resistance to a particular disease, increased productivity and characteristics that enhance animal welfare.

A beneficial genetic change introduced into an animal using gene editing may already occur naturally in another animal.

For example, gene editing was used to make dairy cattle hornless by introducing into them a genetic change found in naturally hornless cattle. This is important as many dairy cattle have horns, resulting in the painful practice of dehorning calves to reduce the risk of injury to the animal and the farmer.

It's important not to confuse gene editing with genetic modification, which entails transferring a gene from one species to another. This distinction is necessary for regulatory purposes, especially as the older genetic modification technology has faced stringent regulations in many countries, hampering its development.

To produce the gene-edited chickens in our study, we used the powerful molecular scissors known as CRISPR/Cas9 to make a single gene edit. We targeted the ANP32A protein in chickens.

Compared to normal chickens hatched simultaneously, these gene-edited chickens reached maturity without any discernible adverse consequences on their health and well-being.

To test their resistance, we exposed the gene-edited chickens to a low dose of the bird flu virus. Remarkably, 9 out of 10 of these birds displayed complete resistance, and no transmission occurred to other chickens.

Taking a more ambitious step, we inoculated the gene-edited chickens with a high, unnatural dose of the virus – 1,000 times the low dose. This time, 5 out of the 10 inoculated gene-edited chickens became infected.

We also found that the bird flu virus was capable of adapting to use the edited ANP32A protein, as well as two related proteins – ANP32B and ANP32E. But we demonstrated through experiments in cells that simultaneously editing all three proteins could completely suppress the virus.

What's next?

Ongoing research aims to identify the specific combination of gene edits needed to create the next generation of gene-edited chickens, providing complete and permanent protection against bird flu.

Gene editing should be regarded as an essential tool for preventing and controlling deadly animal diseases.

Supportive government regulations will be required to promote the development of gene editing aimed at enhancing animal health and welfare.

The potential for disease-resistant animals to protect global food security and public health is a compelling reason to pursue this innovative path in biotechnology.

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