Mortality rises among public when health workers get sick in an outbreak, model suggests

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When healthcare workers become ill during a disease outbreak, overall case counts and mortality rates may significantly increase, according to a

new model created by researchers at Penn State. The findings may help to improve interventions that aim to mitigate the effects of outbreaks such as COVID-19.

"Each year dozens of potentially lethal outbreaks affect populations around the world. For example, Ebola ravaged western Africa in 2014; Zika damaged lives in the Americas in 2015; and now we are in the midst of a worldwide pandemic—COVID-19," said Katriona Shea, professor of biology and Alumni Professor in the Biological Sciences, Penn State. "Healthcare workers are essential to providing care during such outbreaks. Yet, their exposure to the diseases they treat means they too may become victims of the outbreak. Conventional epidemic models do not usually consider this important driver of quality of care, and may thus underestimate epidemic burdens."

In their new model, the researchers investigated the direct impact of the loss of healthcare workers on outbreak outcomes. Specifically, they examined the impacts of healthcare workers becoming infected and unable to work on case counts and mortality. In the model, they refer to this as 'loss impact.' They also examined 'redundancy,' which they define as the minimum number of health care workers required to provide adequate care.

"When the loss impact is high, declines in quality of care for each infected healthcare worker are more extreme," said Amalie McKee, former Ph.D. student at Penn State and now adjunct professor in analytics, Harrisburg University of Science and Technology. "Higher health system redundancy represents a healthcare system that is safeguarded and able to withstand the loss of more healthcare workers before it cannot provide adequate care."

McKee explained that the model assumes that quality of care determines the rate at which vaccines are administered, the probability of dying

from infection and the rate of recovery from infection. The model also assumes that vaccines grant lasting immunity and that health care workers are vaccinated at a higher rate than the general population. It also assumes a basic reproduction ratio (R0)—or the number of cases generated by one case in a population that is fully susceptible—of roughly 2, which is roughly consistent with recent outbreaks of COVID-19, Ebola, pandemic flu and SARS.

In addition, the model assumes a 0.1% percent baseline chance of dying from disease, which is lower than that for Ebola and SARS, but a conservative estimate of mortality associated with COVID-19. Finally, the model assumes that healthcare workers are infected at a rate that is 50% higher than the general population.

The results will publish today (Feb. 25) in the journal *Epidemiology and Infection*.

According to the researchers, the model predicts that high loss impact —a large drop in quality of care for each healthcare worker that is infected—paired with low redundancy —a healthcare system that is not able to withstand the loss of workers—causes the most severe epidemic outcomes with respect to case counts and mortality.

"This outcome represents a fragile health system that has a rapid decrease in quality of care after only a few healthcare workers are infected," said McKee.

In contrast, the mildest outcome results from the combination of high system redundancy and high loss impact.

"This combination represents a strong health system with a minimal decrease in quality of care until nearly all healthcare workers are infected, McKee added.

Results of the team's model predict that when declining quality of care is considered, total disease cases could increase by up to 15% and the total number of deaths could increase by as much as 1,716%. The model also predicts that the number of vaccinations administered will decrease by 10.8% and the number of individuals that recover will decrease by as much as 8.9% when declining quality of care is considered.

"We demonstrate the importance of considering the loss of healthcare workers on epidemic outcomes," said Shea. "Addressing such losses will allow epidemiologists to anticipate, plan for, and mitigate negative outcomes."

For example, she noted, to address problems of low redundancy, in which quality of care drops significantly when only a few workers are infected, healthcare providers and governments could recruit and train volunteer workers.

"In the COVID-19 pandemic, moving medical personnel from less-affected locations, recruitment of recently retired healthcare workers and accelerated graduation of final-year medical students have all been used to sustain the health care system in pandemic hotspots," said Shea.

The team's model also suggests a benefit to managing healthcare workers differently from the rest of the population in order to slow the decline in quality of care. This strategy has been effective in the COVID-19 pandemic, as healthcare workers have been prioritized for limited supplies of personal protective equipment and COVID-19 vaccinations.

Shea said, "We show that the inclusion of quality of care in disease outbreak models may significantly impact predicted health outcomes and can therefore inform medical interventions related to healthcare workers who are the primary source of care in epidemics."

More information: Analysing how changes in the health status of healthcare workers affects epidemic outcomes. *Epidemiology & Infection.* Published online by Cambridge University Press: 08 February 2021, e42