

IN DEPTH



INFECTIOUS DISEASES

When Ebola protection fails

Repeated cases among health care workers are a puzzle, but more staff and better training may lower risks

By Jon Cohen

In July, as Ebola was exploding in Liberia, Senga Omeonga worked as a doctor at St. Joseph's Catholic Hospital in Monrovia. Among the patients he cared for was the hospital's director, who had diarrhea and was vomiting repeatedly, but tested negative for the Ebola virus. "I was exposed to that patient day by day," says Omeonga, who originally is from the Democratic Republic of the Congo. When the director didn't respond to treatment, a second test was done, which came back positive. That was 10 days after his first test.

Omeonga wore what he calls "light" personal protective equipment (PPE) after he learned the man was infected, which included a surgical gown as opposed to a heavy plastic apron, gloves that he thought were too short, and a face shield and mask. By the last few days of the patient's life, he says, the staff was keeping its distance. "Everyone was afraid to touch him," Omeonga says. "He was screaming. I removed his nasogastric tube and he was fighting." On 2 August, the hospital director died and Omeonga himself came down with Ebola.

Omeonga, along with two other health care workers infected in Liberia, Kent Brantly and Nancy Writebol, has received widespread media attention for receiving an

experimental cocktail of antibodies called ZMapp. All three survived; none of them knows if the treatment helped. But all three wonder about another question that has important implications for other health care workers: How did they become infected?

Surprisingly, no one has a firm answer. "Every day I'm still thinking, When was I contaminated?" Omeonga says, although he suspects the hospital director was the source. Writebol, a clinical nurse associate who worked for a missionary group called SIM at the ELWA 2 Ebola Treatment Center in Monrovia and helped health care workers don and doff PPEs, is similarly stumped. "Nobody is really sure, least of all me," she says. Brantly, a doctor in the same center, also has only hunches but says, "I am fully convinced that I did not contract Ebola in my work in the treatment unit." (Read Q&As with Ebola survivors at <http://scim.ag/ebola14>.)

As of 23 September, the outbreak had sickened 375 health care workers and killed 211, according to the World Health Organization. A clearer understanding of the risks could lead to better precautions and ease the minds of those thinking of joining the fight. But few studies have analyzed the relative risks of blood, urine, vomit, and other bodily fluids that health care workers encounter. And doctors and nurses rarely can pinpoint risky lapses in their behavior, says epidemi-

Nancy Writebol helped health care workers in Liberia don protective equipment before they entered an Ebola treatment unit.

ologist Daniel Bausch of Tulane University in New Orleans, Louisiana, who worked in Ebola units in Guinea and Sierra Leone when this outbreak surfaced.

"Very few people have anything specific to say," Bausch says, although many, like Brantly, doubt that they got infected in the Ebola unit itself, where precautions are most stringent. "There's a tendency to want to believe people get infected outside the ward because it makes us feel better. It's probably a mixed bag."

Brantly, Writebol, and Omeonga say they had ample training about how to protect themselves. "Our process was very safe," says Brantly, who worked for the Christian relief group Samaritan's Purse. "It is my opinion that during an Ebola outbreak, the safest health care job is working in the Ebola treatment unit." The hidden danger, they say, lies in patients whose status isn't known.

Brantly suspects he was infected while working in the emergency room, outside the treatment unit, and saw a patient who was diagnosed with Ebola only after she died. He wasn't wearing PPE at the time. "It is in clinics and emergency rooms and hospitals where you have to look at every patient and ask yourself 'Should I be concerned that this patient might have Ebola?'" he says. But it's a risk that is, in practicality, impossible to eliminate.

Omeonga, too, says new patients present a serious risk. "A lot of them were lying when they came to the hospital," he says. "They didn't even tell you they're having fevers. They'd say they fell down or were on a motorbike or someone pushed them or they went to work and passed out." He was one of 15 who became infected at his hospital, presumably all by the ailing director. Nine of them died. The hospital closed.

When helping staffers doff PPEs, Writebol says she wore gloves and a disposable apron; she was separated from workers exiting the treatment unit by a line that she never crossed. Thinking back, she believes a co-worker who did the same job may have infected her. He became ill with what he thought was typhoid; he died from Ebola. "I never remember touching him," she says—but it's possible she picked up a sprayer he had used.

When Writebol first developed a fever on 22 July, she thought she had malaria, which a test confirmed. Her husband, David, cared for her while they continued sharing a bedroom. But she could not shake the fever, and 4 days later, a doctor gave her an Ebola test "to relieve everyone." After the results came

back positive, she was isolated, and David began speaking to her through a window near her bed. He did not develop Ebola.

An Ebola outbreak in Uganda in 2000, which Bausch helped bring under control, yielded some clues about the risks that infected people pose. Bausch and co-workers studied samples from 26 patients. In acute cases, the virus turned up most often in saliva but was also present in stool, tears, nasal blood, and breast milk. Although their sample sizes were small, the team did not find it in sweat or urine, and Bausch says he doesn't think people well enough to walk around the streets secrete the virus in those fluids—which means something like a handshake probably presents little risk. In one recovered patient, the virus turned up in semen 40 days after the onset of his disease.

Bausch says other studies have clearly shown that sicker people have higher viral levels. Corpses have the highest levels of all, and the virus “will seep into other tissues to saliva or sweat,” he says, putting family members and burial teams at risk. Environmental surfaces—unless they're “grossly contaminated with blood”—are unlikely sources of transmission, he says. “It's not jumping off the walls or hanging around when there's not infectious bodily fluid there.”

Rigorous training can bring down the risk of infection. Doctors Without Borders (MSF), which literally has written the book on operating an Ebola treatment unit, has so far had only one worker contract the disease despite taking care of the majority of patients in this epidemic. Last week, the U.S. Centers for Disease Control and Prevention (CDC) held the first of what will be many 3-day training courses in Anniston, Alabama. It took place at an old Army base where working conditions resemble those in the affected countries, including a hot climate with no air conditioning. CDC's Michael Jung, who is leading the program, says nearly every trainee had breaches of protocol, such as skin showing. Bausch attended the session, along with MSF staffers, to share some firsthand stories.

Adequately staffing Ebola treatment units also helps reduce the risk. At the training, Bausch recounted his work as one of two doctors in a 55-bed treatment unit. “You go into that ward and there are probably five or 10 patients who have fallen out of bed or are in delirium and have crawled out, there's blood and vomit and diarrhea everywhere,” he says. “And there's no one with a sprayer behind you cleaning it up.”

Still, when everything is done right, working in an Ebola treatment unit need not be a life-threatening endeavor, Bausch stresses. “Otherwise, I wouldn't do it myself and it wouldn't be ethical for me to counsel other people to do it.” ■



Tsunami waves ravaged Taro, Iwate, Japan; was a massive undersea landslide to blame?

GEOSCIENCE

Double-whammy tsunami?

Japan's 2011 quake may have had a hidden accomplice

By Roland Pease

On 11 March 2011, a magnitude-9 earthquake jolted northern Japan and sent a devastating tsunami sweeping down the coast, overwhelming seawalls with a surge more than 10 meters high. Along one 100-kilometer stretch of mountainous coastline called Sanriku, however, the incoming waves reached 40 meters. Those monstrous waves claimed about a quarter of the tsunami's 18,000 victims, yet experts have struggled to explain them.

Now, an international team of researchers says its computer models suggest a previously unsuspected answer: An under-water landslide the size of Paris combined with waves from the quake to deal the coast an extra-deadly blow. But others say they'll need stronger evidence to convince them.

Geoscientists have long known that undersea landslides can trigger tsunamis. But most saw no evidence that one had accompanied the 2011 quake. Instead, seismologist Kenji Satake of the University of Tokyo's Earthquake Research Institute proposed that an undetected second earthquake, involving a thin sliver of crust, had struck north of the main submarine thrust.

But Stephan Grilli, an oceanographer at the University of Rhode Island, Narragansett Bay, says fault movements don't jolt the sea surface in the right way to focus a band of waves as narrowly as at Sanriku. In the new study, he and colleagues worked back from details of the water motion recorded by gauges along the Japanese shore on the day of the earthquake to infer the ocean floor disturbance responsible. They conclude that a slab of sediment measuring 20 by 40 kilometers and up to 2 kilometers thick slid

about 300 meters down the steep slope of the Japan Trench, “acting like a piston.”

Grilli estimates that the slump must have happened near the northern end of the 2011 rupture, 170 kilometers from the Japan shore, and under 4.5 kilometers of water. A co-author, marine geologist David Tappin of the British Geological Survey, compared Japanese seafloor maps from before and after the earthquake and saw signs of just the right kind of slump in the target area. The team's paper is in press at *Marine Geology*.

The authors make a good case but are far from proving it, says Costas Synolakis, a tsunami expert at the University of Southern California in Los Angeles. Synolakis collaborated with Tappin and Grilli on previous studies that showed a similar slump caused a deadly 1998 tsunami off Papua New Guinea. This time, however, he worries the researchers are fixated on details of the tsunami modeling at the expense of the big picture. “Anyone who thinks you can model the behavior of a tsunami to better than a factor of 2 is crazy!” he says. A detailed survey of the sea floor would settle the case, he says. Satake, however, maintains that his two-quake explanation is adequate and that the existing seafloor mapping reveals nothing.

If a submarine landslide was responsible for the Sanriku surge, “then it's a game-changer,” says team member Robert Geller, a seismologist at the University of Tokyo. Geller has long criticized as unscientific the Japanese earthquake-forecasting program and hazard maps based on it. If towering tsunamis can also be produced by collapses along the Japan Trench, he says, there's little hope of anticipating the next one. ■

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