

## Reports from the Field

The Robert Koch Institute's mission against Ebola virus disease in West Africa





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## Reports from the Field

Since early 2014, West Africa has been confronted with the largest outbreak of Ebola virus disease (EVD) in history. According to the World Health Organization, more than 28,000 people have fallen ill with Ebola, and more than 11,000 died of the disease in Guinea, Liberia and Sierra Leone. In the meantime, however, only single cases of EVD are detected in the affected countries. The great efforts of the local and international helpers seem to pay off at last.

There is neither an approved EVD vaccine nor specific drugs for EVD treatment. However, the helpers managed to contain the virus mainly with non-medical interventions. This is feasible, because the Ebola virus only spreads through body fluids of the patients. Infected people are only contagious when they show symptoms, and the incubation period takes up to three weeks. Therefore, an early and reliable diagnosis is most essential: EVD patients need to be identified, isolated and treated as quickly as possible, their contacts need to be quarantined and monitored. Healthcare workers must be trained, the outbreak response needs to be organized and coordinated. Our colleagues from the Robert Koch Institute greatly contribute to this on the ground. They have been supporting the international efforts to combat the disease in West Africa since 2014.

Since May 2014, virologists from the RKI analyse blood samples from suspected Ebola cases in the three European mobile laboratories (EMLab). On behalf of WHO and others, RKI epidemiologists identify new cases of EVD, isolate them and track down all contacts. Others watched the exit screenings at the international airports in West Africa and supported the WHO in their headquarters in Geneva. Moreover, the Robert Koch Institutes helps prepare neighbouring West African countries for possible imported EVD

cases: In Ivory Coast, a new laboratory was set up for the diagnosis of highly pathogenic viruses. In Senegal and Burkina Faso, RKI staff trains doctors and nurses how to take care of patients with EVD and how to protect themselves from infection. The Robert Koch Institute also carries out research in the outbreak area: A team of scientists from the RKI and others were able to narrow down the wildlife origins of the West African epidemic. So far, RKI staff has been on more than 80 missions to West Africa. Learn more about their work in the following reports which also have been published on the English RKI website [www.rki.de/EN](http://www.rki.de/EN).

With their deep commitment, our colleagues help control the Ebola epidemic in West Africa. We would like to say thank you. We are very proud of you. We would also like to thank our staff here in Berlin who are not only willing to take over the work of their colleagues abroad for many weeks, but who also worked hard to prepare Germany for possible imported EVD cases and made sure that infected helpers could have returned home safely and by high medical standards.

The number of confirmed EVD cases drops sharply. However, the outbreak is not over yet. We need to be vigilant. The health systems in the affected countries have to be sustained. West Africa still needs help from the international community. Our commitment will go on.

*Prof. Dr. Lothar H. Wieler, president*

*Priv. Doz. Dr. Lars Schaade, vice president*

More information: [www.rki.de/ebola-en](http://www.rki.de/ebola-en)

# RKI STAFF IN WEST AFRICA







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RKI colleagues supporting West Africa during the Ebola virus disease outbreak in alphabetical order (date: 8.10.2015), the pictures show some of them.

# FIRST CONTACT



A hollow tree trunk. A little child. An infected bat. That's how the largest Ebola virus outbreak in history probably began. Scientists from the Robert Koch Institute reconstructed the source of the epidemic in Guinea.

What happened precisely will probably remain a mystery forever. Probably the little boy crawled inside the hollow tree trunk. Maybe he found a bat on the ground there, weak or dead. Maybe he played with it and was bitten. Perhaps he skewered it on a stick, roasted it over a fire and ate it, as the children do here. Or perhaps he touched bat droppings with his hands and subsequently wiped his face.

Only one thing is certain: At the end of December 2013, the two-year-old from Meliandou, a small village in southeastern Guinea, becomes gravely ill. He dies, followed shortly after by his sister, his pregnant mother and his grandmother. So far, Ebola has taken the lives of more than eleven thousand people in West Africa. It is the largest Ebola virus disease (EVD) outbreak in history, and it most likely goes back to this one momentous contact between a toddler and a bat that carried the virus. "It was a random accident," says Fabian Leendertz from the Robert Koch Institute (RKI). He reconstructed the origin of the epidemic with an international team of researchers.

Fabian is head of the RKI project group Epidemiology of Highly Pathogenic Microorganisms. He and his colleagues investigate new pathogens in the animal kingdom which could possibly pose a danger to humans as well, so-called zoonotic diseases the Ebola virus belongs to. Time and again, they are drawn to the high risk areas of Africa: the Congo Basin, Sierra Leone and Ivory Coast.

The team is dependent on collaboration with scientists and organisations on the ground. Among others, they have worked with the Wild Chimpanzee Foundation (WCF) in Ivory Coast for years. They are well connected. That's how Fabian came to receive reports from acquaintances in Guinea of hemorrhagic diarrhea from unknown causes as early as the beginning of 2014.

On March 23, 2014, the World Health Organization (WHO) confirms for the first time that there is an EVD outbreak in Guinea. Just one week later, Fabian and three colleagues from the RKI are sitting in an aircraft heading for Abidjan in Ivory Coast. From there, the journey to Guinea continues by car. While the first international aid workers are traveling to West Africa to stop the outbreak, Fabian and his team want to know how it all began. How did the virus spill over to human beings in Guinea? "Only when this is understood, we can prevent such outbreaks in future," he says.

### *Mass mortalities in great apes?*

The team organised the journey in record time, and with the help of the Wild Chimpanzee Foundation, obtained official authorizations and cooperation partners. The Robert Koch Institute provided funding for the costs. There is a group of local ecologists and an anthropologist from the Berliner Charité already waiting with an off-road vehicle, tents, drivers and a cook. They are



RKI employees prepare for the expedition.



A briefing at the hotel in Guéckédou.

17 people from various fields and nationalities, and their mission leads them into both of the only two forested regions in southeastern Guinea: the Massif du Ziama and the Forêt Classée de Diécké.

“Previous Ebola outbreaks in Central Africa were always associated with mass mortalities of great apes and antelopes,” says Fabian Leendertz. “First, the animals in the surrounding forests become infected. Then a hunter becomes infected and carries the virus back to his village.” The ecologists on his team are familiar with the forested regions in Guinea from earlier monitoring projects. They record even the smallest details along predetermined routes: sounds, footprints, feces, and sleeping nests in the trees. Simultaneously, the

researchers investigate bats and fruit bats which have long been suspected of spreading the Ebola virus. However, nothing indicates that there are fewer chimpanzees and antelopes in the forest than there were a few months earlier. There is no trace of the virus in bats.

Then, the team receives the message that north of Guéckédou, epidemiologists have tracked down the index village—the village where the epidemic began. They may well have even identified the very first patient. Fabian Leendertz and his colleagues immediately leave for the location. The village is a six hour car drive away from the forested area. It is mid-April 2014. They are the first research team to arrive in Meliandou.

The village of Meliandou. The Ebola outbreak began here in December 2013.





A scientist from the RKI dissects a bat.

### *Investigations in the outbreak area*

At first glance, the field work in Guinea differs little from previous expeditions to Sierra Leone or in the Republic of Congo, says Kathrin Nowak, an RKI specialist in bats. The field work requires a certain amount of routine: You must know exactly

where to span the nets so that as many animals as possible are caught in the trap. You get up at night to collect them. When Kathrin dissects bats—which is absolutely essential when looking for traces of pathogens—she always wears a protective suit, two pairs of gloves, a mask and a visor over the face.

And yet, Guinea is different. “We constantly had to remind ourselves that we were in an Ebola outbreak area,” she says. The team regularly gathers information about new EVD cases in the surrounding villages. When they speak with the inhabitants, they keep a greater distance and avoid all physical contacts. Despite the heat, everybody wears rubber boots which are thoroughly disinfected before they get back in the Jeep. The team maneuvers over the dirt roads and make-shift bridges with a general great sense of caution.

In April 2014, the disease does not yet determine everyday life in Guinea. The number of cases is still relatively low. Only once in a while, the underlying danger becomes reality. Here a



The researchers inspect the bridge on the road to Meliandou.



The researchers spread a net for catching bats in the village of Meliandou.

vacant house, whose residents have died of the disease, there a grave.

The scientists spend ten days in Meliandou. In the beginning, the villagers are sceptic, but gradually, the researchers gain their trust. “They were pleased that we were so interested in finding the source of the outbreak and helped us a lot,” says Fabian Leendertz. They never want to go through that in their village again. And so eventually, the researchers learn about the hollow tree which stands off to the side of the houses. The children have played there, including the two-year-old boy. The villagers say that “small and smelly” bats have inhabited the tree. The researchers also learn that the tree was recently burned down, and the bats along with it.

### *Nothing left but soil and ash samples*

The news hits the team like a slap in the face. If the bats had still been living, the scientists might possibly have found the Ebola virus in them. Not only would they have discovered the source of the outbreak in Guinea with absolute certainty. For the first time, they would have been able to prove that bats represent a natural reservoir for Ebola viruses. “That would have been a breakthrough in Ebola research,” Fabian says.

The researchers switch tactics. They collect soil and ash samples in the vicinity of the tree. Back at the Robert Koch Institute, they discover the genetic traces of the bat species *Mops condylurus* (Angolan free-tailed bat). From earlier laboratory

experiments, it is known that this species survives an Ebola virus infection undamaged and that it quite possibly spreads the virus.

The scientists found no further evidence for Ebola virus in wildlife on their expedition. The virus does not seem widespread. The little boy most likely was infected by one single infected bat. “He simply had unbelievably bad luck.” The researchers have only indications, no evidence for that. However, they won’t get any closer to finding the origin of the outbreak.

In December 2014, exactly one year after the child fell ill, the results were published in the scientific journal *EMBO Molecular Medicine*. In total, 30 scientists from Germany, Canada and Ivory Coast were involved in the study. Nevertheless, many questions remain. One of them is how the virus travelled from Central Africa to distant Guinea.

Fabian Leendertz is already planning the next study. Bats of the species *Mops condylurus* occur in every village in Africa. The researchers now want to attach transmitters to individual bats in order to track their flight routes and gathering areas. The search for the origin of the outbreak enters the next stage.



The boy was most likely infected with the Ebola virus in this hollow tree.

**AT THE EPICENTRE**



The European Mobile Laboratories can be set up in an outbreak area at lightning speed. Here, virologists from the Robert Koch Institute and their colleagues from all over Europe investigate blood samples from suspected Ebola cases. Here is decided which patient will have to stay at the treatment centre. And who may go.



It's hot in the tent. Temperatures of 30°C prevail in Guéckédou in June. Andreas Kurth is covered in protective clothing from head to toe. There is sweat in his safety goggles, he tilts his head slightly backwards to prevent it from getting in his eyes. The twins lie in one bed together, two tiny, emaciated bodies. They are just six months old and completely dehydrated. Time and again, the nurses try to infuse them with water and electrolytes, but to no avail. The children are going to die. "They had no chance," Andreas says.

In June 2014, Guéckédou, Guinea, was the epicentre of the Ebola virus disease (EVD) outbreak in West Africa. The patient visit is an exception. Andreas needs to install an instrument for measuring blood parameters. Here at the treatment centre of Doctors Without Borders, he and his team are normally responsible for diagnostics. They test the blood from suspected EVD cases in the European Mobile Laboratory, a kind of high-security laboratory in a 20-square-meter tent. Here is decided which patients will

have to stay at the treatment centre, and who may go.

Andreas Kurth is a virologist. He runs the new BSL4 laboratory at the Robert Koch Institute (RKI), a laboratory with the highest level of security. When they asked him whether he would provide support for the European Mobile Laboratory in Guinea, he didn't hesitate for a second. "We know the pathogen. We know how to handle the samples. Who else is going to do the job, if not us?"

### *A European project*

The European Mobile Laboratory, or EMLab, is a special laboratory for highly pathogenic agents that can be set up and operated in an outbreak area at lightning speed. The mobile laboratories themselves—there are a total of three—were conceived by the Institute for Microbiology of the German Bundeswehr in Munich. The Hamburg-



The Doctors Without Borders treatment centre in Guéckédou, Guinea. On the left, patients are sitting under an umbrella. On the right, clothing of doctors and nurses are drying in the sun.



A bucket with chlorine bleach sits at the entrance of the mobile laboratory for new samples submitted for analysis.

based Bernhard Nocht Institute for Tropical Medicine coordinates the deployments. The project is funded by the European Commission. Partners from all over Europe are involved, including: Public Health England, the Laboratoire P4 INSERM Jean Merieux in France, and since 2014, the Robert Koch Institute.

The EMLab was deployed in Guéckédou at the end of March 2014, shortly after the first cases of EVD were officially confirmed by the World Health Organization (WHO). Five scientists always work here for four weeks. Afterwards, they are replaced by the next team. Curtailing the outbreak depends on a reliable diagnostics on site. Infected people have to be quickly isolated from others to prevent further spread of the disease.

Andreas Kurth begins his service in Guéckédou at the end of May 2014, along with a colleague from Marburg, a Scot, a French colleague and an Italian. The days are always the same. Around 8:30 a.m., the ventilation system is turned on and the laboratory is opened. The fresh blood samples first arrive in the glovebox, a transparent box with integrated gloves in which the virologists can safely process the infectious material. The sample is tested for malaria and chemically deactivated, i.e. any Ebola virus that may be present is killed. Then, the sample is examined outside the glovebox in order to determine whether it actually contains traces of Ebola virus.

The steps are similar to those in a biosafety level 3 laboratory at the Robert Koch Institute. And

yet, working in the outbreak area is completely different. This is not only due to the simple conditions in the tent which make every step in processing and disinfection longer. When Andreas looks out the window of the tent in Guéckédou, he can see the patients over the red barrier fence. He sees people who are vomiting. He sees how a woman collapses dead. He sees children without parents wandering about the camp. “There is a face for every sample,” he says.

The first week of June is something like a turning point in Guéckédou. The epidemic picks up its speed, the number of cases suddenly shoot



Andreas Kurth analyses blood samples from suspected Ebola virus disease cases.

through the roof. His team processes 20 samples from patients suspected of having EVD per day. Almost all of them are positive.

### *Training session at the German Bundeswehr and rules of conduct for the deployment*

Ebola has been raging in West Africa for more than one and a half years. According to the WHO, more than 28,000 people have been infected with EVD since March 2014. More than 11,000 have died. It is the worst outbreak in history. The European Mobile Laboratory project has long since deployed all three of their mobile laboratories in West Africa. So far, 17 RKI employees have supported the EMLab on-site, some even twice. “On average, we provide two colleagues every month,” says Andreas Nitsche. He leads the Department for Highly Pathogenic Viruses at the Robert Koch Institute and organizes the missions.

He says that anyone who wishes to work in the EMLab should be proficient in the diagnosis of viruses and, as far as possible, already experienced with African countries. The candidates get a five-day training course by the German Bundeswehr in Munich, online safety training for UN staff, a full range of examinations, vaccinations, and rules of conduct for the deployment: avoid crowds, don't spend time outside the hotel or laboratory. Andreas Nitsche says the participants come from a wide range of fields. Even an influenza researcher is among them. “There are many young scientists

who are ready to take on this big responsibility.” He is proud of his colleagues.

The deployment in the EMLab is very demanding. The staff stands in the laboratory for many hours, continuously for four weeks. It's cramped, it's hot. Some teams process up to 70 samples a day. “Then there are the group dynamics to consider,” says Andreas Kurth.

The five team members are cobbled together from all over Europe. For the next four weeks, they spend almost every minute together. “At some point it is getting difficult.”

He could barely communicate with two team members because they didn't speak English well. In the team of his RKI colleague, Constanze Yue, there was even some tension from the outset.

### *Coping with the fear*

Constanze works in the Department for Highly Pathogenic Viruses for the German Partnership Program for Excellence in Biological and Health Security of the Federal Foreign Office which in part is located at the RKI. She helps African partner countries like Morocco or Tunisia expand their diagnostic capabilities. When the request came from the EMLab in June 2014, her friends said: “Don't go.” She went anyway. “I didn't have any time to really think about it much. I simply did it.”

It was a drastic experience, she now says. The individual team members didn't get along well



Constanze Yue has her temperature checked at the entrance to the EVD treatment centre in Foya, Liberia.



In the glovebox, infectious material can be handled safely.

with each other. One colleague was completely overwhelmed by the outbreak situation. “He refused to handle the samples. His face was pale as if turned to stone. He was suffering severely.” He didn’t want to break off the deployment. His fear, however, was so great that Constanze processed all the infectious samples in the glovebox by herself. The colleague only handled material which had already been deactivated.

The underlying threat of Ebola made it difficult for her, too. News of physicians from Doctors Without Borders or WHO employees who were infected despite taking all safety precautions spread like wildfire. When she sat in her hotel room alone in the evening, she called her colleague at the RKI at home in Berlin. “She bolstered me up.”

Her experiences in Guéckédou have not scared her off. In November, Constanze concludes yet a second deployment in the EMLab—this time in Foya, Liberia, together with a colleague from the RKI. “My condition was that there had to be one member in the team that I knew,” she says.

### *Two employees per month for the EMLab*

When employees participate in the EMLab, they are absent from the Robert Koch Institute for six weeks, including the preparation time and one

week of recovery at the end. This also means that tasks remain unfinished or colleagues in Berlin must take over. “Management has said from the start: Anyone who wants to go to the outbreak may go. We’ll compensate for that here,” says Andreas Nitsche. The RKI will support the European Mobile Laboratory project as long as the outbreak lasts. The RKI coordinator says there are enough candidates: “Most of those who already have been want to go again.”

Andreas Kurth and Constanze Yue greatly benefit from their deployments. They feel that they have done something really useful. They learned that even under hard conditions, highly pathogenic agents can be handled safely. They take their hats off to the helpers from Doctors Without Borders, who sacrificially care for the patients—and to the resilience of the patients,” says Andreas.

For every now and then, there are moments of happiness. The pregnant woman, for example, who defeats the Ebola virus infection, or the 15-year-old boy who, severely weakened by the infection, leads fitness exercises daily and jogs back and forth in front of the treatment tent. There are moments when no more trace of the virus is found in the blood sample of an EVD patient, when even the second one, the confirmation test, is negative the next day. When the patient finally goes home.

There is no approved vaccination preventing an infection with the Ebola virus. Epidemiologists take other measures to bring the outbreak in West Africa under control. Each case must be discovered and isolated. Each contact has to be identified and monitored. The Robert Koch Institute supports the World Health Organization in the field.

# INVESTIGATIVE WORK IN THE OUTBREAK AREA



For many, the Redemption Hospital in New Kru Town, a suburb of Monrovia, appears to be the last hope. It is a reception ward for suspected Ebola cases for which there is no place in a treatment centre. Families have transported their ailing loved ones here on the back of motorcycles; one woman is even lying in a wheelbarrow. The hospital, however, is already overcrowded. Police and security personnel have sealed the entrances. People are angry and desperate and Nadine Zeitlmann is right in the middle of it. She and her team were actually here with their local assistants for an appointment with the Liberian Ministry of Health, but the crowds force them back into their car. Through the windshield, she watches as the woman in the wheelbarrow dies. “The whole situation was shocking.”

Nadine normally works at the Bavarian Health and Food Safety Authority in Oberschleißheim, Germany, where she primarily concentrates on gastrointestinal pathogens such as typhoid, EHEC-HUS, hepatitis, and Salmonella. The biologist is currently completing her post-graduate training for applied epidemiology (PAE) at the Robert Koch Institute (RKI). This training programme is unique in Germany. She and her fellow participants, mostly physicians as well as scientists from other fields, principally learn epidemiological field work. They investigate disease outbreaks and establish their own research projects, either in the Department for

Infectious Disease Epidemiology at the RKI or, like Nadine, in a governmental health agency. Parallel to this, they attend lectures throughout Europe: The German programme is closely associated with the European Programme for Intervention Epidemiology Training (EPIET), which is coordinated by the European Centre for Disease Prevention and Control (ECDC).

In July 2014, the ECDC sends a request to the EPIET mailing list. In West Africa, Ebola is raging. The World Health Organization’s Global Outbreak Alert and Response Network (GOARN), which for years has successfully fought disease outbreaks all over the world, is desperately seeking epidemiologists to help curb the epidemic on the ground. “It was a great opportunity to do something useful myself,” recalls Nadine. She submits her application. Her supervisors at the RKI and in Oberschleißheim are supportive: they organise her examination in Munich to determine her fitness for service in the tropics, clarify the details for the business travel request. At the end of August 2014, Nadine flies to Monrovia, the capital of Liberia, for five weeks.

### *From Oberschleißheim to one of the epicentres of the Ebola epidemic*

At that time, Monrovia is one of the epicentres of the Ebola virus disease (EVD) epidemic. Approximately 200 people are infected with



In search of possible contacts: A case finding team in Monrovia interviews the head of the family of a deceased Ebola patient.





Daily ritual: Nurses form a prayer circle before they enter the isolation ward with the Ebola patients. J.F.K. Memorial Hospital was one of a total of three treatment centres in Monrovia at that time.

the virus per week. “There was too little of everything,” she says. “There were only two teams for safe burials. There was no ambulance, too few helpers and far too few beds in the treatment centres.” She and her colleagues check the database in the Liberian Health Ministry in which cases of Ebola virus disease are recorded. They perform an initial analysis: How is the outbreak developing in Monrovia? When will the greatest number of cases be expected and where? When residents call the national EVD telephone hotline and report a suspected case, the local teams drive there, question the residents about possible sources of infection and, if possible, arrange for the afflicted patient to be taken to an EVD treatment centre. “Creating a list of people with whom the patient had come into contact, putting them under quarantine and checking on them regularly was impossible in the outbreak situation in Monrovia at that time,” says Nadine.



Nadine Zeitlmann and her colleague in the health agency of Margibi, a neighbouring county of Montserrado in Liberia. The experts identify cases of infected health care workers in the Ebola database.

In autumn 2014, the first priority for the local and international aid workers from WHO was to get the situation in the outbreak areas under control. Making sure that infected people were treated and that the deceased were safely buried, that sufficient personal protective equipment and disinfectant were on-hand, and that, in some cases, the exponential increase in the number of cases was stemmed. Only then the path would be clear for the second phase of the battle. WHO calls it “Getting down to zero.” With tight infection control measures, the virus is to be curtailed.



Educational work in Kambia District: The whole village is called together. Maja George and colleagues from UNICEF support the teams on the ground.

### *Nets with gaps*

This means that whenever people fall ill with EVD, the field epidemiologists have to disclose how they became infected and who they may have infected. They have to track down all contacts, place them under quarantine at home for 21 days and check their health daily. Anyone who develops a fever is taken to a treatment centre. Ideally, all confirmed cases, suspected cases and contacts will come together in a seamless net, each one of them being monitored. Thus, additional infections are prevented.

In the field, however, things never work that well. The epidemiologists have to do real investigative work. Nevertheless, there are still gaps in the net. Many cases only come to light after the affected person has died. Then, sources of infection and contacts can hardly be reconstructed. Sometimes not all parties concerned pass on all information immediately. "Obtaining precise information is a big problem," says Maja George. The post-doctorate biologist currently works in the Rhineland-Palatinate State Agency for Consumer and Health Protection in Landau. She will soon conclude the postgraduate training for applied epidemiology at the RKI.

For WHO, she was deployed in Kambia, a rural district in northwestern Sierra Leone, from the beginning of March to the middle of April 2015. There were only a few Ebola cases at that time, but the risk was great that more would spill over from neighbouring Guinea. Maja led her surveillance team of international and local staff over bumpy roads in the remotest areas for hours in order to carry out investigative work in villages, find cases and contacts. It was anything but easy. "People tended to be coy and incommunicative," she says. Often, the team lost valuable time.

### *The fear of being quarantined*

In one village, says the epidemiologist, a man had died of EVD. His highly infectious clothing had been picked up by a friend from a neighbouring village, it was said, on a motorcycle. But the people in the neighbouring village remained silent. "We had to drive there three times before we found the motorcyclist," says Maja. The team then gradually learned that nobody had wanted the clothing of the deceased man. The motorcyclist had left it in



Aid workers are lead into the bush where the bags of clothing from a deceased Ebola patient have been stashed.



The garments are disinfected as prescribed.



Safe burial of a deceased patient in Kambia District, Sierra Leone. As a safety precaution, all deceased people are buried this way in the Ebola outbreak area.

a plastic bag in the bush. “The residents of the village had intuitively done the right thing.” A decontamination team then retrieved the clothing from the bush and disinfected it. The motorcyclist was quarantined. He was lucky: He wasn’t infected with the Ebola virus.

In Sierra Leone, quarantines are established by the government. A temporary barrier is placed in front of the house. Unarmed soldiers ensure that nobody walks in or out for the next three weeks. Every day, the residents’ temperatures are taken. The affected families are provided with food and necessities for that time. Nevertheless, sometimes entire villages conspire to evade the quarantine.

Maja George also experienced that people already quarantined denied symptoms of the disease—because they were afraid they would be taken away and never return, or simply because they had nobody to take care of their children. For security reasons, the actions of the epidemiologists are limited: In order to protect themselves from being infected, they are not allowed to enter the houses. They speak with family members in front of the house and have to rely on the information they are given. One time, Maja and her team weren’t aware that a man who was under quarantine with his wife and seven children was actually infected with EVD. He had probably suppressed the early symptoms with medications; his wife had said nothing to the team. The man and six children died.

“You just stand there powerless and can’t really do anything,” she says. She knows that experiences like these are part of the job.

### *Ask the right questions*

Post-doctorate infectious disease biologist and PAE participant Joana Haußig knew early on that she wanted to help in West Africa. “The work done by my colleagues there has impressed me,” she says. After having performed outbreak investigations in Germany, she learned that one thing is essential in the field: “You have to ask the right questions.”

One PAE learning module was particularly beneficial to her deployment in West Africa: the participants learn to manage an acute outbreak event in a realistic exercise. They must obtain and interpret current information, with all the difficulties associated—time is short, some information must first be translated. “We learned how to work together effectively, even under great pressure,” says Joana. “And we also learned how to communicate in such a situation.” Good communication is critical, especially in West Africa.

From early April until the middle of May 2015, Joana is deployed in Guinea, in a part of the capital Conakry and in Dubréka in the north. She and her team are mainly responsible for hospitals and private medical practices—in other words, locations where, sooner or later, suspected



Team meeting: Local volunteers and WHO employees plan their visits to hospitals and local doctors in Conakry.

cases of EVD will emerge. They compile lists and determine where the greatest number of suspected cases might be expected. “The doctors in the emergency rooms, for example, are supposed to fill out a questionnaire about EVD symptoms for each patient, no matter why he or she came in,” says the epidemiologist. No case may be overlooked. The specialists check the surveys and follow up. “There have been suspected cases every day. Fortunately, most turned out negative,” says Joana Haußig. In Dubréka, the epidemiologists also visit 30 private medical practices, which in some cases consist of nothing more than a small back room. They provide the doctors with additional information and, if necessary, with soap, gloves and thermal scanners. “I liked this work. The doctors were very grateful,” she says.

### *“Examination report? I have that in my head”*

Sometimes, however, she actually had to do a lot of persuading, for example, when it comes to the proper documentation of patient data. “People in Guinea are accustomed to oral reports,” she says. When she asks a local doctor involved in case studies for the relevant documents, he taps on his forehead and says: “I have everything in here!”—“And what do I do if there is a time when your head is not there?” she then asks back. “The EVD outbreak in Guinea has lasted more than one and a half years. The local doctors have their own way. They won’t change overnight,” she says. “All you can do is try to gently improve the system.”



A doctor in Dubréka shows Joana Haußig and her colleague from the WHO patient data.

### *The outbreak is far from over*

Nadine Zeitlmann, Joana Haußig and Maja George have gained much from their missions to West Africa. They admire the great commitment of the locals, who maintain Ebola hotlines with their private cell phones and do dangerous work such as burials despite low pay. They learned the importance of good communication skills. Sometimes, you are most likely to track down someone who might be infected by speaking calmly with the women of the village rather than by threatening to call the police. You cannot always stubbornly insist on following rules, the three epidemiologists say, you have to reach compromises. An epidemiological database with lots of variables may indeed provide the best information, but it isn't feasible in such a situation. The deployment enriched their postgraduate training.

So far, nine PAE participants have supported the World Health Organization and Doctors Without Borders (MSF) in West Africa. For others, the journey to West Africa is still ahead. Although the number of cases in Guinea and Sierra Leone has diminished greatly in the last few months, the outbreak is not over yet.

And yet, there is hope. Liberia, which has been the most severely affected, was declared free of Ebola virus disease by the WHO on May 9 2015. To celebrate the day, Nadine opened a bottle of Liberian beer and ate ginger cookies which she had saved during her deployment for



Joana Haußig and her team wash their hands each time they enter a building—in this case, a health facility.

this very moment. “I was simply proud of the fact that Liberia has accomplished it.”

Seven weeks later, at the end of July 2015, a young man died again of Ebola virus disease in Liberia. Even after everything, countries must remain vigilant.



Red Cross employees give a lecture on safe burials at a meeting in Dubréka, Guinea.

# THE FEAR OF THE PATIENT



Burkina Faso is in West Africa. So far, no cases of Ebola virus disease have occurred here. However, medical staff need to be prepared. The Robert Koch Institute offers training programmes for doctors and nurses.



The supposed Ebola patient is in a very poor state.

The young woman tosses back and forth in the bed. She moans, she whimpers. She strikes at the workers when they try to draw a sample of her blood. She throws up when they give her something to eat. Some of them embrace her then, trying to console her. Others stay back a meter from her bed, anxious and a bit lost in their yellow protective suits.

The doctors and nurses are here in a health centre in Koupéla in Burkina Faso to learn how to take care of Ebola patients. Doctor Luzie Verbeek plays the patient, lying on a couple of chairs pushed together. Her colleague, Min-Hi Lee, instructs the helpers: always approach a patient in pairs. Don't draw blood from an agitated patient, otherwise you risk a needle stick injury. Make yourself understood with gestures. She repeatedly reminds them of the ground rule: "Only one person has direct contact with the patient. The second one remains in the background and watches for possible contamination." If vomit lands on the helper's suit—in this case, red-coloured strips of sellotape which Luzie adheres to the yellow suits with lightning speed—the second helper must disinfect it immediately. "The most important thing for them is not to put themselves at risk," says Min-Hi.

Burkina Faso is located in West Africa. For one and a half years, the region has been

struggling with the largest outbreak of Ebola virus disease (EVD) in history. More than 28,000 people have been infected in Guinea, Sierra Leone and Liberia. In Burkina Faso, no Ebola cases have occurred so far. However, travelers have already carried the virus to other neighbouring countries: Senegal, Mali, Nigeria.

The Robert Koch Institute (RKI) wants to help the adjacent countries be prepared for possible imported cases of EVD. This is the only way to prevent further spread of the disease in the case of an emergency. The German Federal Ministry of Health is providing 2.2 million euros for personal protective equipment and for the training of hospital staff. Luzie Verbeek and Min-Hi Lee both work at the Centre for Biological Threats and Special Pathogens at the RKI. Together with colleagues from the Medical Mission Institute in Würzburg and doctors from Burkina Faso and Senegal, they have developed the training



The virologist, Min-Hi Lee from the Robert Koch Institute (centre), checks the fit of personal protective equipment (PPE).





Basic hygiene procedures must be performed correctly: The participants practice hand washing ...

programme. In December 2014, the team offered their first workshops in Burkina Faso.

### *Lessons from Nigeria*

“The local hospitals play a pivotal role in the fight against Ebola. If someone actually suffers from EVD, he will show up there sooner or later,” says Luzie Verbeek. When the disease hits an unprepared hospital, it can end in disaster.

Nigeria, for example, just narrowly missed a catastrophe in July 2014. When a severely ill man was taken to a clinic in Lagos, the doctors guessed it was malaria and waived additional safety measures. The man, however, was suffering

from EVD. Nine doctors and nurses contracted the virus. The health authorities responded immediately and began monitoring thousands of contacts. That is why they were able to bring the outbreak under control relatively quickly. Lagos is a city with more than 20 million people.

Luzie and her colleagues teach the doctors and nurses in Burkina Faso how to identify patients with EVD, how to isolate them and how to avoid infection. The participants learn about the symptoms and incubation time. They learn how to take off disposable gloves safely and how to use disinfectant properly. A workshop lasts for three days and is designed for 15 participants. “There have always been more than that in attendance,” says Min-Hi Lee. There is great interest.

The Germans work closely with local staff in Burkina Faso. The team trained four future trainers at the very beginning, all of them doctors from the region. “It was them who then carried out the actual training. We only assisted,” says Luzie. In every course, one or two new trainers are being educated. The concept is referred to as “train the trainer”. By this, the knowledge of how to deal with EVD patients can be distributed throughout the whole country.

*“Many expected it to be easier than that”*

Luzie Verbeek and Min-Hi Lee are experienced trainers. In Germany, they teach doctors in the



... and putting on gloves.



Personal protective equipment must be worn properly.

public health system. The differences between Germany and Burkina Faso are enormous. For example, many of the participants in Burkina Faso have never seen a micrograph of the Ebola virus. However, the trials and tribulations are the same for German and for Burkinabè helpers, Luzie says. On the one hand, they want to help. On the other, they are afraid to become infected. “They’re afraid of the patients.”

In addition to fundamental hygiene measures, the most important pillar of the training is dealing with the personal protective equipment (PPE). With this, the helpers can approach the patients safely. However, they need to know how the suit, rubber boots, hood, goggles, and gloves are put on and taken off correctly. The project team had an additional colleague, who works closely with the Medical Mission Institute, come to Burkina Faso just for this. He had already worked in Ebola treatment centres in West Africa and is aware of the pitfalls. “It was very important to us to include somebody who has experience in the outbreak area,” says Luzie.

There are perils in simply removing the protective equipment. If helpers are exhausted and unfocused, they can easily become infected via their own suits. Therefore, a second person has to disinfect the suit and give guidance in removing it. Sweat accumulates in the yellow suits. The goggles fog up. It’s difficult to breathe. “Many participants have said they thought it would be easier,” Luzie says. They practice every single step, again and again.

“The personal protective equipment is only as good as its use. That is why it is so important that participants have also mastered the general hygiene measures,” says the physician. The worst thing would be if the participants felt safe with the PPE, but in the case of an emergency make a mistake and become infected. Confidence in the personal protective equipment would be lost, and the fear of Ebola virus disease would be even greater than before.

The participants are highly motivated. At the latest, the ice is broken for good when Luzie plays the patient, says Min-Hi. “Time and again

they asked me: What can I do so that the patient feels a little better.” Some helpers then bring Luzie magazines. Others bring her a telephone so that she can call home to Germany. “There wasn’t just fear,” she says. “Above all, there was devotion to the patient.”

During the pilot phase in Burkina Faso, the team from the RKI helped conduct three training sessions. Additional training sessions took place in neighbouring Senegal. There are also requests from other countries, sometimes from non-governmental organisations, sometimes even directly from governments. However, the training can only be carried out under relaxed safety situations. The German and African instructors created a manual together that bundles

the course content and can be coordinated with the contingency plans of the individual countries. Future trainers will be able to download the manual from the internet.

The project runs until the end of April 2016. Luzie Verbeek and Min-Hi Lee will continue to accompany the training and educate more trainers in West Africa. Doctor Regina Ellwanger has worked on the project for the RKI team since February: she will assist in designing the training in a didactic manner and assess the benefits. The three are offering the trainers in Burkina Faso and Senegal follow-up trainings as well. “We must ensure that the quality of the training is still right,” says Luzie. “So no mistakes creep in.”



An outdoor teamwork exercise on EVD transmission.

# **WHEN EACH AND EVERY CASE COUNTS**

The number of Ebola cases in West Africa declines. But the outbreak is not over yet. Epidemiologists need to track down every single infection, prevent further spread of the disease. It is a race against time.





Downtown Freetown: In early June 2015, there were no more cases of Ebola virus disease in the capital of Sierra Leone. But then, the disease returned.

A swab from the mouth provides confirmation. The man from a suburb of Freetown in Sierra Leone died of Ebola virus disease (EVD). But where did he contract the virus? Could more cases of infection which are as yet undiscovered occur there? Also with whom had he been in contact since his disease onset? Whom could he have infected?

A race against time begins for the epidemiologist, Anna Kühne, and her colleagues,

who are out and about in Freetown on behalf of the World Health Organization (WHO). They can no longer speak with the patient. "Family and friends didn't know precisely where he had been." The team canvasses the neighbourhood. At some point, it is revealed that the man helped with cleaning the corpse of a traditional healer who also died of EVD. The WHO is already aware of the healer's case. A group of contacts is already being monitored. The contacts of the deceased man, on



Anna Kühne and two District Surveillance Officers will work together to determine the source of infection.

the other side, remain to be determined. His wife, his two children and some of his neighbours who helped him during his illness will be quarantined, as ordered by the government. Their house is surrounded by a thin warning tape. Outside the door, unarmed soldiers ensure that nobody leaves the house—and that nobody attacks the family out of fear. Every day, experts inspect the family for typical EVD symptoms: fever, diarrhoea, vomiting, inflamed eyes, bleeding. When the mother develops a fever, she is immediately isolated and taken to a treatment centre. “The mother survived Ebola. The children didn’t contract it,” says the epidemiologist. The chain of transmission is broken. The tenacity of the helpers has most likely saved the two children’s and the neighbours’ life.

Anna Kühne is a physician and an epidemiologist at the Robert Koch Institute (RKI). She is currently completing her post-graduate studies for applied epidemiology (PAE) in the RKI Department for Infectious Disease Epidemiology. From early March until the middle of April 2015, she and her colleague, Christina Frank, supported the Global Outbreak Alert and Response Network (GOARN) of the World Health Organization in Sierra Leone. “After the EVD outbreak in Sierra Leone, Guinea and Liberia,” says Christina, “we at the RKI spent months preparing for a potential spread to Germany. But this risk is minimal.

The real risk is for the neighbouring countries in West Africa.” The epidemiologists wanted to help where help is needed—in the concerned countries. In addition to the two of them, 12 RKI epidemiologists have travelled so far to West Africa in a total of 18 deployments. Together with other international and local supporters, they want to end the Ebola outbreak.

### “Every case counts”

Sierra Leone is a relatively small country with six million people on the West African coast. “The people are very friendly,” says Christina, “they bear their difficult life with dignity.” Sierra Leone is one of the poorest countries in the world. There is virtually no public health care. Child and maternal mortality rates are high, life expectancy is only 45 years. Added to this, since spring 2014, people also have to deal with EVD. So far the disease has claimed around 3,500 lives in Sierra Leone. Even though the number of new infections has decreased for several months, the outbreak is not over yet.

In March 2015, Christina was assigned to the eastern suburbs of Freetown, Anna to some urban areas in the west. Up to 150,000 people live in each of these sections. The epidemiologists work in the Western Area Ebola Response Centre



The two RKI epidemiologists work in the Western Area District Ebola Response Centre in Freetown.



Challenging sanitary conditions in a neighbourhood in Freetown.

in Freetown. They organise case investigations and trace contacts in the districts for which they are responsible. They frequently go into the field themselves.

“Particularly right now, where there are only a few infections with EVD, it is necessary to be on top of each one of them,” says Christina. In theory, transmission could be stopped quickly. The virus only spreads through a patient’s body fluids. The incubation period is up to three weeks and infected people are only contagious when they are showing symptoms. “If it is possible to isolate them at the first sign of fever—when they

are still not yet highly infectious—then additional infections are prevented.” But in reality, things never go that smoothly. In a country like Sierra Leone, experts are faced with many obstacles. It starts with even finding the infected, says Anna Kühne: “Surveillance is difficult because people cannot afford to go to a health centre or hospital when they get sick. Many take care of their ill family members at home as long as possible, hoping that they are not suffering from EVD. If normally people don’t go to the doctor, one can neither discover cases early nor prevent a further spread of this and other



A man died in the street. It is necessary to determine if he died of Ebola. A burial team takes a swab, which will be tested for Ebola virus. They will then retrieve his body, disinfect the street, and perform a safe and dignified burial.





Final preparations: The response team dons and checks personal protective equipment in anticipation of picking up a patient who is possibly infected with Ebola virus disease.



The patient is being transported by the response team. He will be taken to a holding unit where he is tested for the disease.

diseases. We remain dependent on reports from the population.”

### ***A national EVD hotline and many local helpers***

Reports of suspected cases reach the district situation response centres in various ways. On the one hand, there are individual, specially trained residents in the residential areas who are well-integrated in the community and quickly find out and report when somebody falls ill. On the other hand, there are groups of social workers, who actively go from house to house to educate the residents about the Ebola virus and canvas for symptoms. Additionally, an EVD hotline has been set up in Sierra Leone, via the number 117, where anyone can report suspected cases.

So-called District Surveillance Officers (DSO) investigate every single report in their assigned areas. They look at the patients or, if they are already too ill, speak with their family. “Stringent safety measures apply to all experts deployed: Not

entering houses, keeping a one meter-distance,” Anna says. If the symptoms point to EVD, the epidemiologists are called in. Together with the DSOs they check whether the patient meets the case definition for Ebola virus disease, “sometimes over the telephone, sometimes on-site.” Then they arrange for a transport to a treatment centre and call the disinfection team.

When the patient has been removed, when the house has been disinfected with chlorine bleach and the mattress, frequently contaminated with body fluids, has been replaced, the detective work begins for the epidemiologists. They have to find the source of infection and monitor all contacts who might possibly have been infected. After lengthy research, some cases mesh with already known chains of transmission. Then the circle is complete, as with the man who had attended the funeral of the healer. However, often the source of infection remains a mystery. “We had a young man in Freetown who died shortly after his Ebola diagnosis,” says Christina. “We never got the chance to talk to him. We only heard from his neighbourhood that he occasionally worked in a garage and hung out in a bar.” Maybe

he had cleaned up vomit in a car and had become infected that way. “But we were not able to associate it with a specific chain of transmission,” says Christina.

### *The ambulance only comes for Ebola patients*

The health system in Sierra Leone is in a sorry state, not only since the Ebola epidemic. With only a few exceptions, people must pay for medical treatments themselves. Thus, the majority are denied health care. Many die from infectious diseases such as malaria, diarrhoea, respiratory infections, tuberculosis and HIV. “People don’t understand why Ebola gets so much attention,” says Anna. “The many aid workers from abroad, and ambulance that will only come for suspected cases of EVD. For those with other illnesses, this is difficult to understand.” So they dial 117



A man suspected of having Ebola virus disease climbs into one of the specific ambulances driving through Freetown during the epidemic.

in despair, simply because there is no other number to call, like the parents of a 19 year-old supposedly suffering from Ebola. But when Anna looks at the young woman, she has none of the typical symptoms of EVD, but a severe allergic reaction. Nevertheless Anna succeeds in getting the woman transported to a hospital, but there she dies due to a lack of intubation equipment.

### *A feast to celebrate the end of the quarantine*

The intensive work of the local and international aid workers in Sierra Leone pays off. At the beginning of June 2015, there had been no more cases of Ebola virus disease in Freetown for some weeks. Then, the disease returned. In Freetown, there is always the risk that infected people from other regions of the country could arrive. More than a year after the outbreak, people in Sierra Leone still do not understand the disease. According to the epidemiologists, education is hampered by language barriers. People speak several different languages. Many can’t read. “In addition, the rules and advice of aid workers run contrary to centuries-old traditions,” says Christina. One rule states: Do not touch any infected person. However, in Sierra Leone it is normal and an economic need to care for family members and to prepare the deceased for funeral. Misconceptions mix with fear of the smell of the disinfectant and with the fear of the ambulance. The fear of being taken away, never to return. For those reasons some people shun the aid workers.

But the two epidemiologists also experienced the opposite during their time in Freetown. There were moments when people were very grateful to the team. When EVD patients were detected early, isolated and treated. When the contacts survived the three week quarantine-period without becoming ill. “The lifting of the quarantine is a ceremony each time,” says Anna. The warning tape is removed. The kids frolic around in the street. The adults beam with relief. A city or military official gives an address. A team member gives a health class. Afterwards, all pray together: First the hands are folded

for the Christian God. Then, all the hands are turned palms facing upward for Allah. Being grateful that one chain of transmission has been broken.



Christina Frank in Freetown.

In order to keep the virus from spreading, travelers are screened for signs of Ebola virus disease at the international airports in West Africa. An epidemiologist from the Robert Koch Institute and international colleagues watched the exit screenings at the Lungi International Airport in Sierra Leone.



# QUESTIONNAIRES AND FEVER SCANNERS



On behalf of the European Commission, the epidemiologist, Andreas Gilsdorf (right) and two colleagues watch the exit screening at the airport.

The passenger is sick. He is already lying on the floor in the check-in area of the terminal at the airport in Monrovia. He vomits on the flight to Lagos, Nigeria. Shortly after his arrival, he vomits again, and once again in the car that is supposed to take him to a private clinic. He tells the hospital staff that he suffers from malaria. It is July 20, 2014. Five days later, he is dead.

The man had been infected with Ebola in Liberia. His sister had died of the disease. He had visited her in the hospital and went to her burial. The authorities in Nigeria learned all this much too late. Before he died, the passenger infected nine doctors and nurses who came in contact with hundreds of people. Lagos is a metropolis with more than 20 million inhabitants. It could have been the beginning of a disaster. The fact that the outbreak was comparatively light—in Nigeria, there were a total of 20 cases, including eight deaths—can only be attributed to the quick reaction of the local health authorities.

Since spring 2014, Ebola virus disease (EVD) has been raging in West Africa. In Guinea, Sierra Leone and Liberia, more than 28,000 people have been infected. Today, there is a tight ship at the international airports: anyone who is sick is not even allowed on the premises. And anyone who boards a plane has had their temperature taken at least three times. “Nobody presenting symptoms

gets on board,” says Andreas Gilsdorf. The epidemiologist from the Robert Koch Institute (RKI) investigates how infectious diseases spread through international air traffic. On behalf of the European Commission, he helped examine the exit screenings at the international airports in West Africa.

In July 2014, the Ebola case in Nigeria was a wake-up call for the World Health Organization (WHO). It was the first time that EVD in West Africa was spread to another country by air and triggered an outbreak. On August 8 2014, the WHO declared the Ebola virus epidemic in West Africa a public health emergency of international concern. To keep the virus from spreading, the WHO recommended exit controls in the affected countries. At international airports, seaports and major border crossings, travelers are screened for symptoms of EVD and, in case of doubt, they are prevented from journeying on. In November 2014, the EU Commission wanted to ensure that the recommended standards are still being maintained on-site. The Commission sent three expert teams to the international airports in the outbreak area: to Monrovia in Liberia, to Conakry in Guinea. Andreas Gilsdorf visited the Lungi International Airport in Freetown, Sierra Leone, with a colleague from the United Kingdom and a representative of the European Centre for Disease Prevention and Control (ECDC).



The Lungi International Airport in Freetown, Sierra Leone.

### *A concern of many*

Sierra Leone is a relatively small country of six million people on the West African coast. Its capital Freetown lies in the far West, surrounded by a state forest reserve. “The country is beautiful,” the epidemiologist says. However, it is among the most impoverished in the world. The public health system in Sierra Leone was wretched even

before the EVD outbreak. There are just two hundred doctors for the whole country. Maternal mortality is one of the highest in the world. The life expectancy is only 45 years.

Since spring 2014, EVD has claimed around 3,500 lives in Sierra Leone. On the streets of Freetown, he says, people are made aware of the disease. There are warning signs, temperature checks and canisters of chlorine bleach for washing



First temperature check at the entrance to the airport. Every passenger's temperature is taken four times before departure.

hands everywhere. But the virus doesn't dictate everyday life. The markets are open. "The beach is full of people playing sports in the morning." In Sierra Leone, Ebola is only a concern of many.

*With a body temperature of 37.5°C, the journey is over*

The Lungi International Airport is located at the coast north of Freetown, on the other side of the Sierra Leone River. It takes half an hour to get there by boat. In November 2014, Andreas and his colleagues spent five days here. They looked at the handling of three international flights: one to Brussels, one to Casablanca in Morocco and one to Abidjan in Ivory Coast. More flights no longer existed. At that time, most foreign airlines had dropped the route for fear of Ebola, Andreas says.

The health checks at the Lungi International Airport are tight. The authorities follow the recommendations of the U.S. Centers for Disease Control and Prevention (CDC). At the wrought-iron gates to the airport, workers are already waiting with fever scanners—these are infra-red thermometers which are held at a safe distance from the forehead of the traveler. Passengers must indicate on a questionnaire whether they have vomited in the last two days, experienced pain in their limbs or bleeding, whether they have had contact with Ebola patients in the last three weeks,

or perhaps even helped care for an Ebola patient or came into contact with a corpse.

Before check-in, passengers pass through the actual health check. Nurses, doctors and medical students scan the questionnaires and take their temperatures again. "It is important that the personnel here are medically-trained," says Andreas Gilsdorf. Only they are able to recognize if the passenger appears ill.

If everything is fine, the questionnaire is stapled to the boarding pass with stamp and signature. At Lungi International Airport, about four hours elapse from the time of entering the airport premises to departure. "In this period, every passenger has had their temperature taken four times. The last time is just before departure," says Andreas.

For passengers whose body temperature is more than 37.5°C at one of the checks, the journey is over. The same applies to passengers who report having had direct contact with Ebola patients or their body fluids. They are questioned further in a separate room, examined, and if necessary, moved to an EVD treatment centre.

The measures are the same at all three international airports in the West African outbreak area: in Freetown in Sierra Leone, in Conakry in Guinea and in Monrovia in Liberia. At all three airports, they work well. "The probability that a feverish passenger will board a plane is practically nil," the team concludes in their report to the European Commission. The experts, however,



A thermal scanner in the terminal. The health check is carried out by trained medical personnel.





Symptoms—and contacts with Ebola patients—are queried in a questionnaire.

have found a few vulnerabilities. It still remains to be ensured that passengers suspected of having Ebola virus disease are transported quickly to a treatment center for further examination. In addition, resources must be secured so that the departure controls can still be carried out long-term.

Andreas Gilsdorf says: The exit screening has its limits. You can only filter out those passengers who are obviously ill. People who are indeed infected with the virus but not yet exhibiting symptoms slip through. The incubation period of EVD can take up to three weeks. In case of doubt, a questionnaire doesn't help. "Anyone who absolutely wants to leave the country won't answer the questionnaire honestly," he says. "But that's not a problem with Sierra Leone or the other



A family is checked at the entrance of the terminal.

countries. That's rather an inherent problem of the screening methods." Additional entry controls, as have been performed in the United States or the United Kingdom, don't alter the fact. There will never be absolute certainty.

So far, it happened four times that an infected person departed from the affected countries during the incubation period. Three of them were foreign aid workers, a physician from the United States, a nurse from the United Kingdom and a nurse from Italy. They treated EVD patients in the outbreak, always wearing personal protective equipment. It is still not clear how they became infected.

When Andreas Gilsdorf examined the departure controls at the Lungi International Airport in Freetown in the five days in November 2014, not a single passenger was pulled out. "In the past few months, there has only been a handful in Sierra Leone," he says. Each of them was tested. None had EVD.

Probably, the exit screenings discourage sick people from coming to the airport. However, it is more likely that those who are most at risk of EVD never even enter the airport. Ebola is a disease of the poor. They will never afford a flight abroad.

**A NEW LABORATORY  
FOR IVORY COAST**

Bouaké is located in the centre of Ivory Coast. Many travelers from neighbouring Guinea and Liberia pass through this city, possibly carrying the Ebola virus. A team from the Robert Koch Institute set up a new laboratory in Bouake so that possible Ebola cases can be quickly identified.



If Claudia Kohl's mobile phone lights up with the digits + 225, it is possible that she will have to pack her suitcase immediately. +225 is the country code for Ivory Coast. Claudia and her colleagues from the Robert Koch Institute (RKI) just recently built a new laboratory for the diagnosis of Ebola virus disease (EVD) in Bouaké. A mobile laboratory is stored there as well, which can be quickly set up and operated in any region of the country in which EVD cases might occur. That's why the virologists maintain an unofficial on-call status: "If an actual case of EVD emerges there, we fly there the next day and take over the work."

Claudia works for the German Partnership Program for Excellence in Biological and Health Security of the German Federal Foreign Office, which is partly housed in the Centre for Biological Threats and Special Pathogens at the RKI. The program aims for preventing biological vulnerabilities and setting up the necessary laboratory capacities with the help of African partner nations. Ivory Coast is located in West Africa. It borders on Guinea and Liberia, those countries in which EVD has been raging for more than one and a half years. The virus has often overcome borders in West Africa. There have been cases in Senegal, Mali and Nigeria. So far, Ivory Coast has been spared. All suspected cases have turned out negative. However, experts fear that it might be only a matter of time until the first true infection occurs.

Therefore, the RKI virologists want to expand the diagnostic capabilities in Ivory Coast. The goal is for the country to identify cases of EVD quickly and reliably. This is the only way to prevent further spread of the disease in the case of emergency. The German Federal Foreign Office provides 1.8 million euros. Claudia Kohl and Andreas Nitsche, head of the Department for Highly Pathogenic Viruses at the RKI, coordinate the project.

### *Waiting for the virus*

In Ivory Coast, people have prepared for the plague as best as they can. "In the cities, posters explain the symptoms, disinfectant is placed on the tables in restaurants," Claudia says. Arrivals have their temperature checked at the airport.

Until now, however, samples from suspected cases have been examined at only one location in the entire country: at the Institut Pasteur de Côte d'Ivoire, the national reference laboratory for EVD. It is located in Abidjan in the South. The Robert Koch Institute and the German Federal Foreign Office have built an additional laboratory for the diagnosis of EVD—in Bouaké. The city in the center of Ivory Coast is a transportation hub. Main roads from the entire country converge here in a star shape. Many travelers from Guinea and Liberia, potential carriers of the Ebola virus, pass through. "The laboratory has been ready



Ivory Coast: On the road between Yamoussoukro and Bouaké.



The temporary isolation ward for patients with Ebola virus disease at the university hospital in Bouaké.

for use since December 13, 2014,” says Andreas Nitsche.

The laboratory is the result of a strenuous logistical and organizational effort which has taken weeks to accomplish. Since October 2014, ten RKI employees have repeatedly traveled to Ivory Coast in order to advance the project. One of the first was Heinz Ellerbrok from the Department for Highly Pathogenic Viruses. Heinz is fluent in French. He

presented the project to the Ivorian Ministry of Health, coordinated with the Institut Pasteur in Abidjan, and explored possible locations with his colleagues.

The virologist had been to Africa only once before. In the summer of 2014, he had been working in the European Mobile Laboratory (EMLab) in Guinea for four weeks, right in the middle of the outbreak in Guéckédou. He



The laboratory equipment is being delivered.



RKI virologists Andreas Nitsche (front) and Andreas Kurth help unload the equipment.

examined blood samples from suspected EVD cases there, as if on an assembly line. “Guinea is a country with no functioning infrastructure,” he says. The health system had, for all intents and purposes, crumbled to dust.

Guinea and Ivory Coast are worlds apart. Ivory Coast is in good shape, comparatively speaking. The power supply is stable, there are highways with French toll systems. “The

organisation of the university hospital in Bouaké is outstanding.” The RKI has worked with Chantal Akoua-Koffi, head of the hospital laboratory, before. There are suitable rooms and highly motivated employees who regularly take part in training courses on Ebola. A temporary isolation ward for suspected cases has been set up. Bouaké, he says, is the perfect partner.



Claudia Kohl and Andreas Kurth examine the collapsible glovebox for the mobile laboratory.



Heinz Ellerbrok (on the top) and RKI colleague Martin Richter prepare the laboratory room in Bouaké.

### *An empty room, nothing more*

In November 2014, Claudia Kohl, Andreas Nitsche and two other colleagues from the RKI plan the design of the new laboratory in Bouaké. All have been working with dangerous pathogens for years and are familiar with the requirements the laboratory must meet. “We had an empty room, nothing more,” says Claudia. The scientists have to order everything needed for the detection of Ebola virus: gloveboxes (these are transparent boxes with integrated gloves in which blood samples are rendered inactive before being further processed), thermal cyclers, centrifuges, pipettes, reagents, gloves, personal protective equipment.

That’s not all. “In the case of emergency, the samples must be handled according to a standardized procedure so that the risk of infection is kept as low as possible for employees,” says Andreas Nitsche. They work out every detail of the laboratory, from the location of the glovebox

to the washable paint for the walls. The room even needs to be remodeled.

The requirements are tight, for example for the acceptance of samples, says Claudia. In Guinea, where she had also been deployed in the EMLab for some weeks, she received throat swabs from patients with EVD in a knotted rubber glove. Something like that will not be allowed to occur in Bouaké: “Blood or saliva samples must be sealed in a bio-bottle.” A bio-bottle is a special container for highly infectious material for which, in turn, there is only one path of entry into the laboratory: a specially created hatch in the wall.

The renovation work in the laboratory is finished quickly, no matter if a wall must be breached or newly constructed. “Ms. Akoua-Koffi reached for the phone and a couple of hours later, everything was completed,” says Andreas. Laboratory benches, cabinets and shelves are custom-built by a local cabinet maker.

However, getting all the equipment into the country to fully furnish the laboratory is significantly more complicated. “Clearing customs in Abidjan and transporting the load to Bouaké took ten days, despite having all the necessary import permits,” says Claudia.

Finally, the new laboratory at the University Hospital in Bouaké is finished mid December 2014. Now, up to 60 suspected EVD samples could be analyzed here per day. In a second room, the additional mobile laboratory is stored. A second mobile laboratory is stationed in Berlin. In an emergency, it can be sent to Ivory Coast or a neighbouring country quickly.

Thankfully, the director of the university hospital in Bouaké called for his tailor: the RKI staff all received tailor-made Ivorian dresses and shirts.

### *Trainings for the local laboratory staff*

The construction of the laboratory in Bouaké was just the beginning. “It is our goal that our Ivorian colleagues can operate the laboratory alone in the long run, that they will diagnose not only Ebola viruses, but also other highly pathogenic agents like Lassa or Marburg viruses,” says Claudia. The team has trained the local staff in handling the dangerous samples. Seven



Farewell gift from the director: Claudia Kohl with a traditional Ivorian dress.

new employees have been hired by the Robert Koch Institute for that purpose, funded by the German Federal Foreign Office. “The local staff can operate the stationary laboratory at the university hospital by themselves now,” says Andreas Nitsche. Trainings in the mobile laboratory are scheduled for this winter. The on-call status will remain for a while.



