

## From research to field action: example of the fight against cholera in the Democratic Republic of Congo

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**Abstract.** The Democratic Republic of Congo (DRC) is the country in the world which reported the highest number of cholera cases to WHO from 2002 to 2007 (128 936 cases out of a worldwide 902 071 cases). We, therefore, implemented research work which intends to understand the epidemiology of cholera in the DRC and to ensure improvements in the strategy to fight against cholera. This broad study enabled us to accurately determine the cholera epidemic's mechanisms on different scales; to identify the source zones of the disease, and the groups of populations acting as vectors of the spread. It was then possible to demonstrate the role of "sanctuary", played by some suburbs of lakeside cities. A collaborative network, including several scientific institutions in Europe and in the DRC, local and national government administrations in the field of public health and sanitation, international agencies, NGOs and private foundations, was progressively set up. Following the conclusions of our epidemiological studies, a drastic change of strategy was proposed: the limited curative approach on the one hand, the few existing water/sanitation programs on the other hand, have been merged in a global approach involving a larger scale water and sanitation infrastructure improvement, environmental protection, hygiene awareness and medical surveys targeting a few focus areas playing a central role in the epidemics. In conclusion, by better targeting intervention zones, one can gather human and technical resources previously scattered on the vast territory of the DRC. The strategy presented here revives the hope to eliminate cholera in the DRC.

**Keywords.** Cholera, epidemics, Democratic Republic of Congo, sanitation, water supply

### 1 Introduction

Cholera epidemics in Africa represent an emblematic humanitarian emergency, in which most medical non governmental organizations (NGOs) act only once the outbreak was already launched and when the number of victims were overwhelming local capacities. Such reactive posture, even though it greatly limited the number of deaths when promptly and correctly applied, could not achieve a control of the cholera epidemics. Indeed, since its introduction in Conacy in 1970, cholera has spread all over Sub-Saharan Africa and still provokes epidemics, despite

hundreds of emergency programs implemented by NGOs. A recent paper reviewing ProMED (Program for Monitoring Emerging Disease) reports of cholera outbreaks worldwide showed that Sub-Saharan Africa is now the most affected region with 66% of reported outbreaks and 87.6% of cases from 1995 to 2005 (Griffith et al., 2006). According to official reports, cholera was responsible for 902 071 new cases and 21 417 deaths during the last six years (WHO, 2003, 2004, 2005, 2006, 2007, 2008). The true figure is likely to be much higher due to underreporting of cases. WHO experts estimate that the true burden of cholera is as high as 5.5 million cases and about 120 000 deaths each year (Zuckerman et al., 2007). Surprisingly, the dynamics of cholera transmission has almost never been investigated in Africa. A few studies have been published, dealing with the link between climate and cholera (Emch et al., 2008;



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Olago et al., 2007; Mendelsohn et al., 2008; Constantin de Magny et al., 2007) but they were not designed to provide policy makers the skills and knowledge needed to organize more efficiently the fight against cholera. Apart from rare case-control studies implemented to identify risk factors in restricted areas (Acosta et al., 2001; Birmingham et al., 1997; Shapiro et al., 1999), most available reports only describe cholera outbreaks in a given area such as a town or a refugee settlement. This contrasts with Asia, where monitoring programs benefit from a comprehensive knowledge of cholera epidemiology. In countries bordering the Bay of Bengal, the original region of cholera, outbreaks are closely linked to coastal and estuary areas. The environmental *Vibrio cholerae* strains emerge and spread in human communities during monsoon seasons (Koelle et al., 2005; Sack et al., 2003; Huq et al., 2005). In Africa, a similar phenomenon could possibly explain some of the outbreaks of cholera spreading from coastal areas, but it hardly explains how the disease can hit areas located thousands of kilometres away from the coast.

The Democratic Republic of Congo (DRC) is a vast country with a sole narrow maritime façade located in the western region of the country. However, except for an epidemic that hit Kinshasa in the late nineties, large cholera outbreaks only occur in the provinces situated on the eastern continental border of the DRC, namely Katanga, South Kivu, North Kivu, and the Oriental Province. Since the great cholera epidemic in refugees camps in Kivu provinces in 1994, which led to the publication of a few reports, this topic has been totally left out by the medical and scientific community (Heyman et al., 1997; Roberts and Toole, 1995; Siddique et al., 1995; Goma Epidemiology Group, 1995). In eastern DRC, response to outbreaks is almost exclusively dependent on humanitarian assistance. In 1997, a Congo Emergency Team was created in order to provide fast emergency relief to meet sudden needs and to react to emergency situations such as epidemics. Since this period, more than one hundred cholera outbreaks have been investigated, most of them in Katanga, South and North Kivu provinces, and dozens of emergency programs have been implemented. Despite these programs, no significant progress has been registered in the fight against cholera in this region. On the contrary, due to these iterative outbreaks that hit Katanga and Kivu provinces, the DRC is nowadays the country that reports the highest number of cholera cases in the world to WHO. Indeed, during the period 2002–2007 the DRC represents 14% of all cases notified to WHO (128 936 cases out of a 902 071 cases worldwide) and 21% of deaths (4466 deaths out of a worldwide 21 417 cases) (WHO, 2003, 2004, 2005, 2006, 2007, 2008).

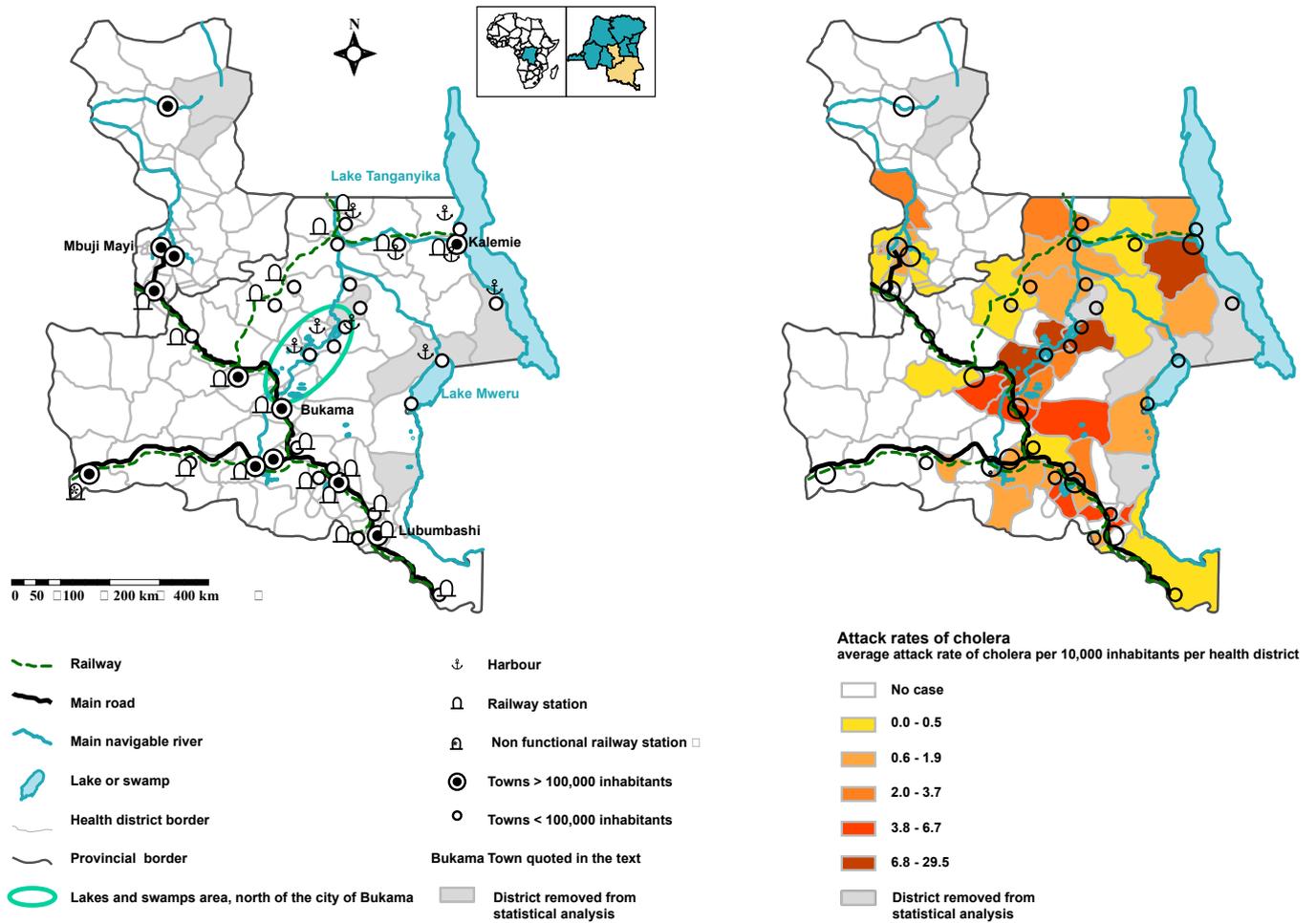
We, therefore, decided to develop research work intended to facilitate the understanding of the epidemiology of cholera in eastern DRC and to disseminate the acquired knowledge so as to ensure an improvement of the strategy for continuing the fight against cholera. One thing leading to

another, a collaborative network, including several scientific institutions in Europe and in the DRC, local and national government administrations in the field of public health and sanitation, international agencies, NGOs and private foundations, was progressively set up and a new plan was drawn up, aiming to eliminate cholera from the DRC before 2012. We present here a brief overview of the development of our project from the initial scientific results to the first steps of the ongoing field work in the main cholera foci of Eastern DRC.

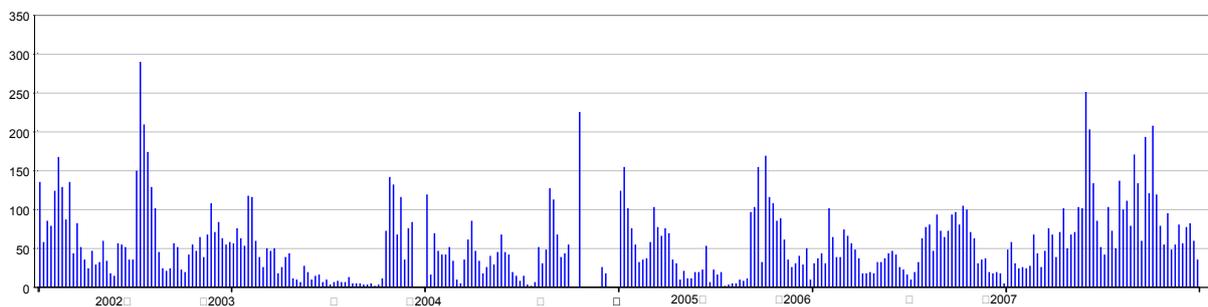
## 2 Cholera epidemiology in eastern DRC

Environmental factors that could explain the recurrence of cholera outbreaks were investigated during an epidemiological study which involved all cases of cholera notified in the DRC since 2002. The first part of this study, which concerns Katanga and Eastern Kasai has been published recently (Bompangue et al., 2008). Detailed methodology and results are freely available at <http://www.cdc.gov/eid/content/14/5/798.htm>. To summarize, from 2002 to 2005, reports of cholera cases and deaths from cholera were collected weekly from each health district of Katanga and Eastern Kasai provinces. A geographic information system was established, based on the data collected from the 106 health districts of the 2 provinces. Using regression techniques, we statistically examined the relationship between the number of cholera cases in each health district and the following list of geographic and environmental variables: area; population; presence of cities whose population ran over 100 000 inhabitants; means of transportation such as railway stations, harbours, major tracks or roads; and lakes.

Results revealed an original epidemiological pattern of cholera, distinct from those described in coastal areas, with specific sources in lacustrine areas, transmission pathways by main roads and railways and seasonal variations related to fishing and commercial activities. Indeed, the heterogeneity of cholera epidemic patterns from one area to another matches their main geographical characteristics: lacustrine areas have been more severely hit (Fig. 1), with intense iterative outbreaks separated by short intermissions; urban areas such as Lubumbashi, the capital of Katanga, and Mbuji-Mayi, the capital of Eastern Kasai, had also experienced intense outbreaks that could persist for numerous months. However, in these towns, epidemics were followed by long, and sometimes apparently definitive, remissions. Remote rural areas had often been spared and if not, experienced only limited outbreaks. The city of Kalemie, located on the side of lake Tanganyika in the North Eastern border of Katanga, was the one which experienced the highest number of cases in the province. In this town, cholera never stopped for more than 6 years (Fig. 2), contrasting with the other areas in Katanga. Each year, several outbreaks were identified in Kalemie,



**Figure 1.** Spatial distribution of cholera in the Provinces of Katanga and of the Oriental Kasai from 2002 to 2005.



**Figure 2.** Cholera evolution in Kalemie city (from 2002 to 2007, weekly number of cases).

occurring each time in areas lacking sustainable access to safe drinking water. Fishermen settlements located around lakeside cities also experienced outbreaks that were favoured by overcrowding during the fishing seasons. The periodic return of fishermen to their home in the lakeside cities, acts as a trigger for cholera outbreaks.

This study also helped to identify the pathways used by epidemics to spread from lakeside areas such as Kalemie to far-off areas, such as the cities of Mbuji-Mayi and Lubumbashi lying hundreds of kilometres away from the lakes. From lakeside to main cities, the spread of cholera was favoured by fishing and fish trading activities that provoke

cascades of outbreaks hitting the successive towns located on the major communication routes, including railway and ship crossings.

Finally, this epidemiological study also pointed out the inadequacy of the past strategy used to fight cholera in the DRC, which was based upon classical reactive posture in emergency situations. Each time an outbreak strikes one of the main towns in southern Katanga or in Eastern Kasai, namely Lubumbashi, Kolwezi, Likasi, or Mbuji-Mayi, local medical staff were reinforced by humanitarian organizations to set up centres for cholera treatment and to implement public awareness and information campaigns. However, in lake areas such as Kalemie and Bukama, humanitarian organizations intervened only in 17 out of the 54 outbreaks that took place from 2002 to 2005 (Bompangue et al., 2008). These interventions almost exclusively targeted patients care whereas sensitisation campaigns were rarely implemented. This situation led to a paradox: for a majority of aid workers dealing with public health, cholera outbreaks were trivialized in Kalemie and other lakeside cities of Katanga due to high frequency of occurrence, when a few cases in the main cities of south Katanga were enough to alarm the public because cholera was not striking there every year. However, one needs to realize that these few cases were imported from the lakeside cities and fighting the outbreak at its root is the only clue.

### 3 A new comprehensive strategy to fight cholera in Eastern DRC

Epidemiological studies, conducted by the 4th Direction of the Congolese Ministry of Health and a North-South university network, clearly pointed out the role of seven cities located on the lake's shore that act as the main source of cholera epidemics, namely Bukama, Bukavu, Bunia, Goma, Kalemie, Kasenga and Uvira. These cities act as a "sanctuary" for cholera. There, more precise epidemiological surveys showed that a great majority of cases occurred in the areas deprived of adequate access to safe drinking water. In these areas, contaminated surface water (mainly lakes) used by thousands of people for drinking or for personal hygiene is obviously the source of cholera epidemics (Fig. 3). Thus, remote or lack of access to safe drinking water in some of the limited areas located in lakeshore cities appears to be the primary cause of cholera outbreaks. Several joint missions of medical specialists in epidemiology of cholera and engineers in water and sanitation in eastern DRC have confirmed that there was a need for drastic improvement of water and sanitation infrastructures, especially in these urban and suburban areas. Finally, it was expected that a strategy against cholera based on access to safe drinking water and good medical surveillance in those areas could eliminate the epidemics of cholera in eastern DRC.

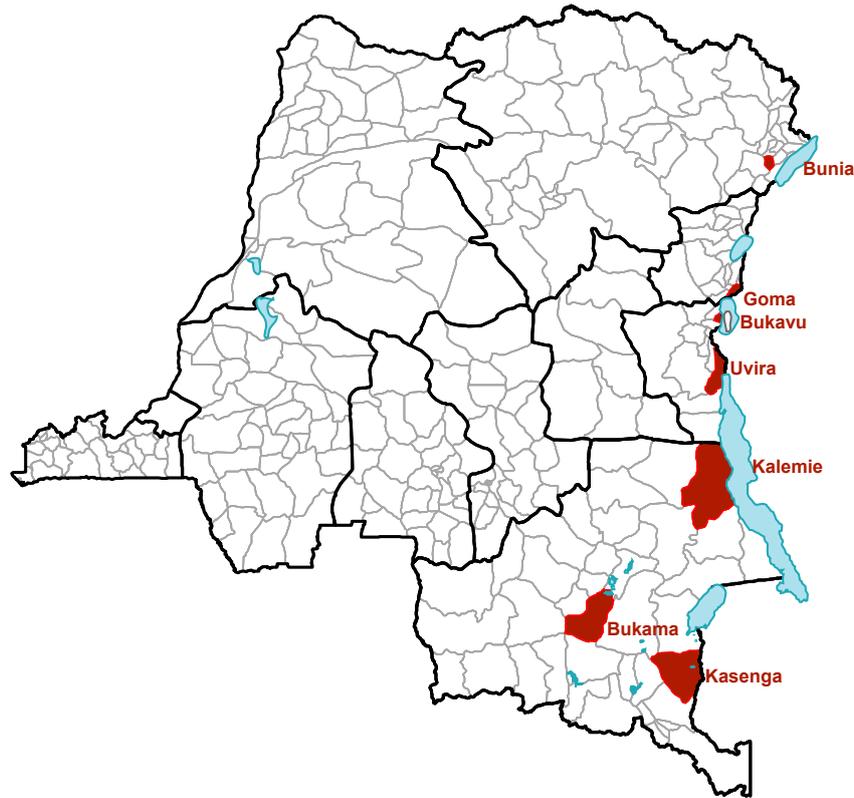


**Figure 3.** Inhabitants of Kalemie city, drawing water for drinking and catering. Picture taken during epidemical period (September 2006).

A drastic change of strategy was therefore proposed: the limited curative approach on the one hand, the few existing water/sanitation programs on the other, will be merged into a global approach involving a larger scale water and sanitation infrastructure improvement, environmental protection, hygiene awareness and medical watch targeting a few focus areas diagnosed as playing a central role in the origin of the epidemics. This new comprehensive strategy was discussed during a workshop gathering the main stakeholders held from 17 to 18 December 2007 in Kinshasa and further formalized in the Strategic Plan for the Elimination of Cholera in the DRC 2008–2012 approved by the Minister of Health of DRC.

The strength and the originality of this Congo strategic plan, emerging from the outcome of the previous epidemiological studies, is based on a grading of the intervention zones outlining several districts in the cities located on the shore of Lake Mweru, Tanganyika, Kivu, and Edward (Fig. 4). Consequently, available human and financial resources are easier to gather on a few sites to hopefully tackle cholera until its complete elimination from the eastern region of the DRC. Moreover, the Ministry of Public Health of the DRC has set the goal of total "elimination" of cholera approaching 2012. More specifically, cholera will be considered eliminated once the annual incidence rate is below 1 case out of 100 000 inhabitants; in other words, less than 500 new cases per year (nowadays, the incidence is on average 270 cases out of 100 000 inhabitants for the whole country). In order to eliminate cholera in the DRC, 7 strategic adjustments have been determined:

- *Empowerment of the activities of epidemiological surveillance.* This empowerment focuses on the combined clinical and biological surveillance. The targeted zones for this activity consists of the previously



**Figure 4.** The 7 targeted health zones according to the strategic plan of cholera elimination in the DRC.

mentioned regions as well as a few nearby-located great urban centres (Lubumbashi, Likasi, Kolwezi, Kamina in Katanga and Mbuji-Mayi in oriental Kasai) where the data analysis stressed their vulnerability to cholera.

- *Empowerment of the preventive measures in the targeted health zones.* In the targeted health zones, preventive actions will focus mainly on hygiene promotion, sanitation of the overall environment, as well as individual and collective awareness on hygiene campaigns.
- *Implementation of specific interventions in the scope of safe drinking water.* The main aim of this activity is to improve the supply of drinking water in sanctuary zones. The activities will proceed in successive stages for each of the 7 zones: a technical diagnosis of the existing facilities (water treatment plant, distribution network, storage facilities,...), a screening of the organisation of the local water board, a mapping of the ongoing activities from the pool of participants involved in the global enhancement of the supply of safe drinking water focusing on their impact on the fight against cholera. The second phase will be the production of a technical document listing the long term work to be done on both the treatment plant and the distribution

network to improve the situation on a timelessness basis. In order to undertake those actions, a critical technical asset will be brought in by the expertise of professionals from water companies. Veoliaforce experts will give a helping hand throughout, from the definition of the strategy to its effective implementation, in order to eradicate cholera. The Veolia Foundation will support the project financially throughout.

- *Implementation of specific interventions in the scope of drainage work and hygiene.* The main scope in this activity is to reduce the contamination of fresh water in the targeted zones.
- *Clinical care plan.* The clinical care of cholera sufferers will continue to be based on rehydration at the treatment centres for diarrhoeal diseases.
- *Coordination's reinforcement* The stakeholders involved in the fight against cholera will be gathered on a communication/coordination platform where the exchange of information and of funding will be centralised for a unified action. A team will be dedicated to secure the inter-sectors' partnerships of the platform.

- *Medical research promotion.* The questions emerging from the cholera project will go through real-time analysis by the “Direction de la Lutte contre la Maladie” (branch of the Congolese Public Health Ministry dedicated to fight epidemics) with the technical support of an international network of universities and the financial support from different stakeholders.

#### 4 First steps in the implementation of this program

The implementation of this new strategy has led to the establishment of an operational platform combining medical experts in epidemiology, water and sanitation specialists, field NGOs and key UN agencies. A first working group was established. It assembles around the 4th Direction of the Ministry of Public Health, REGIDESO, international agencies such as UNICEF, WHO, OCHA, health and environmental experts (Université de Franche-Comté, Université de la Méditerranée, Solidarités NGO, Veoliaforce) and donors (Veolia Foundation, French Embassy, European Union with ECHO, AFD, IMEA- ...) who all share the same strategic vision.

Initial actions began in the Katanga Province in 2008. Kalemie is situated in the eastern part of Katanga province, on the right bank of Tanganyika Lake. It plays a key role in the durability of the cholera pandemics in this region. Thus, this specific zone has been designated as “pilot project” for the implementation of the new strategy. Once this operational process in Kalemie has proved its relevance, the same actions will gradually be duplicated in other sanctuary regions taking into consideration the specificities of each region. The primary phase has already started from 2007 as a pilot project with Solidarités in Kalemie (supported by ECHO). This project aimed to define a medium term action plan that will prevent the worsening of the actual situation and improve it in key identified suburbs. Then, in December 2007 and in July 2008, two field missions were deployed to Kalemie. The missions were led by multi-sector teams comprised of delegates from the Ministry of Public Health in DRC, REGIDESO, experts of the Veoliaforce, a representative of the university of Franche-Comté (France) and water engineers from the NGO Solidarités. The pursued goal was to refine the epidemiological and water supply diagnosis of the cholera recurrence. Those two missions outlined the high correlation between the epidemics and the lack of access to safe drinking water in Kalemie, a lake-shore city with a population greater than 150 000 inhabitants. The plan regarding water supply is two folded: on one hand, a prioritised action plan is drafted for 2008–2009, while, on the other hand, further studies will be pursued on the drinking-water network of the city, including a collection of land-surveying datum to be used later in an ambitious water-supply facilities realignment on priority zones developed by NGO Solidarités and Veoliaforce experts.



**Figure 5.** Waterpoint system implemented in Kalemie by NGO Solidarités.

Henceforth, NGO Solidarités has started acting on the recommendations in the strategic action plan in order to improve the access to safe drinking-water with the construction of twenty water supply facilities, each equipped with ten taps from a 10 m<sup>3</sup> tank connected to the city water system (Fig. 5). In addition, the villages hosting fishermen during fishing season have been equipped with new wells. Indeed, the epidemiological studies have outlined the link between the living conditions of these fishermen and the emergence and the dissemination of cholera epidemics.

A diagnosis of the water treatment plant carried out in 2008 led to the definition of an initial program securing the existing facilities. This program is jointly supported by the Veolia Environnement Foundation and the French Embassy in the DRC. The works will consist mainly of performing basic repairs on the water plant and in rehabilitating several public drinking fountains in a fishermen district.

At the same time, other actions are being followed in the Katanga region in the priority zones identified by the epidemiological studies. Several NGOs are leading those actions with in some cases the financial support of UNICEF (Pool funds) and ECHO. MSF-Belgium performed a detailed diagnosis of the health situation in the health centres located north of Bukama: ICRC and a couple of other NGOs, namely Solidarités, Première Urgence and ACF are very active in the improvement of safe water supply in this same area.

#### 5 Discussion

Even if the epidemiological supervision shows that cholera is receding from Katanga since the first 2008 quarter, it is obvious that the fight against cholera has just begun and that extensive work on safe water supply is to be expected. Furthermore, the ongoing armed conflicts in the North Kivu Province are preventing a widespread action in

the Great Lakes region. However, the project can already be considered meaningful in its progress in the fight against cholera on the African continent simply because the very idea of eliminating this epidemic disease has been brought forward.

In the DRC, the area of the provinces hit by cholera is equal to the size of France, Spain and Portugal together. Such a large surface could represent a major obstacle for any participant wanting to protect the Congolese population from cholera. The basic assumption about cholera was not contradicted for decades: it was simply the disease associated with misery and one could not prevent the epidemics except to counter the outbreaks when they reached a certain intensity. This myth is now vanishing with the results showing that epidemics only originate in lakeshore regions where targeted actions on water supply are reducing cholera epidemics. The revival of the fight against cholera originates from the above described epidemiological studies.

An active unit has slowly built up associating individuals originating from diverse horizons: doctors and field actors working for the Public Health Ministry in Kinshasa and other vulnerable cholera zones, scientists based in France and Belgium, the general delegate of a private foundation and several water engineers related to NGOs or private firms. This extensive mobilization of presumably reasonable participants has played a major role in the attention drawn to the project since the end of 2007. Besides the above mentioned organisations, the project now involves the whole DRC Public Health Ministry since the ratification of the plan by the Health Minister himself, but also UNICEF (supporting the project closely), WHO, and several NGOs (namely but not exclusively, Solidarités, MSF Belgique, MSF France and MDM France that carried out several epidemiological surveys on the field), whilst donors showed a strong interest in the ongoing project, granting initial funds for preliminary actions.

The first originality of the project comes from the scientific surveys lead by a multidisciplinary team composed of doctors, epidemiologists, hydro-geologists, civil engineers, ecologists and lakeshore environment biologists. This broad study enabled them to accurately determine the mechanisms of the cholera epidemics on different scales, to identify the source zones of the disease, and the groups of populations acting as vectors of the spread. It was then possible to determine a scale in the cholera dissemination, pointing out the role of "sanctuary" played by some suburbs of lakeshore cities. The first results given by ongoing programs targeting safe drinking water in lakeshore cities leave space for hope. Indeed, it is expected that, by targeting the population living on the lakes shores where the epidemics originate, the disease would be tackled at its very roots and thus the population of the East DRC, i.e. 30 billion inhabitants could be spared. By targeting intervention zones better, one can gather human and technical resources previously scattered over the vast territory of the DRC. The strategy presented here, as it is

strongly supported by the results of scientific research and as it is targeted to be implemented in a short time, definitely revives the hope to eliminate cholera in the DRC.

The second point of interest of the project, is its capacity to engage rehabilitation phases focusing on infrastructures of rehabilitation with multi-annual perspectives in a relatively short time after a conflict period. In this sense, the project philosophy is clearly a concrete example of the necessary link between emergency, rehabilitation and development.

The plan for the elimination of cholera is now drawn up and ratified. The first actions are being implemented in Katanga. The authorities in charge of this fight against the epidemic play a major part in the scientific search for the solution of the problem and play a key role in the application of the plan. While European research workers accompany them with their experience and methodology, they benefit from a network of very efficient and reactive collectors of epidemiological information, which enables them to produce an excellent tool in order to follow the real-time evolution of cholera and to establish modelled risk patterns. The epidemics are surveyed week after week in each affected zone, be it as precise as a town district or even a street in some particularly sensitive zones. And so, it has been possible to anticipate the emergence of a new wave of epidemics at the end of 2007 at Lubumbashi before the very first cases could be identified. In 2008, it was also possible to warn the field participants about the risks of diffusion of epidemic sources in North Katanga, thus facilitating a speeding up and a reinforcement of the counterattack.

This original network uniting administrative authority, scientific research and volunteer work would not be productive without the concrete actions undertaken to counter epidemics. Here, again, we have to emphasize the originality of this program linking the traditional participants of humanitarian and sanitary program (UNICEF, WHO, DRC medical services and all the organisations involved in access and hygiene related to water) with the professional companies for production and supply of water working either for the national Congolese firm (REGIDESO), Solidarités NGO or for Veolia Environnement. This company supports the program through the actions of its foundation and by sending out engineers from Veoliaforce. The Congolese units of water production located in the lake district of East DRC were facing great problems. Thus, it was essential to receive both the intervention of the sanitary engineers from international humanitarian organisations and the expertise of professionals in water supply in complex urban spaces. We have to point out that these interventions are carried out in a spirit of qualified proficiency aid.

To conclude this report, it is important to mention the financial aspect of the program. Basically, the aim is to improve the re-distribution of the resources in order to warrant the continuum of action between the emergency, rehabilitation and development phases. It defines a comprehensive structure for donors who are not used

to working in such an environment to complement the classical humanitarian emergency funds. UNICEF resorted to local authorities in order to study the scientific and epidemiological relevance of the projects presented by the NGOs before funding the programs dealing with the access to safe drinking-water or the transmission of diarrhoeal diseases. Likewise, the epidemiological arguments and their suitability with the national scheme for the elimination of cholera can be both a real asset in the search for funds in the sphere of sustainable development as well as for emergency answers. In both cases, the recurrent actions should be warranted by their expected fallouts on the reduction of cholera epidemics.

There is, nonetheless, an unsolved question regarding the funding of the scientific research linked to humanitarian actions. Donors have, until now, used their funding almost exclusively for implementation of the humanitarian actions rather than funding the necessary prior scientific researches, especially for epidemiological surveys. As exposed in this article, this can turn out to be a non cost-efficient approach. Only a few NGOs sometimes take part in research studies, either directly or via their specialised branches. Epicentre is a good illustration of the clinical research led for MSF (Brown et al., 2008). At the end of the day, those initiatives are too few to create a real rapprochement between research NGOs, field workers and financial backers.

In the DRC, the needs for medical research are immense and numerous doctors would be ready to work together with their Northern colleagues while waiting to gather research teams in their home country. However, the lack of local financial support is an impediment to local emulation and possible cooperation. Exactly the same problem will arise when the accumulated knowledge in the DRC will have to be transferred to another country hit by cholera epidemics. Indeed, identifying the particular foci that act as the source of cholera epidemics on the whole continent and establishing a map of high risks areas, is an indispensable prerequisite before implementing a program targeting cholera in Africa. Countries hit by cholera are not so numerous, even in Africa (in 2007, among the 34 African countries which have declared cases of cholera to WHO, only 17 had more than one thousand cases (WHO, 2008) and among them, the DRC was one of the hardest places to implement such a study, regarding the immensity of its territory, the difficulties to collect data in remote areas and the conflict in the eastern part of the country. The collection of data and the establishment of risk maps is a challenge that is on the way to be successfully resolved in the DRC. Doing the same for the whole of Africa should, therefore, be considered as a realistic objective to achieve, providing that scientific and humanitarian communities find a way of strengthening their collaborations and receive befittingly African researchers in European research teams.

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