# A community-based confinement strategy to reduce the spread of Ebola Virus Disease: An analysis of the 2018-2020 outbreak in the DRC.

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# Abstract

### Background

Despite tremendous progress on Ebola Virus Disease (EVD), challenges remain in the implementation of holistic strategies to quickly stop outbreaks. We investigated the effectiveness of a community-based confinement strategy to limit the spread of EVD during the tenth documented EVD outbreak in the Democratic Republic of the Congo (DRC), 2018 - 2020.

### Methods

We did a community-based, open-label, two-group, unrandomized controlled intervention. Eligible participants were EVD contacts registered by epidemiological surveillance teams from November 2019 to May 2020 in the two last hotspots (Beni and Mabalako Health Zones). Intervention group participants were confined in specific community sites of their preference for the duration of their follow-up. Control group participants underwent CT without confinement and were allowed to continue their daily activities. The primary outcome was the number of confirmed secondary cases in the two groups. Secondary outcomes included delay between symptom onset and isolation, case fatality rate, survival rate, and vaccination rate. Data were analyzed using various quantitative methods.

### Findings

A total of 27,324 EVD contacts were included in the study. 585 contacts were confined and followed up ('the intervention group'), and 26,739 were followed up without confinement. The intervention group generated 32 confirmed cases (5.5%) in the first generation, while the control group generated just 87 (0.3%). However, the 32 confirmed cases from the intervention contacts did not generate any onward transmission (R=0.00), whereas the 87 confirmed cases from the non-intervention group generated 99 secondary cases (R = 1.14). Results for the secondary outcomes showed significant difference between the two groups. The delay between symptom onset and case isolation was shorter (1.3 vs 4.8 days; p<0.0000), CFR lower (12.5% vs. 52.9%; p=0.0001), and vaccination rate higher (86.0% vs 56.8%; p<0.0000) in the intervention group compared to the control group. A significant difference was also found between intervention and control groups in survival rate at the 16-day follow-up (87.9% vs. 47.7%, respectively; p=0.0004).

### Interpretation

The community-based confinement strategy used in DRC is effective for the rapid cessation of EVD transmission, highlighting the importance of rapidly implemented, innovative and community-oriented control strategies.

# Research In Context

### Evidence before this study

The identification and management of contacts of cases is centrally important to the interruption of epidemics of Ebola virus disease (EVD).

Isolation of cases, quarantines of their close contacts, and other forms of physical isolation are approaches to reducing social mixing of individuals with the potential to transmit infection. Such measures may be enforced by economic, legal, or other sanctions. Given the tremendous health consequences and socioeconomic impact of EVD outbreaks on affected communities, there is an urgent need to identify cost-effective, feasible, and acceptable containment strategies to rapidly control future outbreaks.

We conducted a literature search for any articles concerning confinement and quarantines in the context of EVD epidemics up to April 1, 2022. Of the 717 articles that our search identified, only two reported results comparing contact monitoring versus either quarantine or community-based confinement strategies, neither of which were intervention studies.

### Added value of this study

A community-based confinement strategy implemented in the DRC to curtail an EVD outbreak was found to effectively interrupt transmission from the first generation of confined contacts.

Further, the survival rate of patients hospitalized with EVD was significantly increased by this strategy, due to improved timeliness of case detection.

### Implications of all the available evidence

Applied in various infectious disease contexts, a community-based confinement strategy can save lives of confined contacts that develop infection, and also prevent onward transmission to others.

Further, especially if implemented early in an outbreak response, this strategy may slow transmission, thereby providing time for other important interventions to be organized and implemented (e.g., timely vaccination and treatment).

These findings demonstrate the importance of a community-based approach in implementing confinement and have relevance for policy choices regarding whether to confine contacts or entire populations, which is particularly pertinent in resource-limited settings.

## Introduction

The 10th Ebola Virus Disease (EVD) outbreak in the Democratic Republic of Congo (DRC) was declared on August 1st, 2018 in North Kivu province's Mabalako Health Zone (HZ) (1). This outbreak—the first recorded in the Eastern part of the country—quickly reached large urban cities, before spreading to two other provinces, Ituri and South Kivu. Insecurity in the region triggered mass population movements and made containment of the outbreak much more challenging (2)(3). It eventually became the second largest EVD outbreak globally, after the 2013–2016 West Africa Ebola Epidemic (4): over the course of the outbreak, a total of 3,481 cases (3,323 confirmed and 158 probable) and 2,299 deaths were recorded (1).

Control of EVD outbreaks has been documented to be achievable through a mixed approach involving risk communication and community engagement (RCCE), early case detection, rapid isolation and care, contact tracing (CT), and the safe and dignified burial of deceased confirmed or suspected cases are all crucial (5)(6). The biological features of the Ebola virus, requiring a contact with body fluids for a possibility of human-to-human transmission, places the notion of contact at the center of the interruption of such virus-driven outbreaks (7). CT is therefore among the key EVD control measures, consisting of the identification and listing, tracing (i.e., locating and establishing initial contact), and finally, regular follow-up (8). The core aim is to limit the spread of the infectious disease by offering early support and care as well as isolation if the contact develops disease (9).

Accordingly, during the 2013–2016 West Africa EVD Epidemic—in which more than 28,000 cases were documented—CT was implemented as a key component of the surveillance pillar to prevent further transmission(10)(11). However, poor performance was identified as one of the principal weaknesses of the response (12). For example, CT was successfully performed for only 26.7% of all EVD cases in Liberia, leading to the detection of just 3.6% of new cases (11) (in spite of the fact that CT was made less logistically complex due to enforced quarantine, as was also true in Sierra Leone) (5). This enforced quarantine was likely counterproductive and may have led to negative public health behaviours, such as hiding bodies or sick persons, and not seeking healthcare. This suggests that epidemic control interventions rooted in RCCE, social acceptance, and local practices may be a more effective alternative (13)(14)(15) .

The quarantine of people suspected of being exposed to an infectious agent is one of the most fundamental public health measures that has been used historically to combat the spread of communicable diseases in human communities (16). Recent guidelines indicate that introducing quarantine measures early in an outbreak may delay the introduction of the disease to a new country or area and/or delay the peak of an epidemic in an area where local transmission is ongoing. However, if not implemented properly, quarantine may also create additional sources of contamination and dissemination of disease (17). This is a risk, given numerous issues pertaining to the logistics of the actual implementation of quarantine as a control strategy, such as who should be quarantined and for how long (15). Indeed, quarantine can have major socio-economic and public health implications, including negative impacts on physical and mental health, livelihoods, and food security (16).

In the 2018–2020 EVD outbreak in Eastern DRC, where more than 250,000 contacts were recorded (1), public health performance indicators were initially poor. This included many community deaths, poor CT (8), and delays between symptom onset and case isolation (18). Confinement strategies were not implemented very early, as initial international efforts to control EVD spread during outbreaks have often resulted in clashes and conflict where control measures differ markedly from local practices. Moreover, there were questions about the effectiveness of confinement, as the effectiveness of such strategies has been demonstrated only in modelling studies on the impact of quarantine (16)(19)(20)(15). Further issues included inadequate public health messaging, distrust of those providing the health messages, political instability, and regional conflict (21)(22)(23). Taken together, this allowed EVD to spread and kill thousands, when early containment could possibly have been within reach (24).

This study aimed to provide evidence of the effectiveness of a confinement strategy that is more focused on contact, participation, and community engagement that could be implemented in future epidemics to rapidly mitigate onward transmission.

# Methods

## Participants

The participants in this study were EVD contacts registered by epidemiological surveillance teams from November 2019 to May 2020 in the two last hotspots (Beni and Mabalako HZs). A contact was defined as any person with no sign or symptom of EVD but who had been exposed to a confirmed (alive or dead) or probable EVD patient or with their bodily fluids within the past 21 days (25).

Asymptomatic status is critical since the presence of a single symptom could indicate the person is a suspected case, and thus, requires additional public health actions such as isolation or/and clinical support (26). Therefore, a contact (in the EVD framework) was asymptomatic; not systematically isolated; and seen by contact tracers up to twice a day (according to their willingness to be followed up) for a period of 21 days since date of last contact with a confirmed or probable EVD case so as to promptly detect EVD symptom onset.

## Intervention design and procedures

Whenever a new case was confirmed and reported, a psychosocial team visited the person and his/her family to deliver the result. The surveillance team would then complete a case investigation and update the contact list. In collaboration with the risk communication and community engagement (RCCE) team, the study would be explained to contacts to obtain their informed consent. When fully oriented and consent was provided, participants were alternately assigned to one of two groups (i.e., the intervention group and the control group).

Intervention group participants were confined in specific community sites of their preference (i.e., either households or rehabilitated structures) for the duration of their follow-up. In community site settings, certain contacts were grouped together on the same site, usually within their own households, thereby separating them from the rest of the community. Additional tents for contacts as well as toilets, water, and a solar electricity supply system were added in some areas. Hygiene measures were strengthened, and psychosocial and financial support provided. Risk communication, awareness and sensitization were delivered in a daily basis to the confined contacts. As part of community engagement efforts, the security services were explicitly excluded from the process, despite the outbreak occurring within a conflict zone.

Control group participants underwent CT without confinement and were allowed to continue their daily activities.

In both groups, daily follow-up of contacts was undertaken for a period of 21 days from the date of last contact with the index case (defined for this context as the case that led to the contacts under investigation). Local staff were identified and trained to become "contact tracers". Generally, 6 to 8 contact tracers worked under a designated supervisor and would visit 15 to 20 contacts daily. The supervisor was responsible for: listing the contacts as completely as possible (i.e., partially filling the individual CT form that would later be given to the contact tracers); and summarizing the case for the surveillance team. This information was then supplemented with additional information, thereby constructing the contact line list (an outbreak-specific database listing all known contacts). For every day of follow-up, the contact was either seen (i.e., directly observed and interviewed to identify any signs and symptoms of EVD), or not seen. Unseen contacts were further categorised: single absence (i.e., those not seen for a day or two); lost to follow-up (i.e., those not seen for three consecutive days

and thereafter stopped being followed); and unknown (i.e., those that were displaced, those that had never been traced, and those whose identification was incomplete). Hence, a contact's status was able to vary through the tracing period. If a contact already being traced had a new exposure (i.e., to a more recent confirmed case), the contact was 'recycled' such that the tracing procedure recommenced and continued for a further 21 days after last contact with the most recently identified case.

The community confinement strategy was designed in line with various principles that guided preparation for, and implementation of, CT:

- *Acceptance through community engagement*. All affected families were actively engaged and the rationale for confinement and measures being taken explained (i.e., isolation and prompt treatment of patients, vaccination of contacts, protection of other family members, and compensatory measures in terms of lost economic gain at the family level). Influential family members, local government, or religious leaders were engaged to support this engagement.
- *Listen to and act on the needs and concerns expressed by communities*. The strategy was guided by community feedback, adapting the implementation of activities accordingly. The choice of confinement site was not imposed. Communities were welcome to express any concerns about confinement, and the strategy could be adapted accordingly.
- *Flexibility*. The strategy was adapted: to local conditions (e.g., urban versus rural villages); the relative availability of confinement sites (especially in urban areas); and consideration of the choice of people to confine.
- *Improved living conditions*. Transmission of EVD often occurs in areas with poor access to water, sanitation, and hygiene. Therefore, the strategy sought to improve these conditions by providing additional latrines and water supply to confinement sites in the respect of infection, prevention, and control protocols.
- *Implementation by local staff*. All work to set up and/or adapt the confinement sites (e.g., construction of toilets, installation of water tanks, installation of electrical panels, construction of fences, guarding of sites, *etc.*) was entirely performed by local staff, who were financially compensated for their work.

# Measures

Intervention group participants were compared with the non-intervention group over the same period. As a measure of effectiveness, the primary outcome was measured as the reproduction number ($R$, the average number of secondary cases generated from index cases) in the two groups (27). Secondary outcomes were the follow-up rate of contacts in the two groups, the delay from symptom onset to isolation and case management, and the Case Fatality Rate (CFR).

The first known recorded contacts that were included in the study were considered the first generation. Confirmed cases amongst this group were considered the primary confirmed cases. The second generation corresponds to contacts of the primary confirmed cases. Confirmed cases from this generation were considered the secondary confirmed cases.

A contact was defined as a person who is currently asymptomatic but had physical contact with an EVD patient within the past 21 days. Physical contact could be proven or highly suspected, such as having shared the same

room or bed, cared for a patient, touched body fluids, or closely participated in a burial (e.g., physical contact with the corpse). A high-risk exposure was defined as a percutaneous or mucous membrane exposure to, or direct skin contact with blood or other body fluids of an EVD patient or corpse without appropriate personal protective equipment (PPE). A low-risk exposure was defined as a household contact that was not involved in providing care to, or having close contact with, an EVD patient in health care facilities or in the community that was not otherwise characterized as a high-risk exposure (25)

# Data analysis

Both primary and secondary outcome measures were then summarized using simple descriptive statistics including mean, standard deviation, and percentage. Outcome measures were tested for differences between confined and non-confined contacts using paired-sample t-tests, Wilcoxon Mann Whitney tests, chi-square tests of independence and Fisher's exact tests, depending on the nature of the data collected. R version 4.0.2 (28) and STATA 14.1 were used to perform descriptive and inferential analyses. A multivariate regression analysis was also conducted to assess predictors of death amongst confirmed patients.

# Ethical considerations

This study was approved by the Ethics Committee of the Kinshasa School of Public Health (approval number ESP/CE/03/2021).

# Results

*Description of participants characteristics*

The intervention was implemented in two HZs (Beni and Mabalako), from November 2019 to May 2020. While the outbreak was short-lived in some locations, these two HZs experienced continuous transmission over the epidemic's two-year duration and were the first and last two HZs to report confirmed cases, respectively (Fig.1).

A total of 27,324 contacts met the eligibility criteria and were included in the study (Fig. 2).

585 contacts received the intervention and 26,739 did not receive it. The characteristics of the two groups were quite similar regarding gender (p=0.346), but intervention group were slightly older with regards to age (p=0.013). However, the risk of exposure (determined by the nature of the relationship with the index case and the type of contact) was significantly high in the intervention group, as high-risk contacts were prioritized for confinement. (Table 1. Description of patient characteristics).

*Primary outcome*

In the first generation, the 585 confined contacts (intervention group) produced 32 confirmed cases (i.e., primary confirmed cases), while the 26,739 non-confined contacts (control group) produced 87 primary confirmed cases. There were no secondary confirmed cases arising from the 32 primary confirmed cases in the intervention group, whereas 99 secondary confirmed cases arose from the 87 primary confirmed cases from the control group (R=0.00 vs. R=1.14, p=0.0038; Table 2).

*Secondary outcome*

There were significant differences between the intervention and control groups in all the secondary outcomes explored (Table 2). The delay between symptom onset and case isolation was shorter (1.3 vs 4.8 days; p<0.000), CFR lower (12.5% vs. 48.4%; p<0.000), and vaccination rate higher (86.0% vs 56.8%; p<0.000) in the intervention group compared to the control group. A significant difference was also found between intervention and control groups in survival rate at the 16-day follow-up assessment of hospitalized confirmed patients, (87.9% vs. 47.7%, respectively; p=0.0004, Figure 3).

The multivariate regression analysis showed that neither age, gender nor vaccination status had an impact on CFR in confirmed cases admitted to ETCs. However, the risk of death was more than six times greater in the control group compared to the intervention group (Table 3).

## Discussion

We have described the first ever comparative study conducted during an ongoing EVD epidemic to demonstrate the effectiveness of community-based confinement. The strategy was decisive in the control of the eastern DRC's epidemic, which was arguably one of the most complex in the history of EVD since its discovery in 1976.

The 2018–2020 eastern DRC outbreak lasted two years despite the availability of experimental vaccine (29) and therapeutics (30) at the very beginning of the response. Public health performance indicators were poor, with increasing community deaths, poor CT (indicated by the high number of cases that had no known contacts), and delays between symptom onset and isolation (18)(29)(8). The change in strategy to adapt to a difficult context was necessary, and led to a rapid and drastic reduction in transmissibility which reduced incidence and helped bring the outbreak under control (2). The confinement strategy was then implemented to avoid a new spread of the epidemic, especially as the security situation was more critical.

Although implemented after the peak of the epidemic, this strategy played an important role in accelerating control as it contributed to rapidly stopping the remaining transmission chains. The overall comparison between intervention and control group showed a significant difference in the outcome indicators, namely the reproduction number, CFR, delay from symptom onset to case isolation, and vaccination rate amongst contacts. Moreover, for all confirmed cases from the intervention group, the delay between the date of vaccination and the onset of symptoms was less than ten days, meaning that all these cases were already infected and within the incubation period at the time they were vaccinated. This implies that, even if vaccinated, these contacts could have contaminated other people if they were not confined (vaccination is very effective when administered early to contacts (31). It is most effective in contacts of contacts, but community acceptance is still very important).

Survival analysis showed a higher survival of confirmed cases from the intervention group than the control group. The higher survival rate may be attributable to the early detection of confirmed cases in the intervention group, as supported by the shorter delay from symptom onset to case isolation in this group. This delay was reported as one of the factors associated with EVD death in Guinea during the 2013–2016 West Africa Ebola Epidemic (32). This survival difference is likely not treatment-related, as all hospitalized patients received almost within the same time frame, the same specific molecules that had already been validated in the first stage of a clinical trial conducted during the epidemic (30). Finally, the security context is unlikely to have had an impact as both groups were in the same localities and therefore subject to the same conditions.

The community containment strategy applied in eastern DRC from November 2019 to May 2020 is comparable to quarantine, but had crucial differences in the method of implementation, and the and the acceptance by those concerned. Firstly, it only involved contacts, as opposed to the general population (i.e., it was targeted). Secondly, it was designed by a multidisciplinary team including social scientists. The methodological approach based on community participation and engagement, inclusion of participants' expectations, and the support of psychosocial experts at all levels mitigated the negative impact of confinement on mental health. No cases of mental disorders were reported among the confined population in contrast to what is reported in the confinements during COVID-19 (33). The implementation was also guided by WHO recommendations which state that if a decision to implement quarantine is taken, the authorities should ensure that those in quarantine are adequately supported. This means adequate food, water, protection, hygiene, and communication provisions; infection prevention and control (IPC) measures and monitoring of quarantined persons implemented (34). Introducing quarantine measures early in an outbreak may delay the introduction of the disease to a new country or area and may delay the peak where local transmission is ongoing. However, if not implemented properly, quarantine may also create additional sources of contamination and dissemination of the disease (17). In addition, quantitative models have also shown that quarantine and symptom monitoring of contacts with suspected exposure to an infectious disease are key interventions for the control of emerging epidemics (35).

The novel community confinement strategy that was applied during the 2018–2020 Kivu outbreak has great potential for future outbreaks. This is especially true because, while the availability of the EVD vaccine has massively reduced transmission during EVD outbreaks, there is a possibility of relapse up to five years after infection (36). This reinforces the need to consider, strengthen, and more broadly apply this community confinement strategy for the quick containment of future outbreaks. This will require trust from affected populations, which should not be taken for granted. However, the strategy itself can also serve to engender this trust, and therefore also strengthen the positive effect of other interventions requiring this trust which includes all five core pillars of EVD response (i.e., case management, case finding and contact tracing, infection prevention and control, safe and dignified burial, and risk communication and community engagement) (6).

As evidenced in the 2018–2020 Kivu Epidemic in eastern DRC, a single unaddressed EVD transmission chain can quickly escalate into further (and lethal) transmission. Therefore, CT strategies—including in areas with such weak health systems and conflict—should consider methods of rapid identification and isolation of contacts accompanied by a range of supportive interventions and with community engagement. This study has evidenced that doing so can lead to the rapid cessation of transmission, when done using the community confinement method. This does more than save lives through preventing onward transmission: it also has the added advantage of engaging affected individuals, as well as key and trusted community actors, which can help to engender and maintain trust in the response. This strategy can be adapted for a range of suitable infectious diseases and is inherently adaptable in the face of political or economic hurdles that might limit other interventions (including other and more costly forms of confinement like enforced quarantine or regional lockdowns). In short—for the ease of the strategy's implementation, the integration of social sciences, the engagement of affected communities and trust built amongst them (which is itself key to the overall effectiveness of an outbreak response)—the community confinement strategy should be proactively considered as an effective, and efficient method of saving lives.

# Declarations

## Contributors

MK and JP conceived and designed the study; collected, analysed, and interpreted data; wrote the first draft; incorporated coauthors' suggestions; and prepared the final version for submission. SAM, MKI, AD, HB, JNA, LD, JKN, MKT, ASG, SD, OK, and ISF contributed to the design, interpreted the data, contributed to all drafts, and approved the final version for submission. JN, I.S.C, STB, AD, AY and AF contributed to all drafts and approved the final version for submission.

## Declaration of interests

We declare no competing interests.

## Acknowledgments

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# Tables

Table 1. Characteristics of participants

| Characteristics | Intervention arm Community confinement | Comparison arm Standard contact tracing in the community | p value |
|---|---|---|---|
| Age (years) | n=520 25.9 [24.6; 27.2] | n=24586 24.3[24.1; 24.5] | 0.013 |
| Gender Male Female | 301 283 | 13,140 13,414 | 0.346 |
| Type of contacts 1 2 3 4 | 58 113 225 105 | 4,871 7,130 6,331 2,794 | < 0.00001 |
| Relation with the index case Nosocomial Household family members Community | 69 168 214 | 882 3,817 13,400 | < 0.00001 |

Table 2. Comparison of intervention group and control group according to primary and secondary

| Characteristics | Intervention arm Community confinement | Comparison arm Standard contact tracing in the community | p value |
|---|---|---|---|
| Number of secondary cases | n=32 0 | n=87 1.14 | 0.038 |
| Delay between symptom onset and isolation (days) | n=32 1.3 | n=86 4.8 | 0.0000 |
| Case Fatality Rate (CFR) | n=32 12.5% | n=186 48.4% | 0.0001 |
| Vaccination rate among contacts | n=585 86.0% | n=26739 56.8% | 0.0000 |

Table 3. Results of multivariate analysis to predict death among confirmed cases

| Multivariate analysis | | | |
|---|---|---|---|
| | OR adjusted | IC 95% | P-value |
| **Confinement** Confined (ref) Non confined | 1 6.45 | [1.46-28.38] | 0.01** |
| **Sex** Male (ref) Female | 1 1.02 | [0.44-2.38] | 0.95 |
| **Vaccination** Vaccinated (réf) Non vaccinated | 1 1.04 | [0.31-3.47] | 0.94 |
| **Age group** 0-35 years (ref) 36-65 years 66 years et plus | 1 0.31 0.71 | [0.01- 5.64] [0.05- 8.88] | 0.43 0.79 |

# Figures



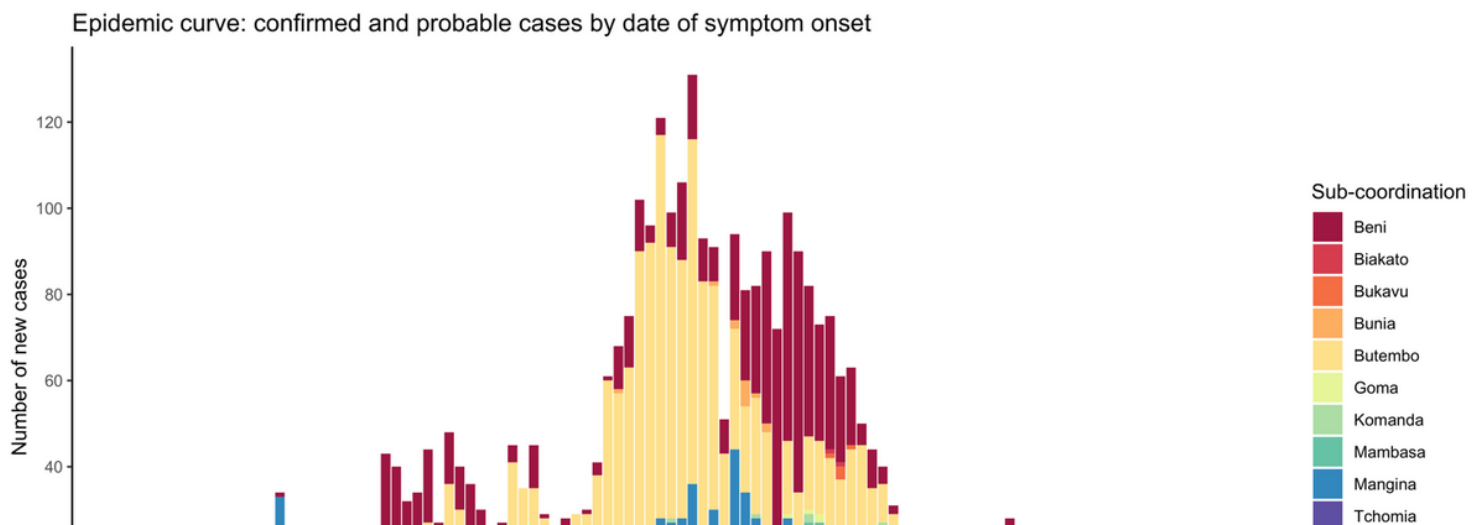Epidemic curve: confirmed and probable cases by date of symptom onset

## Figure 1

Evolution of the weekly number of EVD confirmed and probable cases by sub-coordination (decentralized emergency operations centre established to manage the response across several health zones) in the DRC, August 2018 – June 2020

## Figure 2

Study design (contacts and their outcome in Beni and Mangina sub-coordination (DRC), November 2019 – May 2020).



Estimators of survival functions of confined confirmed contacts (n = 33) and unconfined confirmed contacts (n = 86), Beni and Mangina sub-coordinations
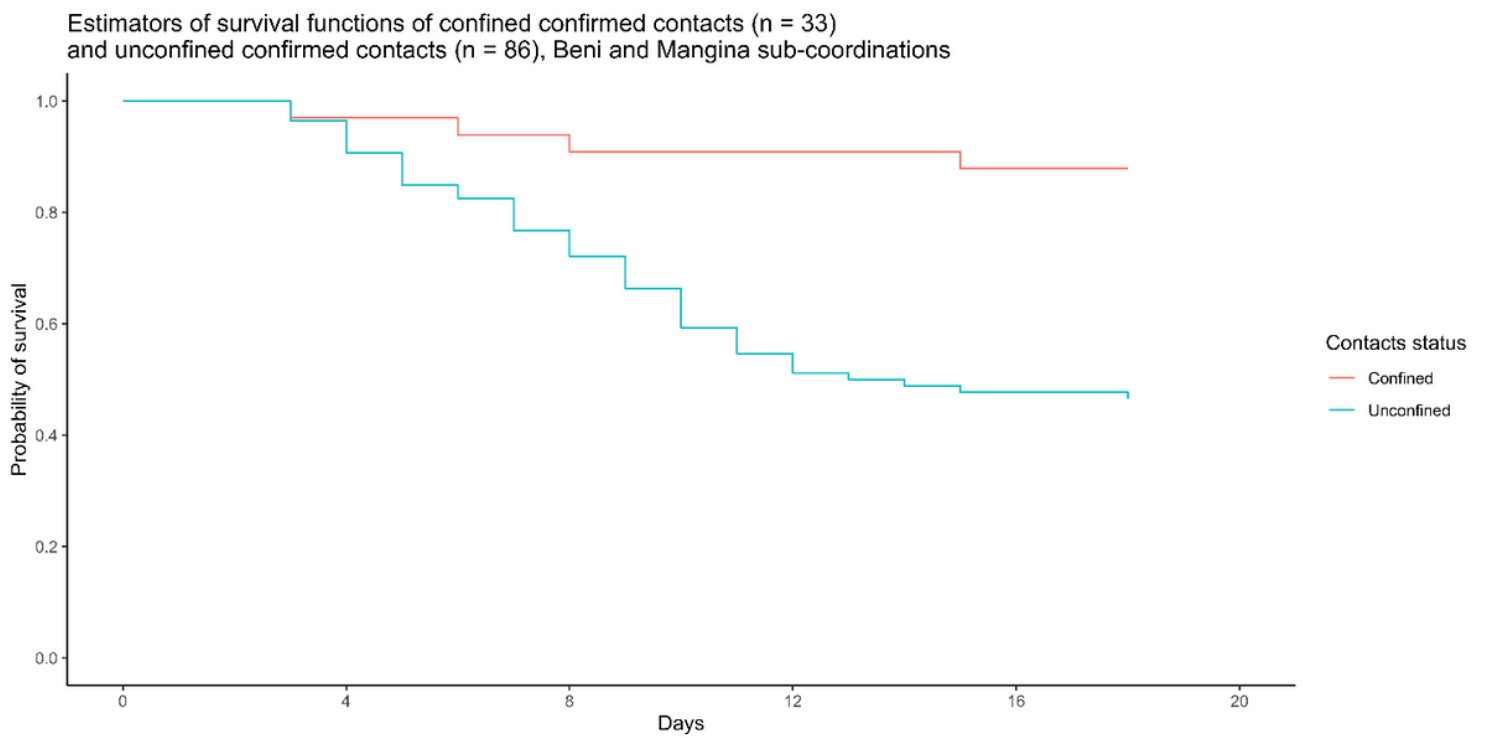
## Figure 3

Overall survival curves in confirmed patients from intervention (confined) group (upper curve) and from control (unconfined) group (lower curve). Survival expressed in percentage and time in days.