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Re-analysing Ebola spread in Sierra Leone: the importance of local level social dynamics

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43 **Re-analysing Ebola spread in Sierra Leone: the importance of local**
44 **social dynamics**

45
46 **Abstract**

47 **Background**

48 *The 2013-15 Ebola epidemic in West Africa was the largest so far recorded, and*
49 *mainly affected three adjacent countries, Guinea, Liberia and Sierra Leone. The*
50 *worst affected country (in terms of confirmed cases) was Sierra Leone. The present*
51 *paper looks at the epidemic in Sierra Leone. The epidemic in this country was a*
52 *concatenation of local outbreaks. These local outbreaks are not well characterized*
53 *through analysis using standard numerical techniques. In part, this reflects*
54 *difficulties in record collection at the height of the epidemic. This paper offers a*
55 *different approach, based on application of field-based techniques of social*
56 *investigation that provide a richer understanding of the epidemic.*

57
58 **Methods**

59 *In a post-epidemic study (2016-18) of two districts (Bo and Moyamba) we use*
60 *ethnographic data to reconstruct local infection pathways from evidence provided by*
61 *affected communities, cross-referenced to records of the epidemic retained by the*
62 *National Ebola Response Commission, now lodged in the Ebola Museum and*
63 *Archive at Njala University. Our study documents and discusses local social and*
64 *contextual factors largely missing from previously published studies.*

65
66 **Results**

67 *Our major finding is that the epidemic in Sierra Leone was a series of local*
68 *outbreaks, some of which were better contained than others. In those that were not*
69 *well contained, a number of contingent factors helps explain loss of control. Several*
70 *numerical studies have drawn attention to the importance of local heterogeneities in*
71 *the Sierra Leone Ebola epidemic. Our qualitative study throws specific light on a*
72 *number of elements that explain these heterogeneities: the role of externalities,*
73 *health system deficiencies, cultural considerations and local coping capacities.*

74
75 **Conclusions**

76 *Social issues and local contingencies explain the spread of Ebola in Sierra Leone*
77 *and are key to understanding heterogeneities in epidemiological data. Integrating*
78 *ethnographic research into epidemic-response is critical to properly understand the*
79 *patterns of spread and the opportunities to intervene. This conclusion has significant*
80 *implications for future interdisciplinary research and interpretation of standard*
81 *numerical data, and consequently for control of epidemic outbreaks.*

82
83 (325 words)

84
85
86 **Key Words**

87
88 Ebola, West Africa, qualitative research, infection chains, humanitarian crisis

93 Introduction

94 Ebola Virus Disease (EVD) is a viral hemorrhagic fever largely spread through contact with
95 body fluids of an infected person. From its first identification from an outbreak close to the
96 Ebola river in the Democratic Republic of Congo in the 1970s there have been over 20
97 outbreaks, mainly in isolated communities in the central African forest belt. In 2013 there
98 was an outbreak in south-eastern Guinea, at the western extremity of the humid forested
99 region in West Africa. Infection rapidly spread to the neighboring countries of Liberia and
100 Sierra Leone, largely through inter-personal contact. Carers – whether medical personnel or
101 family members – are especially vulnerable to infection, through nursing the sick or
102 preparing bodies for burial. The disease became established in urban centers, and cases
103 spread to Europe and North America. A major international effort was mounted to contain
104 the West African outbreak. By the end of 2015 this effort was largely successful, though the
105 virus has resurfaced since in two parts of the Democratic Republic of Congo. To date,
106 however, the West African outbreak remains the largest on record with 28 616 confirmed,
107 probable and suspected cases and 11 310 deaths by June 2016 [1].

108

109 As the first large-scale regional outbreak the West African episode has attracted
110 considerable analytic attention. There is recognition that lessons needed to be learned
111 relevant to other potential large-scale episodes, such as the one that occurred in North Kivu
112 (DRC) [2]. Some of the key epidemiological literature on the West African outbreak deploys
113 what we will here term the standard numerical approach (for example [1], [3] and [4]). This
114 makes considerable use of multivariate statistical methods and models. Applied to the West
115 African epidemic of EVD these methods lead to the identification of numerous local-level
116 heterogeneities. Numerical methods are only as reliable as the data on which they feed and
117 collecting reliable data in the heat of an emergency response to an Ebola epidemic is far
118 from straightforward. Whether heterogeneities apparent in numerical data arise from
119 problems of data collection or complexities on the ground is unclear. Our own work, based
120 on fieldwork in two districts in Sierra Leone, the worst affected country in terms of confirmed
121 cases of Ebola, is intended to address this interpretive challenge. Our research strategy
122 seeks to reconstruct local infection chains through evidence provided by communities, using
123 ethnographic and micro-geographical data gathering techniques. Ebola spread from person
124 to person, meaning that it has an inherently social dimension. This social dimension, we will
125 argue, is key, to understanding heterogeneities in the epidemiological data. Our aim,
126 therefore, is to understand the spread of Ebola in two largely rural districts of central Sierra
127 Leone by assessing the social dynamics of infection and the implications of this for control of
128 epidemic outbreaks in many other settings.

129

130 ***Limitations of previous numerical studies***

131 We examined papers using the standard numerical approach to explore data from standard
132 reporting forms and laboratory records ([1], [3], [4], [5], [6]). These papers exhibit awareness
133 of possible defects in the data set, and exercise care in reaching conclusions. Garske et al.
134 [1] remark that “*unfortunately, no information on the mechanisms by which individual cases*
135 *enter the database was recorded, and it is therefore not possible to assess the impact this*
136 *has on [case fatality] estimates”* (p. 7). After applying editing rules such as the elimination of
137 incomplete records, they reach a conclusion that heterogeneities are real and not just
138 artefacts of noisy data. A picture is presented of Ebola in West Africa not as a single
139 epidemic but as a concatenation of local and at times dissimilar events. We will provide
140 further (qualitative) evidence for supposing that this conclusion is sound.

141

142 The cited papers establish between them a number of broad, descriptive findings about
143 Ebola on an epidemic scale – for example, that risks of cross-infection ran in households
144 and peaked during the final course of the disease and subsequent burials, that the disease
145 affected men and women equally, and that infants and the elderly were especially
146 vulnerable. But on questions with especial significance to protection, such as whether
147 infection was due to local nursing and burial customs or more prosaic practices such as
148 cleaning beds and corpses, or whether the susceptibility of the very young and the elderly
149 was by reason of age, rather than because of body contact between infected mother and
150 child or the exercise of the special responsibilities of the elderly to the sick and dying, the
151 numerical data do not speak.

152

153 It would be good to know whether local disputes, variations in ritual practices, or bad luck
154 modified infection risks. This ambition is clearly articulated in the paper by Fang et al. [3].
155 They surmise that “*the difference in incidence rates among ethnic groups might be due to*
156 *their geographic locations, economic development, social behaviors, or religious traditions”*
157 and propose that “*further investigations are needed to elucidate this issue”* (p. 4492).

158

159 Our own paper takes this call as its starting point. Adopting an anthropological approach,
160 we visited a majority of nodes in the main infection chains identified by eye-witnesses and
161 survivors in two districts, Bo and Moyamba. We then traced with these informants how the
162 various infection chains unfolded. We identified chiefdoms and villages that had suffered
163 contrasting outbreaks (large, small, quickly contained, long-lasting outbreaks) and for each
164 we identified the probable index cases then sought to trace the stories of how the infection
165 spread from these cases to infect others. This information was then cross-checked with the

166 Njala data base records, and with a document kept by a nurse-volunteer at the Moyamba
167 Ebola holding center, that records in careful detail the admission of patients and their test
168 results in the first phase of the epidemic. This proved helpful in confirming statements made
169 by eyewitnesses but not covered in the national Ebola data base. The result of linking
170 quantitative and quantitative information was a richer account of local heterogeneities in
171 infection patterns and response that provides the basis for a wider understanding of the
172 issues that explain heterogeneities in epidemics.

173

174 **Methods**

175 The findings reported in this paper are part of a larger study (*Ebola Gbalo* – Ebola Trouble)
176 analyzing different levels of response – community, district, national and international – to
177 the Ebola crisis in Sierra Leone 2014-15, and the interactions between these various levels
178 [2]. An aim of this larger project was to assess national and local capacities for response to
179 the epidemic, and to place these elements, often masked by the more highly visible
180 international efforts, into a broader collaborative context. Data were collected principally by
181 the second and third authors at various time during 2016 and 2017. Data on the infection
182 chain in Niawa Lenga chiefdom were collected in 2018 by a team of three people led by the
183 first author (see acknowledgements).

184

185 To understand epidemic responses, we first needed a more detailed picture of how infection
186 chains were initiated and sustained, and how they were ended more rapidly in some cases
187 than in others. The purpose of the work described in this paper was to establish what
188 combinations of local factors determined the heterogenous responses to Ebola already
189 determined to have occurred via application of the standard numerical approach. We used
190 ethnographic techniques to elucidate the behavioral factors behind the numbers.

191

192 Ethics approval was received from the ethics review boards of the London School of
193 Hygiene and Tropical Medicine (Approval Reference Number 12016) and Njala University
194 (Institutional Review Board 2016).

195

196 **Sample strategy and ethnographic fieldwork approach**

197 While not possible to apply an ethnographic approach on a national scale, even in a small
198 country like Sierra Leone, it is nevertheless important to examine how local infection chains
199 were concatenated. How did infection chains start off, and die down, and how were
200 adjacent chains related? This suggested a geographically focused case study might be
201 better than a spread of randomly chosen snapshots from different parts of the country.

202

203 A further criterion was to choose a time period after the initial stages (when the epidemic
204 was concentrated in the east of the country), but before the international response was fully
205 ramped up, so that the functioning of local agency would be more readily visible. These
206 criteria led to the selection of two adjacent districts – Bo and Moyamba – in the southern part
207 of the country.

208

209 The propensity for EVD to move along main roads in Sierra Leone, emphasized in previous
210 studies ([3], [7], [8]), provided the basis for our sampling strategy. We followed infection
211 chains down the main roads crossing Bo and Moyamba Districts in the direction of
212 Freetown, while also taking careful account of side branches connecting interior villages,
213 where infection was blocked or rapidly terminated due to the propensity of rural communities
214 to go into “lock down” mode when threatened by dangers. We describe key interconnected
215 infection chains from both districts.

216

217 Members of our research team are based at Njala University, an institution with campuses at
218 Mokonde in Kori Chiefdom, in Moyamba District, and in Bo. Our group had earlier
219 undertaken fieldwork in Ebola affected communities for the Ebola Response Anthropology
220 Platform (www.ebola-anthropology.net.) in 2014-15, and so knew key localities where
221 enquiries were needed. We began with the earliest cases and traced connections from
222 these known nodes. A number of villages were identified for further investigation. We
223 checked these choices against the numbers of confirmed Ebola cases per chiefdom, and
224 then by village, in the national Ebola data base, a copy of which is archived in Njala, and as
225 a result added some places to the sample of communities where enquiries were required.

226

227 Local authorities were then notified. Community-level informed consent for our enquiries was
228 obtained in meetings held to explain the project attended by local chiefs and elders. Key
229 informants were then identified (e.g. survivors, or members of affected families). Potential
230 interviewees were asked for their individual informed consent. Village-level informants were
231 sometimes keen to supply information, either because they felt the story of their suffering
232 should be heard, or because their motives had been misunderstood. These informants often
233 were willing to give their views in informal focus group settings. Other informants were
234 willing to speak only anonymously and in private. Both kinds of interview were conducted in
235 the Mende language, mainly by a single interviewer. Mende is a strongly oral culture where
236 words are counted and remembered. Recording devices were used in village-level
237 interviews sparingly or not at all. Notes were written-up as soon as possible after the
238 interview.

239

240 Stories told were complex and multi-faceted. Several visits were made to key sites of
241 enquiry, to cross-check material and hear other views. We also followed up events by
242 interviewing responders. The Ministry of Health was notified about our study, and medical
243 personnel generally granted requests for interviews. We were not able to get the agreement
244 of security personnel deployed in quarantine operations at district level. In the accounts that
245 follow we link events described to numerical data base sources where appropriate.

246

247 **Numerical data records**

248 Numerical data relating to the West African epidemic of EVD derive from two main sources –
249 admission data collected via (WHO standard) Ebola Case Investigation Forms, completed
250 when a person suspected of having Ebola presented to a care or holding facility, and
251 laboratory records of tests for Ebola applied to blood or swab samples.

252

253 The version of the standard case investigation form used in Sierra Leone had three pages.
254 The first two pages are filled in on first contact or admission. There are sections for names,
255 gender, address, occupation, location where the patient became ill, date on which they
256 became sick, and symptoms and hospitalization. A second page covers contact with Ebola
257 patients, including attendance at funerals, and outcomes (hospitalization and death). The
258 third page provides formats for recording the results of laboratory tests.

259

260 Eye-witness reports confirm that medical personnel coping with the arrival of a patient with
261 Ebola symptoms had limited opportunity to fill in or check the numerous details. Some
262 patients were too distressed to supply necessary information and questions will often have
263 been answered by family members or helpers, not always accurately, either because details
264 were not known, or because information was deliberately concealed to avoid incrimination.
265 Participation in funerals was declared illegal under Ebola emergency regulations and carried
266 the risk of a fine or imprisonment.

267

268 That record keeping was often inconsistent can be illustrated by the case of Bo, the largest
269 town in provincial Sierra Leone. Ebola cases arrived in Bo from Kenema in the early days of
270 the epidemic. A rather large urban outbreak followed, eventually necessitating the opening
271 of a dedicated Ebola Treatment Unit at the outlying village of Bandajuma. The records for
272 Ebola victims in the Bo outbreak were supposed to indicate the district, chiefdom and
273 settlement of origin. Bo town is the headquarters of Bo District and also of Kakua Chiefdom,
274 one of Sierra Leone's 149 chiefdoms (the lowest level of government administration). The

275 data base lists 181 laboratory-confirmed cases for Kakua chiefdom. Eight cases were
276 wrongly assigned and came from other chiefdoms. Of the remaining 173 cases only 36
277 (38%) can be unambiguously assigned to Bo town from information in the data base. In 58
278 other cases (62%) a location in Bo town can be inferred only from the name of the street.
279 Seemingly, there were 94 confirmed cases of EVD in Bo town, but this cannot be known
280 except from fieldwork on the ground, with a street map in hand.

281
282 One further source needs to be explained, since it is not available elsewhere. This is a
283 hand-written log of admissions, test results and outcomes maintained (apparently as a
284 personal initiative) by a nurse at the Ebola Holding Centre (EHC) outside Moyamba town.
285 The Moyamba EHC was hastily improvised facility arranged in an empty (school?) building
286 with few affordances operating from July 2014. It handled many of the early cases of EVD in
287 Moyamba District, until internationally staffed and supported Ebola Treatment Units (ETUs)
288 were opened in Bo and Kenema in October 2014, at which point some Ebola+ cases were
289 referred to the new ETUs. The EHC in Moyamba was replaced (in December 2014) by a
290 better-equipped ETU staffed by international (Norwegian) volunteers, to which all remaining
291 cases were transferred. A photocopy of the admissions log of the EHC from June to
292 November 2014 was made available to us after interviewing its compiler and proved useful
293 in confirming details regarding dates and outcomes of cases referred to in village interviews.
294 An anonymized version is included in the online supporting materials.

295

296 **Limitations of this study**

297 Any study such as this depends on the accuracy of informants' memories and their
298 willingness to be frank. Events described were triangulated from accounts provided by
299 independent witnesses, and discrepancies followed up and resolved. These witnesses were
300 identified by the second author. They were independent in the sense that they were
301 members of the community in question but did not belong to the immediate household of the
302 infected person. In several communities we were also able to make use of base-line data
303 collected by focus group and questionnaire interview for the Ebola Response Anthropology
304 Platform during the epidemic in 2014 (publicly available online at [www.ebola-](http://www.ebola-anthropology.net)
305 [anthropology.net](http://www.ebola-anthropology.net)). Again, inconsistencies were followed up and resolved. An inherent
306 limitation of the approach is that it cannot infer larger regional trends. If the standard
307 numerical approach had found evidence of larger regional trends this would have cast doubt
308 on the utility of ethnographic analysis to understand heterogeneity through case study
309 approaches like ours. Instead, however, numerical research to date has reported local
310 heterogeneity, justifying the disaggregated case-following approach adopted here.

311 Furthermore, we identify categories of elements that explain heterogeneity in this context,
312 which are likely to have wider relevance in other contexts and can be tested in other
313 settings.

314

315 **Results: local Infection chains analysis**

316 Analyzed from the perspective of the standard numerical approach the various episodes
317 making up the 2014-15 Ebola epidemic in Sierra Leone appear highly heterogenous. This
318 heterogeneity can be seen in figures for outbreaks by locality (Table 1).

319

320 Western Urban (Freetown) and Western Rural (Freetown's peri-urban periphery), together
321 accounting for about 30 per cent of the national population, had 41 per cent of all Ebola
322 cases. Provincial Sierra Leone is divided into three provinces, 12 districts and 149
323 chiefdoms (the lowest level of local government), and contained 59 per cent of cases, but
324 these were unevenly distributed. According to the national data base, and including only
325 laboratory confirmed entries, 39 chiefdoms (26%) had no cases at all. Of 110 chiefdoms with
326 cases (74%) as few as 14 chiefdoms accounted for 60% of all chiefdom-level cases (5014
327 cases).

328

329 **Moyamba District infection chains: families begin to keep** 330 **their distance**

331 Village 1A is a typical medium-sized off-road farming settlement on the left bank of the Taia
332 river, in Kori chiefdom, Moyamba District. It is joined to the main Bo-Freetown highway by a
333 7 km track from the right bank of the river. The river must first be crossed by canoe. The
334 track is motorable only in the dry season but can be used by motorcycle taxis (*okada*) at all
335 times of the year. The people are Mende-speakers, but they live along the provincial
336 boundary with Northern Sierra Leone and are intermarried with Temne-speaking families
337 from the other side of the river. The Taia river floods in August and canoe traffic ceases for
338 a period. The settlement is in effect cut off in the middle of the rains.

339

340 Ebola came to Village 1A as a spill-over from the Kenema outbreak. The virus crossed the
341 border from Guinea in early 2014, and an outbreak in Kailahun District resulted in an Ebola
342 case being brought to the Government Hospital in Kenema, where there was an isolation
343 ward for victims of Lassa Fever. Ebola has even more exacting biosafety requirements than
344 Lassa Fever, and the nursing staff in Kenema were not prepared to deal with Ebola in
345 advance.

346

347 The WHO case definition of Ebola at that stage emphasized bleeding as a key sign. Few
348 Ebola patients in Sierra Leone showed signs of bleeding, and cases were misdiagnosed as
349 malaria or Lassa Fever. In addition, the authorities were slow to react to laboratory
350 information that there was an outbreak of EVD in Sierra Leone and supplies of chlorine and
351 personal protective equipment in the hospital were inadequate.

352

353 Kenema Government Hospital became the site of a major outbreak of nosocomial infection
354 in June-July 2014. EVD appears to have come to Village1A via a diamond miner (AA)
355 working in Lower Bambara chiefdom, not far from Kenema. One of his sons (BB) fell sick
356 and was taken to Kenema hospital, where he died. It is not known whether he was already
357 sick with Ebola or became infected in the hospital.

358

359 His death was treated as Ebola and AA was denied sight of the son's body. The stunned
360 father was taken ill at the hospital gates. His family had no wish to let him follow his son into
361 Kenema hospital, perceived as the source of Ebola infection. They conceived a plan to seek
362 medical treatment from a sister, who was a renowned herbalist in Village 1A in Moyamba
363 District. AA was familiar with the village since it was his mother's place of birth and he
364 himself came from a village nearby.

365

366 The government had tried to block the further spread of EVD by reinforcing the check point
367 at the western entrance to Kenema, forcing passengers to submit to medical inspection
368 intended to detect anyone with elevated temperature. Local transporters, however, are
369 familiar with a number of by-pass routes opened during the war. One of them was tasked to
370 evade the checks and deliver AA – described as profusely sweating - to a settlement in Kori
371 chiefdom on the main road to Freetown, where a bike taxi was chartered to take the sick
372 man – held fast as a pillion on the back of the bike by one of his sons - to the canoe crossing
373 to Village 1A. There, too weak to climb up to the village, he was carried up the cliff path by a
374 strong young volunteer, who confirmed details of AA's arrival in an interview in 2016. The
375 date was reported as 9th July 2014, six weeks after the government had first announced the
376 presence of the disease in the country.

377

378 People interviewed in village 1A were doubtful whether AA had arrived with Ebola.
379 Normally, the progression is a 3-day period of headaches and fever followed by a 3-day
380 "wet" period in which vomiting, diarrhoea and bleeding occur, before death or eventual
381 recovery. Unusually, AA survived for two weeks after his arrival as a sick man, alternately
382 sleeping in a family hut and in the mosque, while his sister treated him with various leaf

383 infusions, before he eventually succumbed, and was buried just outside the village. He was
384 not observed to be showing reported signs and symptoms of Ebola.

385

386 AA's sister (CC) then sickened. By mid-July the country was on high alert for Ebola cases.
387 News of the sick woman had reached the Community Health Officer (CHO), head of the
388 Ministry of Health team in Kori chiefdom, based in Taiama, and he arrived with a team on
389 the right bank of the Taia river opposite the village, seeking a blood sample from the sick
390 woman. The CHO phoned across to the chief (DD) explaining that he wanted to send two of
391 his team across the river to collect the blood. The chief responded that this would not be
392 possible as he had had no notification about the visitation, either from the Paramount Chief
393 or the Ministry of Health.

394

395 The chief later explained, in interview, that he knew sick people were sometimes given
396 blood, but he had never heard of blood being taken from the sick, especially on the point of
397 death. Lack of explanation about blood testing, and the arrival of responders in full PPE,
398 convinced some in the village that this mysterious new disease was a cover for a kind of
399 medical "vampirism" (*bona hinda*).

400

401 The CHO was forced to withdraw but came back with his team and authorization the next
402 day. DD required that the CHO cross the river to do the blood sampling in person. The
403 sample was taken for testing, and proved positive, but the woman died before any follow up
404 was made.

405

406 As a *sowei* (an elder of the women's Sande society) CC's burial attracted a group of her
407 peers from surrounding villages. The burial was conducted according to the secret rites of
408 the society. This was before the Ebola burial rules had been promulgated (August 8th 2014)
409 and the CHO later explained in an interview that he did not have any means to prevent the
410 funeral. Interviewees in Village 1A claimed that no further infections occurred among the
411 group of women conducting the burial rites.

412

413 There were, however, further cases of Ebola both in Village 1A, and in Village 1B, a small
414 settlement on the left bank of the Taia, about 3 km to the south, and at least two of the
415 corpses were swabbed on burial. In all, village people report that there were 22 deaths
416 subsequent to the case of CC in Village 1A (14 female, 8 males) and nine deaths in Village
417 1B (7 females, 2 males, with six persons coming from one family related to the family of CC
418 in Village 1A). Several of the people infected in Village 1B had visited CC to express

419 sympathy with her, and later to take part in her funeral. These visits are an inescapable
420 social obligation in tightly intermarried rural communities.

421

422 The evidence that these deaths were Ebola cases is not conclusive but is supported by the
423 Moyamba records. We were able to cross-reference five persons who were admitted to the
424 facility on 24 September 2014 bearing the same family name as several of the persons who
425 died in Village 1B. They are listed as coming from Taiama, the chiefdom HQ for Kori
426 chiefdom; villages IA and IB are inaccessible places, and Taiama is the nearest settlement
427 of any size. Of this group of five patients, two were diagnosed as positive for Ebola, two died
428 without diagnosis, and one (an old man) was negative, and later interviewed for this study.

429

430 A youth organizer in Taiama (EE) reported that he had helped to arrange the transport of
431 two suspected Ebola cases from the right bank of the Taia opposite Village 1B. Even if an
432 Ebola ambulance had been available it would not have been able to travel along the track to
433 the riverbank in rainy season conditions, so a commercial motorbike rider had been hired
434 instead. Motorbikes crossed the difficult places on single track bridges improvised by the
435 commercial riders. The incident was vivid in his mind, because the rescue team arranging to
436 collect one of the patients had only a single PPE suit, and the bike rider and the pillion
437 passenger needed to support the patient were both nervous of becoming infected. A
438 nervous rider on a difficulty rainy season track was more likely to have a spill, with serious
439 consequences for the patient and everyone else in the team, so the decision to dress the
440 patient in the PPE, rather than decide which of the two – rider or supporter – should wear
441 the protective suit, made sense. EE told the story self-deprecatingly, remarking ‘how little
442 we knew about the disease at the time’. In fact, it suggests that everyone engaged in
443 extracting high-risk patients was beginning to understand about the significance of body
444 contact in spreading the disease.

445

446 An elderly man interviewed in Village 1B (FF) told us he had been admitted to the Moyamba
447 holding centre along with two other persons from his village, both of whom he knew had
448 tested positive for Ebola and subsequently died. FF was tested Ebola negative and had
449 come back to the village to give notice of the fate of the two persons with whom he had been
450 admitted. Clearly, some of the deaths were confirmed as EVD through laboratory evidence.
451 But still villagers have doubts about whether all admissions had Ebola on entry, or were
452 cross-infected after arrival, due to the notoriously poor conditions at the Moyamba facility.

453

454 Quarantine was imposed in Village 1A when a small detachment of five police and army
455 personnel arrived on 18th August 2014 and stayed for a month. The recently enacted
456 national emergency regulations authorized military intervention in epidemic response. If the
457 admission of a group of patients “from Taiama” to Moyamba EHC on 24th September 2014
458 corroborates our interviewee’s recollection in Village 1B then infections must still have been
459 occurring in Villages 1A and 1B in the second half of September. So why the security forces
460 were withdrawn about that time is unclear. The national data base records dates for onset
461 of symptoms for patients with positive blood tests in Kori chiefdom from 2nd July to 24th
462 November 2014, with two outliers in January and February 2015. One person from Village
463 1A and five from Village 1B are listed with positive blood samples.

464

465 What is clear from interviews is that local perceptions were changing very quickly. There
466 was now a distinct awareness the disease was spread by body contact. The name for EVD
467 given in Village 1A was *bondawote* (literally “family turn away”), glossed by an informant as
468 meaning “you are completely abandoned to die”. Another interviewee said that “people ran
469 to their farms, [and] most of those who got sick recover[ed] when they stopped touching
470 each other”. Youth leaders in a village at the end of a river-bank track leading to Villages 1A
471 and 1B feared that sick relatives in the two afflicted villages would seek help from the health
472 post in their village. They went out and cut down the stick bridge crossing a rainy season
473 flooded ravine, making further contact impossible. This rendered apparent in dramatic terms
474 the rapidly acquired notion that “touching” was deadly. It is likely that this local “turning
475 away” was a significant factor in ending local infection chains.

476

477 **Spread of infection to a local market center**

478 Village 1C is a small settlement on the main Bo-Freetown highway in Kori chiefdom at the
479 point where the c. 10 km track branches leading to the right bank of the Taia river opposite
480 Village 1A and 1B. This was where AA the sick man from Kenema, transferred from a taxi to
481 a motorbike on his journey to reach his relative, the herbalist, in Village 1A. AA was uncle to
482 GG, a woman living in Village 1C, who joined the CHO’s the team on the trip to collect the
483 blood sample in Village 1A. It is reported that she went to Village 1A to warn her relatives
484 there about the dangers from Ebola. How she became infected is not clear. She tested
485 positive for EVD in Taiama and died there on 12th September 2014. Her sick husband
486 sought treatment from a pharmacist based at road junction market (Village 1D) on the
487 highway to Freetown (Fakuniya chiefdom). The pharmacist also sickened and died,
488 presumably from Ebola, but without test data to confirm it. The man was a member of a
489 Catholic sodality [closed association] and his funeral attracted sympathizers from as far as

490 Freetown and Bo. This was followed by a substantial outbreak of EVD in Village 1D, with
491 spread of cases up and down the Freetown and Moyamba roads, perhaps reflecting local
492 networking among traders. The first 12 patients testing positive for Ebola from Village 1D
493 were admitted to Moyamba EHC on 17th September. In all, 36 patients admitted to
494 Moyamba EHC from Village 1D tested positive for Ebola. Village 1D was quarantined by the
495 security forces. The last E+ case admitted to Moyamba EHC is recorded on 8th November
496 2014. The national data base shows 64 E+ cases from Village 1D, and 11 from adjacent
497 villages (some in Kori chiefdom). The dates for onset of symptoms of the first and last cases
498 in Fakuniya chiefdom are 9th September 2014 and 4th November 2014.

499

500 **Bo District infection chains: good response marred by** 501 **accidents**

502 Village 2A is a village about one km. south of the Kenema-to-Bo highway, some 20 km. east
503 of Bo city. It is a centre of Islamic instruction. A noted teacher (*kamoh*) from a village on the
504 border of Bo and Kenema districts was offering instruction in Village 2A, and then fell sick.
505 Enquiries in his home village suggested he had been in the habit of going to Kenema for
506 treatment for some longer-term medical complaint. It can be surmised he became infected
507 with Ebola as a result of the outbreak in Kenema town.

508

509 The *kamoh* died in Village 2A on 13th August and was buried according to Islamic practice.
510 This requires thorough washing of the corpse. The implications of the brand-new Ebola
511 national regulations had yet to be realized in the village, even if they were known. Some of
512 his pupils are said to have used water from the washing of their learned master's body in the
513 hope of inheriting some of his wisdom and charisma.

514

515 The *kamoh* had been seen by medical personnel in a near-by health centre but he had been
516 discharged without any diagnosis of Ebola or instructions about what to do if his condition
517 worsened. Soon after the burial his pregnant wife (HH) began to complain of joint pains and
518 fever. She turned for help to the mother-and-baby unit in near-by Village 2B. The midwife in
519 charge examined her and offered some treatment for the fever. She had already received a
520 briefing about Ebola risks, and used gloves in her examination. But HH's symptoms were as
521 yet no different from malaria, so she was discharged and sent home with appropriate
522 medicine for her presumed condition.

523

524 Two days later HH died, after giving birth to a still-born child. Her other two children
525 sickened and died two days later. The woman's death was reported to the Paramount Chief

526 for Kakua chiefdom, based in Bo, and the medical authorities immediately intervened.
527 Eleven more people fell sick in rapid succession. Samples were taken and inter-village
528 movements were stopped. The villagers were told that even the nurses who had treated HH
529 would now have to be quarantined for 21 days, and that burials could only be undertaken by
530 a specially equipped burial team.

531 A brother of the *kamoh* died and his body was not buried for 3 days, something that was
532 especially shocking to the villager's Islamic religious sensitivities. The hazard suits of the
533 burial team alarmed villagers, as did the unexpected arrival of police, military and the District
534 Medical Officer.

535 By now a further 13 people had become seriously ill and were taken to Bo Government
536 hospital. There were no preparations to deal with Ebola cases, and the sick villagers were
537 placed in a kind of holding shed. There was no infection of hospital staff or patients, but the
538 episode was disturbing to community members.

539 One remarked that "*to my dismay no treatment was given but [they were] just cluster[ed] into*
540 *a non-caring room, where five of them immediately died*". They were told that there was no
541 bed for admission at the hospital. The district Ebola task force then decided that the sick
542 villagers should be brought back to the village, to be quarantined in the community school.

543 The quarantine was strict. The security forces prevented any movement, even for the
544 essentials of daily life. Families suffered heartbreak as they heard their loved ones crying
545 out for water and were prevented from helping. Nor was there any satisfactory arrangement
546 to feed the patients. Villagers feared the security forces had been ordered to poison them.

547 The situation was improved when the local parliamentarian arranged for the delivery of beds,
548 and (after 12 days) "*9 bags of rice were given to the community with the population of 210,*
549 *including children*". The district Ebola task force helped to mobilize supplies, even though at
550 this stage it lacked a budget and remained reliant on voluntary contributions.

551 New cases were still occurring, and the death toll continued to rise. Villagers formed three
552 burial teams, so that they could bury their own loved ones promptly, and the authorities
553 seem to have concurred in this. Thirteen victims were taken to holding centers in Kenema
554 and Kailahun, and only one person is said to have survived.

555 The total number of laboratory-confirmed cases of Ebola in Village 2A appears, from the
556 national records, to have been 43 (over 20 per cent of the total village population, and 28 per
557 cent of our corrected number for all laboratory-confirmed Ebola cases in Kakua chiefdom,
558 including Bo city). The villagers reported in interviews that there were 37 deaths. This
559 implies either that only six people survived or that the national data base under-estimates

560 the total number of infections in Village 2A. In fact, the names of seven certificated survivors
561 were reported during our enquiries, suggesting the discrepancy may not be large.

562 The strict quarantine was not wholly effective. There was at least one escape, when a
563 young man (II) broke bounds to visit a larger settlement, T, a small town about 12 km. south
564 of Bo. II then showed symptoms of EVD. Whether he was infected in Village 2A or on his
565 arrival in T is unclear.

566 T is close to Bo city where cases are first recorded in the national data base from mid-June.
567 The national data base records 29 laboratory-confirmed cases in T over the period 23rd July
568 to 13th December. The outbreak here is probably connected to infection in Bo. We have no
569 date for the quarantine breach in Village 2A but it is unlikely to have been earlier than
570 September since quarantine was imposed from the second half of August.

571 T was a bridge to a somewhat larger outbreak in the adjacent chiefdom, Bumpah Ngao,
572 where 48 laboratory-confirmed cases are reported in the national data base. The Bumpah
573 outbreak occurred at a later stage in the epidemic, when communities and responders were
574 better prepared. The infection chain ran from 3rd October 2014 to 10th January 2015, a
575 period of 100 days. The Community Health Officer thought that most cases had some
576 connection with a large funeral for a “big person” (Mende: *numu wa*) in T.

577 At Village 2C in Bumpah Ngao chiefdom there is a long-established and well-respected
578 mission hospital. The hospital authorities approached the local community and explained
579 that the hospital (which lacked a ward capable of handling Ebola cases, until international
580 responders built one) would have to close if cases arrived.

581 It was agreed with the chiefdom authorities that in order to keep the hospital open during the
582 Ebola outbreak all potential patients would pass through a screening and triage process
583 located outside the hospital. Any potential patients showing signs and symptoms of Ebola
584 would be conveyed to newly opened Ebola case-handling facilities in Bo and Kenema,
585 where they would receive specialist treatment. Chiefs and sub-chiefs were responsible for
586 conveying a message about why these measures were necessary and the message was
587 widely understood.

588 Not all families agreed with the implications, however. JJ, the female chief of a satellite
589 settlement (Village 2D), attended the “big person’s” funeral in Village T, where she appears
590 to have contracted Ebola. The nurse in charge of the village health center suspected the
591 true cause of her illness and informed the authorities, but JJ’s family objected.

592 Nevertheless, an ambulance was called, and she was taken to the case-handling facility at
593 Bandajuma, where she died. Disagreement over responsibility for JJ’s fate led to a

594 breakdown in relations between the family and the nurse so severe that she had to be
595 transferred to another district.

596 JJ was not alone in trying to hide her symptoms. Interviews with medical personnel in
597 Village 2C and an adjacent community health post elicited several other stories about the
598 lengths to which other patients went to hide symptoms to avoid being transferred to an Ebola
599 case-handling facility. As yet, there were few survivors from such centers, which were
600 suspected of being “death camps”.

601 Informants reported that international advisers wondered why Bumpeh Ngao chiefdom was
602 “difficult”. The fear of being wrongly diagnosed as an Ebola case and cross-infected in a
603 holding or treatment facility grew as stories about Kenema hospital and poor conditions at
604 the holding centre in Moyamba spread. Local doubts over diagnosis were reinforced by a
605 case in which a blood sample sent by the hospital in Village 2C to a laboratory in Kenema
606 had come back wrongly categorized as negative because it had been confused with a
607 sample from a village with the same name in Kenema District.

608 **Null infection chains: A dog that didn’t bark?**

609 Thirty-nine chiefdoms had no cases of Ebola; many were protected from spread of infection
610 by distance or poor roads. Four chiefdoms, however, were situated on or close to the main
611 national road transport network, surrounded by chiefdoms with cases. One of these is
612 Kamajei chiefdom in Moyamba district. Led by their Paramount Chief community activists in
613 Kamajei closed tracks and closely monitored movements of strangers. Interviews and
614 surveys undertaken in this chiefdom during the epidemic (fieldwork in December 2014,
615 www.ebola-anthropology.net) showed widespread acceptance that Ebola was spread by
616 body contact, and not through consumption of bush meat as people had earlier been
617 informed.

618

619 It is also relevant to ask about communities where cases occurred, but where infection
620 chains were closed down promptly. One such chiefdom is Niawa Lenga in Bo District. This
621 was one of four chiefdoms (in Bo and Moyamba Districts) in which an Ebola infection chain
622 lasted for less than 50 days. The other three chiefdoms in this group (Bagbo, Bagruwa and
623 Jaiama Bongor) had few confirmed cases, but Niawa Lenga had a substantial number (19).

624

625 In general, chiefdoms in Bo and Moyamba districts were among the quickest in the country
626 to end infection chains, with an average per chiefdom of 90 days for Bo district, and 95 days
627 for Moyamba, compared to figures for chiefdoms in the first and last districts to experience
628 the outbreak – Kailahun and Port Loko - with an average of 133 and 280 days respectively.

629

630 Why was the outbreak in Niawa Lenga ended promptly? The answer appears to be that by
631 mid-October 2014 the Standard Operating Procedures (SOPs) for Ebola control of the Bo
632 District Ebola Response team were fully implemented and working successfully, and that
633 there was little or no prior opposition to and distrust of local authorities, a factor in a case
634 described in detail by Parker et al. [9]. Lessons from Village 2A had been well-learned.

635

636 Fieldwork revealed two distinct infection chains. One involved the chiefdom headquarters,
637 Village 3A, and the other a village, Village 3B which is close to the motor road from Bo to
638 Yele. Vehicles to Village 3A take the motor road, and branch right just after the town of
639 Dambara. There is a shorter route – a track leading to Village 3A from the northern outskirts
640 of Bo.

641

642 A middle-aged female resident of Bo (KK) was heading along this track, possibly seeking
643 local treatment in Village 3C for a long-standing complaint. Village 3C is located on the
644 boundary between Kakua and Niawa Lenga chiefdoms. Here, KK was taken ill with what
645 turned out to be EVD. Her helpers decided to hire some youths to carry her in a hammock
646 to her family. The hammock party left for Village 3A before dawn, without informing the town
647 authorities, a breach of local protocol suggesting they had something to hide.

648

649 Discharging her hammock carriers at the entrance to Village 3A, and being too weak to walk,
650 KK sent for family helpers to bring her to her house, where she died a day or two later.
651 Others in the home were infected, including a child who had slept on KK's bed. The
652 woman's death was promptly reported to the district response team and the death was
653 confirmed as Ebola; SOPs were promptly activated.

654

655 The community was quarantined – a process supervised by a doctor from the international
656 response. At first security forces kept out all visitors, including relief workers, but villagers
657 complained to the foreign doctor and food and other necessities were quickly supplied.

658

659 Niawa Lenga is a chiefdom of small-scale rice farmers, and October is the harvest period,
660 when daily life centers around the rice farm. Some people doubtless slipped away down
661 unregulated bush tracks and made themselves quietly absent in their farms, while others
662 collected daily necessities from the relief agencies. The demand by the chiefdom authorities
663 for adherence to Ebola byelaws was respected, and no disputes were reported. Infection in
664 Village 3A ceased.

665

666 Infection in village 3B appears not to be connected with the outbreak in Village 3A. The
667 origins of this second outbreak lie in Bo Government Hospital. A nurse contracted Ebola
668 (apparently outside the hospital) and patients on her ward took flight. One of the patients,
669 LL, headed home to Village 3B. A cluster of cases subsequently occurred in Village 3B, and
670 control measures were rapidly implemented by the Bo-based District Ebola Response team,
671 which included establishing quarantine barriers. With a local politician's help quarantined
672 homes were supplied, enabling people to stay put.

673

674 There was one hiccup. At one of the burials the "safe burial" team attended without a
675 stretcher and improvised with sticks from a farm. The farmer collecting these sticks after the
676 burial became another victim of the outbreak.

677

678 The village location records show 12 cases in Niawa Lenga chiefdom, 4 in Village 3A and 8
679 in Village 3B. The records of laboratory confirmed cases show 19 cases in Niawa Lenga
680 between 17th October and 21st November 2014. Villagers in Village 3B insist there were
681 more, with 11 deaths in their village alone. Nevertheless, excepting for the mistake over the
682 stretcher, control measures worked as intended. The first confirmed case was recorded on
683 17th October 2014 and the last on 21st November. The outbreak in the chiefdom was
684 controlled within 36 days.

685

686 **Discussion**

687 The results reported here help confirm a picture of the Ebola epidemic in Sierra Leone as a
688 concatenation of smaller outbreaks. The heterogeneity of the epidemic thus needs to be
689 explained in terms of local behavioral circumstances and, most especially, social
690 circumstances, for which a standardized top-down numerical analysis or externally driven
691 emergency-response is not necessarily the most effective [11]. This was certainly true for
692 our two study districts, which were affected early in the epidemic and had to cope before a
693 national or international response had been fully mobilized.

694

695 The local name for Ebola (in the Mende language of the south and east of Sierra Leone) is
696 *bondawote* – "family turn around". This recognizes an essential truth about Ebola infection;
697 it is a disease of social intimacy, with close family members bearing the highest risks of
698 further infection [7]. The risks of infection peak in the final "wet" phase of the disease and
699 immediately after death, when the corpse is prepared by family members for interment.

700

701 The disease also makes inter-community jumps [8], but our ethnographic data reveal that
702 these jumps are often the result of family networking. Control, or loss of control, over
703 infection thus depended a great deal on cooperation of families, and in particular on whether
704 family care givers were persuaded to collaborate in reducing risks of contact with a sick
705 person or infected body.

706

707 The disease came under control only when the family “turned around”. The heterogeneities
708 of Ebola infection dynamics reflect whether families turned quickly or not, and whether this
709 “turning” was willing or achieved only under pressure. Four different groups of explanatory
710 elements can be discerned in the data presented. As overarching themes emerging from our
711 detailed analysis, they help explain local heterogeneity in ways that need to be considered
712 for other localized outbreaks (either in other parts of Sierra Leone, or in other countries and
713 other epidemics).

714

715 **1. Heterogeneities caused by externalities.**

716 Whether an epidemic chain was controlled or not sometimes depended on externalities –
717 events over which there was little or no control. A good instance of this would be the
718 isolated location of Village 1A, and the seasonal flood of the Taia river, which inhibited
719 initial response and delayed diagnosis.

720

721 Diagnostic accidents – the mix up of blood samples from two different villages with the
722 same name – also help explain why some outbreaks were larger than might have been
723 expected from the current state of knowledge or preparedness on the part of responders.
724 The surge in cases in Bumpeh Ngao, quite late in the epidemic’s trajectory, when
725 response modalities were better developed, is a case in point. Misdiagnosis created a
726 false confidence among family carers that a diagnosis of Ebola was unlikely.

727

728 Panic over nosocomial infection might also be considered a kind of accident, connected
729 to the totally unexpected outbreak of a disease never before seen in the region. The
730 spread of Ebola to patients in the isolation ward at Kenema Hospital, and the notoriously
731 poor conditions in the makeshift Ebola Holding Centre in Moyamba, then led to a sudden
732 and widespread collapse of confidence in medical treatment. Some people became
733 convinced that Ebola was spread deliberately by medical workers, others that Ebola
734 case handling was connected to theft of body parts and blood. Families strategized
735 desperately to prevent patients being consigned to Ebola handling facilities.

736

737 Much of the Ebola response was a race against time to put in place proper procedures,
738 in which improvisation was often required. Allocating the single PPE suit to the patient,
739 rather than to rider and pillion helper when extracting patients from Village 1B, might be
740 seen as an inspired solution. The burial team's lack of a stretcher – did they forget to
741 pack it in their haste? - in Village 3B was a mistake with which a village farmer paid with
742 his life.

743

744 **2. Heterogeneities resulting from structural or health system** 745 **deficiencies**

746 Families often struggled to bring sick patients for diagnosis, and many helpers were at
747 risk of infection during that process. In some instances, little could be done to improve
748 access to services (Villages 1A and 1B, for example). Later in the epidemic, better
749 transport equipment (dedicated Ebola ambulances with trained crew, for example),
750 improved communication (notably, a telephone helpline), and more rapid, mobile
751 laboratory diagnosis certainly improved capacity to reach and transfer patients over a
752 large part of the country.

753

754 The availability of Ebola case handling capacity, and the degree to which communities
755 trusted or shunned those facilities [12], varied locally, and negative impacts are clearly
756 seen in our data. A study of the Kenema Ebola Treatment Unit (open from October
757 2014) reports that it only gained wider acceptance after the first survivors returned to
758 their families [13]. The facility at Bandajuma (Bo) also opened in October 2014, and its
759 presence and impact are glimpsed only in our later case studies. The Ebola Holding
760 Centre in Moyamba town was opened as early as June 2014 and left its (negative) mark
761 across the district. It was eventually replaced by a Norwegian-staffed and funded ETU in
762 Moyamba in December 2014, too late for the infection chains reported above.

763

764 The case-study material relating to Villages 1A and 1B, and 2A illustrate the
765 disadvantages of not yet having in place a clear set of Ebola response SOPs, and a
766 proper relief system supply chain to support quarantine. The benefits of having such
767 organizational procedures are apparent in the speed with which the later Niawa Lenga
768 outbreak was contained.

769

770 The original case definition for Ebola imported from central Africa over-emphasized
771 bleeding as a sign and symptom. The case definition was later changed in line with
772 actual experience, but families varied in the extent to which they took account of this

773 earlier misinformation. Arguments about symptoms emerged where precipitate action in
774 treating a potential case as Ebola was resisted (we documented this in Village 3C, for
775 example).

776

777 Other examples of poor messaging, inappropriate in the local context, exist. For
778 example, bush meat, especially eating of monkeys, was widely warned against over
779 radio and on posters as a cause of infection. Villagers who never ate bush meat (often
780 for religious reasons) imagined themselves to be safe from infection. It was only late in
781 the epidemic that this message was replaced by an emphasis on limiting body contact
782 with persons of unknown Ebola status. Village communities varied in the extent to which
783 they worked out for themselves whether or not bush meat or body contact were risks
784 (www.ebola-anthropology.net).

785

786 **3. Heterogeneities linked to cultural considerations.**

787 Older family members are often heavily involved in caring for and treating the sick and
788 advising on steps to be taken in case of serious sickness and death. This explains the
789 quantitative finding that older people were disproportionately at risk of infection from
790 EVD. There was then a knock-on effect – older people in positions of family leadership
791 are more likely to be senior members of the major male and female sodalities. The
792 elaborate funeral rituals of the sodalities played a significant part in local multiplication of
793 infection (e.g. Villages 1A, and 2A).

794

795 It is not the size of the funeral that determines the infection risk, but the distribution of
796 duties in preparing and taking leave of the corpse [7]. These are matters known only to
797 members of the sodalities. The pattern of subsequent infections might then depend on
798 where the key elders came from across a chiefdom or chiefdom section. The
799 conversation between communities and responders about control of infection risks from
800 funerals improved only when sodality members with information on Ebola infection
801 control talked to sodality elders, who then turned this information into safer practical
802 outcomes ([7], [9]).

803

804 Local government in rural Sierra Leone is dualistic. Chiefdom law is separate from
805 national law. National government intervenes locally only with the collaboration of
806 chiefdom administrations. A slip-up over sending notifications to the local chief through
807 the correct channels hindered the process of establishing that there was EVD in Village
808 1A, and this delayed implementation of infection control.

809

810 Belief in the efficacy of traditional herbal medicine is high in rural areas of Sierra Leone,
811 and this trust was intensified by experience of hospital-based nosocomial infection.

812 Traditional practitioners vary in reputation. A renowned practitioner will draw clients from
813 far and wide. The likelihood of a practitioner being infected by a patient is greater where
814 the catchment is wide. Ebola first spread across the border from Guinea through the
815 patients of a well-known herbalist. The index case in Village 1A was also a renowned
816 herbalist. Villages without noted practitioners were less likely to experience infection.

817 The government banned traditional medical practice for the duration of the epidemic.

818 Arguably, a better approach might have been to find a role for herbalists in the epidemic,
819 perhaps as community interlocutors, to explain the infection risk.

820

821 **4. Heterogeneities as a result of variations in coping options**

822 Once communities realized that Ebola infection risks were linked to contact with infected
823 persons, they began to develop ideas for limiting social contacts, especially with
824 strangers. One approach was to impose self-isolation by controlling entrance to and exit
825 from the community, building on experience with civil-defence during the civil war (1991-
826 2002). Another approach (again widely practiced during the war) was to retreat into
827 *sokoihun* (“corners”). Typically, this would mean the household withdrawing to the hut in
828 the family rice farm, where there was both food and shelter. These solutions were less
829 easily applied in some places than others. The greater the dependence on trade rather
830 than the farm for subsistence livelihood the less practical it was to practice self-isolation.

831

832 Community members in Village 1A explicitly mentioned the self-isolation option, more or
833 less reinforced by the cutting of the footpath bridge linking them to Village 1C.

834 Informants connected living in “corners” with cutting down on bodily contact. Village 2A,
835 however, was more dependent on its external links, as a center for both trade and
836 Koranic education, and had no option but to accept externally enforced quarantine, and
837 to apply for relief assistance. More generally it seems clear that the greater difficulty in
838 ending infection chains in districts closer to Freetown (notably Port Loko and Western
839 Rural) relates to the greater involvement of these districts in trade and transportation.

840

841

842

843

844 **Conclusion**

845 The overall conclusion is that the epidemic of Ebola Virus Disease in Sierra Leone 2014-15
846 is best viewed from a disaggregated perspective, as a series of local, but linked episodes,
847 shaped by a diverse series of factors including bad luck and miscalculation, as well as
848 variation in local cultural imperatives, response strategies and configurations of local
849 livelihood opportunities. Despite local specificity, we have identified four groups of factors
850 that help explain this heterogeneity which are likely to have relevance for other settings. It is
851 critical that epidemic-response rapidly captures the presence of such heterogeneity. To do
852 this implies the continuing need for an ethnographically informed epidemiology:
853 ethnographic research is critical for developing a richer picture of epidemic spread and a
854 better understanding of epidemiological data. Integrating these disciplines in research is
855 challenging, but these are important epistemological considerations that extend well beyond
856 the outbreak of Ebola in West Africa. Critically, understanding this heterogeneity will enable
857 nuanced responses to outbreaks likely to be more effective and better received by the
858 population.

859

860 Indeed, given current debates around evidence in the COVID-19 pandemic, we offer
861 important reflections on how, in collaborations between epidemiologists and social sciences,
862 the complementarity in collection, interpretation and use of qualitative and quantitative data,
863 can produce not only more context-appropriate responses but also more accurate efforts to
864 explain and model an epidemic taking into account social dynamics. Our findings raise
865 questions about what evidence and whose knowledge “counts” ([14], [15]). A key implication
866 of our analysis is the necessity for local knowledge and inputs to be incorporated in the
867 planning of any future outbreak responses – including in the current Covid-19 outbreak. This
868 would involve working closely with key local figures coming from, or based in, the study
869 communities in order to obtain a full picture of what has happened, why, and how outbreak
870 responses can be made more compatible with local realities. It is also important that local
871 nuance informs subnational and national response planning, with local data aggregated at
872 subnational level to identify geographical patterns of disease. Of immediate relevance, in
873 terms of future preparedness and current Covid-19 response, is the training of local
874 researchers, with detailed knowledge of local cultural contexts, in ethnographic field
875 methods, to join teams carrying out real-time epidemiological analysis and help re-frame
876 research as part of crisis response efforts.

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895 **References**

896

897 [1] Garske T, Cori A, Ariyaratna A, Blake I, Dorigatti I, Eckmanns T, Fraser C, Hinsley W,
898 Jombart T, Mills H, Nedjati-Gilani G, Newton E, Nouvellet P, Perkins D, Riley S,
899 Schumacher D, Shah A, Van Kerkhove M, Dye C, Donnelly C, Heterogeneities in the case
900 fatality ratio in the West African Ebola outbreak 2013–2016. *Philosophical Transactions of*
901 *the Royal Society B: Biological Sciences* 2016, **372**. 20160308. 10.1098/rstb.2016.0308.

902

903 [2] Ebola Gbalo Research Team, Responding to the Ebola virus disease outbreak in DR
904 Congo: when will we learn from Sierra Leone? *The Lancet*, 2019, **393**, Issue 10191, 2647 –
905 2650

906

907 [3] Li-Qun Fang, Yang Yang, Jia-Fu Jiang, Hong-Wu Yao, David Kargbo, Xin-Lou Li, Bao-
908 Gui Jiang, Brima Kargbo, Yi-Gang Tong, Ya-Wei Wang, Kun Liu, Abdul Kamara, Foday
909 Daffae, Alex Kanu, Rui-Ruo Jiang, Ye Sun, Ruo-Xi Sun, Wan-Jun Chen, Mai-Juan
910 Ma, Natalie E. Dean, Harold Thomas, Ira M. Longini Jr., M. Elizabeth Halloran, and Wu-
911 Chun Cao (2016) Transmission dynamics of Ebola virus disease and intervention
912 effectiveness in Sierra Leone, *PNAS* April 19, 2016 **113** (16) 4488-
913 4493; <https://doi.org/10.1073/pnas.1518587113>

914

915 [4] International Ebola Response Team, Agua-Agum J, Ariyaratna A, Aylward B, Bawo L,
916 Bilivogui P, et al., Exposure Patterns Driving Ebola Transmission in West Africa: A
917 Retrospective Observational Study. *PLoS Med* 2016, **13**(11): e1002170.
918 <https://doi.org/10.1371/journal.pmed.1002170>

919

920 [5] Wong J Y, Zhang W, Kargbo D, Haque U, Hu W, Wu P, ... Liu C, Assessment of the
921 severity of Ebola virus disease in Sierra Leone in 2014-2015. *Epidemiology and*
922 *infection*, 2016, **144**(7), 1473–1481. doi:10.1017/S0950268815003003

923

924 [6] Krauer F, Gsteiger S, Low N, Hansen CH, Althaus CL (2016) Heterogeneity in District-
925 Level Transmission of Ebola Virus Disease during the 2013-2015 epidemic in West Africa.
926 *PLoS Negl Trop Dis* **10**(7): e0004867. doi:10.1371/journal.pntd.0004867

927

928 [7] Richards P, *Ebola: how a people's science helped end an epidemic*, London: Zed Books,
929 2016.

930

931 [8] Richards P, Amara J, Ferme MC, Kamara P, Mokuwa E, Sheriff AI, et al., Social
932 Pathways for Ebola Virus Disease in Rural Sierra Leone, and Some Implications for
933 Containment. *PLoS Negl Trop Dis* 2015, **9**(4): e0003567. doi:10.1371/journal.pntd.0003567

934

935 [9] Parker M, Hanson TM, Vandi A, Babawo LS, & Allen T, Ebola and Public Authority:
936 Saving Loved Ones in Sierra Leone, *Medical Anthropology*, 2019, **38**:5, 440-
937 454, DOI: [10.1080/01459740.2019.1609472](https://doi.org/10.1080/01459740.2019.1609472)

938

939 [10] Manguvo A & Mafuvadze B, The impact of traditional and religious practices on the
940 spread of Ebola in West Africa: time for a strategic shift. *The Pan African Medical*
941 *Journal*, **22** Suppl 1(Suppl 1), 2015, 9. doi:10.11694/pamj.suppl.2015.22.1.6190

942

943 [11] Ferguson N, Capturing human behaviour. *Nature* 2007, **446**, 733, doi:10.1038/446733a

944

945 [12] Mokuwa EY, Maat H, Rural populations exposed to Ebola Virus Disease respond
946 positively to localised case handling: Evidence from Sierra Leone. *PLoS Negl Trop Dis* 2020,
947 **14**(1): e0007666. <https://doi.org/10.1371/journal.pntd.0007666>

948

949 [13] Richards P, Mokuwa E, Welmers P, Maat H, Beisel U, Trust, and distrust, of Ebola
950 Treatment Centers: A case-study from Sierra Leone. *PLoS ONE* 2019, 14(12): e0224511.
951 <https://doi.org/10.1371/journal.pone.0224511>
952

953 [14] DiGiacomo SM, Can there be a “cultural epidemiology”? *Medical Anthropology*
954 *Quarterly*, 2008, <https://doi.org/10.1525/maq.1999.13.4.436>
955

956 [15] Nichter M, *Global health: why cultural perceptions, social representations, and*
957 *biopolitics matter*, Tucson AZ: University of Arizona Press, 2008
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Table 1: Ebola in Sierra Leone by District, date of first case, average length of infection chains at chiefdom level, and total numbers of laboratory confirmed cases

DISTRICT	DATE OF FIRST CASE	LENGTH OF INFECTION (days)	N OF CASES	
	onset of symptoms		lab confirmed	
BO	13/06/2014	90	315	971
BONTHE	10/10/2014	32	6	972
BOMBALI	06/07/2014	161	1049	973
KAILAHUN	18/05/2014	133	524	974
KAMBIA	12/09/2014	259	241	975
KENEMA	13/06/2014	120	497	976
KOINADUGU	29/08/2014	198	111	977
KONO	27/06/2014	132	260	978
MOYAMBA	02/07/2014	95	211	979
PORT LOKO	02/07/2014	280	1202	980
PUJEHUN	28/07/2014	67	31	981
TONKOLILI	05/08/2014	151	489	982
Western Rural	20/07/2015	300	1146	983
Western Urban	25/06/2015	406	2274	984
ALL PROVINCIAL			4936	985
ALL WESTERN AREA			3420	986
TOTAL			8356	987
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