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Food Insecurity as a Risk Factor for Outcomes Related to Ebola Virus Disease in Kono District, Sierra Leone: A Cross-Sectional Study

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Abstract. Studies have shown that people suffering from food insecurity are at higher risk for infectious and non-communicable diseases and have poorer health outcomes. No study, however, has examined the association between food insecurity and outcomes related to Ebola virus disease (EVD). We conducted a cross-sectional study in two Ebola-affected communities in Kono district, Sierra Leone, from November 2015 to September 2016. We enrolled persons who were determined to have been exposed to Ebola virus. We assessed the association of food insecurity, using an adapted version of the Household Food Insecurity Access Scale, a nine-item scale well validated across Africa, with having been diagnosed with EVD and having died of EVD, using logistic regression models with cluster-adjusted standard errors. We interviewed 326 persons who were exposed to Ebola virus; 61 (19%) were diagnosed with EVD and 45/61 (74%) died. We found high levels (87%) of food insecurity, but there was no association between food insecurity and having been diagnosed with EVD. Among EVD cases, those who were food insecure had 18.3 times the adjusted odds of death than those who were food secure ($P = 0.03$). This is the first study to demonstrate a potential relationship between food insecurity and having died of EVD, although larger prospective studies are needed to confirm these findings.

INTRODUCTION

Despite more than 33 documented outbreaks of Ebola virus disease (EVD) since 1976, the complex biosocial processes associated both with the spread of the virus and with disease outcomes are poorly understood.[1–3] Even before the recent Ebola outbreak in West Africa, food insecurity, defined as having difficulty acquiring safe and nutritionally adequate food in socially acceptable ways, was a major problem.[4–8] In Sierra Leone in 2010, food insecurity was estimated to affect upward of 2.5 million persons of a total population of 6.1 million persons,[9] and a nationally representative cross-sectional survey conducted in 2013 demonstrated a significant prevalence of micronutritional deficiencies in women and children.[10] The World Food Program estimated that the 2013–2016 Ebola outbreak pushed approximately 750,000 additional people into a state of food insecurity.[11] Even though a large proportion of the population was food insecure during the Ebola outbreak, the impact of food insecurity on outcomes related to EVD is poorly understood.

Food insecurity has been associated with higher risks of acquiring human immunodeficiency virus (HIV), tuberculosis, malaria, sexually transmitted infections, and noncommunicable diseases and may act through a conceptual framework that includes nutritional, mental health, and behavioral pathways.[6,12–14] Once a disease has been acquired, a cycle of food insecurity and poor health outcomes may begin.[6] In this conceptual framework, being food insecure can drive poorer nutrition and worse health outcomes, including higher mortality and worse immunologic and virologic outcomes in HIV as well as a higher mortality in hospitalized adults.[5,15]

It is possible that there is an association between outcomes related to EVD and food insecurity via multiple pathways described in the conceptual framework.[6] There is a body of evidence that demonstrates how nutritional status may relate to immune response. For example, a higher body mass index and waist circumference have been associated with a robust, innate immune response,[16] and micronutritional deficiencies may disrupt a normal immune response.[17–19] The lack of a robust immune response has been associated with Ebola virus infection and fatal cases of EVD.[20,21] In addition to nutritional pathways, food insecurity can result in poor access to care both directly and indirectly through the pathway of poor mental health.[22,23] This is important among persons with EVD, as a delay in care is known to confer an increased risk of death.[24,25] Therefore, we hypothesized that food insecurity may worsen Ebola virus–related outcomes through multiple pathways and explored whether food insecurity was associated with having been diagnosed with EVD or having died of EVD.

METHODS

Study design and population. We conducted a cross-sectional study of the community members of Sukudu and Ndogbogi in Kono district, Sierra Leone, from November 2015 to September 2016.[26,27] Sukudu and Ndogbogi are rural communities with approximately 900 and 1,200 inhabitants, respectively. The first-confirmed EVD case in Sukudu was on December 15, 2014, and the last confirmed EVD case was on January 14, 2015. The first-confirmed EVD case in Ndogbogi was on December 4, 2014, and the last confirmed EVD case was on January 15, 2015.

The study protocol was approved by the Sierra Leone Ethics and Scientific Review Committee and the University of California, San Francisco's Committee on Human Research. Written informed consent was obtained from all participants

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with an age of 18 or more, and written assent with parental consent was obtained for all participants between the ages of 12 and 18. Permission to access the Viral Hemorrhagic Fever database was given by the Kono District Ebola Response Center (DERC), a government facility that served as a co-ordinating facility for EVD-related activities.

Study participants and procedures. Persons who were living in the two selected communities during the Ebola out-break were eligible for enrollment. We enrolled persons who were identified as having been exposed to Ebola virus. Ex-posure was defined as having had contact with an EVD case or as having been quarantined because of living in a house or sharing a toilet with an EVD case. We obtained a list of quar-antined households from the DERC, and we interviewed EVD survivors and household members of those who had died of EVD to create a list of close contacts. We asked participants about their age, gender, occupation, educational level, head of a pot group, and food insecurity level. We defined a pot group as a group of people who shared food that was cooked in the same pot, were answerable to the same head of the group, and defined their intra-household relationship structure.[28–30] The term "pot group" is culture specific and synonymous with "household."[29,30]

Food insecurity was our primary explanatory variable and was assessed using an adapted version of the Household Food Insecurity Access Scale (HFIAS), a nine-item scale well validated across Africa.[29] As per guidelines, participants were asked to recall their prior 1-month when considering their re-sponse to each question. Following standard usage of the HFIAS, we repeated administration of the HFIAS and asked participants to consider the 1-month period before the Ebola outbreak when responding to each question. Subsequently, we evaluated the validity of these responses by asking an open-ended question to assess how and why food insecurity changed over time. If discrepancies between qualitative and quantitative measurements were noted, the interviewer dis-cussed the discrepancy with the participant and all data re-lated to the HFIAS were recollected. Food insecurity data were collected at the pot level in both communities and at the individual-level in Ndogbogi. Each participant was assigned to a pot group. Participants who were 12 years old or younger were assigned the same food insecurity score as the head of the pot group. In cases where confirmed or probable EVD cases had died, we interviewed household members to obtain data. In addition to food insecurity, data were collected on age, gender, occupation, educational level, and head of the pot group.

Our outcome variables were having been diagnosed with EVD and EVD-related mortality. We obtained a list of EVD survivors and confirmed and probable dead cases from the DERC. These EVD cases were confirmed by interviews with the community members and leaders as well as the Sierra Leone Association of Ebola Survivors. Confirmed and prob-able dead cases met the World Health Organization case definitions.[31]

Statistical analysis. For the descriptive analysis, age was a continuous variable, and gender, occupation, educational level, and head of the pot group were dichotomous variables. We categorized the food insecurity variable as none, mild, moderate, and severe based on a standard algorithm.[29] After sensitivity analyses, we further dichotomized food insecurity into food secure (no or mild food insecurity) versus food insecure (moderate or severe food insecurity).[32] Additional sensitivity analyses were conducted to evaluate severity of food insecurity in the 1 month before the Ebola outbreak compared with food insecurity in the 1 month before the in-terview, using participants' assessment from their open-ended interviews of whether their food insecurity was better, worse, or the same.

We analyzed the association between pot-level food in-security and the Ebola virus–related outcomes, using logistic regression models with cluster-adjusted standard errors. Clusters were analyzed by the pot group. Covariates with a P value ≤ 0.2 in bivariate analysis were included in ad-justed models. We considered age and sex to be potential epidemiological confounders and included them in adjusted analyses irrespective of their bivariate associations. We cal-culated the proportion of EVD fatal cases from the total number of EVD cases and reported binomial exact confidence interval (CI). We conducted additional analyses to assess re-lationship of individual-level food insecurity with heads of pot groups, using Fisher's exact test; these analyses were re-stricted to Ndogbogi. The analyses were performed in STATA/ IC 13.1 (STATA Corporation, College Station, TX).

RESULTS

We interviewed 326 persons who were exposed to Ebola virus. The mean age was 28.1 years (standard deviation ± 16.9). More than half were men (55%) and worked outdoors (59%). Three-quarters (77%) completed primary school or less. These persons lived in 80 pot groups. Less than one-third (28%) were head of a pot group, and most (87%) were categorized as food insecure. Sixty-one (19%) were diagnosed with EVD, 46 (14%) were diagnosed although under quarantine, and 45 (14%) died (Table 1). The Ebola virus disease case fatality rate was 74% (95% CI: 61–84%).

Among exposed persons, older age, working outdoors, and higher educational level were associated with having been diagnosed with EVD in unadjusted analyses. After multivariate adjustment, age and higher educational level retained their association with having been diagnosed with EVD (age: adjusted odds ratio: 1.03; 95% CI: 1.00–1.05; higher educational level: adjusted odds ratio: 1.95; 95% CI: 1.03–3.70). Before the Ebola outbreak, those who were food insecure had 1.9 times the adjusted odds of having been diagnosed with EVD than those who were food secure, but the association was not statistically significant (95% CI: 0.53–6.62) (Table 2).

In unadjusted analyses among persons who were diag-nosed with EVD, having died of EVD was positively associated

TABLE 1
Sociodemographics and EVD outcomes of participants ($N = 326$)

Characteristics	n	%
Age	28.1 (mean)	SD ± 16.9
Gender (female)	146	44.8
Occupation (works outdoors)	193	59.2
Education (middle school or above)	75	23.0
Not head of pot group	234	71.8
Food insecure	284	87.1
Having been diagnosed with EVD	61	18.7
Having been diagnosed with EVD while under quarantine	46	14.1
Having died of EVD	45	13.8

EVD = Ebola virus disease.

TABLE 2
Associations with having been diagnosed with Ebola virus disease (N = 326)

Characteristics	Unadjusted OR		Adjusted OR	
	OR	95% CI	AOR	95% CI
Age*	1.03	1.01–1.05	**1.03**	**1.00–1.05**
Gender (female)	0.83	0.48–1.43	1.04	0.59–1.82
Occupation (works outdoors)	2.22	1.25–3.96	1.21	0.49–2.94
Education (middle school or above)	1.86	1.00–3.45	**1.95**	**1.03–3.70**
Not head of pot group	0.58	0.29–1.15	–	–
Food insecure	2.39	0.62–9.23	1.87	0.53–6.62

Bold indicates P value was statistically significant; CI = confidence interval.
* Age was a continuous variable.

with those who were food insecure before the Ebola outbreak and negatively associated with being the head of the pot group. After multivariate adjustment, EVD cases who were food insecure had 18.3 times the odds of death than EVD cases who were food secure (95% CI: 1.27–261.57). Ebola virus disease cases who were not the head of the pot group had 8.33 times the odds of death than EVD cases who were the head of the pot group (95% CI: 1.87–33.33) (Table 3). Additional analyses among participants from Ndogbogi showed that heads of pot groups were more likely to be food secure (odds ratio: 3.03; 95% CI: 1.09–9.89) (data not shown).

DISCUSSION

This is the first study to demonstrate potential relationships between food insecurity and outcomes related to EVD. We found no statistically significant association between food insecurity and being diagnosed with EVD in adjusted analyses, though the magnitude of the association was strong. Conversely, there was an association between food insecurity and having died of EVD. High levels of food insecurity have been found among persons quarantined for Ebola exposure. In a study in which all persons living in seven communities were quarantined after Ebola virus transmission started, 50% of the study participants reported that there were times when there was not enough food or water.[33] In future outbreaks, quarantined persons should have access to adequate food not only from a human rights perspective but also because exacerbating food insecurity has potential to increase the risk of EVD mortality.

At the beginning of the Ebola outbreak in these communities, there were delays in care largely due to the delays in disease detection and activation of Ebola response teams.[34] These delays were described in a nearby community, where 30 individuals were diagnosed with EVD before active surveillance and health education efforts were initiated.[35] After the Ebola response team engaged this community, the duration of infectivity to other community members significantly decreased on average, but the high number of EVD cases before arrival of the Ebola response team illustrates how many people did not get timely care as a result of social and structural barriers to care. Our study highlights food insecurity as one such structural barrier that may have negatively impacted EVD outcomes. Food insecurity may have contributed to immune dysfunction from acute caloric and micronutritional deficiencies.[10,36] Families often delayed seeking care because of fear and stigma associated with being placed in isolation facilities or distrust in the health system,[37–39] and because they were hiding, they may have had reduced access to food. In future Ebola outbreaks, additional study on food insecurity is needed to elucidate its contribution to the nutritional, mental health, and behavioral pathways that ultimately predict EVD outcomes.

Before the Ebola outbreak in Sukudu and Ndogbogi, there were high rates of food insecurity among the community members. Being a pot member rather than the head of the pot group was associated with food insecurity and having died of EVD. Heads of pot groups were mostly adult men, and it is plausible that power inequity and relationship dynamics partially determined food distribution, which is consistent with other studies that show inequitable access to food inside family structures.[40] It is not known how food was distributed when members of the pot group developed an EVD-like illness. Equal distribution or greater availability of food throughout the pot group may be a modifiable factor and have downstream benefits if a member were to develop EVD, but qualitative research is needed to improve our understanding of food distribution dynamics within groups during outbreaks.

There were several important limitations to this study. Most importantly, because of the nature of the EVD epidemic and the difficulties with setting up a prospective study in the setting of a humanitarian crisis, we were unable to prospectively study these associations. As such, the cross-sectional design of the

TABLE 3
Associations with having died of Ebola virus disease (N = 61)

Characteristics	Unadjusted OR		Adjusted OR	
	OR	95% CI	AOR	95% CI
Age*	1.00	0.97–1.03	1.01	0.96–1.06
Gender (female)	0.86	0.31–2.34	0.43	0.11–1.77
Occupation (works outdoors)	0.57	0.12–2.78	–	–
Education (middle school or above)	1.10	0.36–3.34	–	–
Not head of pot group	5.88	1.30–25.00	**8.33**	**1.87–33.33**
Food insecure	10.15	0.91–113.06	**18.25**	**1.27–261.57**

Bold indicates P value was statistically significant; CI = confidence interval.
* Age was a continuous variable.

study limits our ability to make conclusions about temporal causality, and hence, it is difficult to determine whether food insecurity was a cause or result of EVD and eventually led to death. To temper this concern, our participants were asked about their food insecurity before the Ebola outbreak in Sukudu and Ndogbogi. The HFIAS, however, was developed to measure food insecurity during a 1-month recall period, and the HFIAS was administered between 11 and 20 months after the Ebola outbreak in these communities. Therefore, we expect our estimates to have recall bias. In addition, possible misclassification bias related to levels of food insecurity and lack of a validation study of the adapted version of HFIAS were important limitations of this study. Our study was likely underpowered because of the small fixed sample size available in Sukudu and Ndogbogi. There may be unmeasured confounders in our analysis, including poverty and comorbid medical factors. Given the biosecurity constraints and weak health system, no data on comorbid medical factors were available for collection. Malaria was the only significant comorbid condition assessed at Ebola treatment units, and there is conflicting evidence about mortality outcomes between those who were EVD positive and malaria positive and those who were EVD positive and malaria negative.[41,42] Last, our findings may not necessarily be generalizable outside of these communities, especially to urban areas. However, we have no reason to believe that the situations in other Ebola-affected villages in rural Sierra Leone were any different.

Despite these limitations, our study provides novel evidence that food insecurity may be associated with EVD death. Future larger prospective studies are needed to confirm these findings and elucidate the contribution of food insecurity to the nutritional, mental health, and behavioral pathways that ultimately predict EVD outcomes. Given that there are high rates of food insecurity in Sierra Leone and other Ebola endemic areas, improving access to adequate food for people who are quarantined and at risk of EVD is not only a human rights issue but also may be a factor in survival in future outbreaks.

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