Risk factors for Ebola virus disease among household care providers, Sierra Leone, 2015

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Abstract

Background: Household contacts who provide care to an Ebola virus disease (EVD) case have a 3-fold higher risk of EVD compared with contacts who do not provide care.

Methods: We enrolled persons with confirmed EVD from December 2014 to April 2015 in Freetown, Sierra Leone, and their household contacts. Index cases and contacts were interviewed, and contacts were followed for 21 days to identify secondary cases. Epidemiological data were analysed to describe household care and to identify risk factors for developing EVD.

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Results: Of 838 contacts in 147 households, 156 (17%) self-reported providing care to the index case; 56 households had no care provider, 52 a single care provider and 39 multiple care providers. The median care provider age was 29 years, 68% were female and 32% were the index case's spouse. Care providers were more likely to report physical contact, contact with body fluids or sharing clothing, bed linens or utensils with an index case, compared with non-care providers (P<0.01). EVD risk among non-care providers was greater when the number of care providers in the household increased (odds ratio: 1.61; 95% confidence interval: 1.1, 2.4). In multivariable analysis, factors associated with care provider EVD risk included no piped water access and absence of index case fever, and protective factors included age <20 years and avoiding the index case.

Conclusions: Limiting the number of care providers in a household could reduce the risk of EVD transmission to both care providers and non-care providers. Strategies to protect care providers from EVD exposure are needed.

Introduction

The Ebola outbreak in Sierra Leone, Guinea and Liberia in 2014–16 was the largest in history. Sustained transmission in these three affected countries for over 2 years resulted in 28 616 cases and 11 310 deaths.[1] Risk factors for transmission in this outbreak included contact with suspected cases, household members,[2,3] care providers,[2] contact with dead bodies and touching of corpses at funerals,[4,5] and high index case viral load.[6] In addition, repeated contact with a sick persons' body fluids during provision of care during a later stage of illness was reported as an important risk factor for transmission in previous outbreaks.[7] In this and previous Ebola outbreaks, household contacts of confirmed cases were at increased risk for Ebola virus disease (EVD) During the Ebola outbreak in Sierra Leone, 83 (10%) of 838 household contacts developed EVD in a household transmission study.[2] In a 1995 study conducted in Democratic Republic of the Congo, 28 (16%) of 173 household contacts developed EVD.[8]

Controlling an Ebola virus outbreak requires important interventions to prevent and treat EVD,[9–11] including safe burials, contact tracing, case isolation and early notification, timely laboratory testing, and providing supportive care with infection prevention and control measures in place for those infected with Ebola.[1,9] The recent development of a safe and efficacious vaccine [12] supports an additional critical role for this intervention. Providing care to an EVD case was an independent predictor of EVD risk among household contacts, in a large study of household transmission conducted in Freetown, Sierra Leone, during the 2014–16 outbreak.[2] In that study, 24% of household care providers developed EVD, and care providers in households for an index case were found to have a 3-fold increased risk of secondary EVD compared with household members who did not provide care.[2] Providing care has also been associated with EVD risk in other outbreaks, including an outbreak in the Democratic Republic of Congo in 1995, where spouses as well as those who provided

nursing care were noted to be at higher risk,[8] and an outbreak in Sudan, where providing nursing care in a family setting had a 5-fold increased risk of infection compared with those who did not provide care.[13]

Although previous reports established EVD care providers[14] as a high-risk group, risk factors and behaviours of care providers within households of an Ebola case have not been previously well described. A better understanding of risk and protective factors among EVD care providers has important implications for refining public health strategies aimed at preventing household transmission of EVD, including the organization and management of care for ill household members and recommended precautions for EVD care providers in households.

We conducted a household transmission study in Freetown, Sierra Leone, during the 2014–16 outbreak, in which we identified index case death, living in the household, longer duration of wet symptoms (vomiting, diarrhoea and bleeding), absence of fever in the index case, no access to piped water and providing care to an index case, as risk factors for Ebola transmission.[2] In the current report, we describe results of sub-analyses of the household transmission data to better describe the care providers' role within households, to identify risk and protective factors specific to providing care to an index EVD case and to examine behaviours associated with risk among care providers in households with an EVD case.

Methods

We conducted a prospective investigation of households with a first case of EVD in Freetown, Sierra Leone, from 15 December 2014 through 30 April 2015.[2] Detailed methods from this investigation have been previously published,[2] but in brief, this investigation included 150 index EVD cases and 838 household contacts. EVD cases and deaths were identified through routine EVD surveillance. Households were monitored for 21-days[15] to determine whether household contacts developed EVD. All infections in index cases (including those deceased) and household contacts were laboratory-confirmed by real-time quantitative reverse-transcription polymerase chain reaction detecting Ebola virus (EBOV) RNA.

At the time of index case detection, data were collected by project staff who interviewed all household contacts and the index case (or head of household proxy). Questionnaires were completed on index case, household and contact characteristics. For each contact, detailed information on behavioural risks and protective factors was collected, including physical contact, contact with body fluids and sharing use of vehicles, bedrooms, beds, linens, toilets, eating utensils and clothing with an index case.

Care providers were household contacts who self-reported providing any type of care to an index case from beginning of symptom onset until removal from the household. Individual secondary attack rate was the number of confirmed secondary cases of EVD among contacts occurring within 21 days after index case isolation, divided by the total number of contacts. Household transmission rate was the number of households with >1 secondary EVD case among contacts divided by the total number of households.[2]

We analysed data using SAS software version 9.4 (SAS Institute). We compared households with and without care providers by use of likelihood-ratio chi square or Kruskal–Wallis tests. We used the same statistical tests to compare characteristics and behaviours of contacts who were care providers of EVD index cases with contacts who were not care providers. We then calculated individual secondary attack rate and household transmission rate and examined the transmission risk within the households according to the number of care providers therein. We used logistic regression to examine risk factors separately for EVD among the group of care providers and the non-care providers to EVD index cases. Variables were considered for multivariable models if their univariate P-value was <0.25. Generalized estimating equations were used to account for household clustering for models with secondary attack rate as the outcome. Data completeness for all key variables was >99%. P-values were exact when sample size necessitated.

This investigation was determined a public health response activity by the Sierra Leone Ministry of Health and United States Centers for Disease Control and Prevention Ethical Review Boards, with a waiver of informed consent.

Results

Of 838 contacts in 147 households, 156 (17%) self-reported providing care to the index case; 56 (38%) households had no care provider within the household, 52 (35%) had a single care provider and 39 (27 %) had multiple care providers (24 households with 2, 8 with 3, 4 with 4, and 3 with   5 care providers). Characteristics of index case households by care provider number are presented in Table 1. Households with single or multiple care providers were more likely to have a spouse in the house compared with households without a care provider (70% vs 66% vs 31%; P<0.001). Households with multiple care providers were more likely to have an index case with wet symptoms (82% vs 54%; P<0.01) and a longer duration of wet symptoms in an index case (2 days versus 1 day; P<0.01) than households with a single care provider.

Of the 156 care providers, 106 (68%) were female, and median age was 29 years (Table 1); 51 (32%) care providers were the index case's spouse, 68 (44%) were first-degree relatives, 21 (13%) were other relatives and 16 (10%) were unrelated to the index case.

Characteristics and behaviours of care providers compared with non-care providers are presented in Table 2. Care providers were more likely to be female (P<0.001) or spouses (P<0.001) of index cases. Most care providers were 20–59 years of age (71%) compared with non-care providers (40%; P<0.001); however, 16% of care providers were children 5–14 years old.

Care providers were more likely to report risk behaviours in association with the index EVD case compared with non-care providers, of which the most common were having physical contact with index case (87% vs 22%), touching or washing bed linens (65% vs 13%) and having contact with body fluids of index case (54% vs 4%) (P<0.001 for each) (Table 2). Contacts providing care were less likely to report protective behaviours compared with contacts not providing care, such as staying 1 m away from the case (18% vs 69%), having

stopped eating with the index case (35% vs 68%), avoiding touching index case (20% vs 71%) and stopping sleeping with index case (29% vs 66%) (*P*<0.001 for each).

For each risk factor, we calculated the proportion of the behaviour that was accounted for by the care providers and ranked them by care provider contribution (Figure 1). Care providers represented 17% of household contacts, and in each risk category, most persons who engaged in that risk behaviour were care providers. Care providers accounted for >90% of persons having contact with the index case's stool, vomit or urine and 73% of the contact with all body fluids. Additionally, care providers accounted for 47% of the persons having physical contact with the index case, 54% of those washing bed linens and 60% of those sharing of a motor vehicle. Conversely, only 11% of care providers reported taking any protective steps to avoid[2] the index case (Table 2).

Among 838 contacts there were 83 secondary EVD cases, of which 37 (45%) were among care providers. Although the care provider risk was high, it did not increase by the number of persons providing care within the household (Figure 2). For non-care providers, the risk of secondary EVD increased with the number of care providers, with the lowest risk associated with no care providers (4%) and the highest risk associated with two or more care providers in the household (13%; *P*=0.02; Figure 2). After excluding care providers from the denominator, the household transmission rate increased with increasing number of care providers in the household, was the lowest when there were no care providers (13%) and was the highest when there were two or more care providers in the household (39%; *P*=0.004).

Other risk factors for infection among care providers and non-care providers are presented in Table 3. In multivariate analysis for care providers (Table 4), there was an increased EVD risk if the index case had no reported fever [odds ratio (OR): 4.5; 95% confidence interval (CI): 1.5, 13.7], and if the household lacked access to piped drinking water (OR: 2.98; 95% CI: 1.11, 8.01), whereas they were at decreased risk if they reported avoiding the index case (OR: 0.18; 95% CI: 0.06, 0.50), and if they were < 20 years of age (OR: 0.37; 95% CI: 0.14, 0.98). Two factors which had been independent predictors of transmission in the parent household transmission study[2] did not reach the threshold for inclusion (*P*<0.05) in the multivariate model and were not included in the present multivariate analysis: being a relative of the index case and the index case having died in the household.

In multivariate analysis, among non-care providers there was an increased risk of becoming a secondary case if the index patient died in the home (OR: 4.33; 95% CI: 1.7, 11.0), and as the number of care providers in the household increased (OR: 1.86; 95% CI: 1.2, 2.8); there was a decreased risk with larger household size (OR: 0.32; 95% CI: 0.1, 0.8).

Discussion

In a large prospective study of household transmission of Ebola, conducted in Sierra Leone during the 2014–16 Ebola outbreak, we found that household contacts who provided care to an EVD case had a 3-fold higher risk of EVD compared with contacts who did not provide care.[2] In the present analysis, we demonstrate that the 17% of household contacts

providing care to an EVD case accounted for >90% of household contacts reporting risk behaviours associated with household transmission of Ebola, including contact with body fluids, physical contact and sharing clothing, bed linens or utensils with an EVD index case. We identify no access to piped water and absence of reported fever for the EVD index case as independent predictors of EVD among care providers, and demonstrate that EVD risk among non-care providers in the household was greater when there were multiple care providers. Further, we show that the risk to individual care providers remained the same regardless of the care provider number. These findings have implications regarding management of care for sick persons in the households, suggesting that designating a single care provider could reduce the risk to others in the household as well as reduce the number of persons at risk on the basis of providing care. These results can help inform public health strategies aimed at EVD transmission prevention in households, including recommended infection prevention and control practices with basic precautions for EVD care providers before the infected case is removed from the household.

In our analysis, not all households had a self-reported care provider. This can be explained by the fact that households with no reported care provider may have had one who lived outside the household or that the index case provided self-care. However, households that had one or more care provider were more likely to have an index case with wet symptoms, as well as longer duration of wet symptoms than households without a care provider. We assume that index cases with wet symptoms[7] required more physical care, thus prompting the need for multiple care providers. A long duration of wet symptoms may make self-care more difficult and thus may increase the likelihood of a household member stepping into the care provider role. Therefore, removal of an index case from the household as quickly as possible is necessary to decrease the risk of EVD to other members and to a care provider.

Due to shortages of health care facilities in many West African settings, it is common to receive care at home from relatives and family members[16] during Ebola outbreaks.[17] Women have previously been reported to be at greater risk of being infected as they were more likely to provide nursing care.[18] In addition, secondary attack rates have been reported to be higher for spouses and other close relatives.[4,18] Although the majority of care providers in our analysis were female, almost one-third were male. Because the survival rate among female EVD cases was higher,[19] awareness of sex-specific differences in risk was promoted to reduce community transmission.[19] Furthermore, in our study, spouses and first-degree relatives accounted for a larger proportion of care providers, and 16% of care providers were children between 5 and 14 years old. Children have been reported to have a lower transmission risk and a lower incidence compared with adults in this and previous outbreaks[5,20,21]; however, they were less likely to provide nursing care than adults[17] and were less likely to have close contact with patients.[18] Thus, a demographically wide array of persons in the household stepped in to provide care. EVD prevention education messages should be targeted to all household members including heads of households,[14] men, women, close family members and parents of children.

Care providers were more likely to report risk behaviours for EVD compared with non-care providers, and a large majority of the contacts reporting risk behaviours were accounted for by the care providers. Many of these risk behaviours were within the scope of providing

care, such as having any physical contact with the case, touching or washing bed linens and having contact with body fluids of index case. As is logical from what is known about EVD exposure, more exposure certainly confers more risk.[17] Direct repeated contact with body fluid during provision of care has been reported as one of the most important risk factors for transmission in other studies.[8,22] It is logical that care providers could be at increased risk of body fluid exposure, but the high proportion of many other EVD risk behaviours accounted for by care providers establishes care providers as a very high-risk subgroup within the household for developing EVD. Because most care provider tasks involved close contact with the EVD case, care providers in our study were less likely to report being able to protect themselves by staying 1 m away from the case, stopping eating with the index case, avoiding touching index case and stopping sleeping with the index case. This is concerning, but may reflect the reality of providing care in settings with a larger number of household members where EVD cases cannot always be separated from the rest of the household. Further, there may not be an abundant water supply for cleaning up body fluids and washing hands and soiled clothing and bed linens. Despite this, some care providers stated they implemented avoidance behaviours while providing care, which could mean the ability to avoid some exposure associated with greater awareness. Nevertheless, care providers cannot avoid all contact with the case while providing care. Collecting more detailed data on care provision behaviours from individuals in EVD households might be beneficial in learning more about care providers' risk profiles. Educational efforts[14,23,24] to promote risk awareness, protective strategies such as vaccination to prioritize contacts of cases including care givers,[11,17] teaching methods to minimize risk behaviours while providing care, and taking protective steps are necessary and should be evaluated in future outbreaks. These educational efforts should emphasize that it is important to use barrier protections such as gloves,[7] and to make sure that barrier precautions are used in households during an Ebola outbreak.

In our study, no access to piped water was an independent predictor of care provider EVD risk. As reported in our parent epidemiological study, having access to piped drinking water most likely meant increased access to water for personal hygiene purposes, to clean up body fluids and to wash soiled bed linens and clothing, which could decrease transmission risk.[2] Further, absence of fever in an index case may have delayed recognition of Ebola illness[25] perhaps delaying the use of infection control measures among care givers.[2] In addition, after controlling for avoiding the index case, piped drinking water and fever in the index case, younger persons were at a reduced risk. Although no other factors came out in the multivariate models, 7–19-year-old care providers were less likely (although not statistically significantly) to have physical contact, contact with the case's body fluids and to have washed laundry of the case, than the older age groups. In protecting children in the home to the degree possible, we believe it is a combination of these factors which reduced the risk of the younger-aged care providers.[18,21]

Importantly, the risk of becoming a secondary case in the household for non-care providers increased with an increase in the number of care providers in the household, suggesting a higher chance of direct and indirect contact with the index case.[3] A possible mechanism may include the delay of a case removal from the house due to availability of care, and thus an increase in risk of EVD transmission to other members of household. With the

secondary EVD risk to non-care providers increasing with the number of persons providing care, and with the risk to care providers being uniformly 3-fold higher, educational messages for high-risk households[26] should be updated to include recommending a limitation in the number of care providers in households whenever possible, to minimize the risk of EVD transmission.

These study findings should be interpreted with the following limitations. Provision of care was self-reported by study participants, and a comprehensive set of activities which constituted provision of care was not delineated when household members were asked if they provided care. Thus, there may have been some misclassification bias, and the possibility that persons not residing in the household provided some care also cannot be excluded. In addition, low sample sizes of persons using protective barriers precluded our ability to evaluate those as protective measures. Furthermore, there is a possibility of lack of recall about risk or protective behaviours associated with the risk of transmission which could not be directly observed by the investigative team, and this could have affected the magnitude of associations. Additionally, we did not collect information on timing of EVD among contacts within the 21-day observation window as part of this study. Finally, this study is observational and subject to the inherent limitations of correlative studies. Nevertheless, the identified risk factors were all biologically reasonable based on the literature on EVD transmission. Strengths of the study were that comprehensive data[2] were predominantly prospectively collected and in the midst of the epidemic. Moreover, secondary cases were laboratory-confirmed and therefore accurate comparisons of transmission risk were made to inform prevention strategies.

Conclusion

Care providers are known to be at increased risk for secondary EVD in households,[2] but until recently little has been known about the degree of risk,[2,7,8,13] and factors associated with increased risk have not been well characterized. In our study, care providers were far more likely than other household contacts to report risk behaviours associated with exposure to EBOV and were less likely to report protective behaviours. When more than one person in a household provided care to an index EVD patient, the risk to each individual care provider was not decreased, and the risk to non-care providers was higher than with a single care provider or no care provider. Our findings suggest that limiting the number of care providers could be an important strategy to reduce risk to other household members, and to reduce the number of persons with care-related exposures. The increased risk associated with being a care provider to an index case without fever emphasizes the importance of communication messages which prompt early recognition and reporting of persons with any Ebola symptoms, even in the absence of fever. Strategies to protect care providers are urgently needed. Ensuring adequate water supplies for personal hygiene and to clean up body fluids and soiled clothes and bed linens is an important protective step. Further studies are also needed to help determine which of the many behavioural differences we identified between care providers and non-care providers are independent predictors of risk, and should also consider evaluating availability of water for cleaning and washing, implementation of simple barrier protections such as gloves and vaccination, as potential ways to reduce care provider risk. Until a set of protective measures can be put in place

and evaluated, care providers will continue to incur risk. Our findings have implications for developing prevention strategies for provision of care to high-risk household contacts and will help to inform recurrent outbreaks in Central and West Africa.

Acknowledgements

Data availability

The data underlying this article cannot be shared for public use because neither the Centers for Disease Control and Prevention Institutional Review Board nor the Sierra Leone Ethics Committee granted such permission.

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Key messages

- Household contacts who provide care to an Ebola virus disease (EVD) case have a higher risk of EVD compared with contacts who do not provide care; however, factors associated with increased risk have not been well characterized.

- Care providers were more likely to report physical contact, body fluid contact or sharing clothing, bed linens or utensils with an index case compared with non-care providers; and were less likely to report protective behaviours.

- EVD risk among non-care providers was greater with more household care providers; the risk to individual care providers was similar whether or not more than one care provider was present.

- Our findings suggest that limiting the number of care providers could reduce risk of EVD transmission to other household members.

- Strategies to protect care providers are urgently needed.
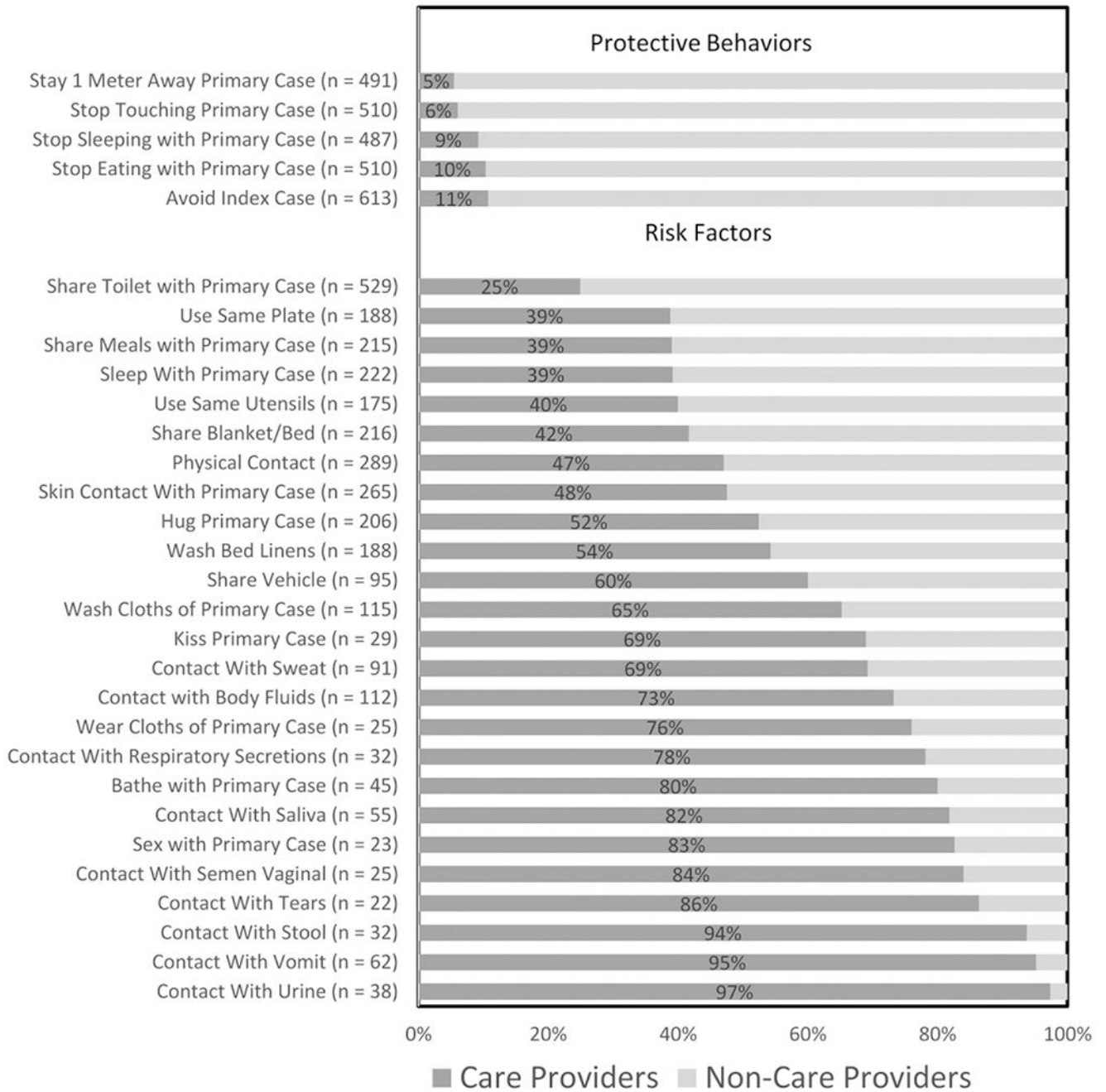
Figure 1.
Proportion of risk behaviours attributed to care providers vs non-care providers, Freetown, Sierra Leone, 2014–15. For example, care providers made up 17% of household contacts (data not shown) but represented 95% of household contacts who had contact with the index cases vomit (second bar from bottom, of 62 contacts who reported contact with vomit, 59 were care providers)
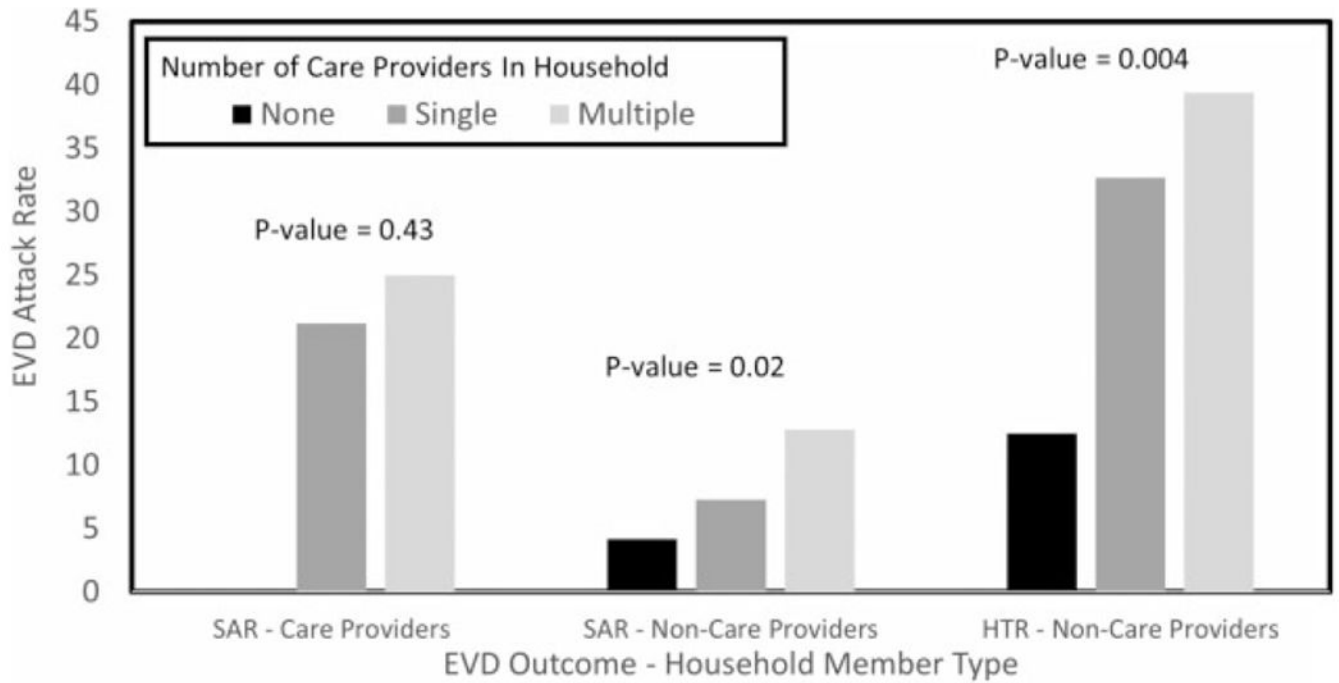
Figure 2.
The Secondary Attack Rate among individuals (SAR) and the Household Transmission Rate (HTR) for households according to the number of care providers in the household, Freetown, Sierra Leone, 2014–15. SAR is the proportion of individuals in the household with confirmed Ebola virus disease (EVD), and the HTR is the proportion of households with 1 secondary case of EVD within 21 days of index case removal. *P*-values were controlled for household size

Table 1

Characteristics of households of index Ebola Virus disease cases with multiple care providers (*n*=39) vs with a single care provider (*n*=52) vs with no care provider (*n*=56), Freetown, Sierra Leone, 2014–15

Characteristic	Level	#1 Households with no care provider (*n*=56)	#2 Households with a single care provider (*n*=52)	#3 Households with multiple care providers (*n*=39)	P-value Column 1 vs 2,3 combined	P-value Column 2 vs 3
Gender of index case	Female	39% (22)	44% (23)	51% (20)	0.34	0.50
	Male	61% (34)	56% (29)	49% (19)		
Age of index case	<20 years	5% (3)	17% (9)	21% (8)	0.12	0.81
	20–39 years	61% (34)	52% (27)	49% (19)		
	40–59 years	29% (16)	25% (13)	21% (8)		
	60+ years	5% (3)	6% (3)	10% (4)		
Spouse in the house (adult index case)		31% (17/55)	70% (32/46)	66% (21/32)	<0.0001	0.71
District	Urban	73% (41)	67% (35)	74% (29)	0.71	0.47
	Rural	27% (15)	33% (17)	26% (10)		
Number of rooms in house[a]		4 (6.9)	4 (5.7)	3 (4.7)	0.19	0.15
Number of people in house[a,b]		6 (6.9)	5 (6.5)	6 (6.7)	0.81	0.40
Dwelling type	Detached house	25% 914)	21% (11)	31% (12)	0.88	0.56
	Apartment	63% (35)	63% (33)	54% (21)		
	Makeshift	12% (7)	15% (8)	15% (6)		
Access to piped water		54% (30)	48% (25)	49% (19)	0.54	0.95
Index case separated after illness onset		46% (26)	35% (18)	21% (8)	0.03	0.14
Days in household before removal[a]		3.5 (3.9)	3.0 (3.8)	4.0 (4.5)	0.68	0.17
Index case with wet symptoms		50% (28)	54% (28)	82% (32)	0.06	0.005
Wet symptom phase length[a]		0.5 (1.25)	1.0 (1.3)	2.0 (2.7)	0.04	0.003
Index case died in the house		7% (4)	15% (8)	21% (8)	0.06	0.52
Index case with a fever		79% (44)	67% (35)	79% (31)	0.41	0.20

[a]Median displayed with mean in parentheses.

[b]Included primary case.

Table 2

Characteristics and behaviours of care providers of index Ebola virus disease cases (*n*=156) compared with household contacts who did not provide care (*n*=682), Freetown, Sierra Leone, 2014–15

Characteristic	Level	Contacts providing care to index case (*n*=156)	Contacts not providing care to index case (*n*=682)	*P*-value
Gender	Female	68% (106)[a]	54% (365)	0.001
	Male	32% (50)[a]	46% (317)	
Relation to index case	Spouse	32% (51)	3% (20)	<0.0001
	First-degree relative	44% (68)	41% (280)	
	Other relative	13% (21)	30% (204)	
	Unrelated	10% (16)	26% (178)	
Age	<5 years	0% (0)	18% (122)	<0.0001
	5–9 years	5% (8)	15% (99)	
	10–14 years	11% (17)	12% (80)	
	15–19 years	8% (13)	13% (91)	
	20–29 years	28% (44)	20% (134)	
	30–39 years	22% (35)	10% (66)	
	40–59 years	21% (33)	10% (68)	
	60+ years	4% (6)	3% (22)	
Sleep in index case's room		56% (87)	20% (135)	<0.0001
Share blanket/bed with index case		58% (90)	18% (126)	<0.0001
Share vehicle with index case		37% (57)	6% (38)	<0.0001
Share toilet with index case		89% (125/140)	63% (388/614)	<0.0001
Share meals with index case		55% (84)	19% (131)	<0.0001
sharing same plate		47% (73)	17% (115)	<0.0001
sharing utensils/cup		45% (70)	15% (105)	<0.0001
Touch or wash bed linens of index case		65% (102)	13% (86)	<0.0001
Wash clothes of index case		48% (75)	6% (40)	<0.0001
Wear clothes of index case		12% (19)	1% (6)	<0.0001
Contact with body fluids of index case		54% (82)	4% (30)	<0.0001
sweat		41% (63)	4% (28)	<0.0001
vomit		39% (59)	0.4% (3)	<0.0001

Characteristic	Level	Contacts providing care to index case (*n*=156)	Contacts not providing care to index case (*n*=682)	*P*-value
saliva		29% (45)	1% (10)	<0.0001
urine		24% (37)	0.2% (1)	<0.0001
stool		20% (30)	0.3% (2)	<0.0001
respiratory secretions		16% (25)	1% (7)	<0.0001
semen or vaginal fluids		14% (21)	1% (4)	<0.0001
tears		12% (19)	0.4% (3)	<0.0001
blood		3% (5)	0% (0)	0.0002
Physical contact with index case		87% (136)	22% (153)	<0.0001
contact with index case's skin		81% (126)	20% (139)	<0.0001
hug, hold or cuddle with index case		69% (108)	14% (98)	<0.0001
wash, clean or bathe index case		23% (36)	1% (9)	<0.0001
sexual intercourse with index case		14% (19)[b]	1% (4)	<0.0001
kiss on lips		13% (20)	1% (9)	<0.0001
Stay 1 m away from index case		18% (27)	69% (464)	<0.0001
Stop eating with the index case		35% (53)	68% (457)	<0.0001
Avoid touching index case		20% (31)	71% (479)	<0.0001
Stop sleeping with index case		29% (45)	66% (442)	<0.0001

[a] There was no difference between male care providers and female care providers in terms of their relationship with the index case.

[b] 12 of the 19 contacts who had sexual intercourse did so with index cases who had wet symptoms.

Table 3

Risk factors among care providers and non-care providers in Ebola virus household transmission study, Freetown, Sierra Leone, 2014–15

Risk factor	Level	Among care providers (n=156)			Among non care providers (n=682)		
		% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]	% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]
Gender (index case)	Female	23.1% (18/78)	0.76 (0.3, 1.9)	0.55	5.9% (19/325)	0.68 (0.3, 1.7)	0.40
	Male	24.4% (19/78)	ref		7.6% (27/357)	ref	
Age (index case)	<20 years	26.9% (7/26)	ref	0.76	9.5% (10/105)	ref	0.68
	20–39 years	19.2% (14/73)	0.66 (0.2, 2.1)		5.1% (16/312)	0.53 (0.2, 1.8)	
	40–59 years	23.3% (10/43)	0.89 (0.2, 3.2)		6.7% (13/195)	0.82 (0.2, 2.7)	
	60+ years	42.9% (7/26)	1.58 (0.3, 8.9)		10.0% (7/70)	1.12 (0.3, 4.8)	
District	Urban	24.8% (29/117)	1.43 (0.5, 4.3)	0.52	8.1% (37/457)	1.62 (0.5, 4.8)	0.39
	Rural	20.5% (8/39)	ref		4.0% (9/225)	ref	
Status of case at time of removal	Dead	40.6% (13/32)	3.24 (0.2, 9.1)	0.03	16.1% (15/93)	5.09 (1.8, 14.8)	0.003
	Alive	19.4% (24/124)	ref		5.3% (31/589)	ref	
Days in household with symptoms	1–2	22.2% (8/36)	1.02 (0.8, 1.2)	0.87	6.3% (10/158)	1.10 (0.9, 1.3)	0.27
	3–4	28.1% (18/64)			6.6% (20/304)		
	5–6	15.4% (6/39)			6.5% (10/153)		
	7	29.4% (5/17)			9.0% (6/67)		
Wet symptoms	Yes	22.6% (26/115)	0.82 (0.3, 2.2)	0.69	7.2% (27/376)	0.98 (0.4, 2.5)	0.96
	No	26.8% (11/41)	ref		6.2% (19/306)	ref	
Number of care providers	None	Not Applicable	1.06 (0.6, 1.8)	0.82	4.2% (14/331)	1.61 (1.1, 2.4)	0.01
	Single	21.2% (11/52)			7.3% (17/234)		
	Multiple	25.0% (26/104)			12.8% (15/117)		
Fever (index case)	Yes	19.2% (23/120)	2.1 (0.8, 5.5)	0.13	5.3% (26/490)	2.4 (0.9, 6.3)	0.07
	No	38.9% (14/36)	ref		10.4% (20/192)	ref	
Piped drinking water source	No	31.3% (25/80)	2.40 (0.9, 6.1)	0.06	8.5% (29/340)	1.63 (0.6, 4.2)	0.31
	Yes	15.8% (12/76)	ref		5.0% (17/342)	ref	
Case separated within house	No	26.3% (31/118)	1.62 (0.5, 4.9)	0.40	7.9% (33/416)	1.62 (0.6, 4.2)	0.32

Risk factor	Level	Among care providers (n=156)			Among non care providers (n=682)		
		% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]	% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]
	Yes	15.8% (6/38)	ref		4.9% (13/266)	ref	
Household size (≥6 contacts)	Yes	17.2% (10/58)	0.54 (0.2, 1.5)	0.23	4.4% (20/450)	0.37 (0.2, 0.9)	0.03
	No	27.6% (27/98)	ref		11.2% (26/232)	ref	
Gender (contact)	Female	23.6% (25/106)	0.81 (0.5, 1.4)	0.42	7.7% (28/365)	1.34 (0.8, 2.3)	0.28
	Male	24.0% (12/50)	ref		5.7% (18/317)	ref	
Age (contact)	7–19	13.2% (5/38)	ref	0.16	8.7% (34/392)	ref	0.41
	20–39	25.3 (20/79)	1.73 (0.8, 3.6)		4.0% (8/200)	0.67 (0.4, 1.2)	
	40+	30.8% (12/39)	2.11 (0.9, 5.0)		4.4% (4/90)	0.87 (0.4, 1.8)	
Relation to index case (contact)[b]	First degree relative	26.9% (32/119)	10.53 (0.5, 204.7)	0.11	9.7% (29/300)	1.54 (0.6, 3.7)	0.09
	Other relative	19.1% (4/21)	8.83 (0.4, 179.8)		3.9% (8/204)	0.70 (0.3, 2.0)	
	Unrelated	6.3% (1/16)	ref		5.1% (9/178)	ref	
Sleep in same room	Yes	27.6% (24/87)	1.56 (0.7, 3.4)	0.27	10.4% (14/135)	1.32 (0.6, 2.7)	0.46
	No	18.8% (13/69)	ref		5.9% (32/547)	ref	
Share blanket/bed	Yes	24.4% (22/90)	1.15 (0.6, 2.2)	0.67	7.9% (10/126)	1.07 (0.4, 2.6)	0.89
	No	22.7% (15/66)	ref		6.5% (36/556)	ref	
Share vehicle	Yes	19.3% (11/57)	0.77 (0.4, 1.5)	0.43	7.9% (3/38)	1.26 (0.4, 3.9)	0.69
	No	26.3% (26/99)	ref		6.7% (43/643)	ref	
Share toilet	Yes	25.8% (34/132)	1.93 (0.8, 4.8)	0.16	7.1% (28/397)	1.00 (0.5, 1.9)	0.99
	No	12.5% (3/24)	ref		6.5% (18/278)	ref	
Share meals	Yes	25.0% (21/84)	1.51 (0.7, 3.5)	0.33	7.6% (10/131)	1.00 (0.4, 2.6)	1.00
	No	20.0% (14/70)	ref		6.5% (36/551)	ref	
Bed linens (touch or wash)	Yes	24.5% (25/102)	1.17 (0.6, 2.3)	0.65	9.3% (8/86)	1.47 (0.7, 2.9)	0.28
	No	22.2% (12/54)	ref		6.4% (38/591)	ref	
Wash clothes	Yes	29.3% (22/75)	1.53 (0.9, 2.7)	0.11	5.0% (2/40)	0.75 (0.2, 2.5)	0.64
	No	18.5% (15/81)	ref		6.9% (44/634)	ref	
Wear clothes	Yes	31.6% (6/19)	1.71 (0.7, 4.5)	0.27	16.7% (1/6)	1.28 (0.1, 12.3)	0.83
	No	22.8% (31/136)	ref		6.8% (45/662)	ref	

Risk factor	Level	Among care providers (n=156)			Among non care providers (n=682)		
		% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]	% of household contacts EVD-positive	OR (95% CI)[a]	P-value[a]
Contact with body fluids	Yes	25.6% (21/82)	1.40 (0.6, 3.1)	0.41	10.0% (3/30)	1.77 (0.4, 7.3)	0.41
	No	19.7% (14/71)	ref		6.5% (42/647)	ref	
Physical contact	Yes	25.0% (34/136)	1.61 (0.6, 4.1)	0.33	10.5% (16/153)	1.45 (0.8, 2.8)	0.28
	No	15.0% (3/20)	ref		5.7% (30/528)	ref	
Avoid index case[c]	Yes	12.1% (8/66)	0.32 (0.2, 0.7)	0.004	6.4% (35/547)	0.85 (0.4, 1.8)	0.67
	No	32.2% (29/90)	ref		8.2% (11/135)	ref	

EVD, Ebola virus disease; CI, confidence interval; OR, odds ratio.

[a] Odds ratio and P-values are calculated from a statistical model accounting for household clustering (generalized estimating equations); OR may not be the same as the crude OR.

[b] Includes parent, children, siblings and spouse.

[c] Avoidance behaviours were highly collinear and were combined into one variable (AVOID INDEX CASE) for consideration in multivariable models.

Table 4

Multivariate model for risk factors for secondary Ebola virus disease among care providers and non-care providers, Freetown, Sierra Leone, 2014–2015

Risk factor	Level of risk factor	OR (95% CI)	P-value
Care providers			
Index case with fever	No vs yes	4.5 (1.5, 13.7)	0.01[a]
Piped drinking water	No vs yes	2.98 (1.11, 8.01)	0.03[a]
Avoid index case	Yes vs no	0.18 (0.06, 0.50)	0.001[a]
Care provider age <20 years	Yes vs no	0.37 (0.14, 0.98)	0.045[a]
Non-care providers			
Index case dead in house	Yes vs no	4.33 (1.7, 11.0)	0.002
Household 6 people	Yes vs no	0.32 (0.1, 0.8)	0.01
Number of care providers in the household		1.86 (1.2, 2.8)	0.03

EVD, Ebola virus disease; CI, confidence interval; OR, odds ratio.

[a] After selection of these four factors; the closest competing risk factors were being a relative of the index case (P=0.06) and the index case dying while still in the household (P=0.07).