

Ebola Virus Disease and Pregnancy: A Retrospective Cohort Study of Patients Managed at 5 Ebola Treatment Units in West Africa

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Background. Reliable data are lacking on pregnancy outcomes during Ebola virus disease (EVD) epidemics. We aimed to characterize symptoms and outcomes among pregnant women admitted to Ebola treatment units (ETUs) with suspected and confirmed EVD to better inform obstetric management.

Methods. We analyzed a retrospective cohort of reproductive-aged women presenting to 5 West African ETUs from September 2014 to September 2015. We compared clinical symptoms, risk of EVD diagnosis, and mortality between pregnant and nonpregnant women.

Results. Of 729 reproductive-aged women admitted to study ETUs, 44 (6%) reported pregnancy. Thirteen of 44 pregnant women (30%) tested EVD positive; 6 of 13 (46%) died. Pregnant women were less likely than nonpregnant women to report anorexia, asthenia, diarrhea, fever, myalgias/artralgias, nausea, or vomiting ($P < .05$) at admission. Pregnant women with suspected EVD had the same risk, however, of laboratory-confirmed EVD (30% vs 24%, $P = .38$). While pregnant women with confirmed EVD had similar Ebola viral loads on presentation to nonpregnant women, as measured by initial cycle threshold (26.4 vs 23.2, $P = .16$), they were less likely to have myalgias/artralgias ($P < .001$) and vomiting ($P = .02$). Both all-cause mortality (14% vs 19%, $P = .39$) and EVD-specific mortality (46% vs 54%, $P = .60$) were not significantly different between pregnant and nonpregnant women. Two neonates born live in the ETU died within 8 days.

Conclusions. We find no evidence to support a difference in the risk of death between pregnant women with suspected or confirmed EVD compared to nonpregnant women. Limited data suggest poor fetal and neonatal outcomes in EVD-affected pregnancies.

Keywords. Ebola virus disease; pregnant; Liberia; Sierra Leone; maternal mortality.

From 2014–2016, West Africa faced the largest recorded Ebola virus disease (EVD) epidemic in history, with 28 616 suspected and confirmed EVD cases and at least 11 310 fatalities [1]. Historically, pregnant women with EVD were thought to be at increased risk of severe illness and death due to altered immune function and placental infection [2, 3]. To date, a total of 111 cases of pregnant patients with concern for EVD have been reported [2–12], with an aggregate maternal mortality rate of 86%. The majority of these cases come from the first recognized Ebola outbreak in Zaire in 1976, where

data retrospectively collected primarily from family member interviews suggested 82 pregnant women had probable EVD, among whom 73 (89%) died. This was similar to the overall outbreak mortality of 88%, though most patients included in this analysis never had definitive testing for EVD. In addition, almost all cases in the 1976 Zaire outbreak had received injections in the setting of poor infection control at a single hospital or one of its prenatal or outpatient clinics or had close contact with a case that did; there were no survivors among all of those with parenteral injection as their mode of contact [2, 3].

In contrast, the limited outcomes data published to date from the 2014–2016 West Africa outbreak suggest that EVD mortality in pregnancy may be lower than previously reported, with only 5 EVD-infected pregnant women dying of 12 reported cases [4–12]. To date, fetal outcomes have been reported for 59 confirmed or suspected EVD cases in pregnancy, which resulted in 47 (80%) stillbirths or miscarriages and 12 (20%) live births, all of whom died within 19 days of life [2–12]. Suspected fatal EVD cases in prior outbreaks were less often laboratory confirmed, potentially biasing mortality estimates.

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Obstetric care providers face considerable challenges and ethical dilemmas managing pregnancy during EVD epidemics, exacerbated by overwhelmed health systems [13] and a scarcity of data on EVD in pregnancy. During an outbreak, pregnant women with vaginal bleeding or other symptoms may be classified as suspected for EVD based on clinical case definitions, even though other etiologies such as placenta previa, placental abruption, or even normal labor may be more likely etiologies of their symptoms. As a result, many EVD-negative pregnant women are evaluated and treated in Ebola treatment units (ETUs), placing them at risk for nosocomial EVD [14]. Once admitted to the ETU, obstetric care guidelines often recommend that healthcare workers do not intervene during delivery to avoid exposure to Ebola-infected body fluids, based on limited historical data suggesting poor maternal and fetal survival [15]. More data are needed on presenting signs and symptoms of EVD in pregnancy, and how EVD outcomes compare to nonpregnant patients, to better inform management principles. Though devastating, the 2014–2016 Ebola outbreak did provide a rare opportunity to learn about EVD and improve the evidence base for guidelines, particularly in subpopulations such as pregnant women. Here, we aim to better characterize symptoms and outcomes among pregnant women and nonpregnant reproductive-aged women admitted to ETUs with suspected EVD to better inform outbreak triage and management strategies.

METHODS

Study Design and Ethical Review

This retrospective cohort includes patient data collected at 5 ETUs operated by International Medical Corps in Liberia and Sierra Leone between 15 September 2014 and 15 September 2015 as part of its comprehensive response to the EVD epidemic [16]. Ethical approval for this study and informed consent exemption was provided by Sierra Leone Ethics and Scientific Review Committee and the institutional review boards of the University of Liberia–Pacific Institute for Research and Evaluation, Lifespan (Rhode Island Hospital), and Partners Healthcare.

Participants and Setting

All women of reproductive age admitted to ETUs run by International Medical Corps between 15 September 2014 and 15 September 2015 were included for analysis. On arrival to the ETU, all patients were triaged by trained clinical staff, who evaluated each patient to be admitted for either a positive EVD test prior to arrival or classification as a suspected case based on national and World Health Organization EVD clinical case definition (Supplementary Appendix). Patients not meeting the case definition were referred to other healthcare facilities. Pregnancy was defined by patient self-report or documentation of positive urine pregnancy test in the patient's chart. All female patients were asked routinely about pregnancy status at

admission to ETUs in Sierra Leone, but this information was collected in Liberia based on provider discretion. Gestational age (GA) was calculated using patient report of last normal menstrual period.

Laboratory Testing

All patients admitted to the ETU were tested within 24 hours for Ebola virus using quantitative Ebola Zaire real-time reverse-transcription polymerase chain reaction (RT-PCR) of blood samples. Patients initially testing negative remained at the ETU and were retested 48 hours later, due to poor sensitivity of RT-PCR early in the disease course. A cycle threshold (Ct) value >40 was considered negative for Ebola virus according to laboratory protocols described in detail elsewhere [16].

Clinical Management

Protocol-based treatment was standardized at all 5 ETUs and included empiric antimalarial therapy, broad-spectrum antibiotics, oral rehydration solution (ORS), gastrointestinal prophylaxis, and nutritional supplementation. Treatment for fever, pain, nausea, and delirium was given as needed. Patients with moderate to severe dehydration or inability to hydrate with ORS received bolus or maintenance intravenous crystalloid fluids (Supplementary Appendix).

Data Collection

Patient demographics including age, sex, and country were collected on admission and whether the patient had contact with anyone ill. Temperature was recorded as febrile (>38.0°C) or afebrile (≤38.0°C). Clinical variables of interest included day of symptom onset, and symptoms on presentation included abdominal pain, anorexia, asthenia, bleeding, diarrhea, dyspnea, fever, headache, hiccups, jaundice, myalgias/arthralgias, nausea, throat pain, and vomiting. Clinical data were recorded at triage and at least daily from admission to discharge. Outcome variables collected included results of confirmatory EVD testing, length of stay, and vital status on discharge.

All data were collected on standardized paper forms by trained clinical staff for routine care and epidemiologic surveillance. Data from each ETU were entered into a separate electronic database by local data officers and later aggregated for all ETUs. Full details on methods for data collection and aggregation have been published elsewhere [16].

Data Analysis

Analysis was limited to women of reproductive age (15–49 years), with vital status data on ETU discharge being our primary outcome of interest. Vital status was defined as death, discharged alive after repeat-negative EVD testing, or transferred for further management. Results of confirmatory EVD testing and ETU length of stay were secondary outcomes of interest. Descriptive statistics were used to characterize the cohort. Comparisons between baseline characteristics and

outcomes were made between pregnant and nonpregnant reproductive-aged women, with a secondary analysis restricted to patients with confirmed EVD. The χ^2 or Fisher exact test was used to compare categorical variables; *t* test was used for continuous normal variables; and Wilcoxon rank-sum test was used for nonparametric variables. Logistic regression analysis was performed to determine the independent association of pregnancy status and each outcome, controlling for potential confounders including age and country of origin. For all analyses, $P < .05$ was considered statistically significant. Analyses were conducted in R version 3.2.1 and Stata 12 software (StataCorp, College Station, Texas).

RESULTS

Among 2351 admitted patients with outcome data, 729 reproductive-aged women were included in this analysis (Figure 1). Forty-four women were pregnant, with a median gestational age (GA) of 26 weeks (interquartile range [IQR], 13–30 weeks). Thirteen of 44 (30%) pregnant women tested EVD positive.

Baseline Characteristics and Outcomes

Of 729 reproductive-aged women, median age was 30 years (IQR, 23–38 years). Approximately 67% were from Sierra Leone, with the remainder from Liberia. Overall, 175 of 729

(24%) had laboratory-confirmed EVD, and 135 of 729 (19%) died prior to ETU discharge. Mortality was significantly higher in women with laboratory-confirmed EVD (93/175 [53%]) compared with EVD-negative women (42/553 [8%]) ($P < .001$).

Baseline characteristics on arrival to the ETU and final outcomes by pregnancy status among all women of reproductive age are displayed in (Table 1). Pregnant women were younger than nonpregnant women and less likely to have fever, myalgias/arthralgias, nausea, vomiting, diarrhea, anorexia, and asthenia on arrival to the ETU. There were no significant differences in likelihood of EVD diagnosis (30% vs 24%, $P = .38$), ETU length of stay (3 days vs 3 days, $P = .86$), or all-cause mortality (14% vs 19%, $P = .39$) between pregnant and nonpregnant women (Table 1). After controlling for age and country of origin, there were no significant differences in odds of EVD diagnosis (odds ratio [OR], 1.6; 95% confidence interval [CI], .8–3.1) or all-cause mortality (OR, 0.8; 95% CI, .3–1.9) by pregnancy status. In an analysis restricted to EVD-negative women, similar findings were observed (Table 2).

Thirteen of 175 (7%) reproductive-aged women with confirmed EVD were pregnant. Baseline characteristics and outcomes among EVD-positive women of reproductive age are presented in (Table 3) by pregnancy status. Pregnant women with EVD were younger than nonpregnant women with EVD,

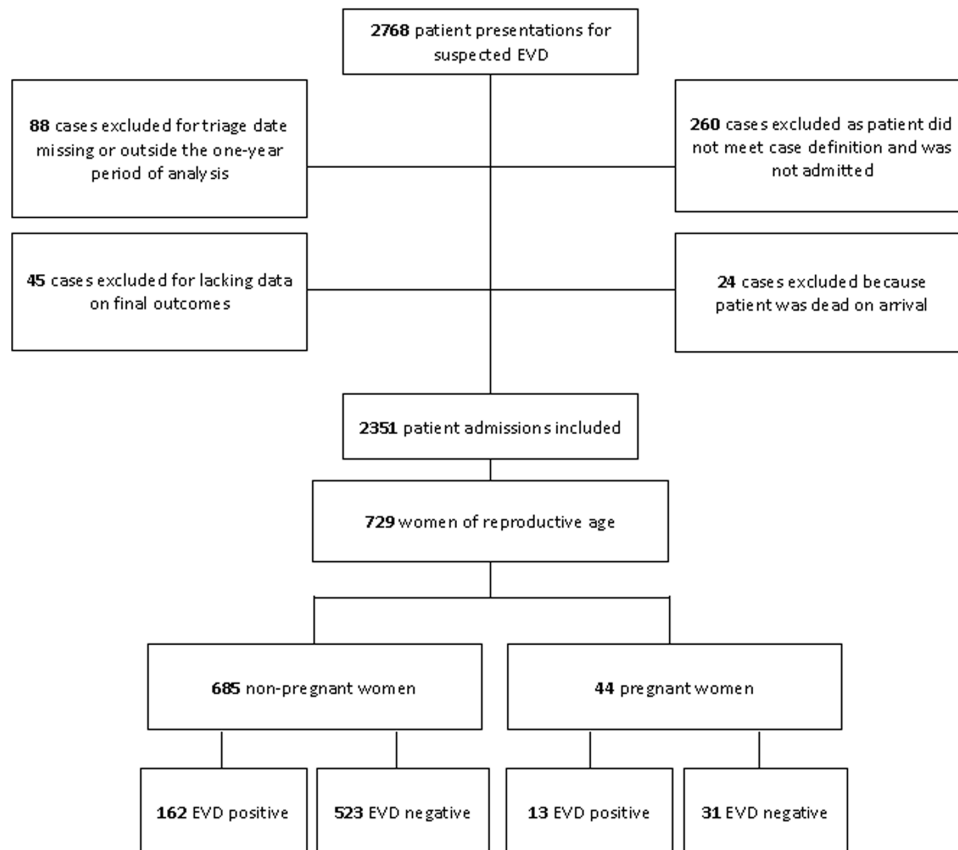


Figure 1. Study flow diagram. Abbreviation: EVD, Ebola virus disease.

Table 1. Comparison of Baseline Data and Final Outcomes for All Nonpregnant and Pregnant Women Admitted to Study Ebola Treatment Units Between 15 September 2014 and 15 September 2015

Characteristic	Not Pregnant	Pregnant	PValue ^a
All patients	94 (685)	6 (44)	...
Demographic characteristics			
Age, y, median (IQR)	30 (23–40)	25 (20–31)	.00
Country01
Liberia	37 (252)	18 (8)	...
Sierra Leone	63 (433)	82 (36)	...
Clinical symptoms at triage			
Days of symptoms, median (IQR)	3 (2–6)	2 (1–5)	.28
Abdominal pain	55 (375)	64 (28)	.25
Anorexia	67 (462)	45 (20)	.00
Asthenia	74 (508)	59 (26)	.03
Bleeding	11 (73)	18 (8)	.12
Diarrhea	40 (256)	15 (6)	.00
Dyspnea	35 (238)	23 (10)	.10
Fever	78 (535)	57 (25)	.00
Headache	64 (435)	50 (22)	.07
Hiccups	11 (75)	9 (4)	.70
Jaundice	5 (37)	2 (1)	.37
Myalgias or arthralgias	62 (424)	34 (15)	.00
Nausea	43 (185)	22 (8)	.02
Throat pain	27 (183)	14 (6)	.06
Vomiting	46 (313)	23 (10)	.00
Epidemiological characteristics			
Contact with someone ill	32 (196)	37 (16)	.44
Laboratory			
EVD positive	24 (162)	30 (13)	.38
Outcome			
Length of stay, d, median (IQR)	3 (2–4)	3 (2–3)	.86
Mortality	19 (129)	14 (6)	.39

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: EVD, Ebola virus disease; IQR, interquartile range.

^aBased on χ^2 test or *t* test as appropriate.

and were significantly less likely to present with myalgias/arthralgias and vomiting on arrival to the ETU. Pregnant women with EVD had similar initial Ct values to nonpregnant women (26 vs 23, $P = .17$), similar length of stay (10 vs 7 days, $P = .69$) and overall mortality (46% vs 54%, $P = .60$) (Table 3). After controlling for age and country of origin in a multivariable logistic regression model predicting mortality among EVD-positive women, pregnancy was not associated with increased odds of death (adjusted OR, 0.9; 95% CI, .3–3.0).

Clinical Course of EVD in Pregnancy

Of pregnant women with laboratory-confirmed EVD, 6 of 13 (46%) died, 6 of 13 (46%) survived to discharge, and 1 of 13 (8%) was transferred to an ETU specializing in pregnancy care and survived to discharge. Pregnant patients with EVD were significantly more likely to have recent contact with someone ill (67% vs 26%, $P = .03$), longer length of stay (10 days vs 3 days,

Table 2. Comparison of Baseline Data and Final Outcomes for Ebola Virus Disease (EVD)-Negative Nonpregnant Women and EVD-Negative Pregnant Women Admitted to Study Ebola Treatment Units Between 15 September 2014 and 15 September 2015

Characteristic	EVD Negative, Not Pregnant	EVD Negative, Pregnant	PValue ^a
All patients	94 (523)	6 (31)	...
Demographic characteristics			
Age, y, median (IQR)	30 (23–38)	25 (20–28)	.01
Country02
Liberia	36 (188)	16 (5)	...
Sierra Leone	64 (335)	84 (26)	...
Clinical symptoms at triage			
Days of symptoms, median (IQR)	3 (1–6)	3 (2–6)	.22
Abdominal pain	56 (293)	68 (21)	.20
Anorexia	68 (353)	42 (13)	.00
Asthenia	74 (386)	52 (16)	.01
Bleeding	11 (60)	19 (6)	.19
Diarrhea	34 (167)	10 (3)	.01
Dyspnea	37 (193)	23 (7)	.11
Fever	80 (416)	55 (17)	.00
Headache	63 (331)	48 (15)	.10
Hiccups	10 (54)	6 (2)	.49
Jaundice	7 (34)	0 (0)	.14
Myalgias or arthralgias	60 (314)	39 (12)	.02
Nausea	43 (143)	23 (6)	.05
Throat pain	27 (141)	16 (5)	.18
Vomiting	44 (228)	26 (8)	.05
Epidemiological characteristics			
Contact with someone ill	18 (84)	26 (8)	.25
Outcome			
Length of stay, d, median (IQR)	3 (3–3)	3 (2–3)	.98
Mortality	8 (42)	0 (0)	.10

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: EVD, Ebola virus disease; IQR, interquartile range.

^aBased on Fisher exact and Wilcoxon rank-sum tests.

$P = .02$), and higher mortality than pregnant patients without EVD (46% vs 0%, $P < .01$).

Figure 2 displays the proportion of clinical signs and symptoms reported during the entire ETU admission course among pregnant ($n = 13$) and nonpregnant ($n = 154$) reproductive-aged EVD-positive patients. The most common symptoms among pregnant EVD positive patients were abdominal pain (85%) and nausea/vomiting (69%). Hiccups (8%) and nonhemorrhagic rash (8%) were the least frequent symptoms.

Pregnancy Outcomes

Pregnancy outcomes of women with EVD are presented in (Table 4). Two of 13 patients (15%) had preterm vaginal deliveries of live neonates in the ETU. One neonate born at 25 weeks GA (by last menstrual period and bedside ultrasound dating at 24 weeks) died on ETU day 2 with maternal survival. The second born at 35 weeks GA was EVD-negative on ETU day 1 but tested EVD-positive on ETU day 5 and

Table 3. Comparison of Baseline Data and Final Outcomes for Ebola Virus Disease (EVD)-Positive Nonpregnant and EVD-Positive Pregnant Women Admitted to Study Ebola Treatment Units Between 15 September 2014 and 15 September 2015

Characteristic	EVD Positive, Not Pregnant	EVD Positive, Pregnant	PValue ^a
All patients	93 (162)	7 (13)	...
Demographic characteristics			
Age, y, median (IQR)	33 (24–42)	24 (20–32)	.02
Country24
Liberia	40 (64)	23 (3)	...
Sierra Leone	60 (98)	77 (10)	...
Clinical symptoms at triage			
Days of symptoms, median (IQR)	3 (2–6)	3 (2–3)	.36
Abdominal pain	51 (82)	54 (7)	.82
Anorexia	67 (109)	54 (7)	.37
Asthenia	75 (122)	77 (10)	1.00
Bleeding	8 (13)	15 (2)	.31
Diarrhea	57 (89)	27 (3)	.06
Dyspnea	28 (45)	23 (3)	1.00
Fever	73 (119)	62 (8)	.35
Headache	64 (104)	54 (7)	.55
Hiccups	13 (21)	15 (2)	.68
Jaundice	2 (3)	8 (1)	.27
Myalgias or arthralgias	68 (110)	23 (3)	.00
Nausea	43 (42)	20 (2)	.20
Throat pain	26 (42)	8 (1)	.19
Vomiting	52 (85)	15 (2)	.02
Epidemiological characteristics			
Contact with someone ill	79 (112)	67 (8)	.33
Laboratory			
Initial Ct value, median (IQR)	23 (20–27)	26 (19–35)	.17
Outcome			
Length of stay, d, median (IQR)	7 (4–14)	10 (2–17)	.69
Mortality	54 (87)	46 (6)	.60

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: Ct, cycle threshold; EVD, Ebola virus disease; IQR, interquartile range.

^aBased on Fisher exact and Wilcoxon rank-sum tests as appropriate.

died on ETU day 9; this case also resulted in maternal death. No disease-specific signs were noted in these neonates. Two other pregnant EVD-positive patients (2/13 [15%]) had spontaneous abortions in the ETU and subsequent maternal death. Three additional patients (3/13 [23%]) died in the ETU while pregnant. One patient (1/13 [8%]) initially had normal fetal activity, followed by ultrasound-documented fetal demise after repeat maternal blood testing became negative for EVD. Induction and delivery of a stillborn fetus was completed prior to ETU discharge. One patient (1/13 [8%]) had a termination of pregnancy after recovery from EVD. Four patients (4/13 [31%]) recovered from EVD and were discharged pregnant; their pregnancy outcomes are unknown. Of note, there were no deaths among EVD-negative pregnant women (Table 2).

DISCUSSION

Our study is among the largest reports to date of pregnancy outcomes during the 2014–2016 West Africa EVD outbreak. Mortality among pregnant women with EVD was lower in our study (46%) compared to prior epidemics (86%) [2, 3]. In addition, we found no evidence of higher mortality in EVD-positive pregnant women compared with EVD-positive nonpregnant women of reproductive age, and no evidence of more severe disease, as measured by initial Ct value. Despite prior data suggesting high mortality in pregnant patients with EVD, our data do not support the idea that pregnant women are at higher risk for death compared with nonpregnant patients with EVD [17, 18].

Large outcome studies from the 2014–2016 West African EVD outbreak have reported overall case fatality ratios of 37%–75% [19–23], also lower than in prior epidemics [1, 19]. Despite small sample sizes, reports from the recent epidemic suggest that EVD mortality rates in pregnancy may be lower than previously reported, with 5 deaths of 12 (42%) women with known outcomes, similar to our finding of 46% mortality. Lower mortality overall during the 2014–2016 West Africa EVD outbreak may reflect improvements in EVD care compared with historical outbreaks, improved detection of less severe cases, or changes in the virulence of the disease.

With only 24% of women admitted to ETUs in our study testing positive for EVD, our findings suggest that most women screened for EVD in an ETU may have an alternative diagnosis. EVD was the diagnosis for a minority (30%) of symptomatic pregnant patients admitted, and the low probability of eventual EVD diagnosis should be considered when making decisions about life-saving invasive treatment while awaiting results of EVD testing [24]. Although no EVD-negative pregnant patients died in our cohort, it is important to acknowledge that ETU admission comes with the risk of nosocomial infection with EVD. In addition, pregnant women admitted to ETUs often lack access to surgical and neonatal care that could be life-saving. Thus, the decision of whether to admit a pregnant woman suspected of EVD to an ETU or triage her elsewhere is critical. Preliminary studies suggest that rapid point-of-care testing could help serve as a screening test for EVD in future epidemics, improving management decisions for pregnant patients [25–27]. Supplemental clinical criteria may also be required to more effectively screen for EVD among pregnant women.

Currently, supportive care is the mainstay of Ebola management until effective Ebola-specific vaccines and therapeutics are available [11], and expectant management of labor seems to be an appropriate strategy [15, 17]. Obstetric interventions such as fetal monitoring, assisted delivery, episiotomy, cesarean delivery, induction of labor, or pregnancy interruption were considered in the 2014–2016 West Africa EVD outbreak on a case-by-case basis [28]. Though the decision to intervene must be individualized and based on the physiological state of the

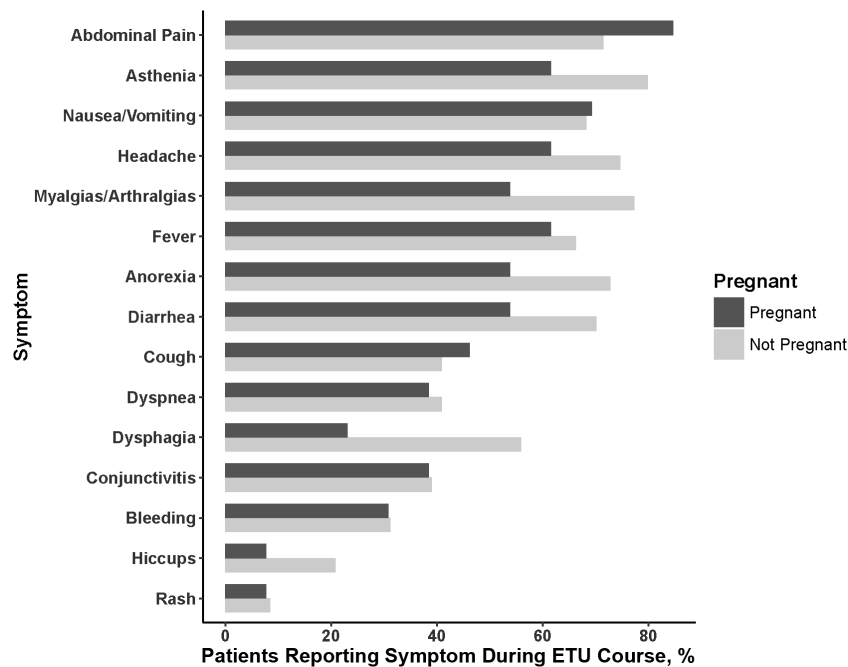


Figure 2. Proportion of patients reporting symptoms at any time during the course of their illness among Ebola virus disease (EVD)-positive pregnant and EVD-positive nonpregnant women admitted to study Ebola treatment units (ETUs) between 15 September 2014 and 15 September 2015.

mother, GA of the fetus, available resources, trained personnel, and protective equipment, more aggressive interventions should not be withheld based on the assumption that maternal

outcomes are generally poor. Fetal outcomes to date are, however, universally poor and should be considered in maternal management plans [2–12].

Table 4. Pregnancy-Related Outcomes for Ebola Virus Disease–Positive Pregnant Women Admitted to Study Ebola Treatment Units Between 15 September 2014 and 15 September 2015

Outcome	Gestational Age, Weeks	Maternal Outcome	Fetal Outcome
Live birth			
Case 1	25	Discharged on ETU day 15	Death on ETU day 2 ^a
Case 2	35	Death on ETU day 3	Death on ETU day 9 ^a
Spontaneous abortion			
Case 1	13	Death on ETU day 10	SAB on ETU day 3 ^b
Case 2	14	Death on ETU day 2	SAB on ETU day 1 ^b
Termination of pregnancy			
Case 1	4	Discharged on ETU day 21 ^c	TOP on ETU day 21 ^b
Fetal demise and induced delivery			
Case 1	30	Discharged on ETU day 32	FDID
Maternal death while pregnant			
Case 1	28	Death on ETU day 6	...
Case 2	30	Death on ETU day 1	...
Case 3	35	Death on ETU day 1	...
Unknown			
Case 1	13	Discharged on ETU day 18	NA
Case 2	NA	Discharged on ETU day 12	NA
Case 3	NA	Discharged on ETU day 11	NA
Case 4	NA	Discharged on ETU day 27	NA

Abbreviations: ETU, Ebola treatment unit; FDID, fetal demise and induced delivery; NA = not available; SAB, spontaneous abortion; TOP, termination of pregnancy.

^aIndicates ETU day of the baby.

^bIndicates ETU day of the mother.

^cPatient was transferred to outside facility on ETU day 18 and discharged 3 days later.

In addition to careful deliberation about obstetric intervention, appropriate anticipatory guidance should be provided to all pregnant women with EVD. Toward this end, urine pregnancy testing should be considered as part of routine ETU testing in order to appropriately counsel pregnant women with EVD on potential pregnancy complications and management options. Those with EVD in pregnancy near to term should be managed in an ETU through delivery to ensure appropriate birth precautions are taken. If an EVD survivor is discharged while pregnant, referral should be made to specialized centers to develop plans for labor, delivery, and access to emergency obstetric and newborn care, as Ebola virus persistence has been documented in amniotic fluid, cord blood, and placental samples in cases of negative RT-PCR testing for Ebola virus in maternal blood [7, 11]. As this presents the risk for infection to family or the community in the case of a home delivery, contact should be maintained between these women and their local EVD management teams. Women should be educated in anticipation of a potential precipitous delivery outside an ETU, and provided with an appropriate clean delivery kit, barrier protection, and decontamination supplies to protect delivery attendants and household members. We report on one of the largest cohorts of pregnant patients managed in an ETU setting to date, but the small overall number of cases still limits the power of our study to detect significant differences between pregnant and nonpregnant patients. However, our results were robust when controlling for age and country of origin in multivariable logistic regression analysis, with no increased odds of all-cause or EVD mortality associated with pregnancy. In addition, we report that initial Ct values were similar between pregnant and nonpregnant EVD-positive patients, an important marker of illness severity.

The results we present here are based on data collected for clinical and epidemiological purposes by clinicians in extremely difficult conditions with limited resources [16]. Another limitation is that pregnancy status and gestational age were often based on patient self-report, as urine pregnancy testing or confirmatory ultrasound were not routinely available in all ETUs. In Sierra Leone, female patients were routinely asked about pregnancy status at admission, whereas in Liberia it was provider-dependent. This difference in practice likely contributes to the higher pregnancy rates documented in Sierra Leone, and may have led patients with early pregnancies to be misclassified as nonpregnant, particularly in Liberia. This limitation of pregnancy self-reporting is, however, common to prior reports of EVD in pregnancy. In addition, EVD outcomes are likely worse in late pregnancy due to physiologic changes. Potential misclassification of early pregnancy as nonpregnant EVD cases is unlikely to significantly impact results. Similarly, lack of diagnostic testing to detect important comorbidities, such as HIV status, diabetes, maternal hypertension, and other medical conditions, limits inferences about the relative importance of these contributors to survival in both pregnant and nonpregnant

patients [4, 8, 11, 12]. The ability to implement rapid testing for EVD, pregnancy, and other comorbidities would greatly aid in triage and management decisions in this population. We have no follow-up data for patients after ETU discharge. Though all EVD patients must have negative EVD testing and be clinically recovered prior to ETU discharge, post-ETU complications cannot be excluded. Last, the fetal outcomes for the 4 pregnant EVD survivors discharged from the ETUs are unknown.

CONCLUSIONS

We found no direct or indirect evidence to support an increased risk of death from EVD in pregnant women, compared with nonpregnant reproductive-aged women. Fetal survival was poor, however, based on the limited outcome data available. Based on our report of higher overall survival rates in pregnant EVD patients as compared with historical data from prior outbreaks, corroboration with other outcomes data is warranted to guide optimal management strategies in future epidemics.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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