# Supplementary Information

## Human movement and transmission dynamics early in Ebola outbreaks

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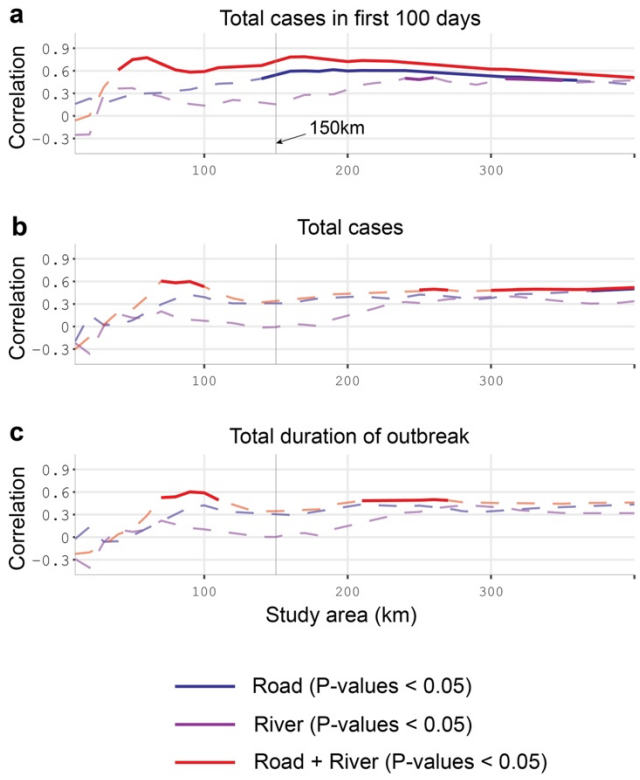


**Figure S1**. Sensitivity analysis of study area for correlations between transportation networks and outbreak measures: (A) cases in first 100 days, (B) total cases, and (C) total duration of outbreak. Dashed lines show p-values > 0.05; solid lines show p-values < 0.05; colors indicate transportation network.

| Spillover location | Net change in road length (km) |
|---|---|
| Yambuku | + 362.99 |
| Tandala | + 105.67 |
| Mekouka | + 9.48 |
| Kikwit | + 184.77 |
| Mayibout | + 0.77 |
| Booue | + 52.49 |
| Mekambo/Mbomo | + 57.48 |
| Mbomo1 | + 13.78 |
| Mbomo2 | + 0.93 |
| Etoumbi | + 14.42 |
| Luebo07 | + 24.31 |
| Luebo08 | + 15.59 |
| Inkanamango | - 5.25 |
| Likati | - 37.86 |
| Bikoro | + 162.38 |
| North Kivu | - 119.55 |
| Mbandaka | + 13.83 |

**Table S1.** Net change in road length from 1963 to 2019 in the 150 km x 150 km study area surrounding the 17 spillover events that occurred in Central Africa. (+) Gain of road length, (-) loss of road length.

| | Outbreak measure | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cases in first 100 days** | | | | **Total cases** | | | | **Total duration (in days)** | | | |
| Study area | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section |
| 50 x 50 | 0.1365 | 0.0827 | 0.5580$^{***S4A}$ | 0.5589$^{***}$ | 0.0137 | 0.0070 | 0.0519 | 0.0071 | 0.0050 | 0.0005 | 0.0114 | 0.0040 |
| 100 x 100 | 0.0201 | 0.1565 | 0.3540$^{**S4B}$ | 0.3940$^{**}$ | 0.0065 | 0.1529 | 0.2812$^{*}$ | 0.1367 | 0.0110 | 0.1780 | 0.3470$^{*S2}$ | 0.1143 |
| 150 x 150 | 0.0259 | **0.3012**$^{*}$ | **0.5377**$^{***}$ | 0.4330$^{**S3}$ | 0.0000 | 0.0939 | 0.1146 | 0.0219 | 0.0000 | 0.0900 | 0.1150 | 0.0178 |
| 200 x 200 | 0.1276 | 0.3558$^{**}$ | 0.5250$^{***S4C}$ | 0.4910$^{**}$ | 0.0200 | 0.1531 | 0.1906 | 0.0735 | 0.0227 | 0.1717 | 0.2143 | 0.1091 |
| 300 x 300 | 0.2168 | 0.2694$^{*}$ | 0.3890$^{**S4D}$ | 0.4306$^{**}$ | 0.1626 | 0.1441 | 0.2311$^{*}$ | 0.1494 | 0.1700 | 0.1184 | 0.2061 | 0.1970 |

**Table S2.** R-squared values for the transportation networks including total river length, total road length, total combined road and river length, and total intersections against outbreak measures: cases in first 100 days, total cases, and total duration in days for each study area examined (*p < 0.05, **p<0.01, ***p<0.001). All spillover events included. Upper case superscripts refer to figures that illustrate each relationship. Bold values correspond to Fig. 3A and Fig. 3B of the main paper, which illustrate these relationships.

| | Outbreak measure | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cases in first 100 days** | | | | **Total cases** | | | | **Total duration (in days)** | | | |
| Study area | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section |
| 50 x 50 | 0.1170 | 0.0738 | 0.5580$^{***}$ | **0.6020**$^{***}$ | **0.0370** | **0.0119** | **0.1352** | **0.2620**$^{*}$ | **0.1190** | 0.0003 | **0.1630** | **0.1804** |
| 100 x 100 | 0.0123 | 0.100 | 0.2710$^{*}$ | 0.3160$^{*}$ | **0.0182** | 0.0223 | 0.0010 | 0.0333 | **0.1130** | 0.0114 | 0.2670$^{*}$ | **0.1800** |
| 150 x 150 | **0.0267** | 0.2450 | 0.4790$^{**}$ | 0.4280$^{**}$ | **0.0690** | **0.1236** | 0.0411 | **0.0855** | **0.0915** | 0.0538 | **0.2460** | **0.1804** |
| 200 x 200 | 0.1030 | 0.2890$^{*}$ | 0.4560$^{**}$ | 0.4590$^{**}$ | 0.0002 | **0.2890**$^{*}$ | **0.2880**$^{*}$ | **0.2330** | **0.2110** | 0.1060 | **0.2790**$^{*}$ | **0.2060** |
| 300 x 300 | 0.130 | 0.1970 | 0.2950$^{*}$ | 0.3740$^{*}$ | 0.0364 | **0.2130** | **0.2420** | **0.2740**$^{*}$ | **0.5710**$^{***}$ | 0.0245 | 0.1960 | 0.1850 |

**Table S3.** R-squared values for the transportation networks including total river length, total road length, total combined road and river length, and total intersections against outbreak measures: cases in first 100 days, total cases, and total duration in days for each study area examined (*p < 0.05, **p<0.01, ***p<0.001). Outlier events

excluded. The outlier events are as follows: Meliandou Guinea in 2013 and North Kivu DRC in 2019. Upper case superscripts refer to figures that illustrate each relationship. Bold values are greater than when all spillover events are included.

| | Outbreak measure | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cases in first 100 days** | | | | **Total cases** | | | | **Total duration (in days)** | | | |
| Study area | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section |
| 50 x 50 | **0.1780** | **0.1340** | **0.6140**$^{***}$ | **0.6110**$^{***}$ | **0.0180** | **0.0090** | **0.0520** | **0.0073** | **0.0070** | 0.0004 | 0.0110 | **0.0043** |
| 100 x 100 | **0.0613** | 0.1560 | **0.3800**$^{*}$ | 0.3720$^{*}$ | **0.0202** | **0.1620** | **0.2910**$^{*}$ | 0.1250 | **0.0452** | 0.1760 | **0.3770**$^{*}$ | 0.0916 |
| 150 x 150 | **0.0831** | **0.3160**$^{*}$ | **0.5910**$^{**}$ | 0.4300$^{*}$ | **0.0020** | 0.0920 | **0.1180** | 0.0162 | **0.0111** | 0.0760 | **0.1260** | 0.0085 |
| 200 x 200 | **0.2030** | 0.3540$^{*}$ | 0.5200$^{**}$ | 0.4650$^{**}$ | **0.0340** | 0.1490 | 0.1820 | 0.0600 | **0.0482** | 0.1470 | 0.1920 | 0.0760 |
| 300 x 300 | **0.2430** | **0.3260**$^{*}$ | **0.4280**$^{*}$ | **0.4490**$^{**}$ | **0.1770** | **0.1620** | **0.2390** | 0.1470 | **0.1930** | **0.1400** | **0.2230** | 0.1930 |

**Table S4.** R-squared values for the transportation networks including total river length, total road length, total combined road and river length, and total intersections against outbreak measures: cases in first 100 days, total cases, and total duration in days for each study area examined (*p < 0.05, **p<0.01, ***p<0.001). Subsequent events excluded. The subsequent events are as follows: Mayibout Gabon in February1996, Mbomo RC in November 2003, Etoumbi RC in May 2005, and Luebo DRC in September 2007. Upper case superscripts refer to figures that illustrate each relationship. Bold values are greater than when all spillover events are included.

| | Outbreak measure | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cases in first 100 days** | | | | **Total cases** | | | | **Total duration (in days)** | | | |
| Study area | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section | River | Road | Road & river | Inter-section |
| 50 x 50 | **0.1490** | **0.1210** | **0.6070**$^{**}$ | **0.6460**$^{**}$ | **0.0514** | **0.0203** | **0.1550** | **0.3090** | **0.1800** | **0.0006** | **0.1920** | **0.2210** |
| 100 x 100 | **0.0418** | 0.1070 | 0.3210 | 0.2970 | 0.0043 | 0.0124 | 0.0043 | 0.0145 | **0.3470**$^{*}$ | 0.0033 | **0.3860**$^{*}$ | **0.1590** |
| 150 x 150 | **0.0782** | 0.2620 | **0.5390**$^{*}$ | 0.4200$^{*}$ | **0.0334** | **0.1150** | 0.0568 | **0.0607** | **0.2980** | 0.0399 | **0.3360**$^{*}$ | **0.1640** |
| 200 x 200 | **0.1650** | 0.2940 | 0.4570$^{*}$ | 0.4370$^{*}$ | 0.0050 | **0.2800** | **0.2800** | **0.1870** | **0.4380**$^{*}$ | 0.0776 | **0.2820** | **0.1620** |
| 300 x 300 | 0.1510 | 0.2580 | 0.3450$^{*}$ | 0.4050$^{*}$ | 0.0484 | **0.3150** | **0.3220** | **0.3100** | **0.7930**$^{***}$ | 0.0460 | **0.2740** | **0.2150** |

**Table S5.** R-squared values for the transportation networks including total river length, total road length, total combined road and river length, and total intersections against outbreak measures: cases in first 100 days, total cases, and total duration in days for each study area examined (*p < 0.05, **p<0.01, ***p<0.001). Subsequent and outlier events excluded. The subsequent events are as follows: Mayibout Gabon in February1996, Mbomo RC in November 2003, Etoumbi RC in May 2005, and Luebo DRC in September 2007. The outlier events are as follows: Meliandou Guinea in 2013 and North Kivu DRC in 2019. Upper case superscripts refer to figures that illustrate each relationship. Bold values are greater than when all spillover events are included.

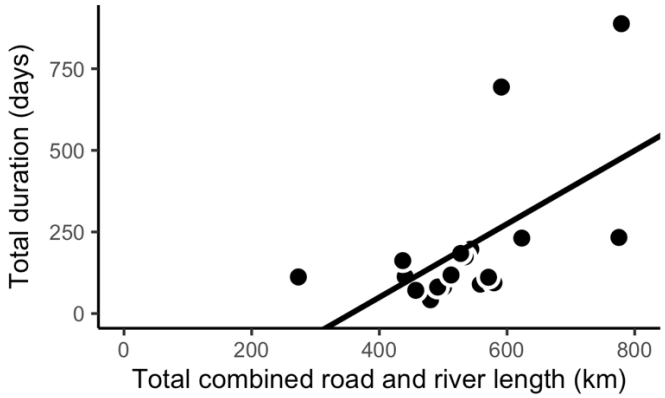


**Figure S2.** Linear Regression model of the total duration in days of each outbreak and the total combined road and river length in km in each 100x100 study area surrounding the spillovers (R-squared = 0.3470 , p = 0.0101).

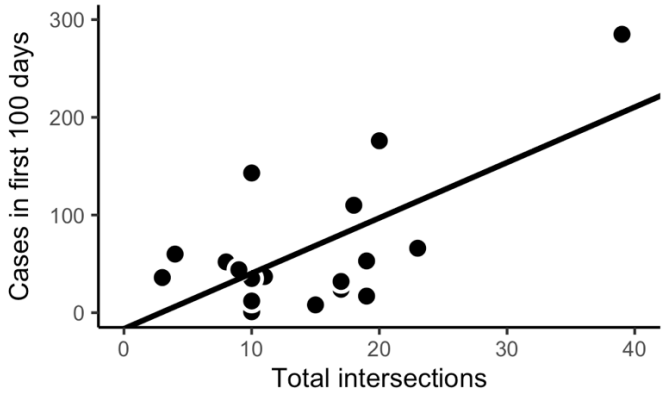


**Figure S3.** Linear Regression model of the total cases in the first 100 days of each outbreak and the total number of intersections in a 150 km x 150 km study area surrounding the spillovers (R-squared = 0.4338, p = 0.0030).

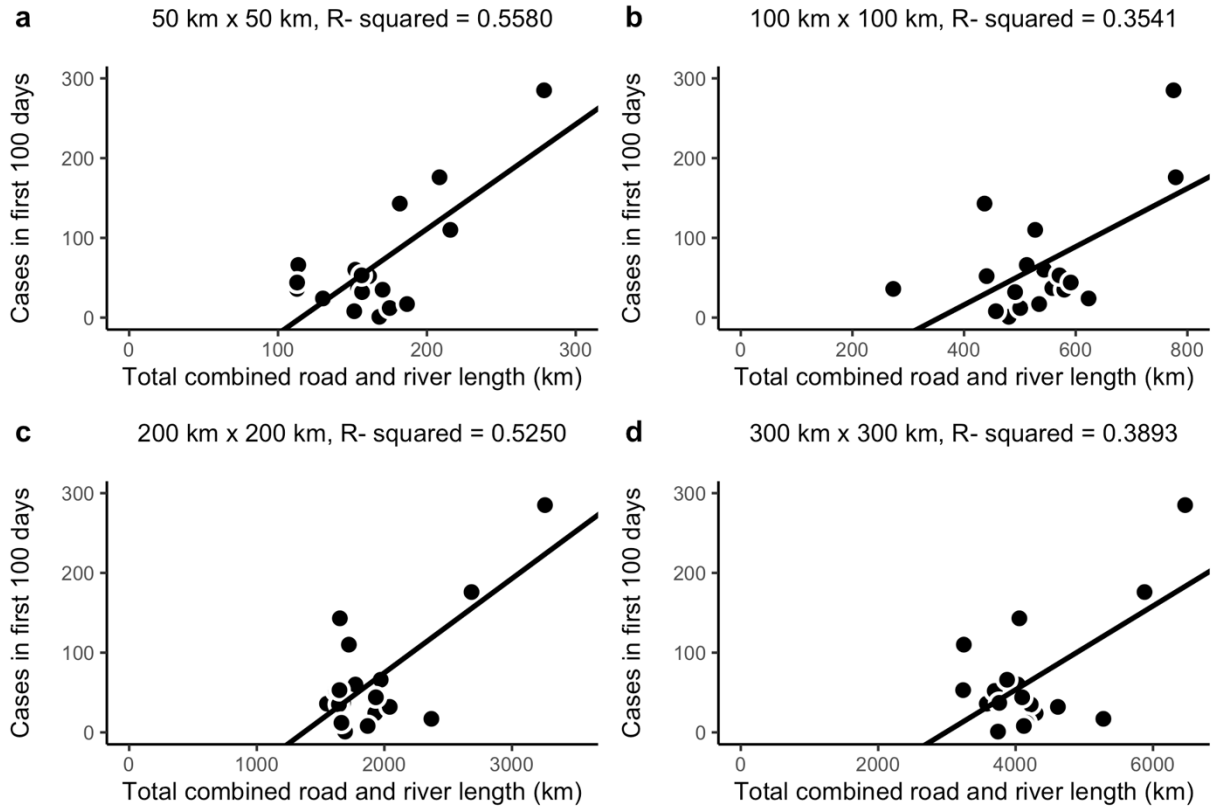


**Figure S4.** Linear Regression models of the total cases in the first 100 days and the total combined road and river length in km in a **(a)** 50 km x 50 km study area (R- squared = 0.5580 , p = 0.0004), **(b)** 100 km x 100 km study area (R-squared = 0.3541 , p = 0.0092), **(c)** 200 km x 200 km study area (R-squared = 0.5250 , p = 0.0007), **(d)** 300 km x 300 km study area (R-squared = 0.3893 , p = 0.0057).