The Potential for Increase in Global Ebola Transmission During End of Year Liberian Holiday Travel

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The 2014 Ebola outbreak has killed five thousand as of the end of October. While infections have primarily been in Guinea, Sierra Leone and Liberia, land travel has brought cases to Senegal and Mali, and air travel has brought them to Nigeria and the US. Cases in the US have arisen through both normal travel of an individual and unsupervised travel of a returning care provider. This does not include cases that were transferred under strict quarantine to the US and Europe for treatment. Current screening protocols that measure traveler temperature at airports do not prevent infected individuals from traveling because of the long latent period, considered to be 2-21 days, in which symptoms do not appear. Concerns exist that the travel of additional individuals will lead to additional risk of spreading and the threat that the Ebola outbreak will become a global pandemic. Here we analyze the historical seasonal variation in travel and point out that in the case of Liberia, the months of September and October represent a low period for travel to the US. Travel increases in December and January due to the holiday season, as Liberia is a primarily Christian country and family members travel to Africa for the holidays, increasing the risk of additional cases.

The current outbreak in West Africa raises concerns that infected travelers will cause outbreaks in other locations. US government officials originally dismissed risks from travelers [1,2]. Still, each infected traveler that has arrived in the US has prompted increased efforts to prevent additional cases through screenings and changes in hospital protocols [3-6] and observation, quarantine or home isolation [7-11].

The number of infected travelers depends critically on the infection dynamics in West Africa. Extrapolations by the Centers for Disease Control and Prevention (CDC) and other models project exponential growth based upon historical counts reported in Liberia, Sierra Leone, and Guinea [12]. The exponential growth reflects a breakdown of contact tracing, especially in the urban areas. This means that individuals who are infected are not identified and quarantined. Recent data in Liberia give indications of decreased numbers of cases, perhaps reflecting new strategies including community based interventions such as door to door screening [13], though the quality of reporting of the data is uncertain, and implementation is not uniform with cases in Monrovia still not under control [14].

More generally, the number of infected travelers depends on: the number of infected individuals in West Africa; the number of travelers; the effectiveness of early identification of exposed individuals in West Africa through either contact tracing or neighborhood based screening; and the effectiveness of screening, monitoring and isolation protocols at departure from West Africa and upon arrival at the destination. Here we focus on the US because of the recent cases identified in Dallas and New York. Some studies suggest that the US is among the five most

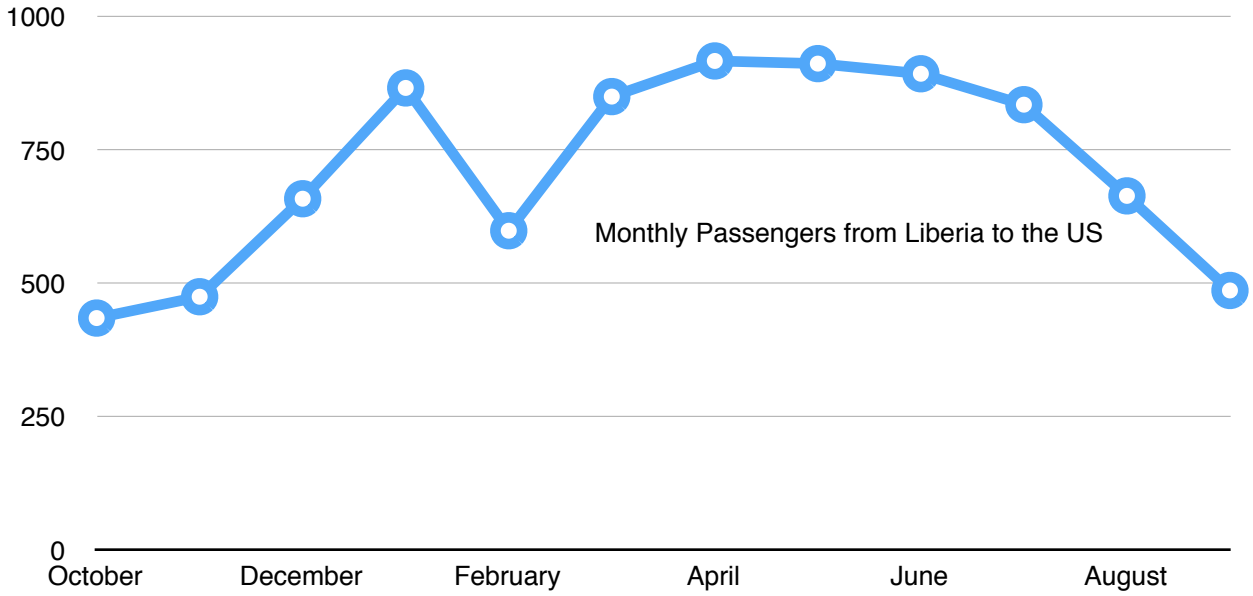

Figure 1: Seasonal variation of the number of travelers from Liberia to the US, averages based upon data from September 2010 through March 2014 [17].

likely countries outside Africa to receive infected cases [15]. Although there has been modeling of the role of flight travel in the spread of Ebola [15,16], the analyses did not consider seasonal fluctuations in travel, assuming travel is evenly distributed over the weeks of the year.

Setting other factors aside, increased travel from the affected countries will lead to an increase in the number of infected persons in the US. The two cases thus far have different origins. The first can be considered part of the natural travel of passengers that would have occurred without the epidemic. The second reflects travel of a health worker whose travel is directly linked to efforts to improve the care in West Africa. We will analyze the implications of each of these types of travel in turn.

The first traveler originated in Liberia reflecting the significant travel from that country to the US due to historical ties, as the country was founded in part by former slaves who returned to Africa [18]. The months of September and October, during which the two existing cases arrived in Dallas and New York respectively, are during the lowest period for travel to the US. Based on travel in recent years, the expected number of travelers from Liberia to the US increases dramatically in the following months, with the number in January doubling compared to October. This increase can be readily understood as due to the Christmas and New Year holiday season. Liberia is estimated to be 85 percent Christian [19] and travel increases for family visits. January is when many are returning to their homes in the US after these holidays. The decreased travel in February is followed by a peak during Easter, and spring break and summer vacations for US students.

The effect of seasonal variation may be more pronounced in the context of the Ebola epidemic. It can be expected that travel to and from West Africa is reduced because of the risk to travelers. However, it might be expected that travel for tourism or business will be impacted

more than family holiday travel. Indeed, personal communication with regular travelers to West Africa and travel agents serving the region suggest travelers are not changing their holiday plans [20,21].

The seasonal trends in travel must be considered in any analysis of risk. The rapid increase in cases in West Africa over the past few months has occurred during the time of year in which the lowest number of travelers are flying from Liberia to the US. If the spread of the disease in Liberia is not curtailed and effective exit or entry screening or quarantines are not implemented, the travel of Ebola-infected persons will grow at an even faster rate than the growth of cases in the country. This period of relatively low travel presents a unique opportunity during which to address the spread of Ebola virus.

The more recent case of the health care worker is not related to the normal dynamics of travel to West Africa, as the reason for the travel was the epidemic itself. In this case, we should understand that efforts to increase the number of health care workers to gain control of the epidemic will result in increasing numbers of returning healthcare workers. Statements that suggest that we can reduce the risk by sending more healthcare workers to West Africa to control the epidemic without measures taken on their return [22] do not consider this effect, which increases the risk of contagion to the US in the short term. Effective control of the epidemic should include consideration of safety upon return.

There are two positive indications that the risk will not increase rapidly. The first is the Liberian data that suggests decreasing cases, and the report of community based screening, which would dramatically reduce the risk of contagion prior to the increasing holiday travel. The second is the increasing action by the US to reduce contagion risk from travelers. The Department of Homeland Security is monitoring more closely travel between Ebola-affected countries and the US. Starting from the end of October, 21 travelers from Liberia, Sierra Leone and Guinea have been routed to five US airports which are implementing enhanced screening for Ebola symptoms [7]. Since the second case, NY, NJ and Illinois, the locations of three of these airports, are implementing 21 day quarantines or home isolation of returning healthcare providers [8-10].

We have recommended that preventing the spread of Ebola to the US or globally should involve effective screening of travelers leaving West Africa [23]. Simulations by some researchers have been taken to imply that screening of travelers will not impact contagion [15,24] and this has been echoed in the press [25] (see also [26,27]). Under the conditions simulated an exponential growth of cases will lead to cases in the US regardless of screening and travel limits and therefore there is no purpose to them. However, this conclusion is based upon a continuing exponential growth of cases in West Africa and the assumption that the policies to reduce infection risk are not better than 80% effective. It also assumes that no vaccine or improvement in medical care will be identified in the short term. Under these conditions Ebola will eventually reach the entire world and will cause as large an epidemic as it would have caused without the travel restrictions, only delayed by perhaps by a month. The conclusions are not true if (a) an effective containment response is mounted within months as is supported by recent data from Liberia, (b) screening or quarantine and home isolation of travelers is sufficiently effective, or (c) new technologies are developed to combat the disease or its spread over the upcoming months. The stated assumptions have not been shown to be valid. Indeed, the recent decrease of cases in Liberia suggests that it is possible to contain the outbreaks by practical interventions, and this, along with the increasing effectiveness of travel screening or quarantines, leads to the

possibility that the travel restrictions will prevent outbreaks in other parts of the world until the West African outbreak is fully controlled.

In summary, increasing travel from Liberia to the US can be expected as the year end holiday season arrives. Improvements in both the early identification and isolation of cases in Liberia and improved measures for preventing transmission to the US would reduce the risk of a global pandemic.

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