



Timelines in epidemiological outbreak investigations

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Abstract

Frequently during the study of an epidemic outbreak, there is a need to assess and communicate the relation that may exist between the occurrence of the outbreak and other events or the temporal relation between cases. We review some ways of presenting visualizations of timelines that can fill such a need.

Keywords: epidemics, disease outbreaks, time factors, epidemiologic methods

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Introduction

In a field outbreak investigation, information obtained from known cases is organized into a case listing. Such a list will probably contain elements such as dates of report and symptom onset. It may also contain data on attendance to an event which upon systematic collection, may lead to uncover a shared experience by all or most of the cases. Such information is usually displayed in a histogram showing the number of cases (y-axis or ordinate) by date of onset (on the x-axis or abscissa), a graph that is known as an epidemic curve. Many times, this graph also contains some notation such as arrows or text boxes on the histogram, and this type of graph with the epidemic curve for example, will additionally have information on a timeline, that is a graphical representation of the evolution of the events over time. since it relates the frequency of cases by time intervals. Such timelines note say the date of notification of the outbreak, or the implementation or duration of interventions such as an educational campaign, a sanitation order, or recall or closure of a vehicle (e.g., food item, swimming site) possibly implicated as a source of infection or other public health actions.

Methods

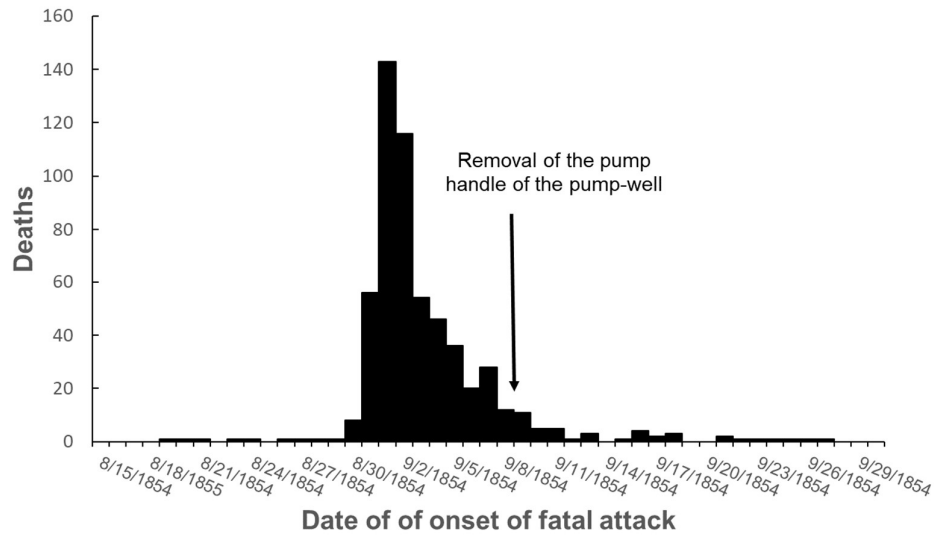
Examples and templates of such timeline charts have been developed by various agencies such as Canada's Public Health Agency [1], which we recommend reviewing. In this article we will review some simple ways to prepare these and other types of timeline graphs.

Timelines adding notes to the epidemic curve

One of the most famous epidemic curves is based on data collected by Dr. John Snow on the occurrence of cholera deaths in Soho, London. A simple timeline adds a not and arrow to note the removal of the water pump handle in Broad Street in 1854 (Figure 1). Note that the ratio of the axes is 5:3, i.e., the abscissa axis (X's or horizontal axis) is of relative size 5 while the ordinate axis (Y's or vertical axis) is of relative size 3. This histogram was obtained in Excel (find it in the "Snow.xlsx" file with instructions in the annexes).

As can be seen the cholera epidemic in the neighborhood of the Broad St. in Soho, was in rapid decline before Snow completed his study and suggested to the authorities to remove the handle of the water pump on Broad Street.

Figure 1. Cholera Fatal Attacks in the Golden Square, Broad St. neighborhood, Soho, London, August-September 1854



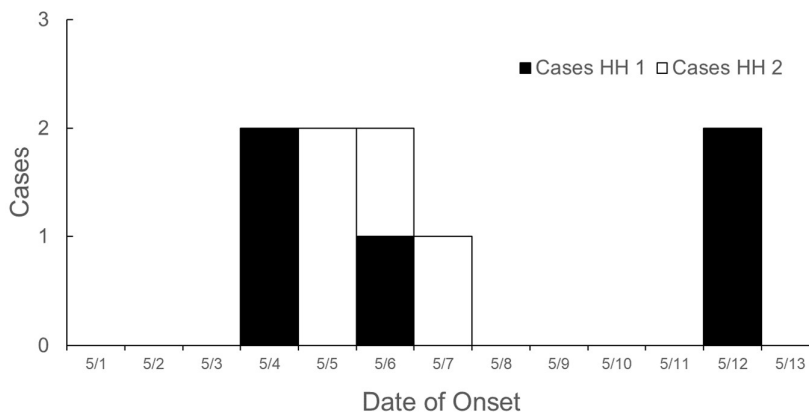
Source: Table 1, page 49. Reference 2

There are other types of timeline charts that add depth to the visualization of interaction between the people at risk as described below.

COVID-19 case and contact investigations provide us with an opportunity for illustration of the use of timeline charts. In May 2020 one of us (VC) made some calls as a volunteer interviewer to inquire about possible contacts of confirmed

cases in the city of Springdale, Arkansas in the United States. These data only represent a chain of cases in two households that share kinship. One person from household 1 visited relatives in household 2 on May 3, 2020. The histogram in Figure 2 shows the nine cases by onset date in two series, black for the first household and white for the second.

Figure 2. Dates of onset of suspect COVID-19 cases in two households in Springdale, Arkansas, May 2020

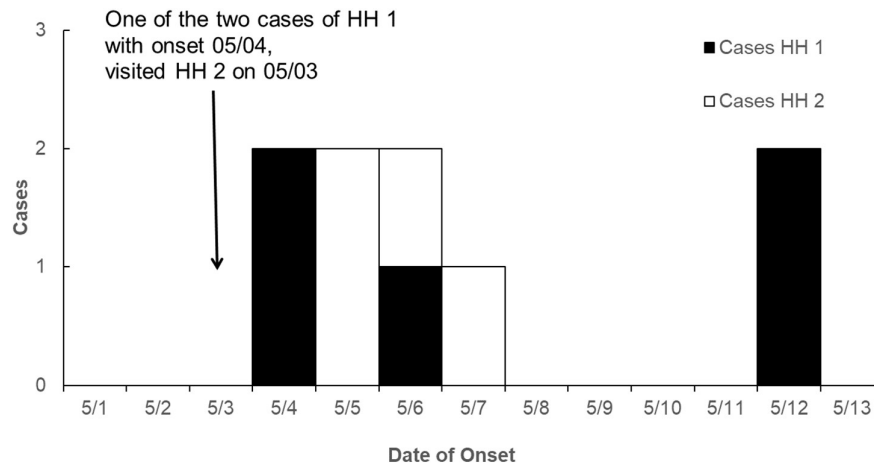


Source: Case and contact investigation by one of the authors, May 2020

Just adding an annotation to Figure 2 results in a much more informative graph as seen in the annotated histogram in Figure 3. All four cases in dwelling two occurred within the first four days of the visit. One can infer that, if the cases in the second

dwelling had no other exposure, the incubation period for this infection could be 2-4 days. We also note that the disease is transmissible before the onset of symptoms. Both of these facts are not as evident without the note in Figure 3..

Figure 3. Dates of onset of suspect COVID-19 cases in two households in Springdale, Arkansas, May 2020



Source: Case and contact investigation by one of the authors, May 2020

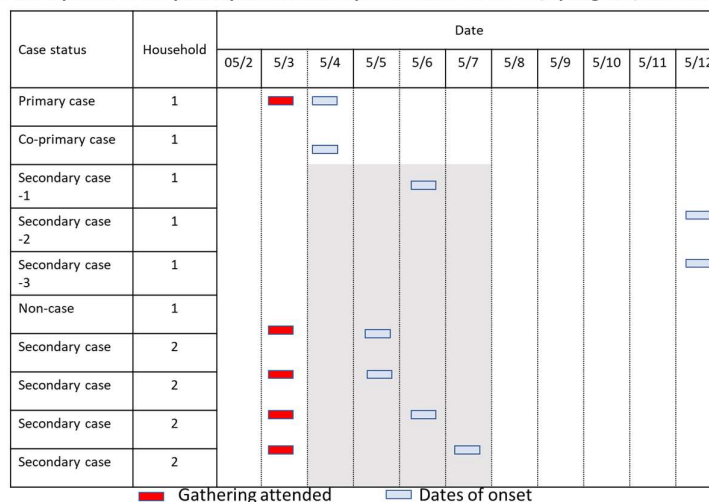
Both graphs 2 and 3 were obtained in Excel (find the “Springdale.xlsx” file with instructions in the other annexes).

Timelines using a table

Obviously, we do not know from the epidemic curve alone, whether there were unaffected persons in the two dwellings,

nor can we learn directly from the graph what interaction there was between the persons in these two dwellings. An alternative is the timeline graph is shown in Figure 4. The shaded area shows the minimum and maximum incubation periods, 2 and 4 days, in the occurrence of secondary cases in house 2, taking as critical exposure the meeting on May 3.

Figur4. Timeline of the exposure to the primary case in a family outbreak of COVID-19, Springdale, Arkansas, May 2020

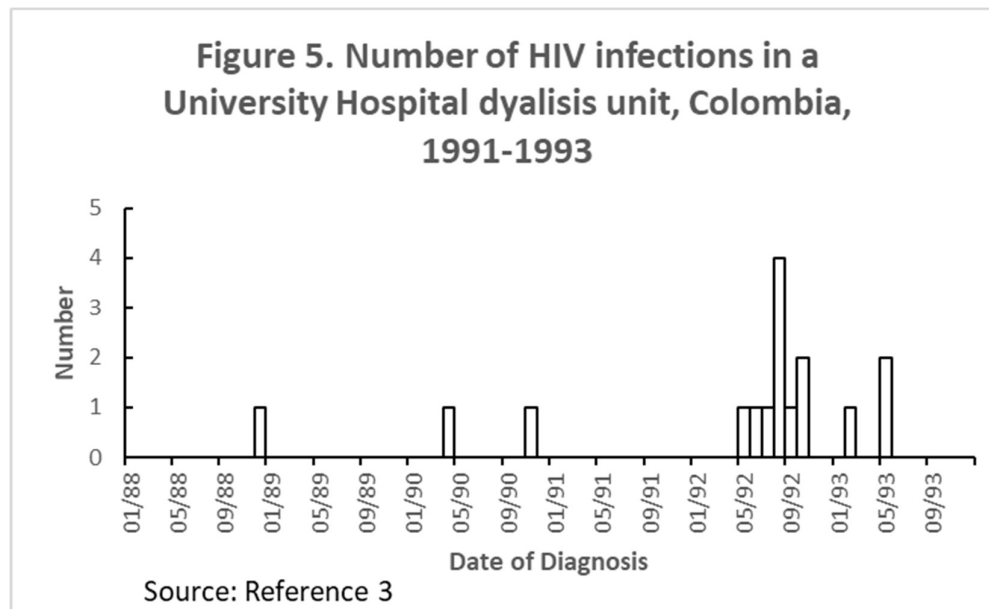


Source: Case and contact investigation by one of the authors, May 2020

Graph 4 clearly shows that the primary case in dwelling one in the first row attended a family gathering in dwelling two and was most likely the primary case of four secondary cases in that dwelling. Graph 4 also gives us a better idea of the secondary attack rate. There were ten people in the two dwellings, eight in addition to the primary case and coprimary, and in just four days of exposure, five of the eight at risk (62.5%) fell ill. It would be debatable whether the other two cases that occurred in dwelling 1 were secondary to the individuals who became ill on May 4 or to the secondary case that became ill on May 6; their source could be any of those and even someone else outside the home. The secondary

attack rate estimate of 62.5% is based on the observations in both dwellings seems more conservative than an estimate of 100.0% among members of dwelling 2, who might have had a longer, closer exposure to a person incubating the disease. This graph was drawn in PowerPoint ("Springdale.pptx" file with instructions in the attachments).

Finally, there are some outbreaks as in the case of an HIV epidemic in a hemodialysis unit that occurred in a university hospital in Colombia in 1992 [3] where the temporal interactions between the cases are important but cannot be inferred by just inspecting an epidemic curve as the one presented in Figure 5.

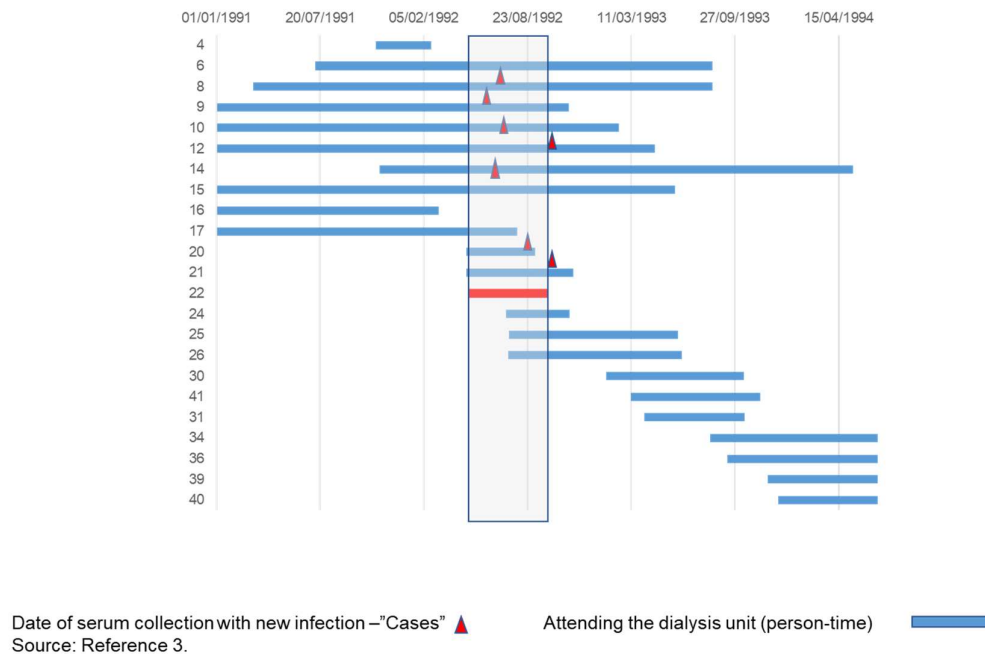


Timelines of person-time and case occurrence

The examination of the timeline of the outbreak investigation suggested that the cases of new infection occurred among a population in which the exposure periods (i.e., attendance) overlapped with patient 22 in Figure 6. The X-axis shows the dates of serum collection for diagnosis of HIV infection and on the Y-axis each number represents the hemodialysis unit patient ID. Note that the at-risk risk contributed by each person receiving dialysis is denoted by blue bars, that is, the person-time of exposure to risk, and the visit in which a serum testing positive for HIV was taken is denoted by a red triangle, that is, the occurrence of newly

diagnosed cases of infection. Serum samples were available for each patient visit and the research protocol call for testing all available samples until finding the first positive specimen of each patient. This document was developed in Excel (file HURGV.xlsx with instructions in the 'Visualization of interactions during the course of an epidemic.docx' file document) and edited in PowerPoint (file HURGV.pptx with instructions) from the figure in reference [3] and the original published timeline was produced by Drs. Scott Fridkin, William Jarvis, and Lee Bland of the CDC nosocomial infections program. There is an attached instruction for producing the bar graph by duration at follow-up..

Figure 6. Chronic dialysis patients in a hemodialysis unit between January 1991, and June 1994, in whom serum for HIV antibody was available for testing, and HIV serostatus by date of serum collection



Clearly there was an excess of new HIV infections among chronic hemodialysis patients who attended the center during the time that patient 22, who was positive on the first sample at admission, was also attending the center. This information could not be inferred from the epidemic curve (Figure 5).

Other methods

As can be reviewed in reference [1] there are other methods for visualizing the sequence of events and interactions. In addition, there are quantitative methods based on graph and matrix analyses, which have been used extensively in sexually transmitted diseases [e.g., 4] and more recently to study the transmission of severe acute respiratory syndrome virus -2 [e. g., 5].

In conclusion, the addition of temporal information to the epidemic curves and the preparation of data visualization showing the temporal relation can be useful to clarify temporal sequences and to understand the causality of the relations and to investigate important parameters such as the incubation period, as shown in the different examples presented.

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