

Epidemiology of a bubonic plague outbreak in Glasgow, Scotland in 1900

Katharine R. Dean, Fabienne Krauer and Boris V. Schmid

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Review timeline

Original submission: 10 October 2018
Revised submission: 23 November 2018
Final acceptance: 26 November 2018

Note: Reports are unedited and appear as submitted by the referee. The review history appears in chronological order.

Note: This manuscript was transferred from another Royal Society journal with peer review.

Review History

RSOS-181695.R0 (Original submission)

Review form: Reviewer 1 (Daniel Curtis)

Is the manuscript scientifically sound in its present form?

Yes

Are the interpretations and conclusions justified by the results?

Yes

Is the language acceptable?

Yes

Is it clear how to access all supporting data?

Yes

Do you have any ethical concerns with this paper?

No

Have you any concerns about statistical analyses in this paper?

No

Recommendation?

Accept with minor revision (please list in comments)

Comments to the Author(s)

This is an important paper that should be published. It is significant because (a) we still know very little about the mechanisms of historical plague transmission, and (b) it is rare we have such detailed documentary information on the dynamics of the spread and transmission process - i.e. something tangible to support abstract modelling.

Some minor adaptations:

1. Bottom p.3/top p. 4. Make clear that better understanding of epidemiological characteristics in the 3rd pandemic does not mean that these characteristics can be simply assumed to be applicable to the 2nd Pandemic. That would have to be demonstrated.
2. Next paragraph down - no evidence for rat epizootics. This is surprising to me. I want to know how unusual this is? How frequently were rat epizootics found in other late 19th- and early 20th century plagues? Basically - is Glasgow a 'special case' or representative of many other Third Pandemic cases.
3. Top of p. 12 - rather than 'historical plague outbreaks' I would explicitly note that these studies find clustering in 2nd pandemic outbreaks from the 14th to the 18th century. on that note - is there really no evidence of household clustering for 3rd pandemics elsewhere? that surprises me.
4. I would like a broader conclusion that notes that you are not dismissing the importance of the rat as a general feature of plague transmission during the 3rd pandemic, but simply suggesting here that the rat-flea-human model is not applicable for every outbreak, and other transmission models (for the bubonic version) can apply in different historical contexts.

Other outstanding problems were already suggested by the previous referees, and well addressed by the authors.

Name free to go forward: Dr. Daniel R. Curtis, Leiden University

Review form: Reviewer 2 (Joris Roosen)**Is the manuscript scientifically sound in its present form?**

Yes

Are the interpretations and conclusions justified by the results?

Yes

Is the language acceptable?

Yes

Is it clear how to access all supporting data?

Yes

Do you have any ethical concerns with this paper?

No

Have you any concerns about statistical analyses in this paper?

I do not feel qualified to assess the statistics

Recommendation?

Accept with minor revision (please list in comments)

Comments to the Author(s)

This paper provides a very interesting analysis of a small scale outbreak of plague during the 3rd pandemic in the city of Glasgow. The use of historical data to explore the likelihood of human-to-human plague transmission (through a human ectoparasite vector) and the household clustering of plague cases, make this study sufficiently original and novel for publications in "Open Science". Especially since the epidemiology of plague (both 2nd and 3rd pandemic) in Europe remain poorly understood as the authors rightfully indicate.

Since two previous referees have already commented on the analysis of the data and the conclusions derived from this analysis. And since I deem the responses of the authors on the comments made by the previous referees to be sufficiently satisfying, I will instead focus on the contextualization of the paper within the broader historiography of historical plague studies.

Afterwards, I will also include some minor comments that the authors can choose to implement or ignore at their own discretion, as I do not think them vital enough to prevent publication of the paper.

Contextualization

At several points in the paper, the authors indicate that their findings "provide important insights into the epidemiology of bubonic plague outbreaks in pre-antibiotic Europe". Although I agree that the paper provides important insights, I would ask that the authors to reflect more critically on the representativeness of findings for the 3rd pandemic as indicative for all bubonic plague outbreaks in "pre-antibiotic Europe". Just as we cannot assume that pre-industrial epidemiological experiences necessarily mirror modern ones, findings for 19th century plague outbreaks might not be so easily transposed to late medieval and early modern plague outbreaks. This may, at first, seem like a trivial point, but the disparities between the 2nd- and 3rd plague epidemics have lead some historical plague experts, such as Samuel Cohn, to claim that , "the Black Death in Europe, 1347-52, and its successive waves to the eighteenth century was any disease other than the rat-based bubonic plague, whose bacillus was discovered in 1894". Even though Cohn wrote these words before laboratory testing could conclusively prove that plague was the causative agent of the 2nd pandemic, the underlying factors that led to his provocative statement remain. Plagues of the 2nd and 3rd pandemic differed noticeably in several key epidemiological characteristics, on the issue of severity alone the present paper illustrates that very fact.

Minor comments (non-compulsory)

To gain further insight in the historical data and provide more information, I would ask the authors to take into account the following elements.

1. What was the geographical occurrence of plague within the city of Glasgow? Were cases clustered in one specific section of the city? Or were they spread out over various parts?
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3. Page 3. For literature reference 1, an additional publication might be the book by Myron Echenberg "Plague ports: The global urban impact of bubonic plague, 1894-1901". This study also refers to the 1900 and 1901 plague outbreaks in Glasgow. Alternatively there is also the article by Echenberg: *Pestis Redux*, in the journal of *World History*, which provides some historical background information on the 1900 Glasgow outbreak.

4. Page 3. The sentence "In general, the epidemiology of plague outbreaks in Europe is poorly understood", can be linked (for the 2nd pandemic) to a recent article by Guido Alfani and Tommy Murphy (2017) "Plague and lethal epidemics in the pre-industrial world" p. 318.

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Decision letter (RSOS-181695.R0)

19-Nov-2018

Dear Ms Dean

On behalf of the Editors, I am pleased to inform you that your Manuscript RSOS-181695 entitled "Epidemiology of a bubonic plague outbreak in Glasgow, Scotland in 1900" has been accepted for publication in *Royal Society Open Science* subject to minor revision in accordance with the referee suggestions. Please find the referees' comments at the end of this email.

The reviewers and handling editors have recommended publication, but also suggest some minor revisions to your manuscript. Therefore, I invite you to respond to the comments and revise your manuscript.

- Ethics statement

If your study uses humans or animals please include details of the ethical approval received, including the name of the committee that granted approval. For human studies please also detail whether informed consent was obtained. For field studies on animals please include details of all permissions, licences and/or approvals granted to carry out the fieldwork.

- Data accessibility

It is a condition of publication that all supporting data are made available either as supplementary information or preferably in a suitable permanent repository. The data accessibility section should state where the article's supporting data can be accessed. This section

should also include details, where possible of where to access other relevant research materials such as statistical tools, protocols, software etc can be accessed. If the data has been deposited in an external repository this section should list the database, accession number and link to the DOI for all data from the article that has been made publicly available. Data sets that have been deposited in an external repository and have a DOI should also be appropriately cited in the manuscript and included in the reference list.

If you wish to submit your supporting data or code to Dryad (<http://datadryad.org/>), or modify your current submission to dryad, please use the following link:
<http://datadryad.org/submit?journalID=RSOS&manu=RSOS-181695>

- **Competing interests**

Please declare any financial or non-financial competing interests, or state that you have no competing interests.

- **Authors' contributions**

All submissions, other than those with a single author, must include an Authors' Contributions section which individually lists the specific contribution of each author. The list of Authors should meet all of the following criteria; 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published.

All contributors who do not meet all of these criteria should be included in the acknowledgements.

We suggest the following format:

AB carried out the molecular lab work, participated in data analysis, carried out sequence alignments, participated in the design of the study and drafted the manuscript; CD carried out the statistical analyses; EF collected field data; GH conceived of the study, designed the study, coordinated the study and helped draft the manuscript. All authors gave final approval for publication.

- **Acknowledgements**

Please acknowledge anyone who contributed to the study but did not meet the authorship criteria.

- **Funding statement**

Please list the source of funding for each author.

Please note that we cannot publish your manuscript without these end statements included. We have included a screenshot example of the end statements for reference. If you feel that a given heading is not relevant to your paper, please nevertheless include the heading and explicitly state that it is not relevant to your work.

Because the schedule for publication is very tight, it is a condition of publication that you submit the revised version of your manuscript before 28-Nov-2018. Please note that the revision deadline will expire at 00.00am on this date. If you do not think you will be able to meet this date please let me know immediately.

To revise your manuscript, log into <https://mc.manuscriptcentral.com/rsos> and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions". Under "Actions," click on "Create a Revision." You will be unable to make your

revisions on the originally submitted version of the manuscript. Instead, revise your manuscript and upload a new version through your Author Centre.

When submitting your revised manuscript, you will be able to respond to the comments made by the referees and upload a file "Response to Referees" in "Section 6 - File Upload". You can use this to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the referees. We strongly recommend uploading two versions of your revised manuscript:

- 1) Identifying all the changes that have been made (for instance, in coloured highlight, in bold text, or tracked changes);
- 2) A 'clean' version of the new manuscript that incorporates the changes made, but does not highlight them.

When uploading your revised files please make sure that you have:

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- 2) A separate electronic file of each figure (EPS or print-quality PDF preferred (either format should be produced directly from original creation package), or original software format);
- 3) Included a 100 word media summary of your paper when requested at submission. Please ensure you have entered correct contact details (email, institution and telephone) in your user account;
- 4) Included the raw data to support the claims made in your paper. You can either include your data as electronic supplementary material or upload to a repository and include the relevant doi within your manuscript. Make sure it is clear in your data accessibility statement how the data can be accessed;
- 5) All supplementary materials accompanying an accepted article will be treated as in their final form. Note that the Royal Society will neither edit nor typeset supplementary material and it will be hosted as provided. Please ensure that the supplementary material includes the paper details where possible (authors, article title, journal name).

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Once again, thank you for submitting your manuscript to Royal Society Open Science and I look

forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Kind regards,
Royal Society Open Science Editorial Office
Royal Society Open Science
openscience@royalsociety.org

on behalf of Dr John Dalton (Associate Editor) and Professor Kevin Padian (Subject Editor)
openscience@royalsociety.org

Reviewer comments to Author:
Reviewer: 1

Comments to the Author(s)

This is an important paper that should be published. It is significant because (a) we still know very little about the mechanisms of historical plague transmission, and (b) it is rare we have such detailed documentary information on the dynamics of the spread and transmission process - i.e. something tangible to support abstract modelling.

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Name free to go forward: Dr. Daniel R. Curtis, Leiden University

Reviewer: 2

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conclusions derived from this analysis. And since I deem the responses of the authors on the comments made by the previous referees to be sufficiently satisfying, I will instead focus on the contextualization of the paper within the broader historiography of historical plague studies.

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Minor comments (non-compulsory)

To gain further insight in the historical data and provide more information, I would ask the authors to take into account the following elements.

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6. Page 9. The authors mention that 60% of patients were female and that the overall case-fatality rate was 42.8%. What percentage of overall deaths were female? This also links up with page 11. In describing the epidemiological characteristics of the Glasgow outbreak, the authors reflect on several factors (case fatality rate, symptomatic period), despite the limited sample-size. Would the authors also be willing to describe female over-mortality (if this is the case) and link it up to contemporary findings of female mortality being skewed towards women in certain African cases (e.g. Tanzania)?

Author's Response to Decision Letter for (RSOS-181695.R0)

See Appendix A.

Decision letter (RSOS-181695.R1)

26-Nov-2018

Dear Ms Dean,

I am pleased to inform you that your manuscript entitled "Epidemiology of a bubonic plague outbreak in Glasgow, Scotland in 1900" is now accepted for publication in Royal Society Open Science.

You can expect to receive a proof of your article in the near future. Please contact the editorial office (openscience_proofs@royalsociety.org and openscience@royalsociety.org) to let us know if you are likely to be away from e-mail contact. Due to rapid publication and an extremely tight schedule, if comments are not received, your paper may experience a delay in publication.

Royal Society Open Science operates under a continuous publication model (<http://bit.ly/cpFAQ>). Your article will be published straight into the next open issue and this will be the final version of the paper. As such, it can be cited immediately by other researchers. As the issue version of your paper will be the only version to be published I would advise you to check your proofs thoroughly as changes cannot be made once the paper is published.

On behalf of the Editors of Royal Society Open Science, we look forward to your continued contributions to the Journal.

Kind regards,
Andrew Dunn
Royal Society Open Science Editorial Office
Royal Society Open Science
openscience@royalsociety.org

on behalf of Dr John Dalton (Associate Editor) and Kevin Padian (Subject Editor)
openscience@royalsociety.org

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Appendix A

Dear Dr. Dalton and Prof. Padian,

We are very pleased that our manuscript, "Epidemiology of a bubonic plague outbreak in Glasgow, Scotland in 1900," has been accepted with minor revisions in Royal Society Open Science. We thank the reviewers for their valuable comments, which have improved the manuscript. Please find below detailed responses (highlighted in bold) to the reviewers' comments.

Sincerely,

Katharine R. Dean

- Ethics- **see page 14 (Section-Ethics statement)**
- Data accessibility- **see page 14 (Section-Data accessibility)**
- Competing interests- **see page 14 (Section-Competing interests)**
- Author contributions- **see page 14 (Section- Author contributions)**
- Funding statement- **see page 14-15 (Section- Funding)**
- Acknowledgement- **see page 15 (Section- Acknowledgement)**

Reviewer comments to Author:

Reviewer: 1

Comments to the Author(s)

This is an important paper that should be published. It is significant because (a) we still know very little about the mechanisms of historical plague transmission, and (b) it is rare we have such detailed documentary information on the dynamics of the spread and transmission process - i.e. something tangible to support abstract modelling.

Some minor adaptations:

1. Bottom p.3/top p. 4. Make clear that better understanding of epidemiological characteristics in the 3rd pandemic does not mean that these characteristics can be simply assumed to be applicable to the 2nd Pandemic. That would have to be demonstrated.

We have changed this sentence to:

“Therefore, there is an opportunity to better understand the epidemiology of plague outbreaks in Europe during the Third Pandemic. Although these outbreaks cannot simply be assumed to be representative of the Second Pandemic, they can provide a valuable point of comparison for future studies.”

2. Next paragraph down - no evidence for rat epizootics. This is surprising to me. I want to know how unusual this is? How frequently were rat epizootics found in other late 19th- and early 20th century plagues? Basically - is Glasgow a 'special case' or representative of many other Third Pandemic cases.

As far as we know, the frequency of rat epizootics during this time period for other outbreaks in Europe or other parts of the world has not been the focus of a study yet, which would be a large study on its own. So, it is hard to answer how unusual the Glasgow situation was. However, we have included the numbers of plague-infected rats caught in Glasgow. This data indicates that plague-infected rats were found in later years, although not in large numbers.

3. Top of p. 12 - rather than 'historical plague outbreaks' I would explicitly note that these studies find clustering in 2nd pandemic outbreaks from the 14th to the 18th century. on that note - is there really no evidence of household clustering for 3rd pandemics elsewhere? that surprises me.

We have changed this sentence to:

“Many studies have reported household clustering of cases during Second Pandemic plague outbreaks in Europe [20-25].”

With regards to the Third Pandemic, we are not aware of any other studies that have reported an increased rate of household transmission of plague in Europe for this time period. We believe that there are very few outbreaks in Europe during the Third Pandemic that are large enough to be used in a quantitative analysis for this purpose. Moreover, without case information on the type of plague it can be difficult to know whether the cluster is bubonic cases or pneumonic cases or both. We do note that an outbreak in Nepal reports clustering of bubonic cases, while outbreaks in Bombay, Sydney, and New Orleans do not.

4. I would like a broader conclusion that notes that you are not dismissing the importance of the rat as a general feature of plague transmission during the 3rd pandemic, but simply suggesting here that the rat-flea-human model is not applicable for every outbreak, and other transmission models (for the bubonic version) can apply in different historical contexts.

We have changed the concluding paragraph to:

“In conclusion, our study describes an outbreak of bubonic plague in Glasgow in 1900 and uses transmission tree reconstruction to better understand the epidemiological characteristics of the outbreak. Based on the clustering of cases, bubonic plague most likely spread from human-to-human, possibly through a human ectoparasite vector. Without diminishing the role of rats in plague transmission during the Third Pandemic, it is important to consider that other models of transmission may apply in different historical contexts. In a modern context, the information in this study can be used to model plague outbreaks where the asymptomatic and symptomatic periods for untreated bubonic cases may be relevant.”

Reviewer: 2

Comments to the Author(s)

This paper provides a very interesting analysis of a small scale outbreak of plague during the 3rd pandemic in the city of Glasgow. The use of historical data to explore the likelihood of human-to-human plague transmission (through a human ectoparasite vector) and the household clustering of plague cases, make this study sufficiently original and novel for publications in "Open Science". Especially since the epidemiology of plague (both 2nd and 3rd pandemic) in Europe remain poorly understood as the authors rightfully indicate.

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Afterwards, I will also include some minor comments that the authors can choose to implement or ignore at their own discretion, as I do not think them vital enough to prevent publication of the paper.

Contextualization

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Just as we cannot assume that pre-industrial epidemiological experiences necessarily mirror modern ones, findings for 19th century plague outbreaks might not be so easily transposed to late medieval and early modern plague outbreaks. This may, at first, seem like a trivial point, but the disparities between the 2nd- and 3rd plague epidemics have lead some

historical plague experts, such as Samuel Cohn, to claim that, "the Black Death in Europe, 1347-52, and its successive waves to the eighteenth century was any disease other than the rat-based bubonic plague, whose bacillus was discovered in 1894". Even though Cohn wrote these words before laboratory testing could conclusively prove that plague was the causative agent of the 2nd pandemic, the underlying factors that led to his provocative statement remain. Plagues of the 2nd and 3rd pandemic differed noticeably in several key epidemiological characteristics, on the issue of severity alone the present paper illustrates that very fact.

We understand the point raised here, and we have been more specific in our wording throughout the paper to make it clearer that the outbreak only represents itself and is not representative of other outbreaks in Europe. We instead say now that it provides a point of comparison for future studies.

Minor comments (non-compulsory)

To gain further insight in the historical data and provide more information, I would ask the authors to take into account the following elements.

1. What was the geographical occurrence of plague within the city of Glasgow? Were cases clustered in one specific section of the city? Or were they spread out over various parts?

We have added the sentence:

"By March 1901, the city had a population of 761,712, but the cases were primarily located in the densely-populated Gorbals area, on the south bank of the river Clyde [10]."

2. What was the total population of Glasgow in 1900. This will help understand how small a percentage of inhabitants died from plague during this outbreak (again see differences between 2nd and 3rd pandemics).

See response to point 1.

3. Page 3. For literature reference 1, an additional publication might be the book by Myron Echenberg "Plague ports: The global urban impact of bubonic plague, 1894-1901". This study also refers to the 1900 and 1901 plague outbreaks in Glasgow. Alternatively, there is also the article by Echenberg: Pestis Redux, in the journal of World History, which provides some historical background information on the 1900 Glasgow outbreak.

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We have added the citation for Alfani and Murphy.

5. Page 5. The authors mention several counter-measures implemented by the authorities to mitigate the impact of plague in Glasgow. Some of these 1, 2 and 4 were also widely used in the late medieval and early modern period. Given the limited number of plague cases, would the authors be willing to formulate a hypothesis regarding the effectiveness of the remaining counter-measures as decisive for the limited spread of plague?

It is difficult to say which countermeasures were effective in stopping the outbreak, especially given that several were enacted and at least some (in theory) would have reduced contact events, and thus transmission. Although we think the reviewer raises an interesting point here, we hesitate to comment on it further because our aim is not to compare aspects of the Second and Third Pandemics in this paper, only to describe an outbreak and the disease in untreated bubonic plague cases.

6. Page 9. The authors mention that 60% of patients were female and that the overall case-fatality rate was 42.8%. What percentage of overall deaths were female? This also links up with page 11. In describing the epidemiological characteristics of the Glasgow outbreak, the authors reflect on several factors (case fatality rate, symptomatic period), despite the limited sample-size. Would the authors also be willing to describe female over-mortality (if this is the case) and link it up to contemporary findings of female mortality being skewed towards women in certain African cases (e.g. Tanzania)?

We have looked into this and changed the sentence in the paper to be more specific. Our data shows that 9/21 (42.8%) infected females died and 6/14 (42.8%) males died. Rather unsurprisingly, a 'test of proportions' shows that there is no difference in these rates ($p=1$) and thus no support for female over-mortality for this outbreak.