PEER REVIEW HISTORY

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ARTICLE DETAILS

<table>
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<th>TITLE (PROVISIONAL)</th>
<th>Probability of males to outlive females, an international comparison from 1751 to 2020</th>
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<td>AUTHORS</td>
<td>Bergeron-Boucher, Marie-Pier; Alvarez, Jesús-Adrian; Kashnitsky, Ilya; Zarulli, Virginia</td>
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VERSION 1 – REVIEW

<table>
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<th>REVIEWER</th>
<th>Dorling, Danny</th>
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<td>University of Oxford</td>
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<td>REVIEW RETURNED</td>
<td>09-Dec-2021</td>
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GENERAL COMMENTS

This is an interesting paper – I think it should be published. I think it only needs light revisions. I have four points to make:

1) Should the paper not be titled: “Over time women are increasingly more likely to outlive men”?
2) At the very beginning you don’t mention Marc Luy’s work on cloistered populations. This is a comparison of the differences in life expectancy between these groups of men and women who live in single-sex, faith-based communities—and whose environments and behaviours are very similar to each other—and those of men and women in society as a whole. Luy’s research leads him to estimate that around 80 percent of the sex difference in life expectancy outcome is really a gender difference, with the earlier mortality of men appearing to be closely related to how maleness is performed in the majority of societies. Compared to the general population, monks and nuns have longer life expectancy, with significantly less of a gap between the sexes. There is also less difference in how often monks and nuns are ill. With so much current focus in the social sciences on performing masculinities (playing the man) and the social construction of so much that we recently considered to be biological, it is surprising Luy’s work isn’t better known and discussed. See: Marc Luy, “Causes of Male Excess Mortality: Insights from Cloistered Populations,” Population and Development Review, 20 April 2004, 647–76. You talk a lot about biological factors – and of course high deaths rates during childbirth in the past were very important, and have become less important to explaining the gaps; but increasingly over time biology may matter less; especially when major killers at young ages are cars (road crashes) and suicide.
3) You say early on that the out survival statistic you create does not account for the dependence between individuals (under strengths and limitations). This is quite an opaque statement. I think what you mean is that for men and women who becomes couples stay together into old age the statistic you are calculating does not apply to them because they are very likely to be of similar social classes and thus the men are much more likely
to die before the women; even more so given that the men (on average) tend to be older. If this is what you mean by dependence it might be worth making that more clear early on.

4) In the supplementary material it would be fascinating if you could look at the years 1889-1893 in particular. These are the years in which the Russian Flu Pandemic circulated worldwide. Did it result in a temporary fall in the chances of men outliving women in those years. The reason why I say it would be fascinating is the theory that that disease was a coronavirus, not influenza, and just as with the pandemic today, men are much more likely to die as compared to women (once age is taken into account).

Finally, you might be interested in this study I did with a colleague some years ago. No need to reference it (referees’ have an annoying habit of trying to get their own papers cited!) but it may be of use in terms of ideas – especially over the very recent trends. By recent I mean the last few decades! Reference: J Epidemiol Community Health . 2007 Feb;61(2):159-64: “Mortality in relation to sex in the affluent world”
Janette E Rigby and Danny Dorling DOI: 10.1136/jech.2006.047381

All best wishes,
Danny Dorling

REVIEWER
Permanyer, Iñaki
Autonomous University of Barcelona (UAB), Centre for Demographic Studies

GENERAL COMMENTS
In this paper, the authors investigate the likelihood that males outlive females when hypothetical male and female individuals are picked at random from sex-specific life table age-at-death distributions. For that purpose, the authors apply the outsurvival statistic (φ; proposed in 2021 by James Vaupel and two other colleagues co-authoring this paper as well) to 44 populations taken from the Human Mortality Database (HMD).

While the study shows some curious results that, to the best of my knowledge, had not been documented before, I can’t help thinking that the paper is a somewhat mechanical application of a simple and intuitively appealing indicator to a “well-trodden database”. The φ indicator was already defined in a previous paper, and the HMD has been used so many times in the past to investigate mortality dynamics that its accessibility and manipulation are extremely smooth. What I mean is that if the key indicator has already been defined and the source of data is very standard for those working in the field, the added value of the paper is somewhat reduced.

There are, however, several ways in which the added value of the paper can be increased (some of which have been hinted by the authors themselves). Here I list (in no particular order) some suggestions the authors could take in case the paper were invited to be resubmitted to the journal.
1. Investigate the values of the outsurvival statistic across different SES groups. For instance, one could hypothesize that the values of $\varphi$ might increase with increasing number of education years, or at higher income quantiles. While the number of countries where such investigation could be carried out is much smaller than 44, I think it would offer much more interesting insights.

2. In the paper, the authors look at the probability that a randomly chosen man outlives a randomly chosen women, so to speak. It would be very interesting to compare such probabilities for the sub-population of married couples, and even comparing single men vis-à-vis single women, or some combinations in between (e.g., the probability that a randomly chosen single woman outlives a randomly chosen married woman).

3. The authors rely on the HMD, which covers 44 high-income populations. However, other than having very high-quality data, there is no other reason why one should be interested in those specific 44 populations. Another possibility might be to carry out the analysis for geographically cohesive regions (e.g., Europe) or even enlarge the scope much further and investigate what happens at a global scale. While based on heavy modeling techniques, sex-specific life tables currently exist for all world countries.

4. In the next to last paragraph in the discussion section, the authors speak about how their measures could help guiding policies aiming at reducing inequalities between the sexes. I found this part of the discussion a bit weak and incomplete. Before speculating what values of $\varphi$ might one expect in case of “perfect gender equality” (whatever that means), it would be important to acknowledge and engage with the debate on the sex gap in life expectancy.

5. When reviewing the literature on similar indicators, the authors briefly mention the KL divergence measure and the “Stratification index” (S) recently proposed by Shi and colleagues (the reference should be updated now, as the paper has been accepted for publication). On the one hand, I do not think the last sentence in the first paragraph in page 3 does help much to clarify what the KL indicator is about and why is it disregarded. On the other hand, I do not understand why the authors consider that the interpretation of the S index is cumbersome. As I see it, the two indicators have much in common, and there is much to praise in both, so I think the current paper could be enriched by engaging more deeply in a comparison between the two approaches (advantages and disadvantages, and so on).
Reviewer: 1 Dr. Danny Dorling, University of Oxford

Comments to the Author:
This is an interesting paper – I think it should be published. I think it only needs light revisions. I have four points to make:

1) Should the paper not be titled: “Over time women are increasingly more likely to outlive men”?

Thank you for your comment. The title has been changed. The editor did not want a declarative title. So, we changed the title for “Probability of males to outlive females, an international comparison from 1751 to 2020”

2) At the very beginning you don’t mention Marc Luy’s work on cloistered populations. This is a comparison of the differences in life expectancy between these groups of men and women who live in single-sex, faith-based communities—and whose environments and behaviours are very similar to each other—and those of men and women in society as a whole. Luy’s research leads him to estimate that around 80 percent of the sex difference in life expectancy outcome is really a gender difference, with the earlier mortality of men appearing to be closely related to how maleness is performed in the majority of societies. Compared to the general population, monks and nuns have longer life expectancy, with significantly less of a gap between the sexes. There is also less difference in how often monks and nuns are ill. With so much current focus in the social sciences on performing masculinities (playing the man) and the social construction of so much that we recently considered to be biological, it is surprising Luy’s work isn’t better known and discussed. See: Marc Luy, “Causes of Male Excess Mortality: Insights from Cloistered Populations,” Population and Development Review, 20 April 2004, 647–76. You talk a lot about biological factors—and of course high deaths rates during child birth in the past were very important, and have become less important to explaining the gaps; but increasingly over time biology may matter less; especially when major killers at young ages are cars (road crashes) and suicide.

Thank you for this comment. Indeed, external mortality has been more relevant in shaping sex differences in survival in recent years. This could be reflected on the decreasing trend of our phi statistic as more males die from external causes than females.

It is an important article that we now cite the results in the first paragraph of the article.

3) You say early on that the outsurvival statistic you create does not account for the dependence between individuals (under strengths and limitations). This is quite an opaque statement. I think what you mean is that for men and women who becomes couples are stay together into old age the statistic you are calculating does not
apply to them because they are very likely to be of similar social classes and thus the men are much more likely to die before the women; even more so given that the men (on average) tend to be older. If this is what you mean by dependence it might be worth making that more clear early on.

Thank you for your comment. We added precision to the statement in the strengths and limitations section. In addition, we compared our results to those found in papers studying the probability of women to outlive their husband. This statistic is around 60-70% in most studies.

4) In the supplementary material it would be fascinating if you could look at the years 1889-1893 in particular. These are the years in which the Russian Flu Pandemic circulated worldwide. Did it result in a temporary fall in the chances of men outliving women in those years. The reason why I say it would be fascinating is the theory that that disease was a coronavirus, not influenza, and just as with the pandemic today, men are much more likely to die as compared to women (once age is taken into account).

Following your suggestion, we did look at this period. However, we found no change in the trends. We attached the trends from 1880 to 1895.

Finally, you might be interested in this study I did with a colleague some years ago. No need to reference it (referees' have an annoying habit of trying to get their own papers cited!) but it may be of use in terms of ideas – especially over the very recent trends. By recent I mean the last few decades!
Reference: J Epidemiol Community Health. 2007 Feb;61(2):159-64: “Mortality in relation to sex in the affluent world”
Janette E Rigby and Danny Dorling DOI: 10.1136/jech.2006.047381

Thank you for the reference. As it was relevant to our study, we decided to reference your article.

Reviewer: 2 Dr. Iñaki Permanyer, Autonomous University of Barcelona (UAB),

Comments to the Author:
In this paper, the authors investigate the likelihood that males outlive females when hypothetical male and female individuals are picked at random from sex-specific life table age-at-death distributions. For that purpose, the authors apply the outsurvival statistic (φ; proposed in 2021 by James Vaupel and two other colleagues co-authoring this paper as well) to 44 populations taken from the Human Mortality Database (HMD).

While the study shows some curious results that, to the best of my knowledge, had not been documented before, I can’t help thinking that the paper is a somewhat mechanical application of a simple and intuitively appealing indicator to a “well-trodden database”. The φ indicator was already defined in a previous paper, and the HMD has been used so many times in the past to investigate mortality dynamics that its accessibility and manipulation are extremely smooth. What I mean is that if the key indicator has already been defined and the source of data is very standard for those working in the field, the added value of the paper is somewhat reduced.

There are, however, several ways in which the added value of the paper can be increased (some of which have been hinted by the authors themselves). Here I list (in no particular order) some suggestions the authors could take in case the paper were invited to be resubmitted to the journal.

1. Investigate the values of the outsurvival statistic across different SES groups. For instance, one could hypothesize that the values of φ might increase with increasing number of education years, or at higher income quantiles. While the number of countries where such investigation could be carried out is much smaller than 44, I think it would offer much more interesting insights.

Thank you for your comment. We added a comparison of the probability of males to outlive females between education levels in the US. The outsurvival statistic was higher among men and women with a university degree, compared to individuals without a high school diploma.

2. In the paper, the authors look at the probability that a randomly chosen man outlives a randomly chosen women, so to speak. It would be very interesting to compare such probabilities for the sub-population of married couples, and even comparing single men vis-à-vis single women, or some combinations in between (e.g., the probability that a randomly chosen single woman outlives a randomly chosen married woman).

We also compared the outsurvival statistic between marital status in the US. The outsurvival statistic was higher among married men and women, compared to unmarried individuals. Interestingly, married men have a probability higher than 50% to outlive unmarried women. In addition, we added a paragraph in the discussion about the probability of men to outlive their wife. This statistic was similar to the outsurvival’s but account for the age difference between wife and husband. Previous studies showed that the probability of men to outlive their wife is between 30% and 40%.
3. The authors rely on the HMD, which covers 44 high-income populations. However, other than having very high-quality data, there is no other reason why one should be interested in those specific 44 populations. Another possibility might be to carry out the analysis for geographically cohesive regions (e.g., Europe) or even enlarge the scope much further and investigate what happens at a global scale. While based on heavy modeling techniques, sex-specific life tables currently exist for all world countries.

Thank you for the comment. We now also used data from the WPP, including data for 199 countries. Trends between regions varied, but for all populations, the outsurvival statistic remained above 25%.

4. In the next to last paragraph in the discussion section, the authors speak about how their measures could help guiding policies aiming at reducing inequalities between the sexes. I found this part of the discussion a bit weak and incomplete. Before speculating what values of φ might one expect in case of “perfect gender equality” (whatever that means), it would be important to acknowledge and engage with the debate on the sex gap in life expectancy.

We revised the discussion section to include more discussion about the implications of the results in relation with current knowledge on sex gap in mortality and life expectancy.

5. When reviewing the literature on similar indicators, the authors briefly mention the KL divergence measure and the “Stratification index” (S) recently proposed by Shi and colleagues (the reference should be updated now, as the paper has been accepted for publication). On the one hand, I do not think the last sentence in the first paragraph in page 3 does help much to clarify what the KL indicator is about and why it is disregarded. On the other hand, I do not understand why the authors consider that the interpretation of the S index is cumbersome. As I see it, the two indicators have much in common, and there is much to praise in both, so I think the current paper could be enriched by engaging more deeply in a comparison between the two approaches (advantages and disadvantages, and so on).

Thank you for the comments. The word cumbersome might have been too strong. We now added a more detail comparison between the KL divergence, the Stratification index (S) and the outsurvival statistic. The main disadvantage of the KL divergence is that it is not symmetric, meaning that the effort needed to transform male’s distribution into female’s is not the same as the effort needed to transform female’s distribution into male’s. S and phi are closely related, but differ in the interpretation. Shi pointed that S measures inequality at the societal level and phi interprets it at the individual level. In addition, while S informs on the level of overlap, it does not directly inform on which population outlive the other. With the phi, we can both assess the overlap and which population has the advantage. However, all three measures are strongly correlated. We added an appendix comparing these measures.

The reference from Shi and colleagues has been revised.
**GENERAL COMMENTS**

I think the paper should be published now.

I have two minor points:

Firstly, on page 8 you state that “Figure 5 shows the same relations as shown in Figure 4 but for survivors to age 50. Lifespan variation at age 50 has stayed roughly constant over time” – however you are only showing the lifespan variation of females in Figure 5. Could you also show it for males? I suspect it has increased over time for men and that is part of what explains what you are finding.

Secondly, in your discussion on page 10 you state that “Not all females outlive males. For example, a sex difference in life expectancy at birth of 10 years can come with a probability of males outliving females as high as 40%, indicating that at 40% of males have a longer lifespan than that of a randomly paired female. Therefore, not all males have a disadvantage of 10 years, something that is overlooked by solely making comparisons of life expectancy.”

Overlook should be overlooked in the above sentence; but my main suggestion is this: Perhaps it would be more fair to rewrite it in some way along these lines: “Not all females outlive males – but a majority do. The minority that do not is not small. A sex difference in life expectancy at birth of 10 years can come with a probability of males outliving females as high as 40%, indicating that at 40% of males have a longer lifespan than that of a randomly paired female. However, people tend not to pair up at random and so the actual probabilities for actual pairs are smaller than this (men with university degrees are more likely to marry women with university degrees, although women who do not marry often live longer than women who do marry). Not all males have a disadvantage of 10 years when the overall difference is 10 years, something that is overlooked by solely making comparisons of life expectancy. However a small number of males will live very short lives to result in that difference. More baby boys die than baby girls in most places and increasingly over time. Young men are much more likely than young women to die when young.”

You do touch on some of these points later on page 12; but you may give an misleading overall impression because you are trying to make your point so strongly.

A similar case could be made for some poorer people living longer than some randomly paired richer people. But that would still not negate the fact that on average poorer people live less longer than richer people.

It is a very good paper using many sources - but I would urge you to look at male variation as well as female (my first point above...
relating to Figure 5) and secondly to be a little more nuanced about what you have found. So men live longer than randomly paired women, a few men live much short lives than randomly paired women. In many cases those that live the short lives will not get to be a pair as they died too young. This happens more for men than for women.

REVIEWER
Permanyer, Iñaki
Autonomous University of Barcelona (UAB), Centre for Demographic Studies

REVIEW RETURNED
04-May-2022

GENERAL COMMENTS
I think the authors have satisfactorily addressed the issues raised in my previous report. As I see it, the new version of the paper is even more interesting than the previous one.

VERSION 2 – AUTHOR RESPONSE

Reviewer Reports:

Reviewer: 1
Dr. Danny Dorling, University of Oxford

Comments to the Author:
I think the paper should be published now.

I have two minor points:

Firstly, on page 8 you state that “Figure 5 shows the same relations as shown in Figure 4 but for survivors to age 50. Lifespan variation at age 50 has stayed roughly constant over time” – however you are only showing the lifespan variation of females in Figure 5. Could you also show it for males? I suspect it has increased over time for men and that is part of what explains what you are finding.

Thank you for your comments. We did find a similar relation between phi and the SD for males from age 50. We added the results in the supplementary materials.

Secondly, in your discussion on page 10 you state that “Not all females outlive males. For example, a sex difference in life expectancy at birth of 10 years can come with a probability of males outliving females as high as 40%, indicating that at 40% of males have a longer lifespan than that of a
randomly paired female. Therefore, not all males have a disadvantage of 10 years, something that is overlooked by solely making comparisons of life expectancy.”

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You do touch on some of these points later on page 12; but you may give an misleading overall impression because you are trying to make your point so strongly.

A similar case could be made for some poorer people living longer than some randomly paired richer people. But that would still not negate the fact that on average poorer people live less longer than richer people.

Thank you. We did modify the first paragraph along the lines you suggested. It softens the tone of the discussion.

It is a very good paper using many sources - but I would urge you to look at male variation as well as female (my first point above relating to Figure 5) and secondly to be a little more nuanced about what you have found. So men live longer than randomly paired women, a few men live much short lives than randomly paired women. In many cases those that live the short lives will not get to be a pair as they died too young. This happens more for men than for women.

Reviewer: 2

Dr. Iñaki Permanyer, Autonomous University of Barcelona (UAB)

Comments to the Author:

I think the authors have satisfactorily addressed the issues raised in my previous report. As I see it, the new version of the paper is even more interesting than the previous one.
Thank you for all the previous suggestions. We believe they did help a lot to improve the paper.

**VERSION 3 – REVIEW**

| REVIEWER       | Dorling, Danny  
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**GENERAL COMMENTS**

It's a great paper. No more comments from me about altering it. But one suggestion for future work. Coronavirus is much more deadly for men than for women, may be 50% more for any particular age group. Increasingly, we are seeing papers in medical journals now appearing in print suggesting that the after effects of having the disease, especially increases in heart disease, are raising mortality more, or much more, in older men than in older women. Your paper may be being published based on data released at the point of lowest recent inequality. As the relatively new disease almost entirely effects people in old age, there may now be a fall taking place now in the proportion of men who live longer than women. But you need data for 2021 and early 2022 to test this for a variety of countries - as it would be very useful to know how universal this new trend is. I hope you do repeat this work but with that very recent data for a future paper. And thank you for writing such a good paper on the historic and recent record.