

PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form ([see an example](#)) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below. Some articles will have been accepted based in part or entirely on reviews undertaken for other BMJ Group journals. These will be reproduced where possible.

ARTICLE DETAILS

TITLE (PROVISIONAL)	Life expectancy and disparity
AUTHORS	Vaupel, James; Zhang, Zhen; van Raalte, Alyson

VERSION 1 - REVIEW

REVIEWER	<p>Vladimir Canudas-Romo, Ph.D. Assistant Professor Department of Population, Family & Reproductive Health Johns Hopkins Bloomberg School of Public Health 615 N Wolfe Street, Room E4634 Baltimore, MD. 21205. USA Ph: 410.955.8694 Fax: 410.502.5831 vcanudas@jhsph.edu</p> <p>I declare that I don't have any competing interest.</p>
REVIEW RETURNED	12-Apr-2011

THE STUDY	<p>I enjoyed greatly reading this paper.</p> <p>I answered "No" in the question above: main outcome measure clear? and here below is the explanation to my confusion:</p> <p>"Figure 2 shows the relationship between total life disparity, early life disparity up to the threshold age and late life disparity after the threshold age." I am wondering how appropriate it is to compare the late and early disparities across time when the threshold mark to define them is moving over time? This is similar to the limitation that some authors have had by describing the disparity in the modal age at death by only looking at the standard deviation after the modal age at death (in this case the modal age at death has moved over time). For the research of the mode I proposed to look instead at the standard deviation to the modal age at death (instead of to the mean), which includes deaths below and above the mode and avoids the problem of only looking at one part of the distribution of deaths when the threshold measure is moving over time (Demog Research 2008). The authors should try to standardized the late and early disparities to account for the moving threshold.</p> <p>Furthermore, in page 4 it is mentioned "Lifespan disparity, on the other hand, narrows or widens depending on the balance between saving lives at 'early' ages, which compress the distribution of lifespan, and saving lives at 'late' ages, which expands this distribution." this seems to suggest a positive and negative term, but actually both terms add positively to the total lifespan disparity in Fig 2.</p>
RESULTS & CONCLUSIONS	I actually have only a minor comment for the conclusion:

	<p>in page9 it is written that "The lower life disparity is, the greater is the rate of progress needed to achieve an additional year of life expectancy. Consequently, it might be thought that countries with long life expectancy would tend to have high life disparity." I don't see how the authors go from one sentence to the next to include the word "consequence". It might indeed be harder for the high life expectancy to reach even higher levels, but those levels were already achieved because of great reduction in life disparity, so at which moment do they go back to have high life disparity?</p>
GENERAL COMMENTS	<p>Recently, I calculated the record modal ages at death which, together with the record life expectancies, complement each other to fully explicate the different stages of mortality (Demography 2010): namely the transition from a phase of infant mortality reductions to a phase of adult mortality reductions. Your manuscript made me wonder if it would make sense to contrast the record modes with their life disparities? I am not suggesting that the authors do it, but it could perhaps be appropriate to include a short paragraph in the discussion of future possible research in the field that the authors suggest on how to take advantage of the life disparity measure.</p>

REVIEWER	<p>Prof Alastair H Leyland MRC/CSO Social and Public Health Sciences Unit 4 Lilybank Gardens Glasgow G12 8RZ</p> <p>I declare that I have no competing interests.</p>
REVIEW RETURNED	17-Apr-2011

THE STUDY	<p>Most of the NO answers above relate to a lack of clarity over methods. It is not clear that the authors are in any way looking longitudinally at how changes in life disparity have led to changes in life expectancy; I think it more likely that they are looking cross-sectionally at associations between the two. This would substantially alter all conclusions. I may have misunderstood what they have done, in which case more detail about the methods may be sufficient.</p>
RESULTS & CONCLUSIONS	<p>See above regarding doubts about the methodology. The results are also very brief at present, with a lot of information being presented as a title/footnote to different figures.</p>
GENERAL COMMENTS	<p>This thoughtful paper examines life expectancy and life disparity for men and women in 40 countries over more than a century. The authors draw conclusions based on causation; the methods remain unclear to me, however, as they appear to be using repeated cross-sections which would show association rather than causation.</p> <ol style="list-style-type: none"> 1. The focus on the fact that in 89 of 170 years, the country with the highest (male) life expectancy had the lowest life disparity is not particularly helpful. We have no sense as to whether this is the same country each time or whether it covered a broad range of countries – I suspect the former. 2. The methods are not adequately described; for example, I cannot tell how the authors calculated “the respective contributions of averting premature and late deaths to increases in life expectancy”. The suggestion is that there is a time element to be able to judge increases in life expectancy. 3. It is not possible to attribute increases in life expectancy to decreases in life disparity (third sentence of results) based on these

	<p>data – or certainly not based on examination of figure 1.</p> <p>4. Results para 1: “Although mortality at older ages has come down considerably...” – presumably you mean the mortality rate at older ages?</p> <p>5. Figure 2 only has time in rather broad groups and so does not in itself show that life disparity has reduced from 25 years in 1840 to between 9 and 12 years at present (we do not know which points represent 1840 or the present, only those for 1840-1899 and 1950-2009). The footnote to figure 2 is lengthy and confusing; it refers to other analyses without detailing them. “The three curves can be fit by linear regression” presumably refers to a regression of life disparity on life expectancy for total, early and late life disparity. And by linear regression I presume that the authors do not mean that only a linear term in life expectancy was fitted, since the relationships are clearly non-linear, but rather that linear (as opposed to generalised linear) models were used. But what about the clustering of observations within countries – was multilevel analysis used? Were the models weighted according to population size or were the data for Luxembourg given the same weight as those from the USA? To what extent does the correlation coefficient reflect correlation between observations within countries? (The same applies to the measures in table 2 of the Appendix.) If the analyses reported in this footnote are considered important then I suggest that they should be moved to the main text and described (methods and results) in detail.</p> <p>6. Without details of methods as suggested in 2 (above), it is not possible to see how the authors are able to suggest that “84% of the increase in female life expectancy resulted from decreases in premature deaths” (results, para 2) or to determine whether this is indeed causation or just association. This also holds for the first sentence of the discussion and the main conclusion of the paper.</p> <p>7. “Life disparity in the U.S. is worse than many Eastern European countries for both males and females”. Whilst this may be true for females, table 1 suggests that only 4 Eastern European countries have a male life disparity lower than that for the U.S. It is unclear why there is a focus on the U.S. (e.g. the highlight in figure 1).</p> <p>8. Figure 3 is not mentioned in the results.</p>
--	---

REVIEWER	<p>M Murphy Professor of Demography London School of Economics UK</p> <p>No conflict of interest</p>
REVIEW RETURNED	22-Apr-2011

THE STUDY	These are not relevant to the content of this paper. They do not affect the paper.
GENERAL COMMENTS	This is an interesting paper that sets out the changing contribution of mortality at different ages to the overall increase in relation to the disparity in ages at death. The paper summarises the literature well, and it introduces a range of indicators of variability in ages at death, many of which may be unfamiliar to readers. It concentrates on an indicator that defines a cut-off age for ‘premature’ deaths. The paper serves to act as a counterweight to some of the more pessimistic views about stalls in future mortality decline by adopting a long-term perspective. The paper also highlights the benefits of considering ‘young’ and ‘old’ ages as relative and dependent on the mortality

	<p>regime, rather than using a fixed indicator such as proportion of deaths above a fixed age limit such as 65 or 80.</p> <p>Although not directly relevant to clinical decision-making, this work reinforces the conclusion of a recent BMJ editorial “Premature deaths should be the priority for prevention” (BMJ 2010; 341:c3946 doi: 10.1136/bmj.c3946 22 July 2010) although differences in the definition of ‘premature’ could be expanded.</p> <p>The fact that the country with the highest life expectancy had the lowest disparity in a given year is consistent with the fact that disparity tends to be smaller with increasing life expectancy. It would therefore be interesting to see how disparity of record holders compared with disparity of non-record holders at the same level of life expectancy rather than in comparison with values in the same year.</p> <p>The question of causality could be expanded – increased life expectancy is assumed to occur because of a decrease in early life disparity. It might be more natural to attribute both increasing life expectancy and reduced disparity to lower early age mortality</p> <p>The threshold age is highly correlated with life expectancy at birth – it would be interesting to know not only the magnitude of the correlation, but also how far the magnitudes are similar (e.g. is the regression coefficient close to 1?).</p>
--	---

VERSION 1 – AUTHOR RESPONSE

Reviewer(s)' Comments to Author:

Reviewer: Vladimir Canudas-Romo, Ph.D.

Assistant Professor

Department of Population, Family & Reproductive Health

Johns Hopkins Bloomberg School of Public Health

615 N Wolfe Street, Room E4634

Baltimore, MD. 21205. USA

Ph: 410.955.8694

Fax: 410.502.5831

vcanudas@jhsph.edu

I declare that I don't have any competing interest.

I enjoyed greatly reading this paper.

I answered "No" to the question above: 'is the main outcome measure clear?' and here below is the explanation to my confusion:

"Figure 2 shows the relationship between total life disparity, early life disparity up to the threshold age and late life disparity after the threshold age." I am wondering how appropriate it is to compare the late and early disparities across time when the threshold mark to define them is moving over time? This is similar to the limitation that some authors have had by describing the disparity in the modal age at death by only looking at the standard deviation after the modal age at death (in this case the modal age at death has moved over time). For the research of the mode I proposed to look instead at the standard deviation to the modal age at death (instead of to the mean), which includes deaths below and above the mode and avoids the problem of only looking at one part of the distribution of

deaths when the threshold measure is moving over time (Demog Research 2008). The authors should try to standardized the late and early disparities to account for the moving threshold.

- The reason we looked at the early and late life disparity components without standardizing them to the threshold age was precisely because we were interested in their relative importance to the total change in life disparity and life expectancy with advances in life expectancy. Too often, changes in lifespan variability are monitored without delving into the mechanisms behind it (changes in the early or late life components).
- We agree that standardizing the early and late life disparity components to the threshold age would be an interesting exercise. This, however, would answer different research questions, more in line with public health research about how mortality changes before or after a fixed age cut-off point (for example life years lost up to age 65). Over shorter time horizons, this would be a good approach.
- Given the long time horizon that we are examining in the current paper, however, we believe that a moving definition of premature vs. late deaths best reflect how we as society perceive a death to be either premature or occurring in later life. In this case, the moving threshold age (or moving mode) is a fundamental dynamic that should figure into the calculations.

Furthermore, in page 4 it is mentioned "Lifespan disparity, on the other hand, narrows or widens depending on the balance between saving lives at 'early' ages, which compress the distribution of lifespan, and saving lives at 'late' ages, which expands this distribution." this seems to suggest a positive and negative term, but actually both terms add positively to the total lifespan disparity in Fig 2.

- The positive and negative terms are the change in life disparity, not life disparity itself. Saving lives at early ages would compress this distribution, and reduce the life years lost due to death, which would decrease life disparity. Saving lives at late ages would increase the average remaining life expectancy from this age onward, which would expand this distribution. We have amended the text to make it clearer.

I actually have only a minor comment for the conclusion:

In page9 it is written that "The lower life disparity is, the greater is the rate of progress needed to achieve an additional year of life expectancy. Consequently, it might be thought that countries with long life expectancy would tend to have high life disparity." I don't see how the authors go from one sentence to the next to include the word "consequence". It might indeed be harder for the high life expectancy to reach even higher levels, but those levels were already achieved because of great reduction in life disparity, so at which moment do they go back to have high life disparity?

- We weren't trying to suggest that they would have had to go back to the old regime, more that an alternative strategy to life expectancy gains could have come from a different age profile of mortality reduction, which would have maintained similar levels of inequality in the lifespan distribution, and require a lower average rate of progress in reducing mortality. This of course didn't happen because of the reductions in premature mortality, which reduced life disparity.

Recently, I calculated the record modal ages at death which, together with the record life expectancies, complement each other to fully explicate the different stages of mortality (Demography 2010): namely the transition from a phase of infant mortality reductions to a phase of adult mortality reductions. Your manuscript made me wonder if it would make sense to contrast the record modes

with their life disparities? I am not suggesting that the authors do it, but it could perhaps be appropriate to include a short paragraph in the discussion of future possible research in the field that the authors suggest on how to take advantage of the life disparity measure.

- We agree that this would be an interesting future research avenue and added a line about this to the discussion.

Reviewer: Prof Alastair H Leyland
MRC/CSO Social and Public Health Sciences Unit
4 Lilybank Gardens
Glasgow G12 8RZ

I declare that I have no competing interests.

Most of my concerns relate to a lack of clarity over methods. It is not clear that the authors are in any way looking longitudinally at how changes in life disparity have led to changes in life expectancy; I think it more likely that they are looking cross-sectionally at associations between the two. This would substantially alter all conclusions. I may have misunderstood what they have done, in which case more detail about the methods may be sufficient.

The results are also very brief at present, with a lot of information being presented as a title/footnote to different figures.

This thoughtful paper examines life expectancy and life disparity for men and women in 40 countries over more than a century. The authors draw conclusions based on causation; the methods remain unclear to me, however, as they appear to be using repeated cross-sections which would show association rather than causation.

- We are indeed looking at cross-sectional associations between life expectancy and life disparity, and are not trying to infer causation. Rather, we are arguing that it is progress at reducing premature mortality which drives differences in life expectancy and life disparity. Our conclusion, that life expectancy leaders have low lifespan variation, comes from the finding that life expectancy leaders have been more effective than other countries in tackling premature mortality (which is best seen by the outcome of having lower early-life disparity).

- We have clarified the text to avoid any suggestion that we are inferring a causal process running from low life disparity to high life expectancy.

1. The focus on the fact that in 89 of 170 years, the country with the highest (male) life expectancy had the lowest life disparity is not particularly helpful. We have no sense as to whether this is the same country each time or whether it covered a broad range of countries – I suspect the former.

- It is certainly many countries. The idea of looking at the record country is in the spirit of Oeppen and Vaupel (2002), where they showed that although individual countries may go up and down in their mortality trends, the trend from the record country is stable and linear. In this paper we show the stable association between record life expectancy and record life disparity. Thus here too any particular country might go up and down relative to others on both dimensions. We have added a table to the appendix which shows the record country for life expectancy and life disparity for each

year, as well as how much this country differed from the average.

- Ref: Oeppen J, Vaupel JW. Broken Limits to Life Expectancy. *Science* 2002 May 10;296(5570): 1029-31.

2. The methods are not adequately described; for example, I cannot tell how the authors calculated “the respective contributions of averting premature and late deaths to increases in life expectancy”. The suggestion is that there is a time element to be able to judge increases in life expectancy.

- We have added the citations to the part in the main text describing the calculation of the respective contributions, which we also further elaborated on in the supplementary material.

- Refs added: Vaupel JW, Canudas Romo V. Decomposing Change in Life Expectancy: A Bouquet of Formulas in Honor of Nathan Keyfitz's 90th Birthday. *Demography* 2003 05;40(2): 201-16.

- Zhang Z, Vaupel JW. The age separating early deaths from late deaths. *Demographic Research* 2009;20: 721-30.

3. It is not possible to attribute increases in life expectancy to decreases in life disparity (third sentence of results) based on these data – or certainly not based on examination of figure 1.

- You're right. It is of course the reduction in premature mortality which drove both the increase in life expectancy and the reductions in early-life disparity. We have changed this section of the paper to make it more clear.

4. Results para 1: “Although mortality at older ages has come down considerably...” – presumably you mean the mortality rate at older ages?

- Yes, we have changed this.

5. Figure 2 only has time in rather broad groups and so does not in itself show that life disparity has reduced from 25 years in 1840 to between 9 and 12 years at present (we do not know which points represent 1840 or the present, only those for 1840-1899 and 1950-2009).

- This is true. The 25 years was referring to the average level in 1840 (see new table S3 in appendix) while the 9 to 12 years at present could be seen from Table 1 females (in fact we changed the text to 9 to 15 years, since we were not referring explicitly to females). We wished to emphasize here the strong relationship between life expectancy and life disparity, which Figure 2 shows to be driven by different levels of premature mortality as opposed to levels of old age mortality. The time period is not so important here, given that mortality levels vary at any given time by country.

The footnote to figure 2 is lengthy and confusing; it refers to other analyses without detailing them. “The three curves can be fit by linear regression” presumably refers to a regression of life disparity on life expectancy for total, early and late life disparity. And by linear regression I presume that the authors do not mean that only a linear term in life expectancy was fitted, since the relationships are clearly non-linear, but rather that linear (as opposed to generalised linear) models were used. But what about the clustering of observations within countries – was multilevel analysis used? Were the models weighted according to population size or were the data for Luxembourg given the same

weight as those from the USA? To what extent does the correlation coefficient reflect correlation between observations within countries? (The same applies to the measures in table 2 of the Appendix.) If the analyses reported in this footnote are considered important then I suggest that they should be moved to the main text and described (methods and results) in detail.

- We agree that the current statistical analysis described in the footnote to figure 2 might be confusing and does not add much value to the overall paper, for this reason have taken it out. The further multilevel analysis that you suggest, though worthwhile to do, would probably go beyond the scope of the current paper and would make an interesting paper on its own – a great idea for further research.

6. Without details of methods as suggested in 2 (above), it is not possible to see how the authors are able to suggest that “84% of the increase in female life expectancy resulted from decreases in premature deaths” (results, para 2) or to determine whether this is indeed causation or just association. This also holds for the first sentence of the discussion and the main conclusion of the paper.

- We have elaborated on the method in the supplementary material.

7. “Life disparity in the U.S. is worse than many Eastern European countries for both males and females”. Whilst this may be true for females, table 1 suggests that only 4 Eastern European countries have a male life disparity lower than that for the U.S. It is unclear why there is a focus on the U.S. (e.g. the highlight in figure 1).

- We changed the text to read ‘most’ for females and ‘some’ for males. The focus on the United States is because they have exceptionally high variability in age-at-death compared to other countries with similar national income. Picking one point also made it easier to describe how figure 1 should be read.

8. Figure 3 is not mentioned in the results.

- Figure 3 was not meant to be a main result of our paper but rather a rebuttal to the conclusions of Smits and Monden, which went directly against our conclusions. This is why it is only brought up in the discussion.

Reviewer: M Murphy
Professor of Demography
London School of Economics
UK

No conflict of interest

This is an interesting paper that sets out the changing contribution of mortality at different ages to the overall increase in relation to the disparity in ages at death. The paper summarises the literature well, and it introduces a range of indicators of variability in ages at death, many of which may be unfamiliar to readers. It concentrates on an indicator that defines a cut-off age for ‘premature’ deaths. The paper serves to act as a counterweight to some of the more pessimistic views about stalls in future mortality decline by adopting a long-term perspective. The paper also highlights the benefits of considering ‘young’ and ‘old’ ages as relative and dependent on the morality regime, rather than using a fixed

indicator such as proportion of deaths above a fixed age limit such as 65 or 80.

Although not directly relevant to clinical decision-making, this work reinforces the conclusion of a recent BMJ editorial “Premature deaths should be the priority for prevention” (BMJ 2010; 341:c3946 doi: 10.1136/bmj.c3946 22 July 2010) although differences in the definition of ‘premature’ could be expanded.

- We have better highlighted differences in the definition.

The fact that the country with the highest life expectancy had the lowest disparity in a given year is consistent with the fact that disparity tends to be smaller with increasing life expectancy. It would therefore be interesting to see how disparity of record holders compared with disparity of non-record holders at the same level of life expectancy rather than in comparison with values in the same year.

- We have added a figure in the appendix showing this.

The question of causality could be expanded – increased life expectancy is assumed to occur because of a decrease in early life disparity. It might be more natural to attribute both increasing life expectancy and reduced disparity to lower early age mortality.

- Yes this is true. We rephrased the text to show that it was progress against premature mortality that achieved both increases in life expectancy and decreases in early life disparity.

The threshold age is highly correlated with life expectancy at birth – it would be interesting to know not only the magnitude of the correlation, but also how far the magnitudes are similar (e.g. is the regression coefficient close to 1?).

- We have added this to the text.

VERSION 2 - REVIEW

REVIEWER	<i>Alastair H Leyland</i>
REVIEW RETURNED	07-Jun-2011

GENERAL COMMENTS	<p>1. The methods section needs a couple of sentences describing the data. Currently the number of countries (40) is mentioned but not the number of years (170) or the number of observations (?).</p> <p>2. I still do not find the fact that in 89 of 170 years, the country with the highest (male) life expectancy had the lowest life disparity particularly informative. In the 170 years there were only 7 countries that had the highest life expectancy in one or more years. In 89 years the same country had the lowest disparity. So 33 of the 40 countries do not contribute to this analysis. Please present a more convincing argument as to why this might be important.</p> <p>3. Whether life expectancy in the US is short compared to countries of similar income per capita cannot be judged from table 1 since the income per capita data are not included. Perhaps a term such as “other developed countries” would suffice?</p>
-------------------------	--

VERSION 2 – AUTHOR RESPONSE

Dear Alastair Leyland,

Please find attached our revised article "Life expectancy and disparity".

We agreed with all of your suggestions and have highlighted the changes in the document using the 'track changes' feature.

In particular:

"The methods section needs a couple of sentences describing the data. Currently the number of countries (40) is mentioned but not the number of years (170) or the number of observations (?)."

1) We added the number of years and number of lifetables used in the analysis in the methods.

"I still do not find the fact that in 89 of 170 years, the country with the highest (male) life expectancy had the lowest life disparity particularly informative. In the 170 years there were only 7 countries that had the highest life expectancy in one or more years. In 89 years the same country had the lowest disparity. So 33 of the 40 countries do not contribute to this analysis. Please present a more convincing argument as to why this might be important."

2) All countries contributed to this analysis. We were surprised by the strength of this relationship, given that there is no reason why the average age at death (life expectancy) and the variability around the average age at death (life disparity) have to be so closely related to one another. This is not only true for the leading country, but as Figure 1 shows, generally the further a country is from the leader in life expectancy, the further is that country from the lowest life disparity level, and vice versa. We have added a few lines to the text to better explain why this is a remarkable finding.

"Whether life expectancy in the US is short compared to countries of similar income per capita cannot be judged from table 1 since the income per capita data are not included. Perhaps a term such as "other developed countries" would suffice?"

3) We changed this to "other highly developed countries".

Thank you for your time and effort to review our manuscript. Please do not hesitate to contact me if you require any further information.

Cordially, on behalf of all authors,

Prof. James W. Vaupel