

Review of "Uncovering the 2010 Haiti earthquake death toll", by J. E. Daniell, B. Khazai, and F. Wenzel

Reviewed by D. J. Wald

This manuscript takes on a rather important issue: getting a best estimate of the 2010 Haiti earthquake death toll. This number plays an important role in a number of other studies, our perception of this particular earthquake, and the scale of earthquake fatalities in general. That said, there are some serious shortcomings in this manuscript that require major revision prior to resubmission and publication.

I first point out that in some endeavors the desire for determining the "right" answer does not necessarily mean the right answer is knowable. This may be the case for the death toll from the Haiti earthquake. There is nothing presented in the manuscript that makes it obvious to this reviewer that we *can* know even an approximate answer, much beyond the authors (likely correct) assertion that the official values reported by the Haitian government are likely both highly inflated and unsupported by evidence. Beyond that, what has been presented gives me little confidence that we now have authoritative or even citable median and uncertainty values for the 2010 Haiti earthquake's total fatality toll. Despite attempting to be quantitative, there are too many assumptions made along the way that, would, if made differently, completely change the range of numbers.

In assessing the science and potential for recovering a death toll for the Haiti earthquake that would make this reviewer comfortable citing, I can't imagine that alternative approaches would not be more fruitful. For instance, a more standard approach than that taken would be to assess the reasonableness and ranges of loss models put forth (and perhaps weight them as well), but probably more useful, pursue back-of-the-envelope reality checks and ranges based on (1) best population data (some quoted in this paper), (2) inferred building inventory and collapse rates, and (3) associated occupancy and fatality rates. The latter two could be generalized, yet could also be ground truthed for specific locations to build confidence. This reviewer is disappointed these avenues were not pursued.

Below are a number of technical issues that are rather important for the authors to address, refine, or toss altogether. Below these enumerated comments, I detail items more editorial in nature. My editorial comments are not comprehensive since I consider much of the writing needs to be replaced and improved and it will thus require a more comprehensive edit at a later point.

Critical comments:

1. [Page 1918.] One serious set of concerns is the lack of a logical strategy to associate fatalities with buildings "destroyed" or "damaged", and more so with building tagging. In particular, I have trouble with the implicit conflation of red tagging and building-collapse. Tagging is (or should be) about future *habitability*. Keep in mind that, among other subtleties, red tagging can simply mean a building is undamaged, but it is adjacent to a large building that may collapse at any moment. More critically, completely collapsed structures that may have caused most of the fatalities do not need tagging. So, essentially,

there is little reason, or at least none is given, to tie the tagging statistics directly with fatality estimates. As this plays a central role in your analysis, the assumptions here need to be much better justified. There are also several indefensible assumptions, like: "Given that red tagged buildings by definition are those unsafe, we assume that nearly all deaths occur in these buildings."

Another difficult, perhaps irreconcilable, task is employing the Haiti government (HG) estimates of buildings "destroyed" and "damaged" to estimate fatalities. This is glossed over and other questionable assumptions are made:

"Although it is impossible to convert building damage levels to tagging levels directly, assumptions have been made to undertake this. The red tagged buildings were distributed using all EMS-98, completely destroyed and severely damaged buildings. For the Haiti Government estimate through the last available SNGRD report, 105 369 buildings were reported to be destroyed, and 208 164 damaged. Of the destroyed, all were assumed to be red. For the damaged buildings however, they include all damage classes – thus, a value of 15 % damaged buildings were added into red buildings, 70 % of these damaged were assumed to be yellow, and 15 % assumed to be green. We assume 400 000 buildings as the building count."

These are rather tenuous assumptions. First, you are highly critical of the HG fatality estimates, yet you employ their building numbers. Second, how do you justify what "destroyed" and "damaged" mean when it comes to fatality *rates* or estimates? It seems like fatality rates for each are still completely unconstrained (neither occupancy nor mortality rates are discussed), unless you can justify them better? The assumption of 400,000 buildings is also disconcerting, as this number is just propagated from the number tagged buildings, not from some comprehensive count or inventory.

The assumptions continue. [P.1923.] "In a more qualitative bottom-up approach, it is the opinion of the authors, using damage data, that the loss estimate via other death methods such as cremation was closer to 20 000. In addition, death tolls in Port-au-Prince area (Port-au-Prince, Delmas, Petionville) should be estimated to be around 70 000 rather than 35 000 using higher population density and destruction rates than in other locations (Melissen, 2010). If approximately 40 000 people were under the rubble instead of the 30 000 detailed by Melissen, distributed across the disaster area, a total value of up to 147 000 dead is found using the initial Melissen death tolls as a basis." Again, there are so many assumptions here, I don't have the time to critique or even parse them all. The Melissen (Radio Netherlands) study cited is not particularly scientific; it's not reviewed, it's really more a hand-waving radio report than a comprehensive study. Why 70K instead of 35K? What justifies 40K instead of 30K? You seem to be using multiples of two, which scares me.

[P.1923.] "Given the number of bodies needed to be found since 1 April, and the historic overestimate of Renois quoting 280 000 buildings destroyed, it can be assumed that the value of 316 000 deaths is an aberration. Instead we correlate the value of 222 570 (+869 missing) deaths to the building damage associated with the Government of Haiti as a first estimate (136 593 buildings red-tagged)." This is the same issue: equating fatalities to

buildings "destroyed" or "red-tagged" is unsupported without an occupancy and fatality rate per structure type being specified. Scaling up and down numbers is not supported.

2. Statements or commentary critical of aid policy should be avoided. There are subtle and not-so-subtle criticisms or policy statements that should be removed or replaced with facts, not commentary. For example, [P. 1915]: There is no question that China's response was impressive in contrast to Haiti's, so it is noteworthy, but only is so much as it affects your thesis concerning fatalities. Yet, some comments are unsupported or biased: "Haiti, unlike China where a very strong military response was mobilized within minutes,...". China's military response was mobilized in minutes? Really? "In China, machines and methods to remove debris, tents and support systems were in place quickly and many decentralized stations were mobilized allowing for relief". Please provide citations (other than from Chinese authorities) to support this. Better, provide numbers pertaining to the issue relevant to this paper: What did Chinese response provide in terms of lives saved? How is that relevant with respect to lives *not* saved (and thus total fatalities) in Haiti? If these numbers are not quantified, how can you relate it back to the relative lack of rescues (also not quantified) or the survival rate in Haiti?

The match of international aid and estimated fatalities is beyond the scope of the manuscript, and also represents unwarranted social commentary. "Studies of international aid in recent natural disasters reveal that large distributions of aid which do not match the respective needs may cause oversupply of help, aggravate corruption and social disruption rather than reduce them, and lead to distrust within the donor community." This is just one limited perspective on a very complex aid picture. Significant editorializing on pages 1927, all of 1928, and in the Conclusions is also, in this reviewer's opinion, unwarranted commentary. All these complex, universal issues would be present even if fatality data were perfect, which its obviously not, so I don't see how it belongs in this manuscript.

3. Significant digits. Since the conclusions are primarily about numbers, please review the basic rules (including the use of fractions, multiplication, weighting, and employing terms with the fewest significant digits). This comes to light throughout the manuscript, but particularly in Table 4, where weighting the various death toll estimates is done with one or two significant digits, some values themselves have only two digits, yet you carry six in the answers. This false precision is inconsistent with the overall point of the paper: the uncertainty in the Haiti fatality numbers. The summary statement on P1925, "Thus, the Haiti death toll is more likely to be 136 933, with a range of 121 843 to 167 082 dead (Table 4)." is indicative of this problem. Elsewhere appropriate precision is applied, but not throughout.

4. Section 5 "The historical difficulties with death toll counts" is uninformative. The authors suggest that through a study of historical earthquake death tolls, that both underestimates and overestimates of earthquake death tolls occur in cases. That does not translate to Haiti specifically, one way or another. The reasons given explaining how the HG estimates may be too high are also, well, rather confused:

[P1920] "1. despite being ill-equipped to handle the rescue of victims, the use of community involvement in rescue cannot be ignored and studies have shown that over 90 % of lightly trapped victims still alive are rescued by people at the scene of collapse (Krimgold, 1989). OK, community rescue is noteworthy, but what is the point here? Did this matter (help or hurt fatality rates) in Haiti? Number 2 (concerning building height and fatality rates) is irrelevant as well: if more than 100,000 *were* killed, why is 150,000 or 300,000 not possible? Obviously, *there are very deadly buildings* in the region. Number 3 also serves as a qualitative but unsubstantiated statement. The contrary statements (1-2), are also, I'm afraid, irrelevant. These are simply factors that can push the total death toll in one direction or the other, but none limit the possible ranges of fatalities.

[P1922] During analysis of historic death tolls through the use of CATDAT (Daniell, 2003-2013), it can be seen that many initial death tolls can be multiplied by 3 to approximate the final death toll. This would make approximately 135 000 to 150 000, using the initial PAHO and UN estimates." "Initial death tolls"? What initial death tolls? How do you declare an "initial" estimate official, and when? This quantitative statement is not properly justified.

5. [P1922]. "This is a total of 93 000 more deaths since the 1 April 2010, thus accounting for 327 bodies found or measured every day since then, if the original Haitian government death toll is to be used." This is disconcerting logic. Updating total fatality estimates is not simply finding more bodies *per day*. There are numerous *legitimate* reasons why surveys would have numbers come out either higher or lower over time, due to double counting, improved data, data consolidation, etc. The assertion that the HG could not have kept up such a daily head count to mock the higher HG number is either naïve or in extremely poor taste. This statement is thrice repeated elsewhere in the manuscript (P1924, for one). These statements simply do not belong.

6. [P1923] "A top-down and bottom-up approach can be used. It can be assumed that the errors in death counts are associated also with double-counting, and the fact officials were overwhelmed by the extent of the disaster." First, I don't understand what "top-down" and "bottom-up" refer to or mean? I've not seen these terms used other than in business management. The second sentence, starting, "It can be assumed that..." besides being grammatically incorrect, is not substantiated. On what basis is this assumption made? Double counting is a specific issue; was this *documented* to be the case? The second (that the HG was overwhelmed) is obvious but does not necessarily result in an outcome *one direction or the other*.

7. I do not believe the statements in the Abstract and Conclusions "Casualty data following the 12 January 2010 earthquake in Haiti from many different sources were used and calibrated by observed building damage states from satellite imagery and reconnaissance reports to arrive at the most realistic estimate of death tolls" are representative of the work presented. This statement "calibrated by observed building damage states from satellite imagery and reconnaissance reports"; does this really jive with what is presented in the manuscript? Does this accurately represent your work?

Actually, as I reread it, I find that many of the methods described in the Methodology section were not actually done in this study. Two are particularly culpable:

- Various occupancy assumptions and building losses are compared to the death toll estimates.
- By using historical data from every damaging earthquake recorded worldwide, the range of death tolls is then compared to historical estimates with a focus on the range of death toll estimates.

Perhaps I missed something, but it doesn't appear that either of these was actually done?

8. I have not the time to address the numerous other assumptions made in the manuscript. Perhaps someone else will do so. For example [P1924]: "In addition we can add 30000 deaths, due to the possible value of found bodies since 28 February 2010 as a found body count since and also for an increased number of people dying due to their injuries since then." I'm not even sure where to start with the above statement.

Editorial Notes:

1. P.1916. "These" for enumeration #5 is orphaned. It's not obvious what part of the bullets above it it refers to.
2. P.1916. L8. "less vulnerable". Don't you mean "less deadly"? They collapse but don't kill at the same high rate.
3. P1918. L8. "causalities were less". "fewer", not "less".
4. P1918, and elsewhere. Normally, "damages" (plural) is used as a legal term; damage can be plural.
5. P1918. "Given that the final distribution values of the Miyamoto International damage are not available". Missing word after damage? "data"?
6. P1919. "area but also all": "but also" is grammatically incorrect given the rest of the sentence.
7. P1919. " It is shown that the Haitian government estimates through SNGRD were about a 70 % overestimate with respect to red tagged building damage". What is meant by "estimates". Be specific. Again, just the phrase "red tagged building damage" is not a basis for comparison.
8. P1920. Melissen 2010. Not a proper citation or reference. Please provide a link to the web archive (which I found after some searching).
9. Throughout "red tagged", when used as an adjective needs a hyphen.
10. Percentages given in Table 2 are not explained.