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The ratio of injured to fatalities in earthquakes, estimated from intensity and building properties

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We estimate the number of fatalities (Fat) within less than an hour of any significant earthquake worldwide as a first order assessment of the extent of a possible disaster and distribute this information to anyone who needs it. However, the number of injured people (Inj) is more directly useful for planning rescue and relief operations, and is indispensable for a proper response of the health-care system. Thus, we attempt to estimate both of these parameters. In the literature the assumption is made that the ratio R=Inj/Fat may be constant and close to three. We reject this notion and propose that R depends chiefly on two parameters. (1) R depends on the resistance of the built environment to strong ground motions. In the industrialized world, the median of all earthquakes we could find for which both parameters are known since 1970 is R(med, 26 events)=50; in the 23 events since 1980 it is 60. In the developing world, R(med)=2.5, derived from 55 events (except 6 special cases) since 1970. We conclude that the better building quality in the industrialized world increases the probability for a person not to die in a strong earthquake by more than a factor 10. (2) In addition, R depends on the intensity of shaking (I on the modified Mercally Scale). It is obvious that small nearby and large distant earthquakes cause only relatively low intensities (for example VI) that cause minor damage to buildings, resulting in zero fatalities, but some people are injured. In such cases R approaches infinity. The six special cases excluded from the sample used above for representing the developing world were of this type and their R(med)=15. For example an M7.3 earthquake with an epicenter near Martinique, but at 145 km depth has been powerful enough to have injured 100 people, but it caused only 1 fatality, resulting in R=100. An extreme case on the opposite end of the possibility is the Bam earthquake of December 2003, which occurred at unusually shallow depth directly beneath a city with poorly constructed buildings. The over all ratio for Bam was R=0.33 and for three districts it was R=0.2. In the only other city in the epicentral area, Baravat, located within about four kilometers of the epicenter R=0.55. Our contention that R is a function of I is further supported by analyzing R(I) for earthquakes where R is known for several settlements. The uncertainties in input parameters like earthquake source properties and Fat are moderate, those in Inj are large. Nevertheless our results are robust because the difference between R in the developed and developing world is enormous and the dependence on I is obvious. We conclude that R in most earthquakes results from a mixture of low values near the epicenter and high values farther away where intensities decrease to VI. The range between settlements in one single earthquake can be approximately $0.2 < R < 100$, due to varying distance and hence varying I. Further, R(developed) = 25 R(developing), approximately. We also simulated several past earthquakes in Algeria, Peru and Iran to compare the values of estimated R(I) resulting from the use of ATC-13 and HAZUS casualty matrices with observations. We evaluated these matrices because they are supposed to apply worldwide and they consider all damage states as possible cause of casualties. Our initial conclusion is that the later matrices fit the observations better, in particular for intensity range VII-IX. However, to improve the estimates for all intensity values, we propose that casualty matrices for estimating human losses due to earthquakes should account for differences in I and in the building quality in different parts of the world.