Isolating social influences on vulnerability to earthquake shaking: identifying cost-effective mitigation strategies.

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Until expensive engineering solutions become more universally available, the objective targeting of resources at demonstrably effective, low-cost interventions might help reverse the trend of increasing mortality in earthquakes. Death tolls in earthquakes are the result of complex interactions between physical effects, such as the exposure of the population to strong shaking, and the resilience of the exposed population along with supporting critical infrastructures and institutions. The identification of socio-economic factors that contribute to earthquake mortality is crucial to identifying and developing successful risk management strategies. Here we develop a quantitative methodology more objectively to assess the ability of communities to withstand earthquake shaking, focusing on, in particular, those cases where risk management performance appears to exceed or fall below expectations based on economic status. Using only published estimates of the shaking intensity and population exposure for each earthquake, data that is available for earthquakes in countries irrespective of their level of economic development, we develop a model for mortality based on the contribution of population exposure to shaking only. This represents an attempt to remove, as far as possible, the physical causes of mortality from our analysis (where we consider earthquake engineering to reduce building collapse among the socio-economic influences). The systematic part of the variance with respect to this model can therefore be expected to be dominated by socio-economic factors. We find, as expected, that this purely physical analysis partitions countries in terms of basic socio-economic measures, for example GDP, focusing analytical attention on the power of economic measures to explain variance in observed distributions of earthquake risk. The model allows the definition of a vulnerability index which, although broadly it demonstrates the expected income-dependence of vulnerability to strong shaking, also identifies both anomalously resilient and anomalously vulnerable countries. We argue that this approach has the potential to direct sociological investigations to expose the underlying causes of the observed non-economic differentiation of vulnerability. At one level, closer study of the earthquakes represented by these data points might expose local or national interventions which are increasing resilience of communities to strong shaking in the absence of major national investment. Ultimately it may contribute to the development of a quantitative evaluation of risk management effectiveness at the national level that can be used better to target and track risk management investments.