

ON THE DEATH TOLL OF THE 1999 IZMIT (TURKEY) MAJOR EARTHQUAKE

by

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Abstract. A bias in earthquake fatality estimates is proverbial in many instances, leading to an *earthquake fatality syndrome*, i.e., a rather large inconsistency among official estimate and the informal (expert) guesstimate(s) [viz., Marza, 2003, Earthquake Fatality Syndrome, *IUGG2003 Abstract Book*, June 30 – July 11, 2003, Sapporo, Japan, Abstract SW04/09P/A134-004, v. II, p. B.520]. In this respect, the present note is a rebuttal to the formal death toll of the Izmit (Turkey) earthquake of August 17, 1999, $M_w(\text{HRV}) = 7.5$ based on a new look at all available data and constraints. The aim of the present note is to get a decent estimate of the Izmit earthquake fatality by assembling, discussing and critically evaluating various pieces of information related to the analyzed event. The Izmit earthquake fatality estimated here (around 45,000 fatal victims, at a confidence level of 90%) is a factor of about 2.5 times larger than the official one (around 18,000 lives lost). This death toll was contrasted against available indirect data as: quantity (number) of plastic bags requested (by Turkish Government) to seals the corpses, amount and severity of building damage (as the fatalities are mainly the result of collapsing buildings), life loss in other comparable size events hitting in resembling vulnerability environments, etc. Eventually, it is conjectured that the 45,000-fatality appraisalment is probably only a lower bound of a decent estimate. Besides the Izmit fatality estimate we worked out or discussed some others afferent characteristics as: the injuries-to-fatalities ratio (close to one), hence a rather unusual ratio; property loss (in the range 10 to 20 billion US\$); and the subsidiary fatalities from related and dependent events (843 lives lost due to subsequent Düzce, Turkey, mainshock of November 12, 1999, $M_w(\text{HRV}) = 7.1$ and roughly 10 fatalities inflicted by four aftershocks of the Izmit mainshock).

Key words: earthquake fatality, earthquake loss, injuries-to-fatalities ratio, death toll estimation, 1999 Izmit earthquake, Turkey.

1. Introduction

By any standards, compilation of fair and reliable earthquake casualty data (be they fatalities and/or property loss) in the aftermath of a high-impact earthquake is rather a cumbersome exercise, involving various unaccounted factors. Frequently the analysts are faced with a dilemma: it is common to note a large disparity amongst official counts and informal estimates (often the former ones being smaller up to a factor of 2 to 3 comparing with the latter ones) a condition referred to as “*earthquake fatality syndrome*” (viz. Marza, 2003). Some would consider this thesis as heretical, but it deserves consideration in the light of transparency, fairness and professional deontology. These biases origin primarily in societies that have authoritarian rules and/or whose political and/or administrative leaders are obsessed with keeping or gaining credentials or power, but could be a result of the incompetence to manage

the situations of disaster crises and the inadequate information systems available at the best of times or simply trivial mistakes, as well.

One of the best and probably most notable examples to substantiate the above assertion is certainly the case of the infamous Tangshan (China) 1976 major ($M_w = 7.8$) earthquake whose death toll ranges from official figure of 242,000 victims (e.g., Marza *et al.* 1980) to informal estimates running from 655,000 to 800,000 (I.S.C. 1979, Wallace 1983 etc). Moreover, taking into account the particulars of the event: a great earthquake (maximum intensity XI on the Chinese macroseismic scale, roughly equivalent to the MSK-64 scale, the parent of the current EMS-92 scale (Grünthal *et al.*, 1993)) at shallow depth beneath an heavily populated area (Tangshan city population alone was about a million), striking during the nighttime (03h43m A.M., local time) and leveling about 95% (see Gere & Shah, 1981; Marshall, 1988) of civil and industrial structures it is conceivable to put the death toll *at least* at three quarters of million, a figure widely circulated among the contemporaneous well informed and responsible western analysts (New Scientist, 1979). Therefore, if this informal assessment is correct, which it is highly plausible (*viz.* Gere & Shah, 1991, p.7), the formal figure of fatalities is underestimated in the Tangshan case by a factor of (at least) 3. As Wallace (1983, p.103) notes “almost certainly, the exact number will never be known”, and this leaves a ‘door’ to the guesstimate that Tangshan fatality figure may be as high as one million, amount supported by some anecdotal accounts originating from responsible scientists or engineers who visited Tangshan in the aftermath of the quake or analyzed the episode. For other similar examples see Marza (2003).

Aware of this frequent bias in the earthquake fatality estimates and noticing that a recent impressive (526 pp.) special issue of the *Bull. Seism. Soc Am.*, February 2002, vol. 92, no. 1 (M. Nafi Toksöz, guest editor) dedicated to the Izmit 1999 earthquake strangely does not tackle in-depth the casualty issue, mentioning *en passant* the formal death toll of approx. 18,000 (*viz.* Barka *et al.*, 2002; Atakan *et al.*, 2002; Bakir *et al.* 2002), we carefully examined the available Izmit 1999 casualty data in order to work out a reliable assessment and to compare it to other appraisals or indirect data (amount and severity of destruction, death toll of comparable earthquakes striking into similar vulnerability environments, etc).

2. Methodology

In assessing the earthquake death toll we follow the usual procedure (e.g., NEIC/USGS) to work out the fatality count, i.e., we combine the reported dead and missing (and supposed dead) people. We access as many sources as possible in order to get an overall and comprehensive portrayal of the effects. We analyze various sources such as: mass media information (print, TV, electronic etc), specialized web sites, special reconnaissance and/or technical reports done by professional organizations etc. With that we considered the most sound (trustworthy) reports and eventually we exploit independent constraints (if any) to warrant the adopted death toll so to justify a relevant final estimate.

3. Data Presentation and Analysis

With respect to Izmit (dubbed also as Kocaeli or Gökük), Turkey, earthquake, M_w (HRV) = 7.5, we have searched a wealth of information yielded by various sources (Turkish official data, international TV and newspapers broadcasts, press releases, professional reports, research papers, online materials available on websites etc). A representative summary of the loss estimates concerning the Izmit event is provided by Table 1, where for sake of convenience we included (where available), besides fatality figures, the figures of injured people and property loss values, as well. The Table 1 brings altogether information from fifteen sources (issued in a time frame of approximately one year since the event) plus the outcome of the present paper. To illustrate how the total loss is made out we segregated the death toll in two parts: reported dead and missing. The order of presentation is also approximately the chronological one, with the purpose to have a progressive perception of the estimates’ evolution.

Table 1. Summary of loss estimates concerning the Izmit /Kocaeli, Turkey earthquake of 1999

#	Source	Life Loss			Injured	Property Loss (US\$ 10 ³)	References
		Confirmed Dead	Missing	Total			
1	NEIC/USGS Earthq. Bull. (Update of Aug. 20, 1999)	6,866	35,000	≈42,000	33,000	Extensive	a
2	O Globo/The Globe (1999) (as of Aug. 21, 1999)	More than 10,000	More than 35,000	More than 45,000	About 45,000	-	b
3	UNCHS (Habitat) Geneva Office (Switzerland)(as of Aug. 21, 1999)	-	-	It could reach 40,000	-	-	c
4	CNN (as of Aug. 24, 1999)	17,997	Thousands more may still be buried	?	42,442	-	d
5	Turkish Prime Ministry Crisis Management Center (as of Aug. 28, 1999)	13,479	-	13,479	27,162	-	e
6	US 39 th Air Expeditionary Squadron (as of Aug. 29, 1999)	-	-	As high as 40,000	-	-	e
7	McGeary & Finkel (as of Aug. 30, 1999)	-	-	Estimated 35,000; it could exceed 40,000	-	20	f
8	EOS (as of Aug. 31, 1999)	-	-	It could reach 40,000	-	It could be 40	g
9	EQE (as of Sep. 03, 1999)	-	-	30,000 to 40,000	-	-	h
10	EERI Special Quake Report (as of Sep. 06, 1999)	15,135	-	15,135	23,984	10 to 15	i
11	Barka A. (as of Sep. 17, 1999)	15,000	Thousands are still missing	?	-	-	j
12	Official Turkish estimate (as of Oct. 19, 1999)	17,127	-	17,127	43,953	3 to 6,5	k
13	Gore R. (as of July, 2000)	-	-	It may be 40,000	-	-	l
14	Shakhramajyan M. A. and co-workers (as of Sep. 2000)	-	-	Estimations between 22,340 to 34,910	-	-	m
15	Erdik (sine ano, but inferred to be as 2000)	-	-	17,454 ^{*)} Accounted deaths	48,901	16	n
16	Present paper	≈ 20,000	≈ 25,000	≈ 45,000	-	-	See text comment

References: a) NEIC/USGS (1999); b) O Globo/The Globe (1999); c) Romania Libera/Free Romania (Online); d) CNN (Online); e) EERC (On line); f) McGeary & Finkel (1999); g) EOS (1999); h) EQE (online); i) EERI (Online); j) Barka (1999); k) USGS (2000); l) Gore (2000); m) Shakhramajyan *et al.* (2000); n) Erdik (Online).

Note: ^{*)} This figure is worked out from the overall amount (18,737) for cumulative Izmit and Düzce fatalities, considering that the toll due to Izmit event was 95 % of the aggregate, cf. Erdik (Online).

Our estimate, item 16 in Table 1, resulted from considering the general methodology described above and applying it to the specific situation of the Izmit earthquake. In the very days after the quake, when the number of dead people was grossly underestimated, the appraisal for the missing people was put at about 35,000. While gradually the number of accounted dead was increasing the number of missing accordingly lowered until the official count of confirmed fatality ‘frozen’ (at about 20,000), at that moment we appraised that the missing were still around 25,000 (NB: the official estimate ‘forgot’ of these missing people!), hence our inferred total life loss during the Izmit earthquake is around 45,000 fatal victims (*i.e.*, the sum of confirmed dead and reported missing). Interestingly enough, we serendipitously have found in media [<http://adevarul.kappa.ro/a287-03.html> (last accessed August 1999); this is the site of the Romanian newspaper “Adevarul” (“The Truth”)] a stunning coincidence between our estimated figure (*i.e.*, 45,000) and the number (also 45,000 units) of special plastic body bags requested (to United Nations) by Turkish authorities to seal the corpses! Obviously, this coincidence gives support to our estimation and it is a good proof of the synergic use of all available data.

Clearly, it is difficult to assess the reliability of various fatality data sources, as these usually do not make available their methodology and its trustworthiness. However, if you look at the total fatality counts displayed in Table 1 (*i.e.*, 5th column) one might note a bimodal distribution (see Fig. 1, as well), a group (called 1st fatality group) of four ratings around 15,000 victims and another (called 2nd fatality group) composed of nine estimates around 40,000 lives lost. On the other hand, the scattering in the number of injured people is less large, being centered on 30,000. Table 2 presents a synopsis of a simple statistics of the data displayed in Table 1 throwing some further insights on the matter. Based on the data of Table 2 we can do a basic analysis of variance in order to infer statistical significance of the mean values of the fatality groups. A standard *t-test*, applied to the two samples ($t = 7.83$, number of degrees of freedom = 3), proves that the difference in the means of the two groups is significant at (better than) 99.5 per cent confidence level. This high confidence level *per se* does not tell which mean is the real one, but can help in eliminating the bogus one using additional independent information and a heuristic approach to be discussed in the next section.

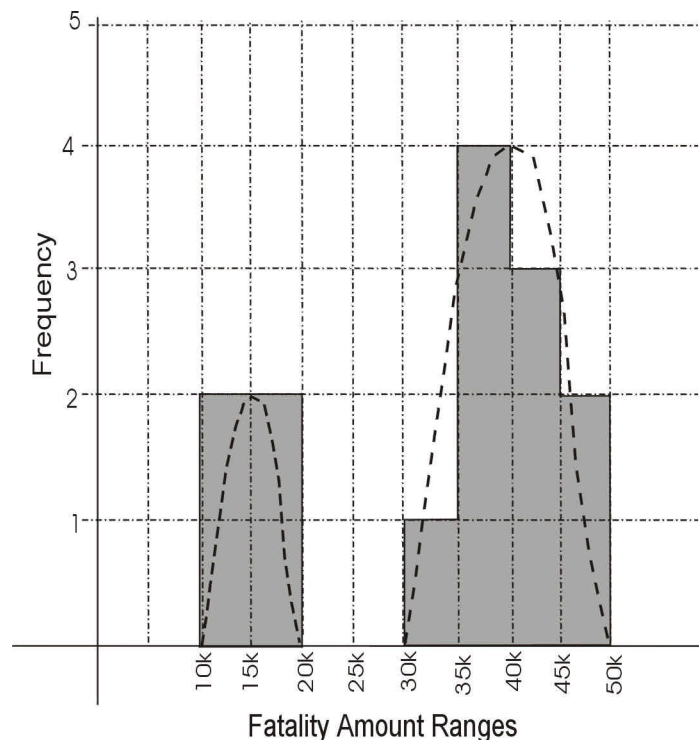


Figure 1. Histogram of binary frequency distribution of the fatality amounts of Table 1. The dashed curves show the idealized distributions.

Table 2. Summary of simple statistics applied to the data of Table 1

Group Category	Average Fatality (\bar{x})	Sample Standard Deviation (σ_n)	Number (n) of Datasets (x_i)
1 st Fatality Group	15,799	1,607	4
2 nd Fatality Group	40,691	2,741	10
Whole Fatality Data	33,579	11,513	14
Injured People	37,777	8,957	7

4. Discussions and Conclusion

From Table 1 it follows that the formal estimate is around 18,000 while the majority of the informal estimates mount somewhere above 40,000, which corroborates with present paper guesstimate (*i.e.*, at least 45,000 fatal victims). It should be remembered that the earthquake was a major one $M_w(\text{HRV}) = 7.5$ hitting during the sleeping hours (03h02m A.M., local time) an area with a population of more than 15 million, causing intensive damage (heavy destruction or collapse) encompassing around 93,000 housing units (Erdik, Online) and many business, industrial and military structures, as well. According to Mucciarelli *et al.* (2002), the maximum intensity topped at X-XI (EMS-98) in a series of towns along the fault rupture. The number of housing units heavily damaged can be used to indirectly infer the fatality amount. If we suppose that only one in two of the housing units that suffered intensive damage caused one life lost (which is a very conservative assumption, *hence defining a lower bound estimate*) it follows that at least 46,500 people were killed. Thus, we feel that under the above unfavorable circumstances the true death toll could be even higher than our estimate presented above.

Another way towards the judgment of a more reliable death toll is to make comparisons with fatality amounts for similar size events hitting in comparable demographic and vulnerability environments. As such events we present for consideration the Rudbar, Western Iran earthquake of 1990 ($M_w = 7.4$) and Quetta, Baluchistan earthquake of 1934 ($M_s = 7.6$) with 50,000 (Berz, 1992) and 60,000 (Press & Siever, 1986) fatalities, respectively. It should also be called to mind that in 1939 another N. Anatolian fault earthquake, the Erzincan event of December 26 ($M_w = 7.6$, *cf.* Pacheco & Sykes, 1992), killed 30,000 to 45,000 estimated fatalities [*viz.* NEIC/USGS home page at <http://www.neic.cr.usgs.gov/neis/eqlists/significant.html>; and Schlermeier (1999), respectively]. Consequently, as the earthquakes of 1939 and 1999 are comparable in size but the demographic density considerably increased since 1939, the current death toll estimate for 1999 event one may be (again) only a lower bound of the true (undisclosed) figure, note that this comparison corroborates well with the inference based on the number of intensively damaged housing units.

At last, we may state, based on several lines of evidences presented above, that a fair estimate of fatality toll for Izmit/Kocaeli, Turkey earthquake of 1999 is around 45,000 and *probably this value is the lower bound* of a decent estimate. Using the accepted standard approach to statistics, we rate the uncertainty (estimation error) of our appraisal, as well, based on the formalisms discussed by Raab & Brosch (1996) and Giles (2002). Considering the variance involved and the statistical uncertainty implied by the so-called objective statistical sampling we infer that our death toll estimate has an ad-hoc confidence level of 90% probability ($Z_c = 1.57$, where the Z_c is the critical-Z variable for normal distribution, which was tacitly assumed as holding). This level of confidence corresponds to the high confidence band, according to the suggested descriptive scale of Moss and Schneider (2000).

The heavy damage and subsequent appalling death toll in the 1999 Izmit earthquake were a result of a summation of series of factors as: many large structures laid astride the fault (and hence were torn apart by the fault rupture, whose offsets were around 3 m), strong liquefaction effects which weakened soils beneath foundations (EERI, Online), local concentrations of damage due to poor site conditions and, last but not least, the high

vulnerability of the multi-story (typically 4 to 8) residential apartment blocks with poor earthquake performance due to unsuitable ground conditions, poor-quality construction material and inadequate engineering and faulty housing development policy and control system (Schlurmer, 1999; Erdik, Online). At this juncture, it is worthy to point out a symptomatic feature, some papers in the Special Issue of *Bulletin of the SSA*, already cited in the section 1 above, strangely do not quote the numbers of fatality but rather cite “catastrophic level of fatality” (Langridge *et al.*, 2002) or “horrible destruction” (Akkar & Gülkan, 2002), refraining to numerically specify the formal toll.

The casualties in the Izmit event show another anomalous feature, i.e., the injuries-to-fatalities ratio (close to one), similarly to other high impact earthquakes (e.g., Armenian earthquake of 1988 December 7), whereas most large earthquakes are characterized by a ratio of three or four to one (Lindley, 1989).

To the Izmit 1999 event death toll we can add a related, subsidiary, fatality of 843 fatal victims and 4,948 injured (see NEIC/USGS home page at <http://www.neic.cr.usgs.gov/neis/eqlists/sig-1999.html>) caused by November 12, 1999 Düzce, Turkey, mainshock, $M_w(HRV) = 7.1$, which is considered as an easterly extension of the August 17, 1999 Izmit rupture (Parsons *et al.*, 2000). As regards the additional death toll caused by the proper aftershocks of Izmit main event (roughly 10 fatalities and 588 injuries resulting from four fatal aftershocks) it is an insignificant contribution to the overall toll, yet the psychological effect of aftershock impact is very distressing, as well. In retrospect, we may point out that the UN's International Decade for Natural Disaster Reduction has been bracketed by the worst earthquakes occurring during its period, that is the Rudbar 1990 and Izmit 1999 events whose cumulative death toll was around 100,000 (*viz.* Marza *et al.*, 2003).

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