Mortality in Flood Disasters

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Introduction

There has been a considerable increase in the number of large floods and in severity of their impacts in the recent decades, worldwide. Although floods are not commonly perceived as public health events, they do clearly lead to deterioration of human health over vast flood-affected areas. Flood-related morbidity and mortality raise considerable concern. Each year, the global number of flood-related fatalities is in the range of thousands.

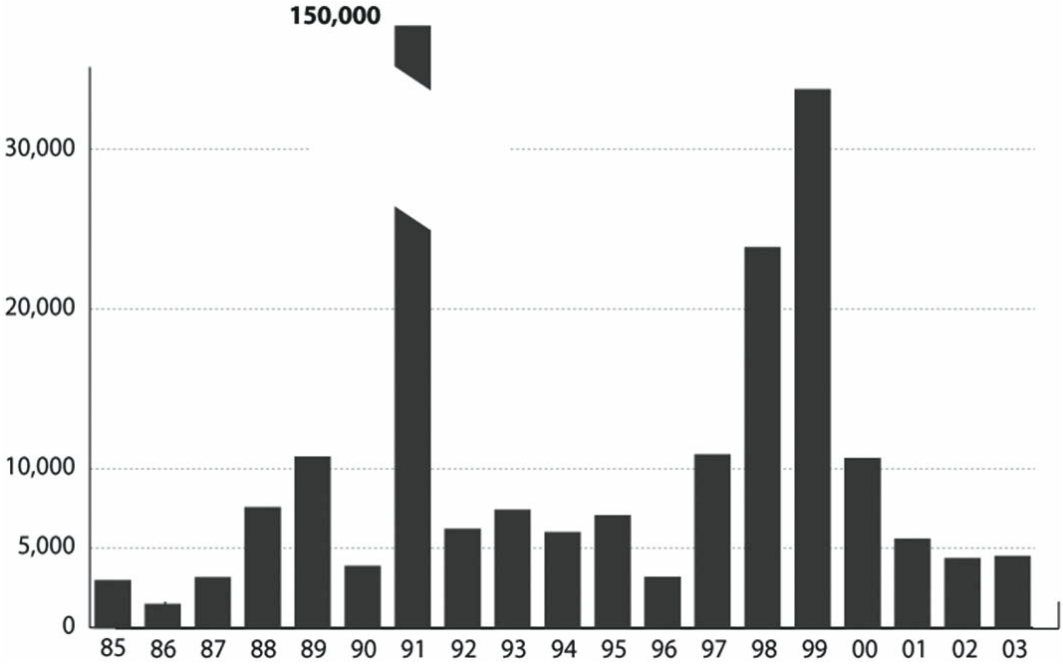
The paper looks into the data on flood fatalities. It does not aim to present a detailed overview of the worldwide situation. It focuses on a couple of national data sets, with primary reference to the 1997 flood in Poland.

Mortality estimates

The two most essential socio-economic characteristics of a disastrous flood are: the number of fatalities and the economic damage. Neither of these characteristics is easy to quantify in a reliable way. Estimates of human and economic losses in a particular flood do considerably vary, depending on the information available to the searching body and the timing at the assessment. The assessment of the number of flood victims is, in a number of ways, problematic. Kundzewicz (2003) gave an example of assessment of the number of flood fatalities in the huge floods in July and August 1931 on the River Yangtze in China, according to various sources. The estimates largely differ, ranging from 145,000 through 400,000, 1,400,000, to 3,700,000 fatalities. That is, the lowest and the highest estimates differ as much as 1 to over 25. It would be of much interest to decipher the reason for such significant differences. Possibly the higher estimates are based on some way of double counting (data from different sources?). Identification of "flood-related deaths" (additional deaths) in a region devastated by a flood must have caused huge problems. The higher estimates may include fatalities caused by flood-related starvation. As stated by Smith and Ward (1998), such estimates are notoriously unreliable.

A worldwide statistics on floods since 1985 has been collected by the NASA-supported Dartmouth Flood Observatory of the Dartmouth College in Hanover, New Hampshire, USA. *Figure 1* produced by the Dartmouth Flood Observatory, and available on the net, (http://www.dartmouth.edu/~floods/archiveatlas/fatalitiesgraph.htm) shows the number of flood fatalities worldwide in individual years since 1985. According to these data, the number of flood fatalities worldwide, during the 18 years, 1985 – 2003, was about 300,000. It can be stated that, in general, mortality in disastrous floods has not been curbed at the global scale. This pertains in particular to less developed countries, such as Bangladesh, India, and China, where the average number of flood fatalities remains at a high level.

Fig. 1



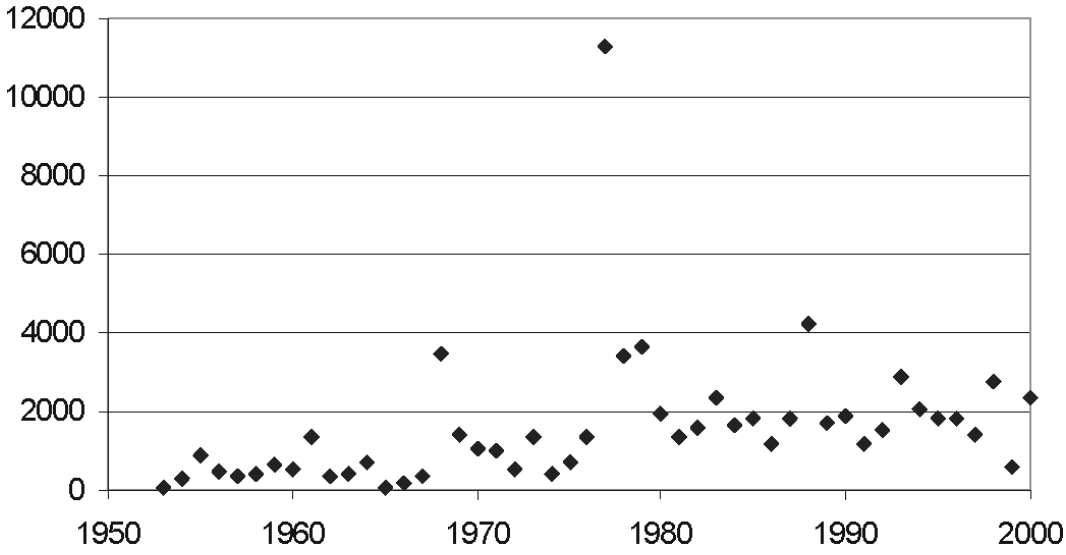
Annual records of flood fatalities worldwide in 1985-2003. Result of compilation by NASA-supported Dartmouth Flood Observatory, Dartmouth College, Hanover, New Hampshire, USA. From: http://www.dartmouth.edu/~floods/archiveatlas/fatalitiesgraph.htm.

The most destructive flood was a coastal surge in 1991 in Bangladesh, when during two days of April, nearly 140,000 people were killed (Munich Re, 1997). In the last two decades there were two further years with the number of flood fatalities in excess of 20,000, namely 1998 and 1999. More than 40,000 people died during three single extreme events. In October – November 1998, Hurricane Mitch caused 10,000 fatalities in Central America, in October – November 1999, a cyclone in Eastern India resulted in 10,000 casualties, while a flood in December 1999 in northern Venezuela and Columbia killed 20,000 people.

Mohapatra & Singh (2003) present data on the number of flood fatalities in river basins of India in the time period 1953 – 2000. *Figure 2,* based on this data, shows that floods continue to be a massive killer in India. In the year 1977, the number of flood fatalities in India was equal to 11,316. In 1953 – 1967, it was rare that the annual number of flood fatalities exceeded 1000 (only once, 1374 in 1961). Now, it is rare that this number goes below 1000. From 1976 to 2000, it happened only once that the annual number of flood fatalities in India dropped below 1000 (576 fatalities in 1999).

Long time series of annual numbers of flood fatalities in the USA have been compiled by the Hydrologic Information Center of the US National Oceanic and Atmospheric Administration (NOAA). The data (time series of values collected over 101 years, 1903 until 2003) can be found under the address http:/www.nws.noaa.gov/oh/hic/flood_state/recent_individual_deaths.html. A disclaimer states that in the earlier years not all isolated fatalities were accounted for due to more limited communication capabilities. That is, even if data are available since 1903, they may underestimate the number of victims in early years, reflecting fatalities associated with major floods and some, but not all, isolated events. In the USA, the number of flood

Fig. 2



Number of flood fatalities in India, based on data published by Mohapatra & Singh (2003).

fatalities continues to be high. From 1961 to 2000, there were 21 years in each of which at least 100 flood fatalities were recorded in the USA (up to 554 in a single year, 1972).

Figure 3 shows numbers of flood fatalities in the USA as running means over subsequent five-year periods since 1903. A value of the running mean for a year N is equal to one fifth of the sum of values for five adjacent years: N-2, N-1, N, N+1, and N+2. A clear long-term decreasing tendency cannot be deciphered.

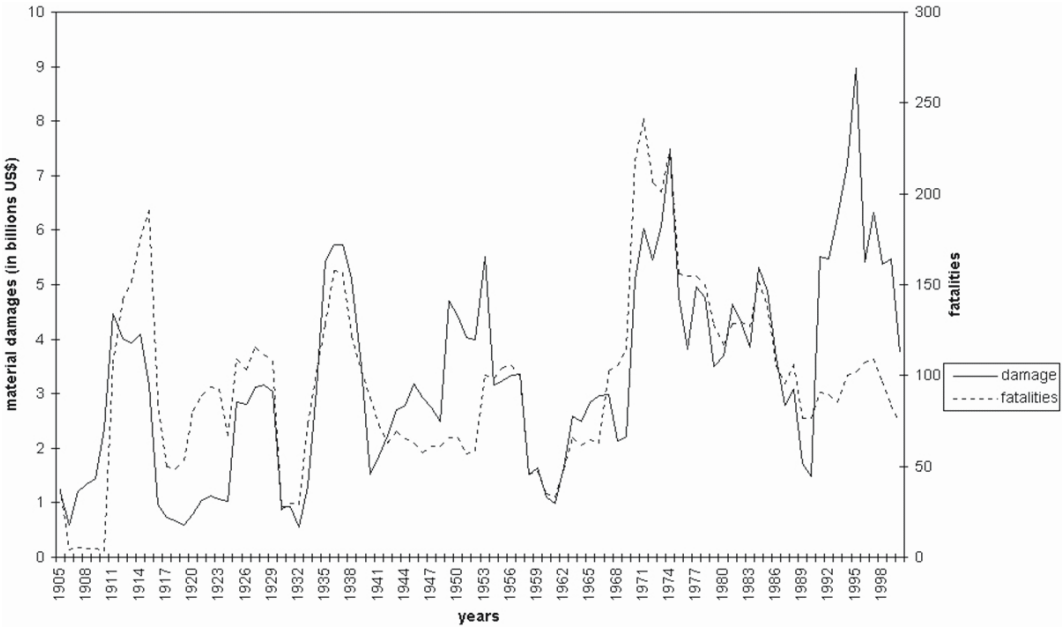
In some countries, there has been a tendency of decrease of the number of flood-related fatalities. This is a sign that flood preparedness systems, including forecast-warning-dissemination-response systems may considerably contribute to saving lives. In the first 15 years after the World War Two, destructive floods frequently visited Japan, killing a thousand or more victims almost every year (Kundzewicz & Takeuchi, 1999). In 1953, there were 3000 fatalities, and in 1959 – even 5600. This can be partly explained by the lack of appropriate maintenance of channels and flood defences (dikes), related to the general hardship of a nation, which had lost the war. It also turned out that the existing system of levees led to increase of catastrophic flows, jeopardizing major cities. After 1960, Japan has never got more than 1000 flood fatalities per year, and except for the year 1962, the number of fatalities was always less than 600.

Material damage vs death toll

Annual flood damage statistics in the USA has been also compiled by the Hydrologic Information Center of the NOAA (address: http:/www.nws.noaa.gov/oh/hic/flood_state/flood_loss_time_series.html). *Figure 3* shows the flood-related material damage, in inflation-adjusted dollars, as a running mean over subsequent five-year periods since 1903. Amidst strong oscillations, even in five-year running means, the material losses show an increasing tendency.

Having ignored the earlier data containing several years when the number of flood-related fatalities in the USA was equal to zero, one can observe that the value of the ratio of the running means of the mate-

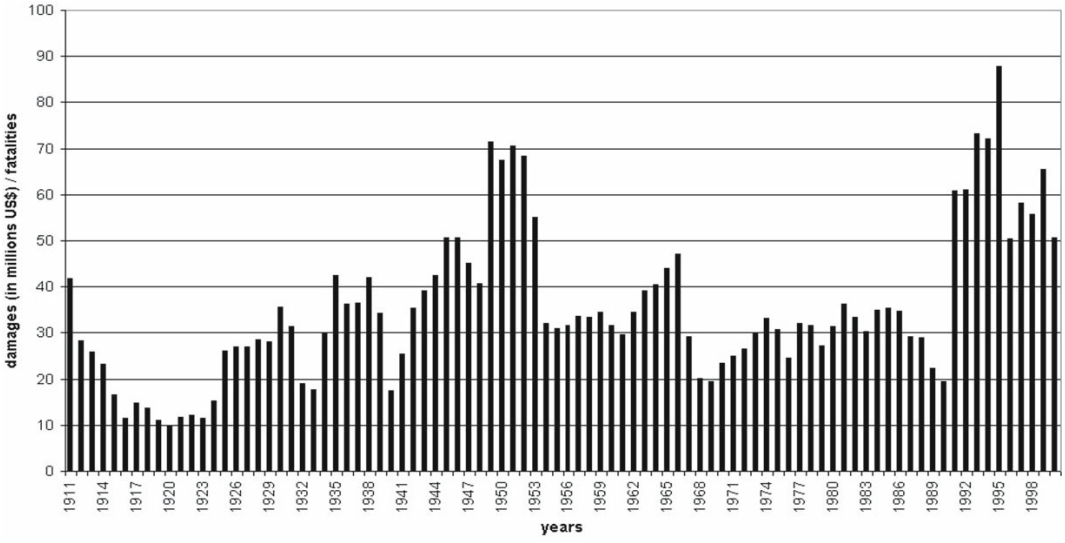
Fig. 3



Flood-related fatalities and material damage in the USA (five-year running means). Data source: Hydrologic Information Center of NOAA.

rial damage and the number of fatalities has been somewhat growing with time (*Fig. 4*), though not in a uniform way.

Fig. 4

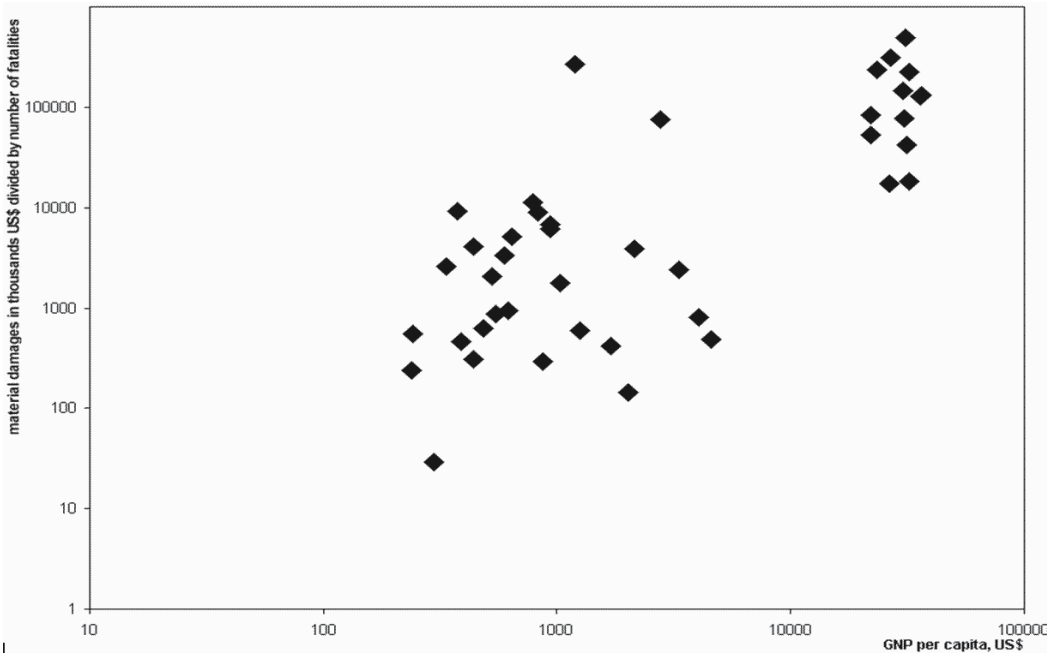


Ratio of flood-related damages (in millions of US$) to number of flood-related fatalities in the USA (five-year running means). Data source: Hydrologic Information Center of NOAA.

Kundzewicz and Takeuchi (1999) studied relationships between the GNP of a country and the value of the ratio of material damage to number of fatalities for individual most dramatic flood events, based on the 1990 – 1996 data from Munich Re (1997). Their observations were as follows:

- in general, the ratio of material losses to number of fatalities grows with the wealth level measured by the GNP per capita of a country
- repeated occurrence of a disastrous flood twice in the same place may visualize existence of a learning effect. The values of the damages-to-fatalities ratio, for the first flood and for the second flood of comparable magnitude (coming not long after the first one) do largely differ. The damage caused by the second flood is usually considerably lower. Occurrence of a flood raises awareness and triggers actions towards improvement of flood preparedness system.

Fig. 5



Ratio of economic damages (in thousands of US$) to number of fatalities for national data on most disastrous flood events, as a function of wealth of the country (GNP per capita).

Figure 5 shows an update of the global event-based analysis by Kundzewicz & Takeuchi (1999), of the ratio of flood-related material damage to the number of flood fatalities. The data used in Figure 5 stem from different statistics, collected by Munich Re (e.g., Munich Re, 1997 and a number of more recent annual publications); and from other sources available to the authors, and refer to the time period 1990 – 2002. Only large events were considered, in which 100 (or more) fatalities and/or 500 (or more) million dollars material damage were observed. The GNP data were assembled from various publications of the World Bank. Both flood damage and GNP were adjusted for inflation. Those Munich Re data, which give aggregate estimates of losses for a group of countries (with different GNP per capita), were simply ignored and not disaggregated into individual countries.

Figure 5 demonstrates that the ability of countries to invest in flood defence, being related to the country's wealth, plays a significant role in curbing the death toll. On the top of costly structural measures

(levees), such factors as education and awareness, access to information, and early warning help reduce the number of flood fatalities.

How do fatalities occur?

There is a scarcity of information on the direct reasons of flood-related deaths. Interesting material has been assembled by journalists of the Polish weekly Fakty (journal, which is not published anymore) during the devastating summer flood of 1997 in Poland (on the Odra, the Vistula, and their tributaries), which took a high death toll (over 50 fatalities). Actually, the 1997 Odra flood has an international dimension, affecting the Czech Republic (also with more than 50 fatalities and high material losses), Poland, and Germany (material losses only). An edited excerpt from the material published in Fakty (Anonymous, 1997) is presented here, in *Table 1*. It conveys information on the gender, age, and the details of fatal incidents, where available. Information, which is not relevant to the present paper, e.g. on the name and surname of a victim, references to place of residence, name of the river and place of the fatal event (some exceptions being in Kłodzko, devastated by a flash flood), or where the body was found (including, at times, reference to street names), reference to the district (this extensive flood affected many districts in Poland, and beyond), even if it was available in the original material, is not reproduced here.

It is believed that flood vulnerability is particularly high among elderly citizens, poor persons, those with prior heath problems (especially – motorically handicapped), and with small children. *Table 1* clearly demonstrates that the flood killed not only elderly, motorically-handicapped people who were alone at night in their bedrooms inundated by fast rising waters, and not exposed to forecast, warning, and evacuation. Some of the fatalities were a consequence of human taking (and underestimating) a risk and literally encroaching into the harm's way. Some deaths could have been avoided it the awareness were better and if other, more fortunate, decisions were taken by those involved. Lack of imagination about what can happen, underestimation of danger, and lack of discipline are behind several deaths. It may have been beyond imagination to many a victim that a river current can be very strong, and that it does not allow even a good swimmer to move in a controlled way (while the likelihood of being hit against hard objects is high). All this results from the lack of experience with a catastrophic flood, which was considerably larger than all events happening in recent decades.

Some reservation as to the quality of information in *Table 1* may be justified. The list is definitely not uniform, it is incomplete, and some entries are suspicious. However, the data compiled in *Table 1* is a unique source anyway, and raises interest. Possibly sources related to insurance could tell a different story.

How did flood fatalities happen? In several cases, a silent mystery was taken to grave and reconstruction of circumstances is not possible. However, in some cases journalists could collect relevant information. There were far more male fatalities (43) than female fatalities (6). *Figure 6* presents distribution of fatalities into age classes (both genders together). The average age of a victim was about 46 years. It is worth noting that, contrary to intuition, a vast majority of victims (over 71 %) were between 20 and 59 years of age.

Tab. 1

Information on the gender, age, and circumstances of flood-related fatalities in the July 1997 flood in Poland (ordered after the age of victims, in ascending order). Data source: Anonymous (1997). Not all flood-related fatalities are included in the source. Notation: NA – information not available

Age	Information about fatalities
Gender male	
Child	Died in result of breast injury, while being transported in a car, which fell into a road breach.
10	On 13 July, fell into water. Helicopter was used. Reanimation action was unsuccessful.
20	On 9 July, evening, drowned falling to a stream.
22	On 11 July, body was found in a river (injury of body and head).
23	Jumped from a bridge to a river in order to win a bet. His body has never been found.
24	Went to watch the flood. Body found on 18 July.
25	On 15 July, left to take flood photographs. Drowned in unknown circumstances.
26	On 8 July, about 18 h, fell from a railway bridge into a river.
27	Went fishing in a stream, in which his body was found.
27	On 8 July about 14.00 he was washed away by a flood wave while walking over a foot-bridge and drowned.
30 – 40	Unidentified; found in a gravel exploitation area.
32	On 8 July about 19.50, walked along the bank of a river, fell into a river and drowned.
32	NA
32	On 11 July, a mud-covered body was found in a channel of a river.
34	On 8 July about 20.30, having consumed alcoholic beverages, fell from a foot-bridge into a river and drowned.
34	On 7 July, while working on clearance of a bridge, fell into water and drowned.
34	On 9 July, evening, while securing a bridge on a stream, fell into water and was carried away by the stream current.
34	Body found in a stream.
≈ 40	(Unidentified, 175 – 180 cm), Drowned on 12 July in a river.
43	On 7 July, body found in water in an underground passage (in Kłodzko).
44	On 9 July, jumped into the water of a river in order to save a drowning dog, and was carried away by strong river current and drowned.
45	Drowned in the current of a river.
47	Floating body found.
50	Found in a river.
50	Tried to cross a river, with three children, in a rubber boat in order to collect his property. The boat capsized. Children were saved.
51	NA
52	Body found at a sport stadium.
56	On 10 July at 17 h, was hit by a truck Star A-26 owned by a Fire Brigade, due to lack of adequate attention, while the truck was driven on a rear gear during the flood fighting action.
57	Drowned, carried away by water current after having gone in a canoe in order to collect grain for evacuated farm animals.

Tab. 1 (Continued)

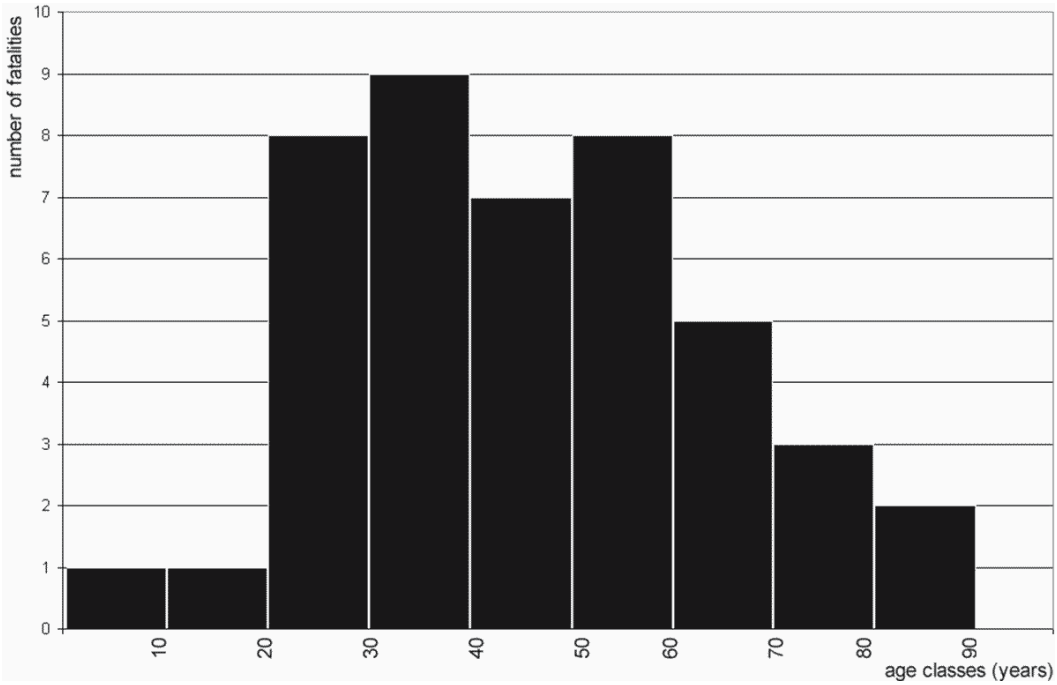
Age	Information about fatalities
58	Body found. Reason of death – drowning.
59	NA
60 – 70	(Unidentified, height 165-170 cm) Body found in a stream.
61	On 8 July, drowned in his apartment (in Kłodzko).
64	On 7 July, drowned carried away by flood waters.
75	On 8 July, body found under a hedge (drowning).
78	NA
81	On 8 July drowned in his apartment (in Kłodzko).
84	Commited suicide, jumping from a bridge into water. Has left a letter. His body has never been found.
NA	German citizen. Body found on 16 July
NA	Drowned.
NA	On 7 July at 19.50, was captured by the current of a river.
NA	Body found on 15 July evening.
NA	Body found near a river gate.
Gender female	
39	Body found in a river.
51	On 9 July about 23 h died under earth masses after a hillslope slided onto a house.
57	Drowned in a channel. Municipal police reported about it on 13 July at 6.20 a.m.
60	On 8 July, the body was found on the land owned by the victim, in a basement filled with water. No external wounds.
68	On 13 July about 16 h, divers of the police troops found a body in an inundated house by a river.
75	Drowned in inundated apartment. Motorically impaired.

Table 1 shows that some victims died by taking a risk, in a conscious or unconscious way. Some may have walked home, as usual, and crossed a stream using a slippery foot-bridge, perhaps without a handrail, which served adequately in normal times, but the flood time was not normal. Several records (male) contain the classifier: "fell into a river and drowned", possibly, having been carried away and hit against hard objects. Some victims tried to collect their belongings, or to save a life of a dog. Some just wanted to watch an unusual event – the flood (possibly making photographs) and were not careful enough. Fatal accidents during flood-fighting activities are also reported. A death resulting of a highly irresponsible behaviour – a bet between young parties – is mentioned. Flood-related suicide during the flood was also recorded.

Hajat et al. (2003) reviewed psychological distress of the July 1997 flood in Poland and Czech Republic. No suicides or attempted suicides during the flood were recorded in the Czech Republic. In Poland, 50 flood-related suicides were reported in the two months after the flood. Psychological health effects, such as post-traumatic stress disorder (PTSD) – anxiety, depression – can last several years after the event.

It is clear from US data that many flood fatalities were trapped in cars. Hydrological Information Center data show that over half of the number of flood-related fatalities in the USA were vehicle related. Victims literally drove into harm's way. In 1998, 86 out of 136 flood fatalities recorded in the USA were vehicle-related fatalities, in 1999: 39 out of 76, in 2000: 20 out of 41, in 2001: 31 out of 66, in 2002: 31 out

Fig. 6



Distribution of flood fatalities (Poland, July 1997) into age classes. Data source: Anonymous (1997). Not all Polish flood-related fatalities are included in the source. In a few cases no information on the age is available

of 50, and in 2003: 45 out of 80. So, over the six-year period, 1998 – 2003: 252 of 449 flood fatalities (over 56 %) were vehicle-related.

In the dry year 2003, a local flash flood was reported in Poland, taking a death toll of five persons, who drowned in a car.

Conclusions

Number of flood-related fatalities is one of the most essential socio-economic characteristics of a flood disaster. A question emerges as to the counting process. The term "flood-related fatalities" is self-explanatory and can be interpreted in a rather broad way. However, there is a substantial difference between a death of an old handicapped woman, who drowned in her bedroom, alone at night, and a young, strong, and self-assured man, who underestimated the danger and encroached into the harm's way. Each death is a human tragedy. Every death has economic consequences (e.g. insurance). Some of the fatalities resulted from humans' taking (and underestimating) a risk. The data compiled in Table 1 demonstrate that many a young life could have been saved, if the awareness were better and if other, more fortunate, decisions were taken by those involved. Lack of imagination about what can happen, underestimation of danger, and lack of discipline are behind several deaths. All this results from the lack of experience with a catastrophic flood of extreme dimension. Obeying simple rules of conduct by car drivers alone could help reduce the number of fatalities in many flood events, even if no vehicle-related drownings were listed in Table 1 in the 1997 flood in Poland (yet, there were two vehicle-related incidents).

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