CAN LIGHTNING REALLY HIT YOU? – RISK PREPAREDNESS SURVEYS IN INDIA, BRAZIL, GERMANY AND AUSTRIA

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I. INTRODUCTION

The meteorological phenomenon of lightning is also a subject of risk assessment research (Slovic, 2000), which distinguishes ″hazard″ as potential, statistical risk from ″risk″ as probability of personal harm. ″Lightning is the second most efficient storm-related killer, floods being the first″ (Rakov and Uman, 2003, 648). Lightning is a frightening ″dread risk″ and a complex threat – it is rare, very short, happens at random, not anticipated, with stochastic secondary events. Some risk elements are counter-intuitive: Lightning conductors give safety, if you keep your distance. A motorcar is safe, a cabriolet is not (Keul, 2009). Psychologists have documented aftereffects of lightning accidents (Dollinger et al., 1984; Greening and Dollinger, 1992), like subsequent Post-Traumatic Stress Disorder (Coorray et al., 2007). Personal exposure to weather hazards still goes with a false security over-optimism. Simplistic ″lay theories″ increase the subjective, but not the objective security (Furnham, 1988). Protection against meteorological hazards follows a ″diffusion of innovations″ (Rogers, 1995).

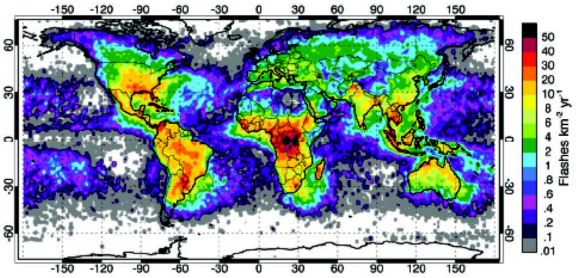

FIG. 1: Global OTD lightning map (Christian et al., 2003).

Internationally, cloud-ground lightning flashes shows geographical hotspots – flash frequencies over 20 per square km and year – in the Americas, Africa, Asia, and Australia (Christian et al., 2003; Fig.1), not in Europe (below 5 flashes per square km and year). The distribution is corroborated by a thunderstorm severity re-analysis of sounding data (Brooks et al., 2003; Fig.2).

Laypeople survey results from hotspot areas are relevant as a subjective protection indicator. Does the objective hazard and risk level shape lightning interest, knowledge and preparedness of the local population? Will formal education and personal experience of physical damage play a role?

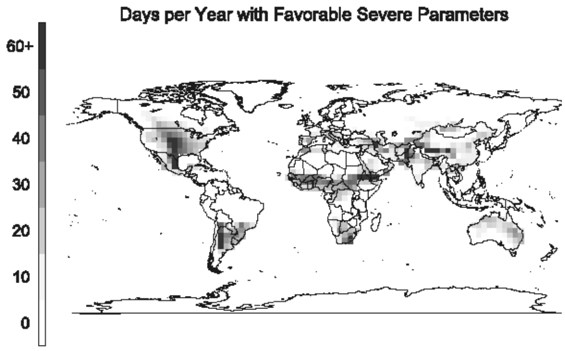

FIG. 2: Global severity re-analysis (Brooks et al., 2003).

The first author does not follow the conservative opinion of some lightning protection specialists that safe behavior is already in the textbooks, so it is not necessary to survey ″silly″ public opinions. On the contrary, lay theories and strange beliefs are evaluation results that the mission of public lightning protection has not been accomplished properly (Keul, 2012).

Austrian and German lightning surveys in 2008 and 2010 tested knowledge and safety behavior via questionnaire (Keul et al., 2009, 2011). On a list of natural hazards, lightning was rated as a medium risk. 66% in Austria and 74% in Bavaria felt well informed about thunderstorms. Self-reported lightning fear was low. The general lightning knowledge and behavioral safety level was high, but some deficits remained. Three of four respondents failed in a simple lightning distance calculation task.

II. PRESENTATION OF RESEARCH

After the ECSS 2011 in Spain, a three-area pilot study was done by the authors in 2012 as team-work on Brazil (n=104), India (n=100), and Germany (n=80). On the lightning topic, a dataset from Austria (n=133) was also used for comparison purposes. Layperson questionnaires of the first author on severe weather and lightning were merged into a two-page questionnaire with items about media weather (report) interest/sources/legibility, basic weather knowledge, subjective risk assessment (especially on lightning), preparedness, self-reported behavior, actual physical damage by weather events, and sociodemographic data.

The India sample covered the mountainous, northeast state of Nagaland over 1,000 m above sea level and with a humid subtropical climate with heavy rainfalls and thunderstorms (Fig.3).

FIG. 3: Hail at Kohima, Nagaland, 2013 (Sharma).

The Brazilian survey data came from Campinas, sea level 685 m, state São Paulo, a city with about 1 million inhabitants, subtropical climate with heavy rainfalls, winds, and thunderstorms (Fig.4).

FIG. 4: Campinas, Brazil, lightning, Dec 16, 2009 (Chaval).

The German and Austrian surveys were done in the foothills north of the Alps, 300-400 m above sea level, in warm summer continental climate. Shower and thunderstorm precipitation is high from late spring throughout summer.

What is the statistical background of lightning activity? Holle (2008) gave an international overview on available lightning death rates. He lists 2.5 deaths per million for Orissa, India, 0.8/million for the São Paulo area of Brazil, and 0.6-1.3/million for Austria. In the still sketchy picture, personal danger seems to be similar at Brazil and Germany/Austria, and could be higher at India.

In Brazil, Pinto et al. (2007) reported over 7.5 CG flashes per square km and year for São Paulo-Campinas 1999-2004. 1998-2011 municipality data for Campinas (ELAT, 2013) give 9.7 CG flashes and 6 fatalities for the time period. A long-term lightning study has just been finished (Pinto et al., in press). The India Meteorological Department (2013) recorded a mean 4.8 severe thunderstorms days from March until May 1986-2006 at Guwahati, Assam airport, around 250 km aerial distance west of the Nagaland survey area. Kandalgaonkar et al. (2005) published a maximum average flash density of 18 per square km in May in the 23-28°N belt. The region from South Bavaria, Germany, to Upper Austria showed 3-5 CG flashes per square km and year in an ALDIS re-analysis 1998-2009 (Diendorfer et al., 2011). Hoeller et al. (2009) reported similar mean peak currents of 8.2 kA for negative CG flashes at South Germany and 7.7 kA for Brazil, measured with LINET VLF/LF lightning detection stations in 2005.

III. RESULTS AND CONCLUSIONS

The national surveys interviewed around 100 persons with a mean age of 36-43 years. The quota samples were gender-balanced, with a high-education bias of the Indian and Brazilian samples (Tab.I). Single houses were common in India and Brazil, multistoreys in Germany.

Hazard	**India**	**Brazil**	**Austria**
sample (n)	100	104	133
mean age yrs.	35.8	37.2	42.6
male %	50.0	50.0	47.4
female %	50.0	50.0	52.6
basic educ.%	17.0	16.3	39.8
high educ.%	66.0	53.8	18.0
single houses%	52.0	68.3	-----
multistorey h.%	21.0	2.9	-----

TABLE I: Survey sample population characteristics.

Subjective risk assessment (Tab.II) identified landslides as India's major risk, floods in Brazil (Fig.3), and tornadoes in Germany (n=80). The Austrian sample did not rank the full range of risks. Lightning was regarded a main risk in India and Brazil, but not in Germany and Austria.

Hazards	**India**	**Brazil**	**Germany**
hurricane*	**5.1**	**7.8**	**7.6**
landslide	**7.6**	**8.9**	6.2
hail	3.9	6.8	**6.7**
tornado	4.4	**7.4**	**8.1**
flood	4.4	**9.1**	**7.8**
avalanche	3.2	5.9	**6.4**
lightning	**5.2**	**7.4**	5.5
rainfall	**5.6**	7.1	5.1

TABLE II: Highest subjective risks of meteorological hazards (10-point scale, danger 0=no, 10=high), means.
* "severe storm" in Germany

Actual events	**India**	**Brazil**	**Germany**
lightning nearby	58.0	**68.3**	40.0
lightn. damage	4.0	**27.9**	22.5
flood damage	9.0	8.7	**28.7**
storm damage	11.0	29.8	**40.5**

TABLE III: Frequency of actual events, percentages.

Recalled physical damage events (Tab.III) were sparse in India (11% storm, 9% flood), medium in Brazil (30% storm, 28% lightning) and in Germany (41% storm, 29% flood, 23% lightning). The damage items were not asked in Austria.

Lightning know-ledge (% correct)	**India**	**Brazil**	**Austria**
distance estimat.	**3.0**	30.6	21.8
supernatural	87.8	86.9	-----
killed instantly	**29.4**	68.4	83.5
tree hit rate	**10.3**	**28.0**	43.3
boat safety	88.7	88.5	85.4
building safety	77.8	86.2	85.7
lie flat down	**51.0**	**43.4**	***55.9**
distance 3 m	72.3	91.8	64.7
reanimation	70.6	71.7	84.8

TABLE IV: Lightning knowledge level, percentages.
* question in Austria: crouched position

In general, meteorological lay knowledge (tested with several items) was low in India, medium in Brazil, and high in Germany (items not tested in Austria). For a comparison of lightning knowledge, a number of safety-relevant statements (e.g. ″Who is hit by lightning, is killed instantly. ″) had to be answered correctly. The item „distance estimation“ asked for the distance of lightning when thunder was heard 3 seconds later (correct: about 1 km). Tab.IV lists the percentage of correct responses. Several answers indicated a good general knowledge in the survey areas – no supernatural force, no safety on a boat, relative safety in a building, keep distance of 3 m to objects in the open, quick reanimation after lightning hit. The India sample was bad in distance estimations and held the belief that people are killed instantly by lightning. In India and Brazil, trees were seen as differential lightning targets, which can lead to dangerous decisions. Although there is no safe place outside in a severe thunderstorm, people should know how to react when no building, car or other cover is within reach – only half of them know that lying flat on the ground is contraproductive; in Austria, the same goes for a crouched position. For further analysis, items were added to a lightning information score.

In a correlation analysis, formal education levels showed no significant knowledge outcome in Brazil. In India, more educated residents had higher weather interest and assumed a higher lightning risk. In Austria, higher education even lowered the search for information. Actual lightning strikes at respondent's homes in Brazil (reported by 28%) went with higher lightning information scores (i.e. stimulated information seeking), whereas in India (4% strikes) and Austria (12% strikes), no such correlations were present. In Brazil, increased weather interest corresponded with a higher awareness that lightning could hit the house. Also, reported preparedness in Brazil correlated with the assumed lightning risk and the lightning information score, and in India with weather interest, weather report attention and the lightning information score. In Austria, higher lightning information scores paradoxically resulted in lower expected lightning risk, whereas the subjective lightning risk rose with weather report attention and wish for more information.

It is concluded from the international pilot study that a) a high CG flash rate influences population risk parameters when it results in visible physical damage. Therefore, media should show material consequences of the lightning hazard to stimulate further attention, interest, and preparedness. b) Formal education is no predictive factor as lightning is no school topic. c) The situation of lightning protection knowledge is good for some basics (e.g. boat, building safety, reanimation) and bad for others (e.g. distance, trees, no-cover-situation). In areas with high thunderstorm and CG lightning rates, lightning protection information should be a continuous, yearly media subject.

Interest to replicate the risk preparedness survey has been expressed by colleagues from North America, Africa, Asia, and Australia. A more dense network of social lightning statistics will sharpen the picture and help to identify the strengths and weaknesses of laypeople.

IV. ACKNOWLEDGMENTS

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