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Geoscience Communication
Discussions

Impact of an educational program on earthquake awareness and preparedness in Nepal

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ABSTRACT

Scientific education of local communities is key to help reduce the risk associated with natural disasters, such as earthquakes. Western Nepal has a history of major seismic events and is highly prone to further earthquakes; however, the majority of the population is not aware about or prepared for them. To increase earthquake awareness and improve preparedness, a seismology education program was established at 22 schools in Nepal. In each school, educational activities were performed by teaching earthquake related topics in classrooms, offering training to teachers and through installing a low-cost seismometer network which supported both teaching and awareness objectives. To test the effects of this program we conducted two surveys with school children, one before and one after the initiation of the program, with several hundred participants in each. The survey findings highlighted that educational activities implemented at schools are effective in raising the awareness levels and in improving the adaptive capacities and preparedness for future earthquakes. However, perceptions of risk did not change so much. Furthermore, we know there was dissemination of this information to the broader community though social learning, leading to broad scale awareness. A high and positive impact of program on the students and the community is encouraging to continue and expand the program.

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INTRODUCTION

It is becoming increasingly important to educate people in the era of global change about environmental hazards to ensure they are well prepared to face the rising number of challenges. Education may play a central role for the risk management of natural hazards and help to reduce vulnerability and improve adaptability though allowing people to anticipate and prepare for hazards (Godschalk, 2003; IRGC, 2005).

Exact earthquake prediction is currently not possible, but responses to such events can be prepared for in advance to mitigate the effects they can have on society and human well-being (Turner, 1976). The impacts of earthquake disasters can be minimized by learning what to do before, during and after earthquakes, and by taking a variety of personal safety measures (Lehman & Taylor, 1987). Whether people prepare for future earthquakes or not can be significantly influenced by their education and their engagement on the topic (Tanaka, 2005). All-inclusive public awareness and education is fundamental to reducing causalities, personal injuries, and property damage from natural disasters (NRC, 1991; Torani et al., 2019). Researchers can contribute and play a key role in the education of society; not just to engage more people in research, but also to provide scientific explanations for natural hazards and related consequences to local communities and help to develop polices for mitigation of effects.

Earthquakes are the most common and deadliest natural hazard in Nepal with a long history in the country (Bollinger et al., 2016). Historical records indicate that many houses and temples in Nepal collapsed during the 1255 earthquake, and one third of the population including the King, Abhaya Malla, was killed. There are also records of an earthquake with a magnitude >8 in 1505 (Ambraseys and Jackson, 2003) and indications that even larger earthquakes are plausible in the Himalayas (Stevens and Avouac, 2016). In 1934 during a M8.2 earthquake, over 8’500 people lost their lives, 126’000 houses were severely damaged and more than 80’000 buildings completely collapsed (Fig. 1). The most recent major earthquake in 2015 hit central Nepal with a magnitude of 7.8, resulting in about 9’000 causalities; nearly 800’000 buildings were damaged or destroyed, leaving millions of people homeless, the resulting losses were equivalent to 50 % of total national GDP (Chaulagain et al., 2018). In addition, 19’000 classrooms were destroyed and 11’000 damaged (NPC, 2015b). It is suggested that if people had better awareness preparations could have been better and the negative impacts might have been lower (Hall & Theriot, 2016).

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The topic of earthquakes is not included at any level of the official school curriculum in the Nepali education system. However, recently the National Society for Earthquake and Technology (NSET) initiated the Public-School Earthquake Safety Program in Nepal, in a few districts of the country (Dixit, 2014). This program focuses mainly on the retrofitting of school buildings to restore and minimize future damage following the 2015 earthquake. Following the devastating 2015 Gorkha event, and considering the history of major earthquakes and the likelihood of many more, we initiated and implemented a seismology education program in schools in Western Nepal (Fig. 1; Subedi et al., 2020) including the area affected by the 2015 earthquake and expanding towards the West (Fig. 2).

The aim of the program is to increase the earthquake awareness level in Nepal, starting from the schools, with the hope that this knowledge will be spread into the community through social learning, and partly through the establishment of a low-cost seismic network (Figs. 1, 3). In this study, the effects of the education program for earthquake awareness and preparedness are evaluated. The evaluation was performed by collecting data from students through two surveys, before and after initiation of the program.

METHODS

The data for this study were collected using two questionnaire surveys in paper, conducted in Nepali language: in 2018, before the initiation of our program, and in 2020, nearly a year after the full implementation of our program.

Before the initiation of our program, we undertook fieldwork to help inform our strategy and the educational materials, and to ensure the education program was well adapted to the Nepali education system. In 2018, during the first visit, we talked with the school leaders about our program and its benefits, and gave sample lectures (ca. 1-2 hours including questions) to students of age 14-16, providing key information on earthquakes. Before the sample lecture and in each school, students were requested to fill in a paper questionnaire survey on earthquake related questions. In special lectures we also taught how to prepare before an earthquake, how to save lives during an earthquake, and what to do after an earthquake, using a flyer containing detailed information and pictures (Fig. 4), of which we distributed 500 copies. We have also designed a

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sticker to remind people about earthquake hazards (Fig. 3), and distributed this to students and teachers (3'000 pieces so far).

In April-May 2019, during the second visit, the program was fully implemented with the installation of an educational, low-cost seismometer in every school. The seismometer's record is displayed on a computer, which is easily accessible to students in physics class, or through an online application. During our visit, we also identified the open place near the school where students should meet in case of earthquake and installed an Emergency Meeting Point sign in Nepali. To increase the efficiency of the learning and to keep its effect for long-term, we organized a 2-day workshop for nearly 100 school teachers, which was very well received. The full details of the program are documented in an earlier paper (Subedi et al., 2020) and the all the material is accessible on the program website (www.seismoschoolnp.org).

In this article, we focus on evaluating the efficiency of our program in terms of knowledge and behavior change of students related to earthquakes. Out of 22 schools participating in the program, 15 schools were chosen for the survey, covering a range of socio-economical contexts. Students for the surveys were selected randomly from grades 9 and 10, representing the 14-16-year-old age group. The total number of responses collected was 318 in 2018 and 480 in 2020, respectively. For logistical reasons, 27 % of the answers were collected from different schools. While the first set of students surveyed had no earthquake education whatsoever, those who filled out the second survey were exposed to information and lectures frequently about earthquakes from the teachers who were trained in our program.

When the exact same question was asked before and after our program's implementation, we quantify the change using chi-square test analysis. In doing so, our null hypothesis H_O is that our program had no effect on the students. If this null hypothesis is not true (i.e., the chi-square value is above the threshold for the corresponding number of possible answers, and the respective p-value is below 5%), then we interpret that the program had an effect on the students as their answers show a clear, statistically significant change.

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RESULTS

The first measurement of this study, performed in the 2018 survey, was about the experience of the 2015 Gorkha earthquake. The majority of respondents, 94 %, felt the shaking. As the earthquake was on Saturday, schools were closed and students were at home; 71 % of students answered that they ran out of a building, and only 15 % hid under a table, 8% did not know what to do, 3% stood next to the wall or the doorframe, 3% had other reaction.

Knowledge about the causes and possibility of earthquakes in Nepal

Before the implementation of the program, 7 % students believed that earthquakes were caused by a moving fish carrying the Earth (a Hindu belief and myth). However, 64 % still chose the correct scientific answer: plate tectonics. The majority of students, 84 %, chose this (plate tectonics) answer in 2020, and the percentage of responses relating to the cultural/religious reasons dropped to 2 % (Fig. 5).

Regarding the probability of a future earthquake greater than in 2015, more students knew that such an earthquake in their region was quite likely after the education program (Fig. 6a). At the same time, there was a clear drop in the number of responses for very unlikely (17 % in 2018 to 5 % in 2020) and a slight drop in the percentage answering that a future great earthquake is impossible.

Relating to the effects of a M>8 earthquake, after the program, the answer *I could die* has increased by a factor of 1.8, and all other answers (*I could be buried alive*, *I could get hurt*, *I could lose friend* and *My home could collapse*) are increased by a factor of at least 1.3 compared to 2018 (Fig. 6b; multiple answers were possible).

In 2018, 31 % students answered they know when an earthquake will occur, which is reduced to 11 % in 2020. The answer itself is not true, and this mis-information could drive people to incorrectly prepare for or act during an earthquake. While our efforts clearly decreased this mis-conception among the students, we could not yet reach each and every student to teach them about the unpredictability of earthquakes. The students answer agreeing on the impossibility of preventing an earthquake has recorded an absolute increase of 18 % in 2020 and reached 86 %. This question also shows that by 2020, more than double of the respondents have participated in disaster risk education training compared to 2018 (Fig. 7).

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Knowledge and perceptions about how to behave during and after an earthquake

Three quarters (75 %) of respondents in 2020 chose the answer that their family knows what to do and where to go during an earthquake, an increase from 55 % in 2018. Only 37 % of students in 2020 believed that their home could resist a large earthquake. For comparison, 65 % students were scared and 22 % panicked during the Gorkha earthquake in 2015 (10 % had calm reactions, 3 % did not care) according to answers in 2018.

In 2018, 62 % respondents didn't know that they should not call others after an earthquake to leave the phone lines available for rescue operation, but in 2020 nearly 80 % students knew this useful practical point (Fig. 8).

After the implementation of our program, 65 % of the students believed that they can survive if a large earthquake occurred at night, whereas in 2018 57 % felt they could not survive. This information reflects more confidence of students as they become familiar with earthquake topics and heard more information about them.

In 2020, 93 % of respondents know that during an earthquake, the majority of injuries and deaths are caused by people being hit by objects, collapse of constructions; the proportion of people not knowing this dropped by 2/3 after the educational program was implemented. More than 60 % of the students were aware about the additional hazards, such as fire, landslides and floods that can be triggered by an earthquake in 2020 survey. This is a decrease of 7 % from the 2018 survey, but as students who claimed partial knowledge increased by 7 % as well, a net change is not really perceptible.

The proportion of students who regularly discuss earthquake related topics within their families has increased by 18 % (absolute increase; see Table 1). This shows that the education program at schools has led to widespread social learning within communities. This is reinforced by the finding that nearly all students (98 %) are interested to learn more about earthquakes in detail, which will help lead communities towards better earthquake preparedness.

Earthquake preparedness and adaptation

In 2018, 36 % of students perceived that to remain alive during an earthquake depends on luck, while this number has decreased by a relative 60 % after our program started and is a concern for only 21 % of students (Fig. 9). All possible answers regarding adaptation options to earthquakes record an increase from 2018 to 2020 (Fig. 11). The majority (72 %) of respondents answered that

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they are aware of the shelter areas and open space where they can go in case of an earthquake. The same proportion of people are aware of evacuation areas in 2020, but the increase here is much more important (from 38 to 69 %), potentially thanks to the Nepali Emergency Meeting Point signs we installed in schools. The information about which governmental authority to contact after an earthquake is relatively low, but has increased by 10 % (absolute). Information about earthquake prone areas and the reception of knowledge on earthquake disaster adaptation have increased by the factor of 2.5, from 12 % in 2018 to 31 % in 2020 after the education program.

The relatively small number of respondents who claimed that the government will provide help after an earthquake increased by a factor of almost 3: from 8 % in 2018 to 23 % in 2020. This percentage is not accurate in general, but the improvement following our program's implementation is noteworthy. Moreover, the level of confidence in the government's reconstruction activities has also grown, from 13 to 30 %, which is a good sign and shows increasing level of trust. In 2020, 68 % of the respondents knew about the importance of talking about earthquakes with neighbours, friends and colleagues, a nearly two-fold increase in two years. Furthermore, we found that all students discuss with the people around them in the community to share their knowledge on earthquakes, and what they learned at school. Ninety-one percent of the students talk at least with some people in the community, only 9 % discuss with parents only, and there is no student who had not had a discussion in her/his surrounding (Fig. 10).

Perception of risk

More than 60 % of the answers showed that students considered the level of seismic risk in their city as medium, which means their risk perception is underestimated with respect to the actual seismic risk level in the region (Stevens et al., 2018). Only every 6th person claims to perceive high risk, which is clearly less frequent than people declaring low risk. As opposed to our expectation, there is very little change in the level of risk perception in the group of students from 2018 to 2020: the medium risk level group is the same, and there is minor change in low and high-risk level groups (Fig. 12). This result is a surprise, especially when compared to the 72 % of responses in 2020 who believe that there is more than 70 % chance of experiencing an earthquake larger than the 2015 Gorkha earthquake in their life (Fig. 6a).

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Project acceptance and future education

To measure the program's acceptance level, some questions regarding the program itself were also included in the 2020 questionnaire. It is found that 91 % of the students know that a seismometer is installed in their school for earthquake education purposes. A total of 61 % of the students have observed waveforms recorded by the seismometer, either at the school computer (39 %), on the teacher's mobile phone (18 %) or/and on their parents' or own mobile phone (8-8 %). Furthermore, 85 % of the students answered that teachers teach about earthquakes in the classroom regularly (weekly, monthly, on demand, and/or following an earthquake). Hence, our program and the methods we use for teaching about earthquakes are well accepted. In 2020, 99 % of the students expressed that they like the earthquake information we have provided them. Regarding future plans, almost all students are very much (69 %) or simply (29 %) interested to learn about earthquakes by inserting the theme in the official curriculum, which can be imposed only by the central or the regional government of Nepal.

Statistics

All questions except the last (Question 12 in Table 1, level of interest to learn is 98% in both surreys) record a clear change in the pattern of answers given following our program's implementation (see Supplementary Table 1). The biggest statistical change was seen for Question 6 (avoid post-earthquake use of mobile communications) suggesting a big increase in knowledge and a very new information. Each question (excluding those with multiple choice answers) and their corresponding chi-square and p values are reported in the Supplementary Table 1.

DISCUSSION

Had awareness levels increased?

The themes related to earthquakes are more familiar to the students now than in the past, and their awareness level have increased since the program was initiated. Students know more about the earthquake phenomena and have changed their behavior to better prepare and adapt to forthcoming earthquakes. Earthquake related knowledge learnt by students is not limited to the schools, but also reaches across the broader community, though social learning processes (Reed et al. 2009).

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Why had the awareness level increased?

Beyond the prescribed school education, the teachers have given attention and our program has provided an opportunity to informal and free-choice education forms, in which people can learn about topics outside of formal educational settings (Falk & Dierking, 2002). This is a form of social learning, which is suitable for understanding the knowledge through communication with others, which may lead to changes in attitudes, behavior, and building of trust in the society (Reed et al., 2010). This method is widely applied for the study of natural hazards and its management (e.g., Brody, 2003; O'Keefe et al., 2010). During our program's implementation, despite being in contact only with the school children, the knowledge has spread much more widely in local communities through social learning, thus reaching and impacting the original and intended target group.

People's behavior can be developed through education. The idea is that if people are made knowledgeable of earthquakes, they are more likely to adopt and perform behaviors that will increase their earthquake awareness and preparedness (Hungerford and Volk, 1990). For example, an education program changed the behavior of most but not all people with regards to spreading aquatic invasive species (Cole et al., 2019), showing the role this approach can play but also limitations to full behavior changes.

As a result of our educational program, earthquake related knowledge has increased and the behavior to cope with earthquakes has also changed. Despite this, the earthquake risk perception of students has not changed yet. Our results show that a realistic and appropriate distribution of earthquake related knowledge and increased awareness level are not (or not yet) sufficient to influence the perception of risk. Some studies support the result as relation between increased knowledge and risk perceptions is not defined, and increasing perceived risk does not necessarily result in the reduction of risk behavior (e.g. Noroozinejad, 2013). Furthermore, the effect of positive change related knowledge and attitudes are not adequately linked with the behavior practices (e.g. Petros, 2014). In addition, knowing more of a given topic makes people more certain, self-confident, which may lead to underestimate the related risk, but it seems that risk perception doesn't correlate with people's behavior (e.g. Stringer, 2004).

Moreover, probably because of the presumed increased controllability, increased knowledge should reduce the fear in a risk and therefore reduce the risk perception. The reduction of risk

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perception is due to the proper knowledge of the hazard and how to mitigate it (Ndugwa Kabwama and Berg-Beckhoff, 2015).

Hence, how people perceive risk is not necessarily related to the actual risk. We cannot draw a definitive conclusion as the related knowledge can contribute to the amplification or the attenuation of the related risk; as such, it could be one of the potential reasons for the low risk perception of people having more knowledge (Reintjes, 2016). Risk perception is thus important for preventative actions, but risk perceptions are often biased (Weinstein, 1988). It could be that more time is needed to change students' risk perceptions, and it is also likely that there are other factors such as economic status, gender, age group, location of home in city, etc. that may influence the level of risk perception of people. A repeated survey in the same age category in a few years' time may give an answer to this question.

Since other sources of information, such as newspapers and television, are not easily available to people in the Nepali countryside, we believe that the school is the best platform to transfer knowledge to the community. The proper education at school reaches deep across the families and into the community, and the discussions in those circles are essential to prepare the whole society for future earthquakes. The proportion of students who regularly discuss earthquake related topics within their families has increased by 18 % (absolute increase; see Table 1). This shows that the education program at schools has led to widespread social learning within communities, and possibly beyond our program's current area.

Further action needed

Although this program has increased the earthquake awareness level among students in the program area, it is alone not sufficient for seismic risk reduction. We know that we can help communities to prepare for future earthquakes, but the local, national and regional governments are responsible for the rescue, support and reconstruction operations in case of severe earthquake. People's situation after an earthquake depends on how well they are prepared for the event, on construction quality, and the shaking intensity in the region. Since the shaking level of an earthquake cannot be controlled, the impact of an earthquake on the community is strongly dependent on the actions taken by the government for its preparedness, such as education (as our effort) as well as suitable, locally calibrated and enforced building code. For both aspects, the provincial governments could overtake some of the efforts from our bottom-up approach, and

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adapt them to continue earthquake education in schools, which is an efficient way to make earthquake safer communities. In parallel, local initiatives are encouraged to strengthen these efforts.

CONCLUSIONS

The Seismology at School in Nepal program has been successfully implemented achieved the aim of raising earthquake awareness and preparedness by educating students in their schools. The program itself and the methods we used for teaching about earthquakes and demonstrating with low-cost seismometers are well accepted. The new knowledge learned by the students at school reaches their parents and is transferred into the local communities. The results we observed through two surveys, before and after initiation of the education program, are measurable, statistically significant and with positive changes for earthquake related knowledge and preparedness level, but not (yet) for the perception of the related risk. A high and positive impact of the program on the students and their communities is encouraging for the continuation and expansion of the program in the region.

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Figure 1: Map of Nepal, with the locations of schools participating in the Seismology at School in Nepal program. Background color is population density data (CIESIN and CIAT, 2005). The Main

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Frontal Thrust (MFT), the surface trace of the fault underlying most of Nepal and hosting all great earthquakes in the region, is indicated in red solid line. Three colored segments represent the rupture extent of the corresponding major and great earthquakes with magnitude (M) as indicated (after Bollinger et al., 2016). For the 2015 Gorkha earthquake the rupture area is also plotted (blue contour). Letters P and K refer to cities Pokhara and Kathmandu, respectively, marked with black circles.

Figure 2: Students gathered at the morning assembly in the *Shree Himalaya Secondary School, Barpak, Gorkha* district. The school building was damaged during the 2015 earthquake and students were in temporary shelters. The construction of the new building is visible on the top of the picture. (Photo: S. Subedi, in May 2018, with permission of the school).

Figure 3: Left: The Raspberry Shake 1D low-cost seismometer, installed in 22 schools across Central Nepal (Fig. 1). Right: Earthquake awareness sticker, as a reminder, in English and Nepali language (artwork of M. Dessimoz). The sticker image is available for download from our program's webpage: www.seismoschoolnp.org.

Figure 4: Educational flyer in Nepali language on what to do before, during and after an earthquake. The flyer has been translated and adapted from an English version, compiled by and available from the CPPS earthquake education centre in Sion, Switzerland (www.cpps-vs.ch). The Nepali flyer is available for download from our program's webpage: www.seismoschoolnp.org.

Figure 5: Student opinions on what causes earthquakes, before and after the initiation of our education program. ($\chi 2$ = 78.15, p-value = < .00001, the change is significant).

Figure 6: *(a)* Student views on how likely the occurrence of a next earthquake bigger than the 2015 Gorkha earthquake is, before and after the initiation of our education program. ($\chi 2$ = 43.59, p-value = < .00001, the change is significant). *(b)* Student answer on the outcome of a potential M>8 earthquake in Nepal, before and after the initiation of our education program. *Multiple answers were possible.

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Figure 7: Students' personal knowledge about earthquakes, before and after the initiation of our education program. *Multiple answers were possible.

Figure 8: Student's knowledge on the recommendation to avoid making phone calls after an earthquake to leave lines available for rescue operations, before and after the initiation of our education program. ($\chi2 = 138.72$, p-value = < .00001, the change is significant).

Figure 9: Student's own opinion on earthquake preparedness, before and after the initiation of our education program. *Multiple answers were possible.

Figure 10: Student activities to transfer the knowledge to the community, after initiation of our education program.

Figure 11: Student ideas about earthquake adaptation, before and after the initiation of our education program. *Multiple answers were possible.

Figure 12: Students' perception of the level of seismic risk in their respective location, before and after the initiation of our education program. ($\chi2 = 6.33$, p-value = 0.042, the change is slightly above significant level).

No	Question	Answer in 2020 survey			Answer in 2018 survey		
		Yes	Partially	No	Yes	Partially	No
Q7	If a large earthquake occurred at night, could you save yourself?	65%	-	35%	43%	-	57%
Q8	Do you know that the majority of injuries that occur in earthquakes are caused by people being hit by or stumbling over fallen objects?	93%	-	7%	76%	-	24%

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Q9	Do you know that earthquakes can make additional damage such as fire, landslides and floods?	68%	21%	11%	75%	14%	11%
Q11	The preparedness of a major earthquake is the most important thing. Are you regularly discussing this topic with your family?	71%	-	29%	53%	-	47%
Q12	Are you interested to know more about earthquakes and its preparedness in details?	98%	-	2%	98%	-	2%

Table 1: Questions and respective answers about earthquake preparedness among students who participated in the surveys, before and after our education program was initiated in Central Nepal. Respective statistical indicators are reported in Supplementary Table 1.

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CONFLICT OF INTEREST AND ETHICS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors declare that an ethical approval was not required as per local legislation. The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

The project concept and implementation details were developed by S.S. and G.H. Most of the fieldwork was carried out by S.S. with some help by G.H. The preparation of the manuscript, figures, tables and the calculations were done by S.S. and guided and verified by G.H and R.S. All authors discussed the results, and contributed to the final manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found in supplementary material file.

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DATA AVAILABILITY STATEMENT

The datasets used for this study can be available on request to corresponding author.

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FIGURES

Figure 1

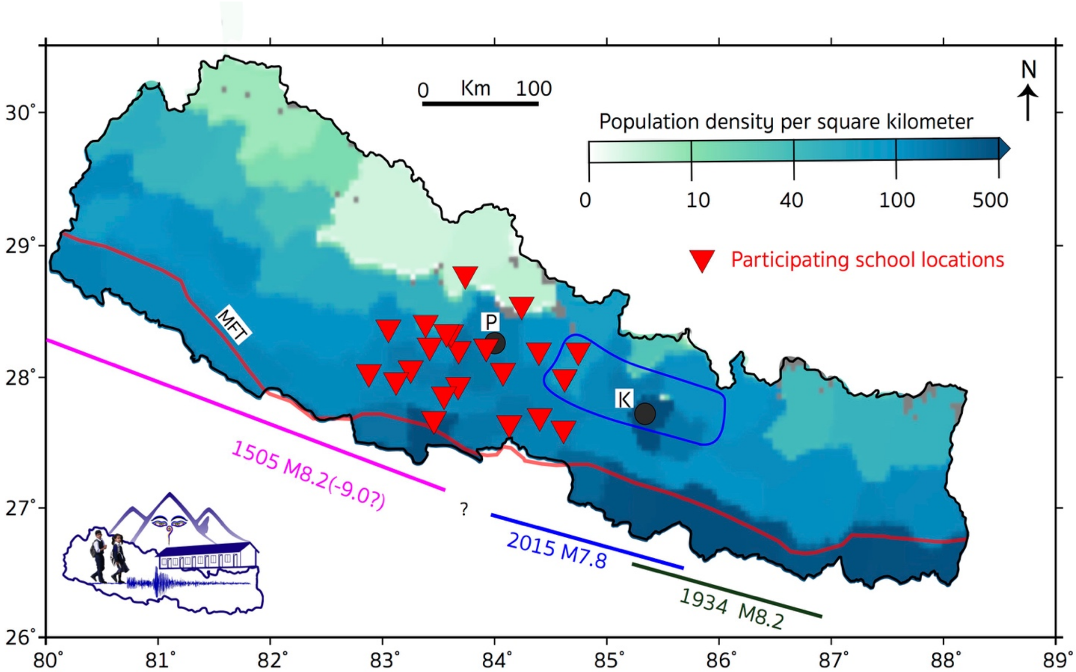

Figure 2

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Figure 3

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Geoscience Communication
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Figure 4

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Figure 5

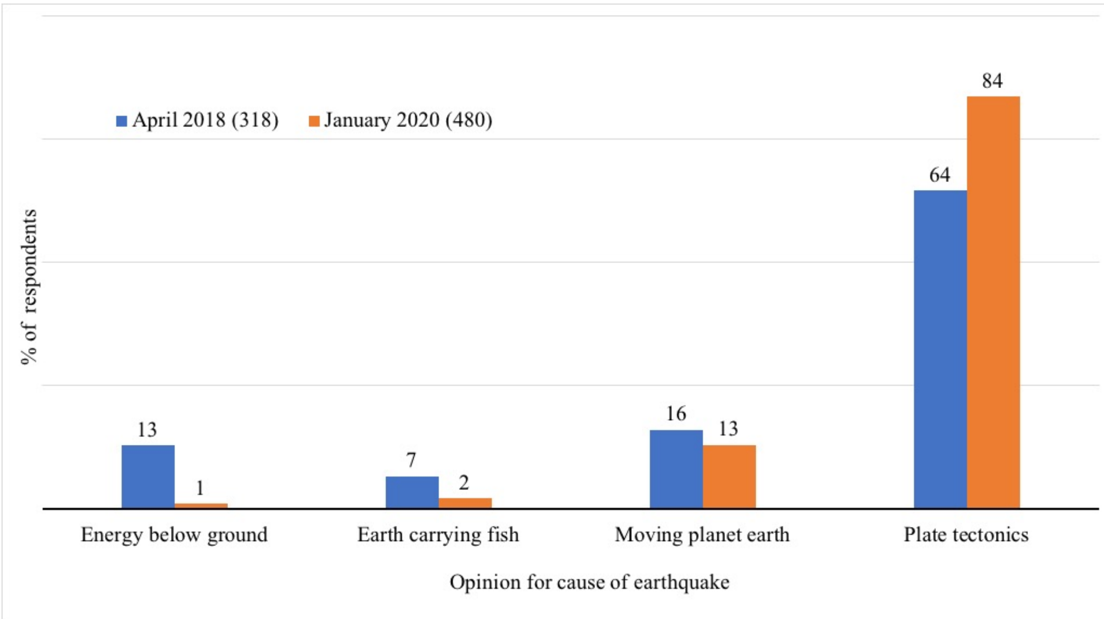

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Figure 6

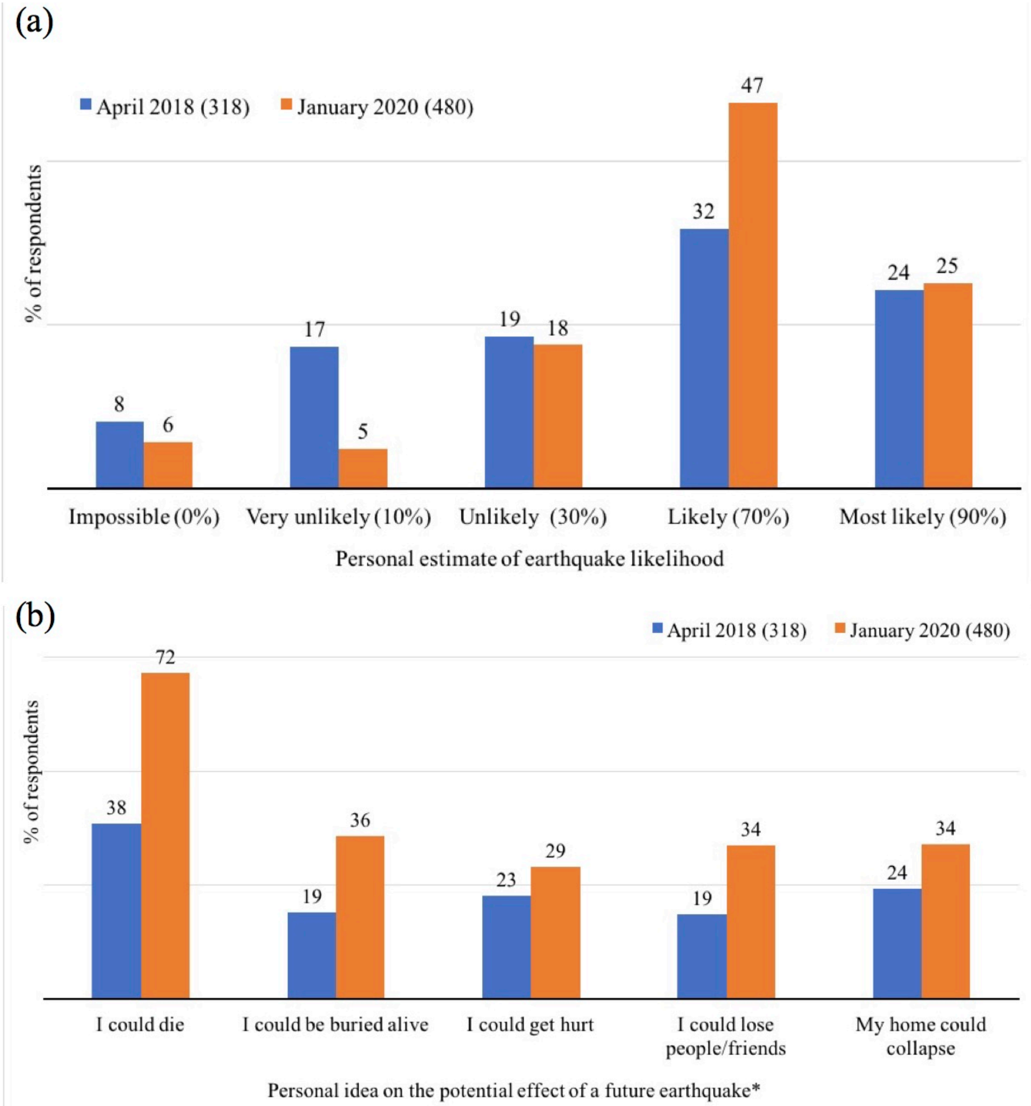

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Figure 7

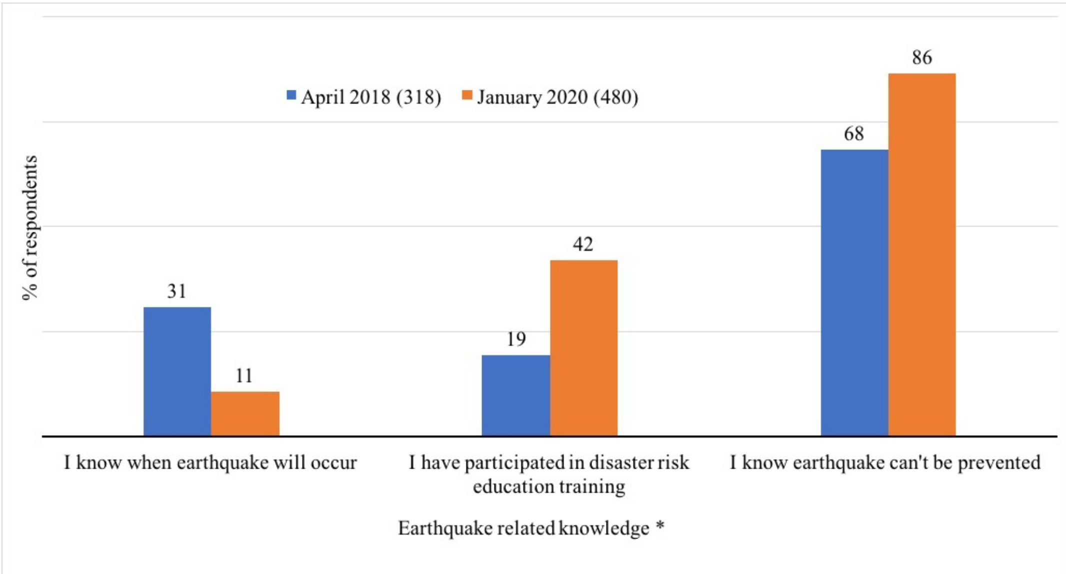

Figure 8

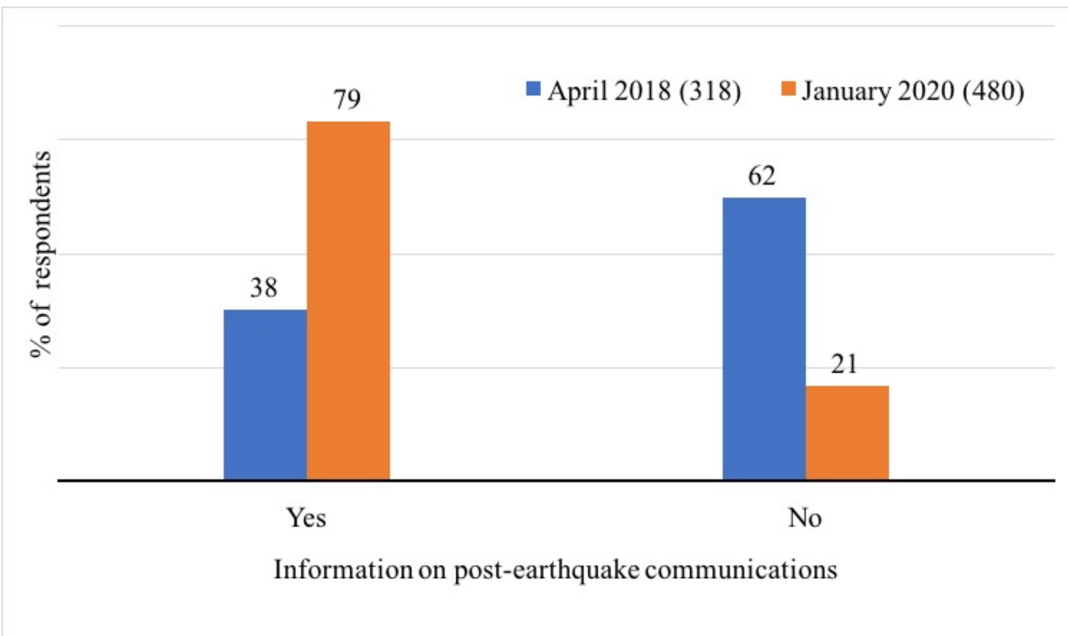

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Figure 9

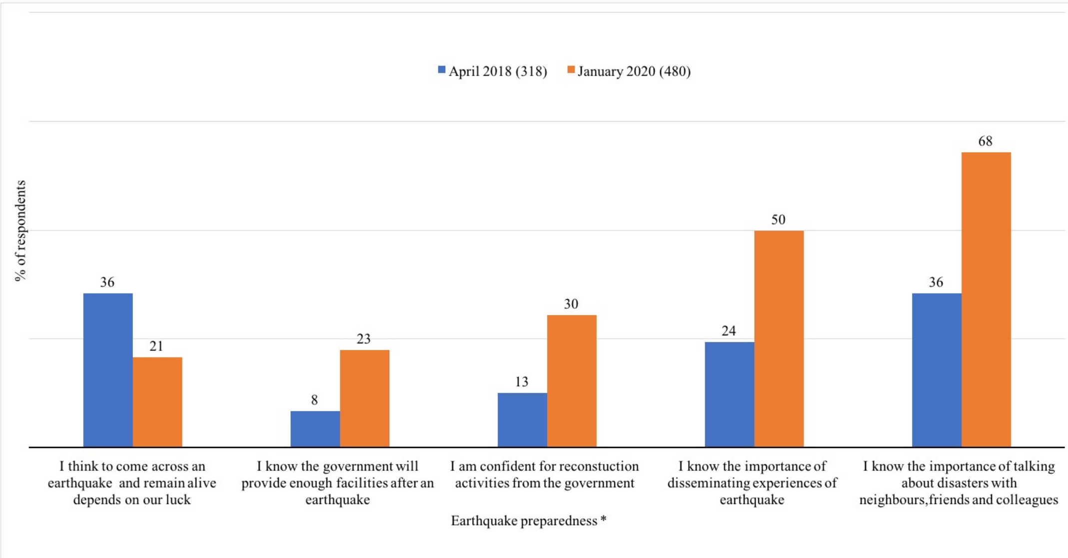

Figure10

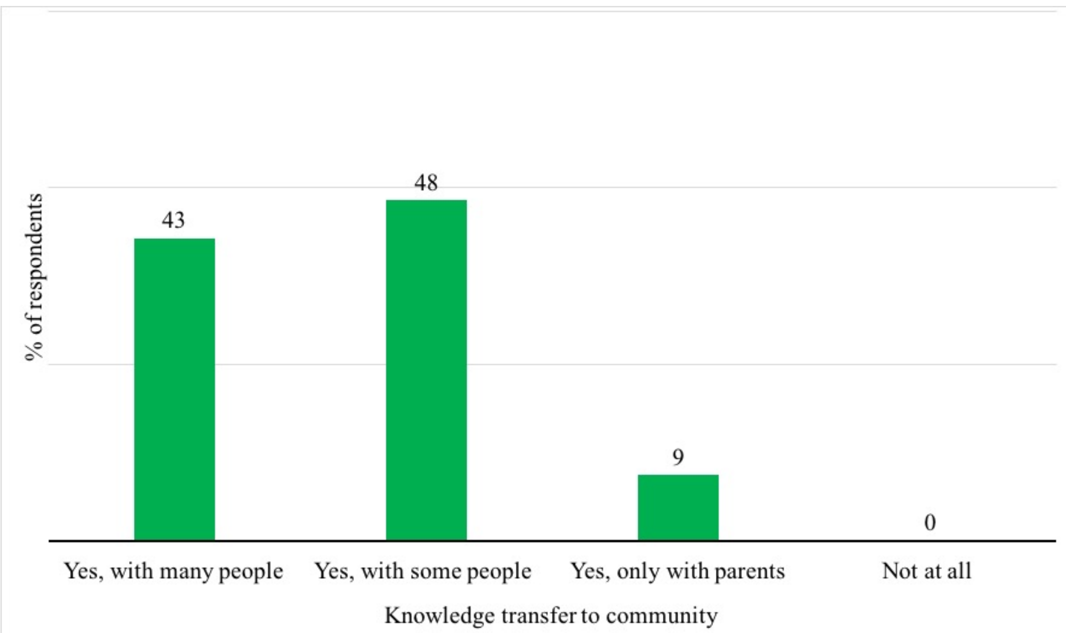

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Figure 11

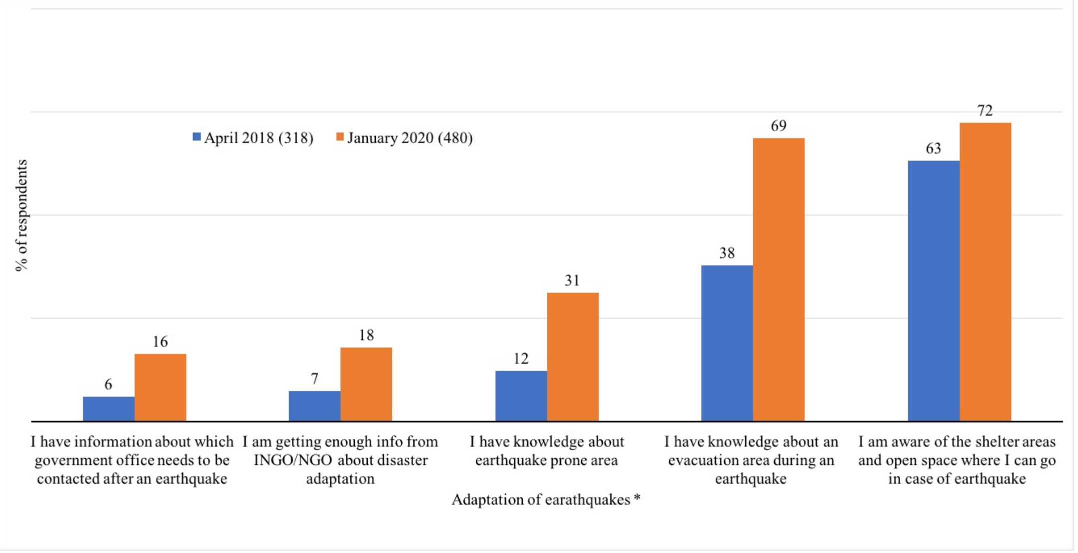

Figure 12