JICA Ogata Research Institute Discussion Paper

Spillover Effects of School-Based Disaster Education from Children to Parents: Evidence from Indonesia

Tetsuya Harada, Masahiro Shoji, and Yoko Takafuji

No. 1
September 2022

JICA OGATA SADAKO
RESEARCH INSTITUTE FOR
PEACE AND DEVELOPMENT

Suggested Citation: Harada, T., Shoji, M., and Takafuji, Y. 2022. Spillover Effects of School-Based Disaster Education from Children to Parents: Evidence from Indonesia, JICA Ogata Research Institute Discussion Paper No.1. Tokyo: JICA Ogata Sadako Research Institute for Peace and Development

JICA Ogata Sadako Research Institute for Peace and Development, Japan International Cooperation Agency (JICA)
10-5 Ichigaya Honmura-cho, Shinjuku-ku, Tokyo, 162-8433, JAPAN
TEL: +81-3-3269-3374
FAX: +81-3-3269-2054

Spillover Effects of School-Based Disaster Education from Children to Parents: Evidence from Indonesia

Tetsuya Harada,* Masahiro Shoji,† and Yoko Takafuji‡

Abstract

The literature demonstrates that school-based disaster education is a cost-effective approach to facilitate children's attitudes, knowledge, and behavior regarding disaster risk reduction. However, effective interventions for adults are not yet well understood. The goal of this study is to evaluate the spillover effects of a disaster education program for children on their parents. Unique survey data were collected from 539 elementary school students and their parents on Nias Island, Indonesia, among whom 214 students participated in the *Maena for Disaster Education* program. The results using an instrumental variable model show that the program encourages children to discuss and share knowledge about natural disasters with their parents, and has positive effects on parents' attitudes, knowledge, and behavior. This impact is particularly large for households residing in risky areas. Therefore, school-based disaster education is effective not only for the participants but also for their parents, suggesting there is a substantial social impact. This is the first study to rigorously demonstrate the spillover effects of disaster education on parents in a developing country. This study also contributes to the literature on intergenerational value transmission by applying an instrumental variable model and providing direct evidence.

Keywords: Disaster education, disaster risk reduction, intergenerational spillover effect, intergenerational learning, earthquake, tsunami, Indonesia

Acknowledgment: This study was financially supported by the Japan Society for the Promotion of Science Grant Number 16K03657 (PI: Masahiro Shoji) and JICA Indonesia (Tetsuya Harada). The authors thank Mai Seki and seminar participants at the JICA. The usual disclaimers apply.

* JICA Ogata Sadako Research Institute for Peace and Development, Japan International Cooperation Agency (JICA), 10-5 Ichigaya Honmuracho, Shinjuku-ku, Tokyo, 162-8433, Japan (Harada.Tetsuya@jica.go.jp)

† Corresponding author, Institute of Social Science, University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan (shoji@iss.u-tokyo.ac.jp)

‡ Centre for Asian Area Studies, Rikkyo University, 3-34-1 Nishi-ikebukuro, Toshima-ku, Tokyo 171-8501, Japan (nre48767@nifty.com)

1. Introduction

Natural disasters, particularly earthquakes and tsunamis, cause immense loss of human life. It is estimated that 1.35 million people were killed in 7000 natural disasters worldwide between 1996 and 2015, of which 56% were victims of earthquakes and tsunamis (UNISDR and CRED, 2016). Given the significance of the issue, a reduction in the number of disaster victims is included in the policy targets of the United Nations' Sustainable Development Goals. However, developing a disaster-prevention infrastructure alone might not be sufficient to achieve these goals. It is also essential to design effective policy interventions to improve citizens' disaster preparedness, such as attitudes to, knowledge about, and behavior for preparation, and disaster response, such as evacuation behavior.

Previous studies have demonstrated the determinants of disaster preparedness and response, such as perception and knowledge of disaster risks and coping strategies, disaster experiences, access to disaster information, social capital, socio-emotional skills, socio-economic and demographic characteristics, and participation in disaster education programs (Becker et al., 2012; Kusumastuti et al., 2022; Levac et al., 2012). These studies suggest that, while there are variations across communities and individuals, individuals' disaster preparedness is generally low, despite previous campaigns conducted by governments and NGOs. However, school-based disaster education programs are a promising approach for children (Amri et al., 2022; Clerveaux et al., 2010; Faupel et al., 1992; Mishra and Suar, 2012; Ronan et al., 2012; Ronan and Johnston, 2003; Seddighi, et al., 2021; Shaw et al., 2004; Shoji et al., 2020a; Soffer et al., 2010; Wang et al., 2022). By contrast, it is challenging to facilitate adult preparedness and response. One obstacle to implementing such policy interventions is the difficulty of outreach (Izadkhah and Hosseini, 2005). Unlike children, adult community members have few opportunities to collaborate in one place. This raises the question of which policy interventions could be effective for adults.

This study attempts to bridge this knowledge gap by evaluating whether a school-based disaster education program could have spillover effects on the participants' parents. Such effects may be observed if the program encourages participants to share their knowledge about appropriate disaster preparation and responses with their families. Previous qualitative studies and policymakers have argued that schools and children play a role in reducing the disaster risks of community members outside schools (Izadkhah and Hosseini, 2005; Mitchell et al., 2008; Oktari et al., 2015; Takeuchi, 2011; UNISDR, 2006; Williams et al., 2017). Studies have also demonstrated the intergenerational spillover effect of other types of non-formal education, such as environmental education (Boudet et al., 2016; Duvall and Zint, 2007). However, rigorous evidence on the causal spillover effects of disaster education programs remains scarce.

In this study, we analyze the impact of the pilot program of *Maena for Disaster Education,* which has been designed for elementary school students on Nias Island, Indonesia. This program has four features that are suitable for analyzing the spillover from children to parents. First, the literature has found this program to have substantially large positive effects on participants' perceptions, attitudes, and behaviors toward disaster risk reduction (Shoji et al., 2020a). Second, the program was designed to encourage participants to communicate about appropriate disaster preparation and responses with their family members through various channels. Third, it is the first disaster education program to be introduced on the island. Therefore, none of the parents had experience of similar programs. Finally, it is a challenge to evaluate compulsory disaster education programs owing to the difficulty of finding children for the control group. However, the pilot program of *Maena for Disaster Education*, which was conducted before the program became compulsory, covers only six elementary schools on the island, enabling us to evaluate the program's impact.

2. Background

2.1 Study Site

Our study site is the South Nias Regency on Nias Island, North Sumatra Province, Indonesia (Figure 1). This island, located off the western coast of Sumatra, is prone to earthquakes and tsunamis owing to its geographic conditions.[1] In particular, the island experienced severe damage from two devastating earthquakes, in 2004 and 2005. The December 2004 Indian Ocean earthquake (M9.0) and the resulting tsunami killed 154 people, leaving 1,832 people missing. Three months later, in March 2005, the Nias-Simeulue Earthquake (M8.7) caused even more damage, with 851 people reported dead and 6,278 missing.

The earthquake damage was exacerbated by weak disaster preparedness arising from socio-economic and cultural factors. First, 90% of the working-age population in South Nias Regency are farmers, and 62% of the working-age population have only elementary education (Badan Pusat Statistik Kabupaten Nias Seltan, 2017). Owing to low socio-economic conditions, many of the houses on the island were vulnerable and collapsed during the earthquakes, resulting in many casualties. Second, people were unaware of the proper evacuation procedures in the event of an earthquake or tsunami owing to the absence of disaster education in the school curriculum at that time. In addition, the island retains indigenous culture and practices based on animism, with the villagers often believing that talking openly about natural disasters invites them to happen, which makes the sharing of disaster prevention knowledge more challenging.

[1] The island is located 100 km east of Sunda Trench, the boundary between the Eurasian Plate (Sunda Plate) and Australian Plate (Sahul Shelf).

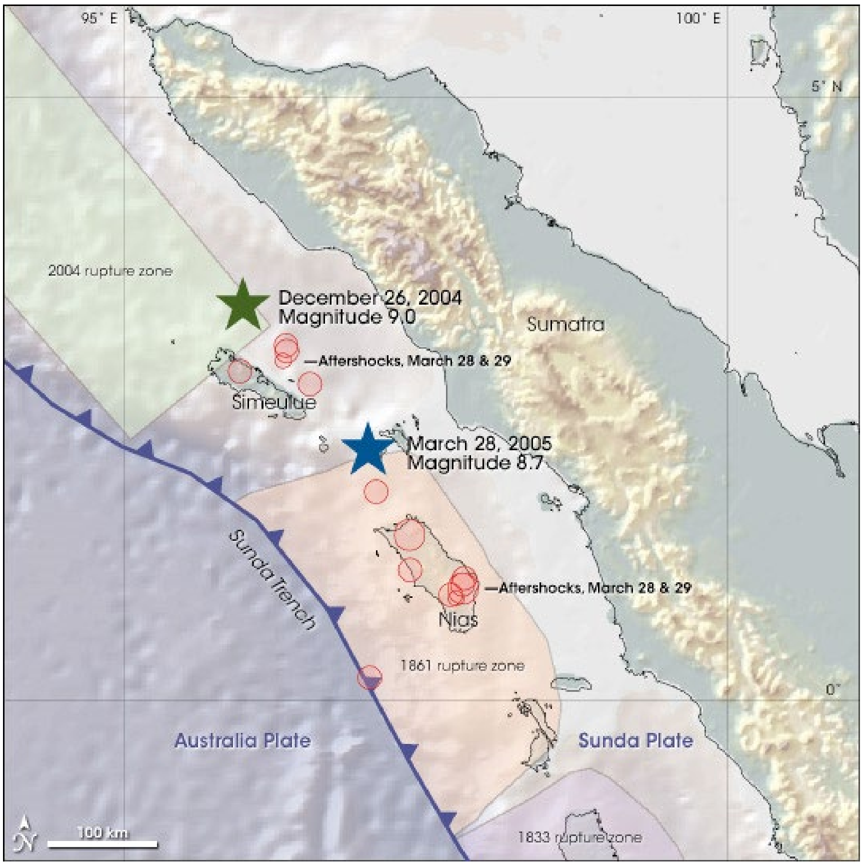

Figure 1: Nias Island and Epicenters of the 2004 and 2005 Earthquakes

Source: NASA (https://earthobservatory.nasa.gov/images/5375/massive-earthquake- along-the-sunda-trench)

2.2 *Maena for Disaster Education* program

In South Nias Regency, the first school-based disaster education program, *Maena for Disaster Education*, was introduced at elementary schools. Initially, the pilot program was implemented in six schools in the southern area in 2017/2018. These schools were selected based on two criteria: distance from the coastline and school size. Subsequently, in 2019, given the cost-effectiveness of the program, the regency government scaled it up to all elementary schools in the regency as a compulsory program.[2] Importantly, it was the first compulsory curriculum for disaster education introduced in North Sumatra Province, despite the high risk of earthquakes and tsunamis.[3]

[2] The compulsory program is implemented by the regency government. However, the pilot program was originally designed by a research team at Wako University in Japan, funded by the Japan International Cooperation Agency as a Grassroots Technical Cooperation Projects, and implemented by a local NGO, Yayasan Obor Berkat Indonesia.

[3] As part of a school curriculum reform by the Indonesian government, after 2020, students can decide whether to participate in *Maena for Disaster Education*.

The program content takes the form of several workshops divided into two phases. In the first phase, teachers learn about local disaster risks and the importance of disaster education, and develop an annual plan as the implementers of disaster education. They also discuss and decide on their roles in the case of evacuation from earthquakes and tsunamis, create a contact list, and identify evacuation routes.

In the second phase, students learn, through workshops with teachers, about disaster knowledge, including exposure to earthquake and tsunami risks in the area, and appropriate responses to these disasters. Various methods, such as lectures, pictures, and evacuation drills, are used in the workshops. The students then create a unique dance with lyrics, *Maena,* which incorporates the lessons learned from the previous workshops. *Maena* is a traditional group dance of Nias Island. Its relatively gentle movements make it easy for anyone to dance, and villagers generally perform it at weddings and other social gatherings. There are versions of *Maena* with different lyrics for each purpose of a meeting. As part of the disaster education program, the students create their own *Maena* that incorporates disaster prevention teachings into the lyrics and they perform it at school and inter-school events. In Table 1, we provide more details about the design of the pilot program, such as the context and timing of each workshop.

The idea for using *Maena* in disaster education was inspired by lessons from Simeulue Island of Aceh Province in Indonesia, located 140 km from Nias Island. A massive tsunami hit Simeulue Island in 1907, killing over half of the residents. Since then, survivors have passed down the message of tsunami disaster prevention in the form of a song called *Smong*, which advises people to flee to higher ground when an earthquake strikes. As a result, when the tsunami of the 2004 Indian Ocean Earthquake devastated Aceh, the residents of Simeulue Island were properly evacuated, and the death count was low (seven villagers), even though the island was extremely close to the epicenter (60 km).

Table 1: Design of Maena for Disaster Education (Pilot Program)

Phase I (August–October 2017): Preparation with teachers
Workshop 1: Meeting with teachers and parents (90 minutes)
Goal: The teachers and parents become aware of the disaster risk in the area and importance of disaster education.
Method: (1) Lecture about Japanese disaster education system and types of major disasters in the area, (2) Discussion
Workshop 2: Making the annual plan for the disaster education program (90 minutes)
Goal: The teachers and parents understand (1) the importance for students of not hesitating to discuss disaster risks, (2) that the school is the best environment to learn about disaster risks, (3) the importance of conducting disaster education based on the local culture, and (4) the goal and contents of Maena for Disaster Education. The teachers also determine the implementation procedure of the program, such as the budget and timing to have the workshops.
Method: (1) Lecture about the contents of Maena for Disaster Education, (2) Discussion among the

teachers about the annual plan for the workshop.

Workshop 3: Determining the roles of teachers in an emergency (90 minutes)

Goal: The school principal assigns the roles of determining the evacuation route and the means of emergency network to each teacher. The teachers in charge determine the evacuation spot and create a map to the spot.

Method: (1) Lecture about the importance of ensuring emergency network, (2) Discussion about the roles of teachers

Phase II (November 2017–March 2018): Implementing the program to students

Workshop 4: Guidance for how to create Maena for Disaster Education (150 minutes)

Goal: The students understand the goal and contents of Maena for Disaster Education.

Method: (1) Lecture about the contents of Maena for Disaster Education, (2) Students fill out the questionnaire about their risk awareness, their perception about coping ability, and the appropriate coping strategies, and (3) Discussion

Workshop 5: Learning about disaster risks and appropriate response (90 minutes)

Goal: The students become aware of the disaster risk in the area, and have knowledge about disaster risk and appropriate responses to disaster.

Method: (1) Lecture about previous disasters and appropriate disaster response using picture-card show, (2) the students fill out what they learned, and (3) the students create their unique Maena.

Workshop 6: Evacuation drill and demonstration of their Maena for Disaster Education (90 minutes)

Goal: The students learn where and how to evacuate through the drill.

Final Contest: Contest of Maena for Disaster Education among the schools (90 minutes)

Goal: Share the message of Maena for Disaster Education with the parents and community members.

Source: Shoji et al. (2020a)

This program has two unique features that effectively encourage participants to discuss and share knowledge about disaster risk reduction with their families. First, the performance of the original *Maena* at local events and ceremonies provides opportunities for children to talk about disaster risk reduction with their parents and other community members. Second, since the program uses the island's traditional dance, it is expected to reduce the psychological obstacles of talking openly about natural disasters attributed to indigenous culture and practices (see Subsection 2.1). More details about the advantages of the program design and the theoretical background are discussed by Shoji et al. (2020a).

2.3 Hypothesis

How does the *Maena for Disaster Education* program affect parents' behavioral patterns? Two behavioral theories could be relevant for addressing this question. First, according to the protection motivation theory of Rogers (1975) and Rogers and Prentice-Dunn (1997), individuals' efforts toward disaster protection behavior are determined by their perceived risk and perceived ability to cope with the risk. Applying this theory to disaster research, the literature provides evidence that these perceptions are positively associated with knowledge about disasters, preparation for future disasters, and prompt responses to the occurrence of disasters (Becker et al., 2014; Grothmann and Reusswig, 2006; Mulilis et al., 1990). Therefore, for spillover effects to occur, children must influence these perceptions of parents.

Second, Knafo-Noam and Galansky (2008) argued that there are five potential channels through which children influence their parents' values: passive child influence, active child influence, differentiation, reciprocal influences, and counter-influence. Among these, active child influence refers to the influence occurring due to "children directly attempting to influence their parents' opinions or providing parents with relevant information that indirectly changes their values" (p. 1145).

These arguments suggest that a disaster education program must satisfy the following conditions to enhance parents' disaster preparedness and response (Table 2). First, it must provide children with relevant information about disaster risks and appropriate preparation for and responses to the risks. Second, it should facilitate children's perceived risk and/or perceived coping ability so that they exert efforts toward disaster risk reduction. Children must recognize the efficacy of communicating about disaster risks and coping strategies with their parents. Third, children should indeed talk with their parents about the risks. Fourth, communication successfully influences parents' risk perception and perceived coping ability. Fifth, parents with high-risk perception and perceived coping ability make effort to learn about, prepare for, and respond to disaster risks.

Although *Maena for Disaster Education* is likely to satisfy these conditions, as illustrated in Subsection 2.1, the fourth condition is still undoubtedly the most challenging. Even if the program encourages children to talk about disaster risks with their parents, it cannot force parents to listen to their children carefully. Therefore, the magnitude of spillover effects is determined critically by the extent to which children's efforts to communicate affect their parents' perceptions of disaster risk and coping ability.

Table 2: Summary of the Spillover Process

Step 1	Providing knowledge about disaster risk reduction to children
Step 2	Changing children's perceived risk and perceived coping ability (particularly changing the perceived efficacy of communication with parents)
Step 3	Communication between children and parents
Step 4	Changing parents' perceived risk and perceived coping ability
Step 5	Parents exerting efforts to learn about, prepare for, and respond to disaster risks

3. Data

3.1 Survey Design and Sample

While *Maena for Disaster Education* was implemented in all elementary schools in South Nias Regency in 2019, a challenge in evaluating the impact of a compulsory program is the difficulty of finding a control group. One may consider defining households in the neighboring regency as the control group, but a drawback of this approach is the differences between households in socio-economic, geographic, and political conditions. To address this issue, we analyzed the pilot program conducted between September 2017 and April 2018 only for fourth- and fifth-grade students in six elementary schools. This design enables us to compare the outcomes of participating students and their parents to those of non-participants with similar characteristics in the same regency.

We conducted a unique survey in 12 elementary schools in South Nias Regency, of which 6 schools implemented the *Maena for Disaster Education* program. We defined these schools as treatment schools and the other six schools without the program as control schools. The control schools were selected carefully to minimize differences in observable characteristics from the treatment schools. Specifically, given that the selection of the treatment schools was based on two criteria, school size and distance from the coastline, we selected the control schools so that these characteristics are comparable. The locations and basic characteristics of the schools are presented in Figure A1 and Table A1, respectively. The average treatment school has 266 students and is located 321 m from the coastline, while the corresponding statistics for the control schools are 159 students and 444 m, respectively.

In these 12 schools, we first conducted a baseline survey for fourth-, fifth-, and sixth-grade students in September 2017 and obtained responses from 963 out of 1,112 sample students.[4] The questionnaire asked about students' knowledge of disaster mechanisms, perceptions of disaster risk and coping ability, disaster preparedness, response to recent earthquakes, and demographic and socio-economic characteristics of the household. The language of preparation was Indonesian and the questionnaire was delivered to each student in the classroom. Our local enumerators read each question slowly and the students filled out the questionnaire by themselves.

After running the disaster education program, we conducted the main survey with the same students and their parents to elicit post-treatment outcomes in April 2018. The child survey was conducted in the same manner as the baseline survey. Of the 963 students in the baseline survey, 843 responded to the endline survey.

The parent survey was conducted with the parents of 600 students who were randomly selected from the 963 students in the baseline survey. The remaining 363 households were used as a replacement sample. Our local enumerators visited their homes and interviewed adult family

[4] Those in the first through third grade students were excluded because of the difficulty in completing the survey alone.

members at home. When adult members were unavailable for the survey because of absenteeism or refusal, a replacement household was selected from the replacement sample. Specifically, we selected households listed below the unavailable household in an alphabetically ordered list of classmates. If this household was already included in the parent survey sample, the next household on the list was selected to ensure the sample size. Similar to the student questionnaire, the parent questionnaire covered parents' knowledge of disaster mechanisms, perceptions of disaster risk and coping ability, disaster preparedness, response to recent earthquakes, and demographic and socio-economic characteristics of the household.

We eventually obtained responses for 539 parent-child pairs, of which 214 students were eligible for the program, that is, the fourth and fifth grades in the treatment schools. Among the 539 parent respondents, 71% were mothers, 16% were fathers, and the remaining 13% were other caregivers, including grandparents.

This survey was approved by the South Nias Regency Education Department and Gunungsitoli City Education Department. It was also approved by all the school principals and teachers. Respondents were informed about the aim of the survey and the confidentiality of their responses.

3.2 Measures

3.2.1 Child Outcome: Learning and Knowledge Sharing

To construct a composite index of a child's attitude/behavior for learning and knowledge sharing about disaster risk reduction, we conducted a principal component analysis using five Likert-scale items (Panel A of Table 3). The results of principal component analysis are presented in Supplementary Material A1.

Table 3: Description of Outcome Variables

Child outcomes:	
A. Learning and knowledge sharing	
[1]	Are you interested in deepening your knowledge about disasters?
	1. Not at all interested 2. Not very interested 3. Unsure 4. Somewhat interested 5. Very interested
[2]	Do you think it is good thing to discuss how to cope with disasters?
	1. Not at all 2. Somewhat 3. Very much
[3]	Do you believe that you can mitigate the damage from disasters if you are well prepared?
	1. Not at all 2. Somewhat 3. Very much
[4]	Since last September, have you talked anything about disasters to your neighbors?
	1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]
[5]	Since last September, have you talked anything about disasters to your parents?
	1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]
Parent outcomes:	
B. Risk perception	
[6]	If a tsunami would occur, do you think the waves would hit your house?

1. Not at all 2. Somewhat 3. Very much 4. Don't know [b]

C. Attitude to learning and knowledge sharing

[7] Are you interested in deepening your knowledge about disasters?
1. Not at all interested 2. Not very interested 3. Unsure 4. Somewhat interested 5. Very interested

[8] Do you think it is good thing to discuss how to cope with disasters?
1. Not at all 2. Somewhat 3. Very much

[9] Do you believe that you can mitigate the damage from disasters if you are well prepared?
1. Not at all 2. Somewhat 3. Very much

D. Learning and knowledge sharing behavior

[10] Have you discussed with the student how and where to evacuate in the event of a disaster since last September?
1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]

[11] Have you discussed with the student about the severity of disaster risk since last September?
1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]

[12] Have you discussed with the student which items to prepare in order to mitigate disaster damages (e.g., transistor radio, flashlight, first-aid kit) since last September?
1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]

[13] Have you discussed with the student how, when, and where disasters occur since last September?
1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]

[14] Since last September, have you learned about disasters from the student?
1. Yes 2. No 3. Don't remember [b]

[15] Since last September, have you learned about disasters from your family (incl. relatives living together)?
1. Yes 2. No 3. Don't remember [b]

[16] Since last September, have you learned about disasters from your neighbors?
1. Yes 2. No 3. Don't remember [b]

[17] Since last September, have you learned about disasters from TV/radio/internet/books/newspapers?
1. Yes 2. No 3. Don't remember [b]

E. Knowledge about disaster response

[18] Suppose a strong earthquake occurs when you are in the first floor of a building. Which do you think is the most appropriate response?
1. Curl the body under the desk to wait for it to be over, and then get out of the building with protecting your head
2. Stay just as usual and wait for it to be over
3. Get out of the building immediately with protecting your head

[19] Suppose a strong earthquake occurs when you are in the second floor of a building. What is the most appropriate response for you?
1. Curl the body under the desk to wait for it to be over, and then get out of the building with protecting your head
2. Stay just as usual and wait for it to be over
3. Get out of the building immediately with protecting your head

[20] Suppose you feel a strong earthquake when you are near the sea. What do you think is the most appropriate response?
1. Stay where you are and wait for the evacuation order.
2. Evacuate immediately to an upland or inland as far as possible from the sea.
3. Evacuate immediately to a riverside.
4. Go to the seashore to check if anything is happening
5. Don't know

[21] Suppose you feel a strong earthquake when you stay alone in the house. Which do you think is the most appropriate response?
1. Evacuate to a safer place after waiting for your family coming back.
2. Evacuate to a safer place after making sure that the evacuation order is set off.
3. Evacuate to a safer place immediately.
4. Don't know

F. Disaster preparation behavior

[22] Have you participated in tsunami/earthquake drill since last September?
1. Not at all 2. Somewhat 3. Very much 4. Don't remember [a]

[23] Does your family have transistor radio and spare batteries? If yes, when did you obtain?
1. Yes, after last September 2. Yes, even before 3. No

[24] Does your family have a working flashlight? If yes, when did you obtain?
1. Yes, after last September 2. Yes, even before 3. No

[25] Does your family have first-aid kit? If yes, when did you obtain?
1. Yes, after last September 2. Yes, even before 3. No

G. Disaster response

[26] Since last September, after feeling an earthquake (real, not drill), have you had an actual experience of trying to evacuate considering the risk of tsunami?
1. Yes.
2. Never. Because I didn't imagine a tsunami will come.
3. Never. Because the earthquakes were small.
4. Never. Because I didn't know what to do and where to go.
5. I have never experienced an earthquake since last September.
6. Don't remember

[27] Since last September, have you ever taken any reaction(s) when you felt earthquakes?
1.Took reactions in the building (moving to a safer place such as under the table, etc.)
2.Moved to a safer place outside.
3.Both 1 and 2.
4.No, because I thought nothing serious would happen.
5.No, because I didn't know what to do and where to go.
6. I have never experienced an earthquake since last September.
7.Don't remember

H. Knowledge about disaster mechanisms

[28] What do you think is the major cause of earthquake?
1. Movement of groundwater 2. Movement of the earth's plates 3. God's wrath 4. Other reason 5. Don't know

[29] Which is true about the frequency of earthquakes across the world?
1. The frequency of earthquakes is about the same anywhere in the world.
2. Some regions of the world experience earthquakes much more often than the others.
3. Don't know

[30] Which is true about the frequency of earthquakes across seasons?
1. Earthquakes happen in any seasons.
2. Earthquakes happen much more often in the particular season than the others.
3. Don't know

[31] What do you think is the major cause of tsunami?
1. Storm 2. Earthquake 3 Man-made activities 4. God's wrath 5. Other reason 6. Don't know

[32] Which do you think is the correct statement about tsunami?

	1. A big wave of Tsunami will come only once. 2. After the first wave, subsequent waves may come some hours later. But the first wave is always the biggest. 3. After the first wave, subsequent waves may come some hours later. They may be bigger than the first one. 4. Don't know	
[33]	Do you think that a tsunami could occur even without you feeling a strong earthquake? 1. Yes 2. No 3. Don't know	
[34]	Do you think that the sea water always becomes lower before a tsunami comes? 1. Yes 2. No 3. Don't know	

Notes: a) In the empirical analyses, these answers were recoded as answer option 1 to ensure the sample size. b) Answers were recoded as answer option 2.

3.2.2 Parent Outcomes

Our dataset includes seven types of parent outcomes: (1) risk perception, (2) attitude to learning and knowledge sharing, (3) learning and knowledge sharing behavior, (4) knowledge about disaster response, (5) disaster preparation behavior, (6) disaster response, and (7) knowledge about disaster mechanisms. Panels B–H in Table 3 present the items used to quantify these outcomes. Parents' risk perception was elicited from a single item measured using a Likert scale. The second and third outcomes are composite indexes derived from the multiple items listed in Panels C and D, respectively. We used principal component analysis to construct the indexes, and the results are reported in Supplementary Material A1. The scales of knowledge about disaster response and disaster mechanisms were derived from the items in Panels E and H. Because these items have multiple answer options, of which only one is correct, these scales were defined as the proportion of correct answers, ranging from 0 to 1. Finally, the two behavioral outcomes of disaster preparation and response were defined as the proportion of behavior of the respondent. Regarding disaster response, our study site experienced 226 earthquakes, including 12 earthquakes sensed by the people, before the parent survey (between September 2017 and March 2018). In particular, the largest earthquake on March 1 had a magnitude of 5.7. According to our field interviews, although the earthquake lasted only a short period, it was large, and some villagers evacuated to a safer place. Therefore, our disaster response measure is likely to capture the response during this earthquake.

3.2.3 Program Participation

As mentioned in the previous subsection, the *Maena for Disaster Education* program was implemented only for fourth- and fifth-grade students in the six treatment schools. Our measure of program participation takes one if the child is included in these members and zero otherwise.

3.2.4 Controls

The control variables include information about children, parents, households, and schools. Information about children includes their grade and gender, while that of parents includes age, gender, educational background, and experience of the earthquake/tsunami in 2004 and 2005. Household-level characteristics include age and educational background of the household head, household size, and geographical characteristics of residence. Finally, there are two variables on school-level characteristics: the number of students in the school and distance to the coastline.

4. Empirical Strategy

4.1 The Impact of Program Participation on Child and Parent Outcomes

This study estimates the following ordinary least squares (OLS) as a benchmark model:

$$S_{igs} = \alpha_0 + \alpha_1 Maena_{gs} + \alpha_2 School_s + \alpha_3 X_{igs} + \varepsilon_{igs} \tag{1}$$

$$P_{igs} = \beta_0 + \beta_1 Maena_{gs} + \beta_2 School_s + \beta_3 X_{igs} + \varepsilon_{igs} \tag{2}$$

where S_{igs} denotes the learning and knowledge-sharing index of child i in grade g of school s. P_{igs} denotes parent outcomes. $Maena_{gs}$ takes one if children in grade g of school s participated in *Maena for Disaster Education*. $School_s$ include two school-level controls: school size and distance to the coastline. Finally, X_{igs} includes controls at parent, child, and household levels.

The underlying assumption to obtain a consistent estimate of α_1 and β_1 is the selection of observables or no omitted variables. This assumption is likely to hold in our model, because the eligible schools were determined based only on school size and distance to the coastline, and in these schools, only those in grades 4 and 5 participated in the program, as discussed in Section 2. Therefore, after controlling for these characteristics, the coefficients should be consistent estimates of the program's treatment effects.

In Supplementary Material A2, we test the validity of this assumption by conducting balancing and falsification tests.

4.2 The Impact of Child Outcome on Parent Outcomes

While the benchmark model in Subsection 4.1 is useful for evaluating the overall impact of school-based disaster education on the participant children and their parents, it does not allow us to provide direct evidence on the spillover, that is, the causal relationship between children's and parents' outcomes. As discussed in Subsection 2.3, it is relevant to identify the magnitude of the causal effects of children's attitude/behavior of sharing knowledge about disaster risks on their parents' outcomes.

A challenge in estimating such causal impacts is endogeneity issue. If we regress the parent outcomes on child outcomes and controls using OLS, the estimated coefficients will be biased owing to reverse causality and unobserved confounders. Specifically, the estimated coefficients may capture the impact of parents' outcomes on children's outcomes as well as the impact of omitted variables that are correlated with both parent and child outcomes, such as family- and community-level characteristics.

To address this issue, we employ an instrumental variable (IV) model. This model enables us to estimate the causal impact if an IV that satisfies the following two conditions is available. First, the IV should strongly predict child outcome S_{igs}. Second, it should not be correlated with the residual ε_{igs}. In this study, we use the indicator of program participation, $Maena_{gs}$, as our IV. It is expected to be a strong predictor of child outcomes (Shoji et al., 2020a). Furthermore, the program participants are selected based only on the grade of the children and two school-level characteristics, which are controlled for in our estimation model. Therefore, our IV is likely to satisfy the second condition.

Given the availability of a suitable IV, the causal impact of child outcomes on parent outcomes can be estimated using a two-stage model. In the first stage, we regress S_{igs} on IV and controls. Therefore, in this study, Equation (1) serves as the first-stage equation. Subsequently, we use this result to compute the fitted value of S_{igs}. Finally, in the second-stage equation, the parent outcomes are regressed on the fitted values of S_{igs} and the controls as follows:

$$P_{igs} = \gamma_0 + \gamma_1 \widehat{S_{igs}} + \gamma_2 School_s + \gamma_3 X_{igs} + \varepsilon_{igs} \quad (3)$$

where $\widehat{S_{igs}}$ is the predicted value of S_{igs} in Equation (1).

The basic idea for this model is as follows. In this model, $\widehat{S_{igs}}$ captures the exogenous component of child outcomes determined by the intervention at school. Therefore, it should not be influenced by the parent's outcomes or unobserved confounders that affect both the parents' and children's outcomes. This feature enables us to estimate the role of *exogenous* child outcomes on parent outcomes. Therefore, the estimated coefficient γ_1 can be interpreted as the causal effect of child outcomes on parental outcomes. To the best of our knowledge, this approach is frequently used in the economic literature on the intergenerational transmission of human capital (Black et al., 2005; Lundborg and Majlesi, 2018), but not in the literature on disaster education or intergenerational value transmission.

5. Results

5.1 Summary Statistics

Table 4 presents the summary statistics of the used variables relative to the program eligibility. In this table, the mean differences are tested between the program participant group (Column (1)) and each non-participant group (Columns (2) through (4)). It appears that respondent characteristics (control variables) are similar between the groups, except for school characteristics, as expected.

By contrast, we find significant differences in the outcome variables. The scores for children's learning and knowledge sharing are significantly higher for the program participants. Parents' outcomes, such as learning and knowledge sharing behavior and knowledge about disaster response, are also higher among the program participant group. However, a simple comparison between groups demonstrates insignificant differences in risk perception, attitude to learning and knowledge sharing, and disaster preparation behavior. The participant group exhibits a counter-intuitively lower propensity for disaster response behavior.

Table 4: Summary Statistics by Program Eligibility

	Grade 4 and 5				Grade 6			
	Eligible school (Program Participants)		Noneligible school		Eligible school		Noneligible school	
	(1)		(2)		(3)		(4)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Outcome Variables								
Child outcome								
Learning and knowledge sharing	0.20	1.01	-0.28	1.02***	0.07	0.98	-0.10	0.84**
Parent outcome								
Risk perception	2.02	0.71	2.06	0.84	2.00	0.69	2.18	0.80*
Attitude to learning and knowledge sharing	0.04	0.96	-0.05	1.03	-0.11	1.02	0.10	1.02
Learning and knowledge sharing behavior (component 1)	0.19	0.89	-0.17	1.09***	-0.04	0.91**	-0.16	1.11***
Learning and knowledge sharing behavior (component 2)	0.17	1.03	-0.12	0.92***	-0.08	1.04**	-0.14	0.96**
Knowledge about disaster response	0.70	0.21	0.63	0.26***	0.66	0.20*	0.64	0.24*
Disaster preparation behavior	0.34	0.32	0.36	0.33	0.34	0.32	0.37	0.33
Disaster response	0.26	0.44	0.39	0.49**	0.33	0.47	0.37	0.49*
Control Variables								
Child respondent characteristics								
Boy	0.46	0.50	0.53	0.50	0.48	0.50	0.42	0.50
Parent respondent characteristics								
Male	0.14	0.35	0.18	0.38	0.22	0.42*	0.19	0.40
Age	38.56	9.27	37.26	9.27	39.70	8.06	40.45	11.05
Years of schooling	5.38	5.44	5.34	5.57	5.83	5.38	3.92	5.13**
Affected by the 2004/2005 tsunami	0.51	0.50	0.47	0.50	0.48	0.50	0.51	0.50
Household characteristics								
Age of head	42.65	8.05	40.70	8.01**	43.33	7.84	43.47	10.23
Years of schooling of head	5.15	5.52	5.07	5.60	5.99	5.58	4.83	5.29
Household size	6.72	3.33	7.10	6.56	6.79	2.29	7.18	2.81
There is a symbol of the past disasters in the village	0.42	0.49	0.53	0.50**	0.35	0.48	0.49	0.50
Residence is within10 minutes from river	0.31	0.46	0.34	0.47	0.37	0.49	0.34	0.48
Residence is within10 minutes from coast	0.43	0.50	0.39	0.49	0.52	0.50	0.33	0.47*
School characteristics								
School size	263.61	63.53	169.93	38.72***	269.15	55.44	167.69	39.30***
Distance from school to coast (meter)	332.0	254.6	567.2	440.0***	356.1	255.0	563.8	440.3***
N	214		148		94		83	

Notes: Mean differences are tested between the program participant group (Column (1)) and each non-participant group (Columns (2)–(4)). *** p<0.01, ** p<0.05, * p<0.1.

5.2 The Impact of Child's Program Participation on Child and Parent Outcomes

Table 5 presents the results of Equation (1). Column (1) shows the full-sample results for the composite index of children's attitudes to and behavior of learning/communicating about disasters. We find that the disaster education program had a significantly positive impact. Participation in the program improves the index score by 0.45 standard deviations. In Column (2), we restrict the sample to those whose residences are located within 10 minutes from the coastline and are exposed to higher tsunami risks. This shows that the impact of participation is even larger (0.72 standard deviations).

Table 6 shows the impact on parent outcomes. The odd-numbered columns show the full-sample results, and the even-numbered columns show the subsamples of those residing within 10 minutes from the coastline. Overall, we find that the program has a positive impact on most adult outcomes, and the impacts are particularly large for those at higher risk. Columns (3) and (5) suggest that the program improves parents' attitude to and behavior of learning and knowledge sharing about disaster risk reduction by 0.26 and 0.32 standard deviations, respectively. We also find a positive impact on the knowledge score regarding appropriate disaster response by 6 percentage points (Column (9)). These impacts become even larger for those at higher risk (Columns (6) and (10)). Importantly, in this subsample, we also find a positive impact on disaster preparation behavior (Column (12)). By contrast, we do not find any impact on parents' risk perception or disaster response.

We discuss the robustness of our findings in Supplementary Materials A3.

Table 5: The Impact on Child Outcomes

	Learning and knowledge sharing	
	Full	Coastal area
	(1)	(2)
Program participant	0.447***	0.724***
	(0.131)	(0.219)
Controls	Yes	Yes
Kleibergen-Paap rk Wald F statistic	11.61	10.88
N	536	224
R-squared	0.084	0.128

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: The Impact on Parent Outcomes

	Risk perception		Attitude to learning and knowledge sharing		Learning and knowledge sharing behavior (component 1)		Learning and knowledge sharing behavior (component 2)	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Program participant	-0.025	0.107	0.261**	0.289	0.318***	0.601***	0.057	-0.269
	(0.097)	(0.151)	(0.125)	(0.194)	(0.117)	(0.183)	(0.131)	(0.204)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	536	224	536	224	536	224	536	224
R-squared	0.064	0.091	0.041	0.072	0.206	0.171	0.095	0.174
	Knowledge about disaster response		Disaster preparation behavior		Disaster response			
	Full	Coastal area	Full	Coastal area	Full	Coastal area		
	(9)	(10)	(11)	(12)	(13)	(14)		
Program participant	0.060**	0.103**	0.007	0.197***	-0.042	-0.032		
	(0.030)	(0.049)	(0.039)	(0.055)	(0.059)	(0.095)		
Controls	Yes	Yes	Yes	Yes	Yes	Yes		
N	536	224	536	224	536	224		
R-squared	0.059	0.088	0.119	0.172	0.072	0.118		

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.3 The Impact of Child Outcomes on Parent Outcomes

Table 7 presents the results of the IV estimation. The table provides evidence of spillovers from children to parents. A one standard deviation increase in child's learning and knowledge sharing index leads to the increases in parents' attitude to and behavior of learning and knowledge sharing index by 0.58 and 0.71 standard deviations, respectively. It is also associated with a higher score for knowledge about disaster response. However, spillover effects on risk perception and disaster response were not observed. These patterns are consistent with the findings presented in Table 6.

Table 7: IV Estimation of Spillover Effects

	Risk perception		Attitude to learning and knowledge sharing		Learning and knowledge sharing behavior (component 1)		Learning and knowledge sharing behavior (component 2)	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Child's learning and knowledge sharing	-0.056	0.148	0.583*	0.399	0.710**	0.830**	0.127	-0.371
	(0.214)	(0.204)	(0.330)	(0.297)	(0.326)	(0.357)	(0.292)	(0.287)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	536	224	536	224	536	224	536	224
	Knowledge about disaster response		Disaster preparation behavior		Disaster response			
	Full	Coastal area	Full	Coastal area	Full	Coastal area		
	(9)	(10)	(11)	(12)	(13)	(14)		
Child's learning and knowledge sharing	0.134*	0.142*	0.015	0.273**	-0.094	-0.044		
	(0.076)	(0.078)	(0.085)	(0.111)	(0.131)	(0.126)		
Controls	Yes	Yes	Yes	Yes	Yes	Yes		
N	536	224	536	224	536	224		

Notes: IV coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6. Discussion

Using unique survey data collected from elementary school students and their parents in Indonesia, we evaluated the spillover impact of school-based disaster education programs for children on their parents' attitudes, knowledge, and behavior toward disaster risk reduction. The results showed that the program significantly improved the outcomes for both children and parents. First, the participants' learning and knowledge sharing scores were significantly higher than those of non-participants. Second, the program has positive and substantially large effects on parents' attitude to and behavior of learning and knowledge sharing, knowledge about disaster response, and disaster preparation behavior. Importantly, these impacts are larger for those exposed to higher risks who reside close to the coastline. However, we did not find any impact on parents' risk perception or disaster response behavior. Third, to test the causal spillover effect from children to parents more directly, we conducted an IV estimation. The results demonstrate that increases in child outcomes have substantial spillover effects on parents' outcomes. Finally, supplementary analyses suggest that these results cannot be explained by unobserved confounders.

Protection motivation theory argues that individuals' disaster preparation and response are motivated by their high perception of disaster risk and their perception of the ability to cope with disasters (Rogers, 1975; Rogers and Prentice-Dunn, 1997). In this study, we did not find any impact on the former factor, presumably because many parents were aware of the high disaster risk regardless of the program, given their experience of the 2004 and 2005 earthquakes and tsunamis. However, our findings about the positive effects on attitude toward learning and knowledge sharing suggest that the *Maena for Disaster Education* program was successful in improving the latter. These arguments suggest that the improvement in parental outcomes may be moderated by the increase in their perceived coping ability.

These findings contribute to the literature in three ways: The first contribution is the intergenerational spillover effects of non-formal education. Earlier studies have demonstrated that school-based non-formal education, such as environmental education programs, has spillover effects on participants' parents and promotes intergenerational learning (Boudet et al., 2016; Duvall and Zint, 2007; Legault and Pelletier, 2000; Meeusen, 2014; Vaughan et al., 2003; Williams et al., 2017). However, rigorous evidence from other types of non-formal education is still scarce. In the context of disaster education, MacDonald et al. (2017) analyzed a museum-based disaster education program in New Zealand. Although insightful, their findings rely on small sample data from a developed country. To the best of our knowledge, our study is the first to provide rigorous evidence of the spillover effects of disaster education in a developing country.

The second contribution this study makes is to the broad literature on determinants of disaster preparedness. Previous studies have demonstrated that disaster preparedness is determined by such factors as individuals' education, social capital, socio-emotional skills (e.g., locus of control), disaster experience, risk perception, and access to disaster information (Aldrich and Sawada, 2015; Baker, 1991; Baumann and Sims, 1978; Cato et al., 2021; Dash and Gladwin, 2007; Drabek, 1999; Hanson-Easey et al., 2018; Hoffmann and Muttarak, 2017; Karanci et al., 2005; Sims and Baumann, 1972; Shoji et al., 2020b, 2021, 2022; Shoji and Murata, 2021). This study contributes to this strand of literature by adding another channel: learning from children.

Third, this study contributes methodologically to the literature on intergenerational value transmission. Earlier studies have discussed the influence of children on parents' values and behavior (De Mol and Buysse, 2008; Pinquart and Silbereisen, 2004; Roest et al., 2009). However, rigorous direct evidence is still scarce given the difficulties in identifying the effects (Knafo-Noam et al., 2020; Knafo-Noam and Galansky, 2008). First, parents and children share many characteristics, such as neighborhood, socio-economic status, and genes. Therefore, the similarity in their values may be attributed to these characteristics. Second, it is difficult to rule out the possibility of a causal impact in the opposite direction, that is, of parents influencing their children's values. These issues are known as common shock and reflection problems, respectively, in econometrics (Manski, 1993). Third, many parents have multiple children, and they interactively influence each other's values, complicating the estimation of causal impact. To the best of our knowledge, this is the first study to address these issues by employing an IV model.

However, we should be cautious about interpreting our results because they hinge on the validity of our data and empirical strategy. First, our results rely on the definition and measurement of the outcome variables. Second, our data were collected in a particular region of Indonesia. Furthermore, this study evaluated a unique program tailored to the study site, raising the issue of generalizability of the results. To verify the efficacy of intergenerational spillovers, further evidence from different regions, programs, and outcomes is required.

7. Conclusion

The following policy implications are derived from our findings. The positive spillover effects on participants' parents suggest that school-based disaster education programs may be a cost-effective approach for enhancing disaster risk reduction for all community members outside the school. Therefore, the social impact of school-based interventions is greater than previously thought, and policymakers should benefit from introducing such programs in disaster-prone communities.

In particular, the positive impacts on parents' learning and knowledge sharing behavior are relevant, because encouraging such behavior has long been one of the main goals for practitioners in many developing countries. Due to their religion or traditional culture, rural villagers often believe that natural disasters are a supernatural act of punishment or expression of wrath (Ghafory-Ashtiany, 2009; Gianisa and Le De, 2017), which leads them to abandon their disaster prevention efforts or even shy away from talking about disaster prevention. This belief is a crucial obstacle to their appropriate preparation for and response to disaster risks. This study suggests that disaster education for children may be a solution to this problem.

Finally, this program failed to encourage parents' appropriate disaster responses, such as evacuation behavior. This is counter to the finding that it has significant effects on the disaster response of participant children (Shoji et al., 2020a). To encourage parents' disaster response, policymakers should consider combining multiple interventions, such as the development of early warning systems and social capital in addition to disaster education programs.

References

Aldrich, D. P., & Sawada, Y. (2015). The physical and social determinants of mortality in the 3.11 tsunami. *Social Science & Medicine*, 124, 66-75.

Amri, A., Lassa, J. A., Tebe, Y., Hanifa, N. R., Kumar, J., & Sagala, S. (2022). Pathways to Disaster Risk Reduction Education integration in schools: Insights from SPAB evaluation in Indonesia. *International Journal of Disaster Risk Reduction*, 73, 102860.

Badan Pusat Statistik Kabupaten Nias Seltan. (2017). *Kabupaten Nias Selatan Dalam Angka 2017*. Badan Pusat Statistik Kabupaten Nias Seltan

Baker E. J. 1991. "Hurricane Evacuation Behavior." *International Journal of Mass Emergencies and Disasters* 9:287-310.

Baumann, D. D., & Sims, J. H. (1978). Flood insurance: Some determinants of adoption. *Economic Geography*, 54 (3), 189-96.

Becker, G., Aerts, J. C. J. H., & Huitema, D. (2014). Influence of flood risk perception and other factors on risk-reducing behaviour: a survey of municipalities along the Rhine. *Journal of Flood Risk Management*, 7 (1), 16-30.

Becker, J. S., Paton, D., Johnston, D. M., & Ronan, K. R. (2012). A model of household preparedness for earthquakes: how individuals make meaning of earthquake information and how this influences preparedness. *Natural Hazards*, 64 (1), 107-37.

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2005). Why the apple doesn't fall far: Understanding intergenerational transmission of human capital. *American Economic Review*, 95 (1), 437-49.

Boudet, H., Ardoin, N. M., Flora, J., Armel, K. C., Desai, M., & Robinson, T. N. (2016). Effects of a behaviour change intervention for Girl Scouts on child and parent energy-saving behaviours. *Nature Energy*, 1 (8), 1-10.

Cato, S., Iida, T., Ishida, K., Ito, A., Katsumata, H., McElwain, K. M., & Shoji, M. (2021). The bright and dark sides of social media usage during the COVID-19 pandemic: Survey evidence from Japan. *International Journal of Disaster Risk Reduction*, 54, 102034.

Clerveaux, V., Spence, B., & Katada, T. (2010). Promoting disaster awareness in multicultural societies: the DAG approach. *Disaster Prevention and Management*, 19 (2), 199-218.

Dash, N., & Gladwin, H. (2007). Evacuation decision making and behavioral responses: Individual and household. *Natural Hazards Review*, 8 (3), 69-77.

De Mol, J., & Buysse, A. (2008). The phenomenology of children's influence on parents. *Journal of Family Therapy*, 30 (2), 163-93.

Drabek, T. E. (1999). Understanding disaster warning responses. *The Social Science Journal*, 36 (3), 515-23.

Duvall, J., & Zint, M. (2007). A review of research on the effectiveness of environmental education in promoting intergenerational learning. *The Journal of Environmental Education*, 38 (4), 14-24.

Faupel, C. E., Kelley, S. P., & Petee, T. (1992). The impact of disaster education on household preparedness for Hurricane Hugo. *International Journal of Mass Emergencies and Disasters*, 10 (1), 5-24.

Ghafory-Ashtiany, M. (2009). View of Islam on earthquakes, human vitality and disaster. *Disaster Prevention and Management*, 18 (3) 218-32.

Gianisa, A., & Le De, L. (2017). The role of religious beliefs and practices in disaster: The case study of 2009 earthquake in Padang city, Indonesia. *Disaster Prevention and Management*, 27 (1) 74-86.

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: why some residents take precautionary action while others do not. *Natural hazards*, 38 (1-2), 101-20.

Hanson-Easey, S., Every, D., Hansen, A., & Bi, P. (2018). Risk communication for new and emerging communities: the contingent role of social capital. *International Journal of Disaster Risk Reduction*, 28, 620-28.

Hoffmann, R., & Muttarak, R. (2017). Learn from the past, prepare for the future: Impacts of education and experience on disaster preparedness in the Philippines and Thailand. *World Development*, 96, 32-51.

Izadkhah, Y. O., & Hosseini, M. (2005). Towards resilient communities in developing countries through education of children for disaster preparedness. *International Journal of Emergency Management*, 2 (3), 138-48.

Karanci, A. N., Aksit, B., & Dirik, G. (2005). Impact of a community disaster awareness training program in Turkey: Does it influence hazard-related cognitions and preparedness behaviors. *Social Behavior and Personality*, 33 (3), 243-58.

Knafo-Noam, A., Barni, D., & Schwartz, S. H. (2020). Parent–Child Value Similarity: Broadening from Intergenerational Transmission to Reciprocal Influences, Genetics, and Environmental Antecedents. In *The Oxford Handbook of Moral Development: An Interdisciplinary Perspective.*

Knafo-Noam, A., & Galansky, N. (2008). The influence of children on their parents' values. *Social and Personality Psychology Compass*, 2 (3), 1143-61.

Kusumastuti, R. D., Nurmala, N., Arviansyah, A., & Wibowo, S. S. (2022). Indicators of community preparedness for fast-onset disasters: a systematic literature review and case study. *Natural Hazards*, 110, 787-821.

Legault, L., & Pelletier, L. G. (2000). Impact of an environmental education program on students' and parents' attitudes, motivation, and behaviours. *Canadian Journal of Behavioural Science / Revue Canadienne des Sciences du Comportement*, 32 (4), 243-50.

Levac, J., Toal-Sullivan, D., & OSullivan, T. L. (2012). Household emergency preparedness: a literature review. *Journal of Community Health*, 37 (3), 725-33.

Lundborg, P., & Majlesi, K. (2018). Intergenerational transmission of human capital: Is it a one-way street?. *Journal of Health Economics*, 57, 206-20.

MacDonald, E., Johnson, V., Gillies, M., & Johnston, D. (2017). The impact of a museum-based hazard education program on students, teachers and parents. *International Journal of Disaster Risk Reduction*, 21, 360-66.

Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The Review of Economic Studies*, 60 (3), 531-42.

Meeusen, C. (2014). The intergenerational transmission of environmental concern: The influence of parents and communication patterns within the family. *The Journal of Environmental Education*, 45 (2), 77-90.

Mishra, S., & Suar, D. (2012). Effects of anxiety, disaster education, and resources on disaster preparedness behavior. *Journal of Applied Social Psychology*, 42 (5), 1069-87.

Mitchell, T., Haynes, K., Hall, N., Choong, W., & Oven, K. (2008). The roles of children and youth in communicating disaster risk. *Children Youth and Environments*, 18 (1), 254-79.

Mulilis, J. P., Duval, T. S., & Lippa, R. (1990). The effects of a large destructive local earthquake on earthquake preparedness as assessed by an earthquake preparedness scale. *Natural Hazards*, 3 (4), 357-71.

Oktari, R. S., Shiwaku, K., Munadi, K., & Shaw, R. (2015). A conceptual model of a school–community collaborative network in enhancing coastal community resilience in Banda Aceh, Indonesia. *International Journal of Disaster Risk Reduction*, 12, 300-10.

Pinquart, M., & Silbereisen, R. K. (2004). Transmission of values from adolescents to their parents: The role of value content and authoritative parenting. *Adolescence*, 39 (153), 83.

Roest, A., Dubas, J. S., & Gerris, J. R. (2009). Value transmissions between fathers, mothers, and adolescent and emerging adult children: the role of the family climate. *Journal of Family Psychology*, 23 (2), 146.

Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change1. *The Journal of Psychology*, 91 (1), 93-114.

Rogers, R. W., & Prentice-Dunn, S. (1997). *Protection Motivation Theory*.

Ronan, K. R., Crellin, K., & Johnston, D. M. (2012). Community readiness for a new tsunami warning system: quasi-experimental and benchmarking evaluation of a school education component. *Natural Hazards*, 61 (3), 1411-25.

Ronan, K. R., & Johnston, D. M. (2003). Hazards education for youth: A quasi-experimental investigation. *Risk Analysis*, 23 (5), 1009-20.

Seddighi, H., Sajjadi, H., Yousefzadeh, S., López, M. L., Vameghi, M., Rafiey, H., & Khankeh, H. (2021). School-based education programs for preparing children for natural hazards: a systematic review. *Disaster Medicine and Public Health Preparedness*, 1-13.

Shaw, R., Shiwaku, K., Kobayashi, H., & Kobayashi, M. (2004). Linking experience, education, perception and earthquake preparedness. *Disaster Prevention and Management*, 13 (1), 39-49.

Shoji, M., Ito, A., Cato, S., Iida, T., Ishida, K., Katsumata, H., & McElwain, K. M. (2021). Prosociality and the uptake of COVID-19 contact tracing apps: survey analysis of intergenerational differences in Japan. *JMIR mHealth and uHealth*, 9(8), e29923.

Shoji, M., Cato, S., Iida, T., Ishida, K., Ito, A., & McElwain, K. M. (2022). Variations in Early-Stage Responses to Pandemics: Survey Evidence from the COVID-19 Pandemic in Japan. *Economics of Disasters and Climate Change*, forthcoming.

Shoji, M., & Murata, A. (2021). Social Capital Encourages Disaster Evacuation: Evidence from a Cyclone in Bangladesh. *The Journal of Development Studies*, 57 (5), 790-806.

Shoji, M., Takafuji, Y., & Harada, T. (2020a). Behavioral impact of disaster education: evidence from a dance-based program in Indonesia. *International Journal of Disaster Risk Reduction*, 45, 101489.

———. (2020b). Formal education and disaster response of children: evidence from coastal villages in Indonesia. *Natural Hazards*, 103 (2), 2183-2205.

Sims, J. H., & Baumann, D. D. (1972). The tornado threat: Coping styles of the North and South. *Science*, 176 (4042), 1386-92.

Soffer, Y., Goldberg, A., Avisar-Shohat, G., Cohen, R., & Bar-Dayan, Y. (2010). The effect of different educational interventions on schoolchildren's knowledge of earthquake protective behaviour in Israel. *Disasters*, 34 (1), 205-13.

Takeuchi, Y., Mulyasari, F. and Shaw, R. (2011), Roles of Family and Community in Disaster Education, Shaw, R., Shiwaku, K. and Takeuchi, Y. (Ed.) *Disaster Education (Community, Environment and Disaster Risk Management, Vol. 7)*, Chapter 4, 77-94, Emerald Group Publishing Limited, Bingley.

UNISDR (2006). *Disaster risk reduction begins at school: 2006-2007 World Disaster Reduction campaign*, Geneva: Author.

UNISDR and CRED (2016). *Poverty & Death: Disaster Mortality 1996 – 2015*, Geneva: Author

Vaughan, C., Gack, J., Solorazano, H., & Ray, R. (2003). The effect of environmental education on schoolchildren, their parents, and community members: A study of intergenerational and intercommunity learning. *The Journal of Environmental Education*, 34 (3), 12-21.

Wang, X., Peng, L., Huang, K., & Deng, W. (2022). Identifying the influence of disaster education on the risk perception of rural residents in geohazard-prone areas: A propensity score-matched study. *International Journal of Disaster Risk Reduction*, 102795.

Williams, S., McEwen, L. J., & Quinn, N. (2017). As the climate changes: Intergenerational action-based learning in relation to flood education. *The Journal of Environmental Education*, 48 (3), 154-71.

Supplementary Materials
(NOT FOR PUBLICATION)

A1. Principal Component Analysis

For data reduction, three sets of principal component analyses are performed separately, using the items reported in Panels A, C, and D. The number of components is determined based on the confidence interval of the eigenvalue and scree plot. The composite index is standardized (mean=0; SD=1).

The results are reported in Tables A2–A4. In Table A2, we keep only the first component (eigenvalue=1.681, 95% CI:1.482–1.880), which explains 33.6% of the variation in the original items. Item [2] on the positive attitude to discussion about natural disasters demonstrates the highest factor loading, followed by Item [3] on the perceived efficacy of disaster preparation. In Table A3, we keep only one component (eigenvalue=1.540, 95% CI:1.357–1.724), which explains 51.3% of the variation. Items [7] (positive attitude to learning about disasters) and [8] (positive attitude to discussing disasters) exhibit high factor loadings. Finally, in Table A4, considering the eigenvalues, we retain two components. Regarding the first component, which explains 31.2% of the variation, Items [10], [11], and [14] on knowledge sharing with children show high factor loadings.

A2. Validity of Empirical Strategy

The underlying assumption in our estimation models is selection-on-observables. To indirectly test the plausibility of this assumption, we conduct the following two tests. First, we conduct a balancing test by regressing respondent characteristics on the binary indicator of program participants, school characteristics, and grade of children. We expect the coefficient of program participation to be statistically insignificant. Table A5 provides supporting evidence. Among the 11 estimated equations, only one coefficient is significant.

Second, we conduct a falsification test using the outcome of knowledge about disaster mechanisms (Panel H in Table 3). As *Maena for Disaster Education* does not focus on teaching students about disaster mechanisms, we should not expect a significant impact on this outcome. However, we might still find a positive coefficient if the results are driven by unobserved confounders. The results reported in Table A6 eliminate this concern. As expected, the coefficient is small and statistically insignificant.

A3. Robustness Tests

We test the robustness of our findings by conducting two analyses. First, since the participants performed their original *Maena* at school, the program might have indirectly affected the outcomes of the sixth-grade students in the treatment schools, even though they did not participate in the program. This would cause bias in the estimation results. Therefore, we re-estimate the models without including this sample of students. Second, in our parent survey, 13% of the respondents were family members other than the parents, such as grandparents. We also re-estimate the models after excluding these respondents. The results in Tables A7 and A8 confirm the robustness of the findings.

Figure A1: Location of Survey Schools

Note: Flags A–F denote treatment schools. Flags G to L denote the control schools.

Table A1: School Characteristics

School ID	Year of Establishment	Affected by the 2004/2005 Disasters	Distance to Coastline	Num. of Teachers	Num. of Students
Treatment Schools					
A	1982	1	100	24	331
B	1975	1	875	13	223
C	1993	0	100	26	351
D	2008	0	300	24	265
E	1987	1	150	14	147
F	1961	1	400	23	279
Mean	1984.3	0.7	320.8	20.7	266.0
Control Schools					
G	1980	1	200	12	143
H	1980	1	225	17	129
I	1985	1	100	17	186
J	1952	1	1090	20	196
K	2011	0	100	14	96
L	1979	1	946	14	206
Mean	1981.2	0.8	443.5	15.7	159.3

Table A2: Principal Component Analysis (Child Outcomes)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	1.681	1.172	0.863	0.730	0.555
(95% CIs)	(1.482, 1.880)	(1.035, 1.309)	(0.765, 0.961)	(0.648, 0.812)	(0.490, 0.619)
Proportion	0.336	0.234	0.173	0.146	0.111
Factor Loadings					
Item [1]	0.518				
Item [2]	0.688				
Item [3]	0.675				
Item [4]	0.434				
Item [5]	0.544				

Table A3: Principal Component Analysis (Attitude to Learning and Knowledge Sharing)

	Factor 1	Factor 2	Factor 3
Eigenvalue	1.540	0.862	0.598
(95% CIs)	(1.357, 1.724)	(0.760, 0.964)	(0.527, 0.668)
Proportion	0.513	0.287	0.199
Factor Loadings			
Item [7]	0.792		
Item [8]	0.773		
Item [9]	0.563		

Table A4: Principal Component Analysis (Learning and Knowledge Sharing Behavior)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Eigenvalue	2.494	1.617	0.887	0.758	0.687
(95% CIs)	(2.197, 2.790)	(1.426, 1.808)	(0.788, 0.987)	(0.684, 0.833)	(0.630, 0.745)
Proportion	0.312	0.202	0.111	0.095	0.086
Factor Loadings					
Item [10]	0.696	-0.181			
Item [11]	0.691	-0.323			
Item [12]	0.507	-0.516			
Item [13]	0.623	-0.308			
Item [14]	0.656	0.178			
Item [15]	0.479	0.676			
Item [16]	0.349	0.711			
Item [17]	0.324	0.352			

Note: The results of only five components are reported.

Table A5: Balancing Test

	Program participant		Grade 5		Grade 6		School size		Distance to coast		Constant		N
Dependent Variables	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	
Child respondent													
Boy	-0.071	(0.065)	-0.029	(0.052)	-0.091	(0.064)	-0.000	(0.000)	-0.000**	(0.000)	0.704***	(0.083)	539
Parent respondent													
Male	-0.029	(0.050)	-0.043	(0.040)	0.013	(0.049)	0.000	(0.000)	0.000	(0.000)	0.162**	(0.063)	539
Age	1.555	(1.223)	0.529	(0.989)	3.186***	(1.205)	-0.002	(0.007)	0.000	(0.001)	37.279***	(1.559)	539
Years of schooling	-0.702	(0.686)	0.692	(0.555)	-0.529	(0.676)	0.015***	(0.004)	0.003***	(0.001)	0.847	(0.874)	539
Affected by the 2004/2005 tsunami	0.022	(0.065)	-0.029	(0.053)	-0.003	(0.064)	0.000	(0.000)	-0.000	(0.000)	0.480***	(0.083)	539
Household													
Age of head	1.620	(1.091)	1.083	(0.882)	3.032***	(1.074)	0.005	(0.006)	0.001	(0.001)	39.116***	(1.390)	539
Years of schooling of head	-0.464	(0.701)	0.793	(0.567)	0.413	(0.692)	0.013***	(0.004)	0.003***	(0.001)	0.921	(0.899)	536
Household size	-0.079	(0.557)	0.402	(0.450)	0.214	(0.549)	-0.001	(0.003)	0.001**	(0.001)	6.402***	(0.710)	539
There is a symbol of the past disasters in the village	-0.129**	(0.065)	0.099*	(0.052)	-0.075	(0.064)	-0.000	(0.000)	-0.000	(0.000)	0.525***	(0.082)	539
Residence is within10 minutes from river	-0.009	(0.062)	0.014	(0.050)	0.035	(0.061)	-0.000	(0.000)	-0.000	(0.000)	0.430***	(0.078)	539
Residence is within10 minutes from coast	-0.009	(0.064)	-0.052	(0.051)	-0.010	(0.063)	-0.000	(0.000)	-0.000***	(0.000)	0.555***	(0.081)	539

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Falsification Test

	Knowledge about Disaster Mechanisms			
	OLS		IV	
	Full	Coastal area	Full	Coastal area
	(1)	(2)	(3)	(4)
Program participant	0.015	0.018		
	(0.027)	(0.046)		
Child's learning and knowledge sharing			0.034	0.024
			(0.061)	(0.063)
Controls	Yes	Yes	Yes	Yes
N	536	224	536	224
R-squared	0.180	0.188		

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Robustness Test: Exclusion of Sixth-Grade Students in Treatment Schools

	Learning and knowledge sharing (Children)		Risk perception		Attitude to learning and knowledge sharing		Learning and knowledge sharing behavior (component 1)	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Program participant	0.409***	0.601***	-0.052	0.125	0.304**	0.346*	0.324**	0.460**
	(0.154)	(0.219)	(0.107)	(0.145)	(0.134)	(0.191)	(0.129)	(0.179)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	442	297	442	297	442	297	442	297
R-squared	0.087	0.091	0.075	0.090	0.047	0.065	0.239	0.200

	Learning and knowledge sharing behavior (component 2)		Knowledge about disaster response		Disaster preparation behavior		Disaster response	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Program participant	0.046	-0.207	0.067**	0.110**	0.023	0.158***	-0.024	-0.108
	(0.149)	(0.191)	(0.033)	(0.048)	(0.041)	(0.055)	(0.064)	(0.091)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	442	297	442	297	442	297	442	297
R-squared	0.083	0.153	0.073	0.101	0.126	0.156	0.072	0.100

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A8: Robustness Test: Exclusion of Respondents Other Than Parents

	Learning and knowledge sharing (Children)		Risk perception		Attitude to learning and knowledge sharing		Learning and knowledge sharing behavior (component 1)	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Program participant	0.461***	0.708***	-0.028	0.176	0.351**	0.417*	0.419***	0.703***
	(0.142)	(0.243)	(0.105)	(0.163)	(0.136)	(0.213)	(0.126)	(0.206)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	465	195	465	195	465	195	465	195
R-squared	0.076	0.115	0.065	0.094	0.051	0.091	0.213	0.193

	Learning and knowledge sharing behavior (component 2)		Knowledge about disaster response		Disaster preparation behavior		Disaster response	
	Full	Coastal area	Full	Coastal area	Full	Coastal area	Full	Coastal area
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Program participant	0.080	-0.282	0.057*	0.109**	0.022	0.218***	-0.081	-0.071
	(0.141)	(0.222)	(0.032)	(0.051)	(0.042)	(0.061)	(0.062)	(0.104)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	465	195	465	195	465	195	465	195
R-squared	0.110	0.202	0.060	0.110	0.114	0.159	0.093	0.146

Notes: OLS coefficients are reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Abstract (in Japanese)

要　　約

学校での防災教育は、児童の防災・減災への態度、知識、行動を促進するうえで費用対効果の高いアプローチである。一方、成人に対する効果的な介入方法はまだ十分明らかになっていない。そこで本研究は、児童向けの防災教育プログラムが、児童の親に与える波及効果を検証することを目的とする。分析には、インドネシアのニアス島における防災教育プログラム「防災マエナ」に参加した 214 名を含む 539 名の小学生、およびその親から収集した独自のデータを利用する。操作変数を用いた推定の結果、このプログラムへの参加によって、児童が自然災害に関して親と話し知識を共有すること、またこれにより、親の防災に関する態度、知識、行動も促されることが明らかになった。この効果は、特に災害リスクの高い地域に住む世帯でより大きかった。したがって、防災教育は参加者だけでなくその親に対しても有効であり、その社会的インパクトが大きいことが示唆された。本研究は、途上国において防災教育の親への波及効果を厳密な手法で検証した初めての研究である。また、価値観の世代間スピルオーバーに関する一連の研究に対しても、操作変数モデルを用いた精緻かつ直接的なエビデンスを示した点で学術的貢献がある。

キーワード : 防災教育、防災・減災、世代間波及効果、世代間学習、地震、津波、インドネシア