How People Find Their Way Back Home During a Natural Disaster

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Abstract. The 2011 Tohoku Earthquake, which was a 9.0-magnitude earthquake, caused a paralysis of the railway system and stranded as many as 5.15 million people in Tokyo, which is about 380 km from the location of the epicenter. In this study, an online questionnaire survey was conducted on how individuals returned home during the aftermath of the earthquake. In particular, we investigated how they obtained their route information to return home when regular transportation services and adequate information were not available. We performed a logistic regression analysis, and found that the level of difficulty and the process of acquiring route information varied by age, travel time, distance, level of knowing the way, departure time and initial location.

Keywords: earthquake disaster, public transportation, route map information, stranded commuters

1. Introduction

The Greater Tokyo Metropolitan Area has a population of approximately 35 million and about 8 million regular rail commuters, whose average commuting time is more than 90 minutes a day. Therefore, it is assumed that a vast amount of people will have difficulty in returning to their homes during the aftermath of a strong earthquake due to suspended rail services. In 2003, the Central Disaster Management Council (Chuo Bousai Kaigi), Cabinet Office, Government of Japan, organized an expert panel for an anticipated Tokyo metropolitan earthquake. The expert panel has also discussed how rail commuters return home on foot during an earthquake disaster. In response, some efforts have been made, both publicly and privately, to assist those walking home during a disaster's aftermath. For example, several adjacent prefectures have organized a network of designated shops and restaurants to support those walking home by offering drinking water, restrooms, maps, etc. Furthermore, specific walking maps have been published to guide those walking back home on foot.

On Friday, March 11, 2011, at 2:46 p.m. (JST), a 9.0-magnitude earthquake occurred off the northeast coast of Japan, which is known as the 2011 Tohoku Earthquake. The epicenter was located 130 km from Oshika Peninsula and 24 km in depth under the Pacific Ocean. The city of Tokyo, which is about 380 km from the location of the epicenter, experienced strong tremors. Although human and physical damage was relatively modest in Tokyo, paralysis of the railway system stranded as many as 5.15 million people (an estimate by the Cabinet Office) in the Greater Tokyo Metropolitan Area.

Almost all train and subway services ceased immediately after the earthquake. The Ministry of Land, Infrastructure, Transport and Tourism (2012) reported that some train and subway services were restored after 8 p.m., and 38% of train and subway services within 30 km of the Central Business District (CBD) and 24% within 80 km of the CBD were restored by 12:00 a.m., while 95% of services within 30 km and 80% within 80 km of the CBD were restored by 2 p.m. the next day.

After the 2011 earthquake, the Tokyo Metropolitan Government (TMG) and the Cabinet Office, Government of Japan, began examining how to strengthen measures to support mass amounts of stranded people during the aftermath of an anticipated Tokyo metropolitan earthquake. In March 2012, TMG enacted an ordinance to comprehensively promote measures to support stranded persons based on concepts of self-help, mutual assistance, and public assistance. The ordinance is currently enforced and is effective as of April 2013.

Literature has been recently published that focuses on travel behavior during the aftermath of a natural disaster, such as an earthquake. Osaragi (2009, 2012) constructed models that describe the decision-making process and behavior of individuals attempting to reach home on foot after a devastating earthquake. Lamb and Walton (2011) conducted a survey and examined travel behaviors during the aftermath of an earthquake in Gisborne, New Zealand, 2007. Takada et al.'s (2012) study focused on when people started returning home after the 2011 Tohoku Earthquake.

In the current study, focus is placed on route information acquisition. A questionnaire survey was conducted on how individuals returned home during the aftermath of the 2011 Tohoku Earthquake. We also investigated what type of difficulties people had and, in particular, how they obtained their route information to return home when regular transportation services and adequate information were not available.

2. Methods

During this study, 978 individuals (Table 1.) were questioned via an online questionnaire survey from December 8 through December 19, 2011. The respondents included:

- those who were away from home at the time of the earthquake;
- those who were in the central area of Tokyo (12 wards within and on the Yamanote railway loop line) at the time of the earthquake; and
- those who reside in one of Greater Tokyo's four prefectures: Tokyo Metropolitan Prefecture, Kanagawa Prefecture, Saitama Prefecture, and Chiba Prefecture.

As shown in Table 1., respondents were distributed across five age groups, two sex groups and four residential area groups. Questions consisted of each person's actions from the time of the earthquake to when he/she reached his/her home, with stop-off points en route being a primary concern.

		place of residence (prefecture)				total
		Tokyo Met.	Kanagawa	Chiba	Saitama	
age, sex	**men**	**125**	**125**	**125**	**125**	**500**
	20-29	25	25	25	25	100
	30-39	25	25	25	25	100
	40-49	25	25	25	25	100
	50-59	25	25	25	25	100
	60-69	25	25	25	25	100
	women	**125**	**125**	**115**	**113**	**478**
	20-29	25	25	25	25	100
	30-39	25	25	25	25	100
	40-49	25	25	25	25	100
	50-59	25	25	25	25	100
	60-69	25	25	15	13	78
total		**250**	**250**	**240**	**238**	**978**

Table 1. Respondents of the online questionnaire survey.

3. Summary of the Survey Results

3.1. Going-home process

Figure 1. shows the origin and destination, or the initial location and home, of the 978 individuals. Approximately 70% of the respondents were at their office or at their school during the time of the earthquake, since it was a weekday afternoon. This percentage is lower for the older age groups, especially for women. Table 2. shows the respondents' usual commuting time and their travel time back home after the earthquake. Those who departed before 6 a.m. on March 12 took on average 7.2 times longer to return home than their regular commuting time, while those who departed after 6 a.m. on March 12 took on average 3.3 times longer than their regular commuting time. Although travel time after 6 a.m. is much shorter than that before 6 a.m., travel time was still exceedingly longer than usual. In particular, individuals from the eastern regions of Greater Tokyo had longer travel times.

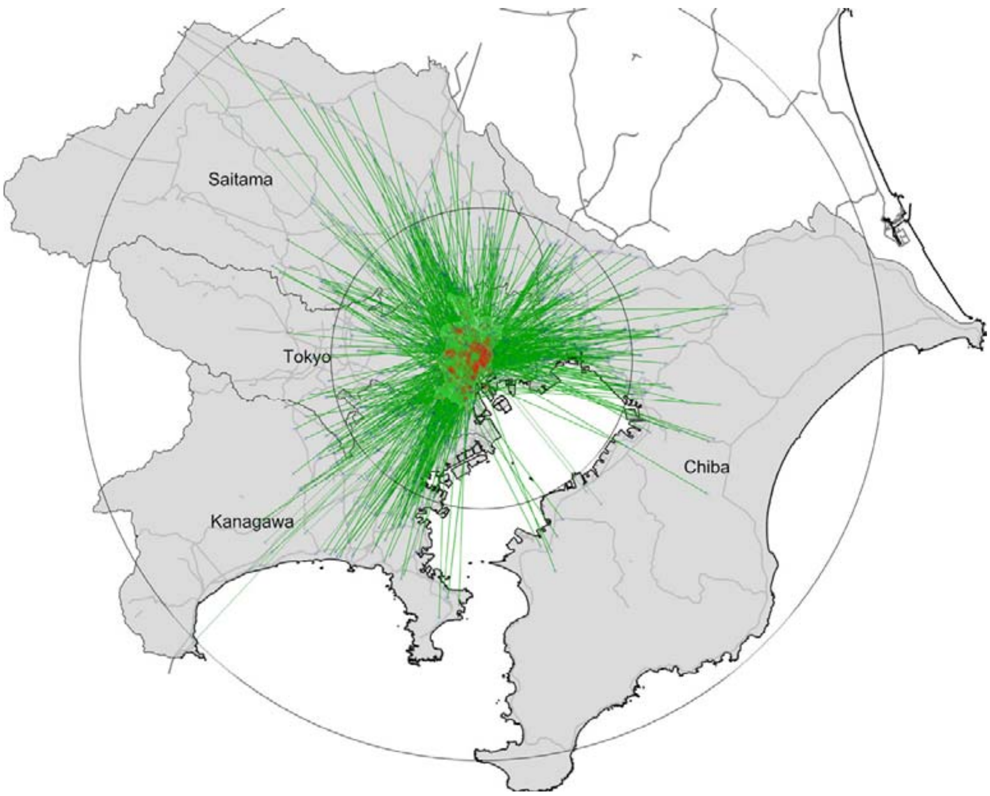

Figure 1. The origin and destination of the 978 individuals after the earthquake.

		departed before 6 a.m. on March 12			departed after 6 a.m. on March 12		
		A: usual commuting time	B: travel time on March 11 or 12	B/A	A: usual commuting time	B: travel time on March 11 or 12	B/A
place of residence (prefecture)	Tokyo Met.	45.7	255.9	5.6	52.2	163.3	3.1
	Kanagawa	68.2	502.1	7.4	74.2	202.6	2.7
	Chiba	70.9	630.4	8.9	75	260.1	3.5
	Saitama	69.9	488.5	7	72.3	254.2	3.5
	overall mean	61.4	440	7.2	72.1	234.4	3.3

Table 2. Usual commuting time and travel time back home after the earthquake

3.2. Difficulties

Figure 2. shows the percentage of difficulties the respondents incurred during their return home. Almost half the respondents had difficulty due to their mobile phone network jammed. More than 30% of the respondents had to wait in long queues for transit services. Furthermore, 10% of the respondents had difficulty in finding their way home without a map, and 3% of the respondents had difficulty in finding their way home with a map.

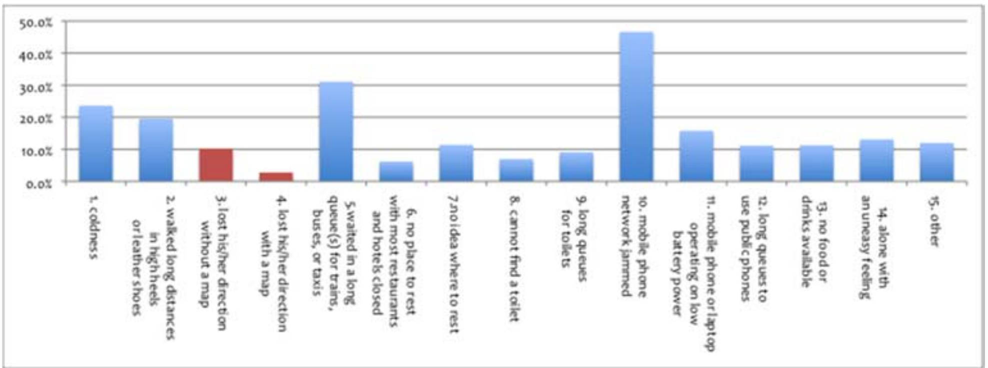

Figure 2. Difficulties during the respondents’ return home.

3.3. Stop-off points en route home

Figure 3. shows what type of facilities the respondents visited en route home and Figure 4. shows what types of services were provided. Approximately 60% of the respondents whose travel time was less than 3 hours did not visit any facilities during their return home. As travel time increases, the number of facilities visited increases. Those with a travel time longer than 3 hours tended to obtain route information at the facilities they visited, such as at a train or subway station, a local police substations, or store.

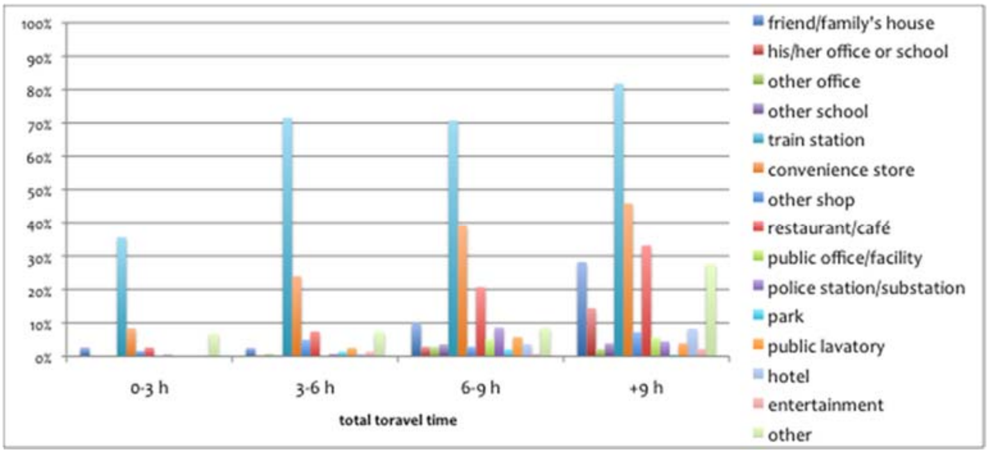

Figure 3. Types of facilities the respondents visited en route home.

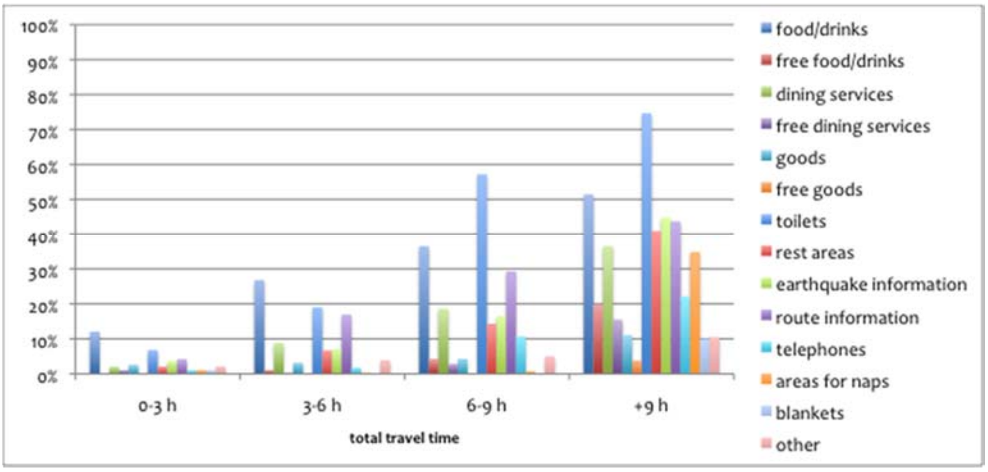

Figure 4. Types of services provided at the facilities.

Those who were in their office or at school, or their family's or friend's home, at the time of the earthquake (hereinafter "individuals with a base") had relatively less difficulty than the others who were not (hereinafter "individuals without a base"). Individuals without a base tended to have stronger intentions to return home during the day, while individuals with a base tended to stay the night at their base to wait for the restoration of public transportation services.

4. Logistic regression analysis of route-information-obtaining

4.1. Where to obtain route information

Respondents answered all stop-off facilities up to 6 and what kind of services they received at each facility. As shown in Figure 4., some respondents obtained route information at some facilities. Table 3. shows a cross-tabulation of type of facilities where the respondents obtained route information by how they knew each of the facilities. A rail station that he/she had known was the most answered, and some various types of facility that he/she came across was also answered.

		facility type																			
		his/her office	his/her school	rail station	convenience store	retail shop	restaurant/café	hotel	government office	police station	police substation	local community facility	cultural facility	school	university	religious facility	park	(not his/her) office	friend's or family's house	other	total
how to know the facility	had known and visited the facility	11	1	112				3							2				6	5	140
	had known and never visited the facility			8			1			1	3				2				1	1	17
	came across the facility in passing			1	4	1	3	2	1	1	13	1								2	29
	was called in front of the facility															2					2
	asked at a police box													1							1
	was told by a companion			1															2	3	6
	was told by a friend or family by phone			1																	1
	word of mouth from someone											1					1				2
	other	3		1							1		1	1				1	1	1	10
	total	14	1	124	4	1	4	5	1	2	17	2	1	2	4	2	1	1	10	12	208

Table 3. Facility type where individuals obtained route information.

4.2. Who lost his/her direction

As shown in Figure 2., some people had difficulty in finding their way home with/without a map. In order to explore how individuals' attributes and situation influence the probability of losing his/her direction, we estimated a logistic regression model. The binary dependent variable is "Lost his/her direction without a map" (1=Yes; 0=No) (Table 4. left) or "Lost his/her direction with a map" (1=Yes; 0=No) (Table 4. right).

As travel time increases and level of knowing the way back home decreases, the chances of getting lost both with and without a map significantly increases, and a decrease in age and a increase in and departure between 15:00 and 21:00 significantly increases the chances of getting lost without a map. Restoration ratio of rail service could be one reason. Since almost no rail service was restored before 8 p.m., most of those who departed between 3 p.m. - 9 p.m. were supposed to return on foot or wait for transit services for a long time.

	Lost his/her direction without a map				Lost his/her direction with a map			
	Estimate	Std. Error	exp (Estimate)		Estimate	Std. Error	exp (Estimate)	
(Intercept)	-0.3180	0.6511	0.7276		-2.5220	1.1120	0.0803	*
sex	-0.1599	0.2361	0.8522		-0.1048	0.4162	0.9005	
age	**-0.0193**	0.0086	0.9809	*	-0.0158	0.0149	0.9843	
familiar to the initial location	-0.1499	0.1295	0.8608		-0.1040	0.2366	0.9012	
knew the way back home	**-0.3419**	0.0825	0.7104	***	**-0.3598**	0.1485	0.6979	*
total travel time	**0.0255**	0.0130	1.0258	*	**0.0624**	0.0177	1.0644	***
distance between initial location and home	-0.0177	0.0102	0.9824	.	-0.0006	0.0100	0.9994	
with a base	-0.4322	0.2636	0.6490		0.0972	0.4983	1.1021	
departure between 15:00-21:00	**1.1070**	0.2639	3.0256	***	-0.3061	0.4518	0.7363	
departure between 21:00-6:00	0.0249	0.4321	1.0252		0.3287	0.5595	1.3892	
AIC	583.01				243.83			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table 4. Estimated logistic regression model for losing direction.

4.3. How and where to obtain route information

Next, we explore how and where they obtained their route information to return home under the situation that regular transportation services and adequate information were not available. Logistic regression models were estimated both for obtaining route information at a stop-off point (Table 5.) and for obtaining route information on street (Table 6.).

As shown in Table 3., a rail station that he/she had known and some various types of facility that he/she came across in passing are distinctive. Therefore, the binary dependent variable is "obtained route information at a stop-off point" (1=Yes; 0=No) (Table 5. left), and also "obtained route information at a rail station that he/she had known" (1=Yes; 0=No) (Table 5. middle) or "obtained route information at a facility that he/she came across in passing" (1=Yes; 0=No) (Table 5. right).

The chances of obtaining route information at a general stop-off facility significantly increases when travel time increases, distant between the initial location and home increases and chances of getting lost without a map increases. As travel time increases, the chance of obtaining route information at a rail station that he/she had known significantly increases. The chances of obtaining route information at a facility that he/she came across in passing increases when he/she lost his/her direction without a map and his/her travel time is longer. Some of those who visited rail stations that they had known were supposed to obtain route information additionally, while those who obtained route information at a facility that they came across in passing tend to search for it more seriously.

The chances of obtaining route information from someone on street increases when a person was an individual with a base and lost his/her direction without a map. The level of knowing the way back home, travel time, departure between 3 p.m. - 9 p.m. and lost his/her direction without a map significantly increases the chance of obtaining route information by signs on street. As age increases, utilization of a GPS and other location-based resources on the person's mobile device decreases. Some felt that the use of a mobile GPS was useful in finding their way home. However, some had difficulty since their mobile phone or laptop was operating on low battery power. Each of the ways to obtain route information (Figure 6.) corresponds to human base media, physical spatial base media and digital base media respectively, and the users' attribute and situation differs with each other.

	obtained route information at a stop-off point			visited a familiar rail station and obtained route information			obtained route information at a facility in passing		
	Estimate	Std. Error	exp (Estimate)	Estimate	Std. Error	exp (Estimate)	Estimate	Std. Error	exp (Estimate)
(Intercept)	-2.7940	0.6072	0.0612 ***	-1.9800	0.6974	0.1381 **	-4.8140	1.2700	0.0081 ***
sex	-0.0121	0.2042	0.9880	0.2203	0.2466	1.2465	-0.6669	0.5076	0.5133
age	0.0042	0.0075	1.0042	-0.0119	0.0092	0.9882	0.0036	0.0168	1.0036
familiar to the initial location	0.0397	0.1315	1.0405	-0.1603	0.1509	0.8519	-0.2322	0.2392	0.7928
knew the way back home	-0.0708	0.0682	0.9316	0.0478	0.0820	1.0490	0.0135	0.1737	1.0136
total travel time	**0.0580**	0.0103	1.0597 ***	**0.0319**	0.0127	1.0324 *	**0.0568**	0.0233	1.0585 *
distance between initial location and home	**0.0072**	0.0033	1.0073 *	0.0025	0.0027	1.0025	0.0030	0.0063	1.0030
with a base	-0.2794	0.2318	0.7562	0.1185	0.2971	1.1258	0.1914	0.5687	1.2109
departure between 15:00-21:00	0.2113	0.2185	1.2353	-0.0442	0.2690	0.9568	0.6000	0.5679	1.8221
departure between 21:00-6:00	0.0539	0.3262	1.0554	0.2341	0.3507	1.2638	-0.5045	1.1600	0.6038
lost his/her direction without a map	**0.9744**	0.2653	2.6495 ***	0.2909	0.3664	1.3376	**2.8730**	0.5193	17.6814 ***
lost his/her direction with a map	-0.4283	0.5841	0.6516	-0.3798	0.7603	0.6840	-15.17	1129	0.0000
AIC	722.03			556.87			181.37		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table 5. Estimated logistic regression model for obtaining route information at a stop-off facility.

	route information given by someone present			obtained route information by signs on street			utilization of mobile GPS for finding route		
	Estimate	Std. Error	exp (Estimate)	Estimate	Std. Error	exp (Estimate)	Estimate	Std. Error	exp (Estimate)
(Intercept)	-4.0270	0.9278	0.0178 ***	-2.3440	0.9773	0.0959 *	-0.4258	0.8408	0.6533
sex	-0.0618	0.2990	0.9401	-0.1092	0.2932	0.8965	0.3567	0.2696	1.4286
age	0.0052	0.0106	1.0053	-0.0215	0.0112	0.9787 .	**-0.0590**	0.0117	0.9427 ***
familiar to the initial location	0.2110	0.1879	1.2350	0.0138	0.2135	1.0139	0.0267	0.1809	1.0271
knew the way back home	0.1740	0.1031	1.1900 .	**0.2270**	0.1027	1.2549 *	-0.0019	0.0907	0.9981
total travel time	0.0170	0.0175	1.0171	**0.0390**	0.0147	1.0398 **	-0.0003	0.0165	0.9997
distance between initial location and home	-0.0096	0.0127	0.9905	-0.0135	0.0128	0.9866	-0.0096	0.0105	0.9905
with a base	**-1.2320**	0.3188	0.2917 ***	0.2137	0.3587	1.2382	-0.2175	0.3221	0.8045
departure between 15:00-21:00	0.2507	0.3321	1.2849	**-0.6138**	0.3088	0.5413 *	0.4203	0.3040	1.5224
departure between 21:00-6:00	0.7473	0.4505	2.1112 .	-1.0380	0.5554	0.3541 .	0.4030	0.3960	1.4963
lost his/her direction without a map	**2.3650**	0.3215	10.6392 ***	**1.2230**	0.3760	3.3986 **	-0.0359	0.4011	0.9648
lost his/her direction with a map	0.8596	0.6694	2.3621	-1.0930	1.1090	0.3350	-0.0735	0.7672	0.9291
AIC	403.88			421.19			476.96		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table 6. Estimated logistic regression model for obtaining route information on street.

5. Conclusion and future plans

It was predicted and confirmed that a vast amount of people would have difficulty in returning home during the aftermath of a strong earthquake. Actual behavior after the 2011 Tohoku Earthquake was shown via the results of a questionnaire survey. It was shown that some people had difficulty in finding their way home without a map.

The level of difficulty and the process of acquiring route information en route home varied by age, travel time, distance, level of knowing the way, departure time and initial location. Redundancy in providing route information, that is, providing several forms of route information both in digital and analogue, is required.

Our future plans include investigating the route of each respondent whose level of knowing the way is low and who walked home, which may indicate a wayfinding model.

On the other hand, TMG encourages businesses to keep employees from all simultaneously leaving the office immediately after an earthquake, and to stock 3 days worth of food and water for all employees. Therefore, individuals without a base should be focused in our future studies. Furthermore, an anticipated Tokyo metropolitan earthquake is ex-pected to cause much more severe conditions, such as the destruction of buildings, fires, subsequent closure of roads, a much longer time for the restoration of public transportation services, food and water shortages, etc. Considering and simulating conditions that are more severe will be a challenge in future studies.

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