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Bridging the Gap Between Saviours and Survivors: Exploring Uncertainties in Search, Rescue, Emergency, and Evacuation Operations in Earthquake and Flood

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ABSTRACT

This exploratory study reports the behaviors in situations in which transportation services are required in earthquakes and floods for search, rescue, emergency, and evacuation exit operations. The study focuses on a comparison of how two disasters, predictable i.e., floods and unpredictable i.e., earthquake happening in emerging and emerged economies and how institutions are responding with their own set of available resources and facilities. The case studies are three in number, which include a high-population density city facing extreme seasonal floods from a river, under-resourced, and belonging to a developing country. second case study is a high-population-density city, richly resourced, and an advanced city in a developing country considered for earthquakes. The third case study for floods is an advanced city in a developed country that faces floods almost every year. The data were collected through a questionnaire, and a systematic sampling technique was adopted by considering the most disaster-exposed households. The results gave a broader perspective regarding the use of information and communication technologies (ICT) used by disaster-affected residents to gain and exchange transport-disaster-related information, the frequency of ICT-usage, reliable information sources, and preferred institutions to contact among rescue authorities, police, and government authorities. The study also explores the behavioral differences in pre-, during-, and post-disaster situations in which disaster-affected people engaged ICTs in choosing evacuation vehicles, helping dependents to evacuate safely, informing other disaster-affected community members, and relying on authorities for support and services. The study is helpful in managing transport-disaster scenarios to save lives, maintain information flow among people and authorities, improve the efficiency of transport operations, build resilience, and design technologically advanced, well-connected future smart cities.

Keywords: Search and rescue operations, Emergency, Evacuation, Transportation, Disasters, Institutions, Uncertainties

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INTRODUCTION

In disaster-prone countries, fragmented information and communication flow (ICF) between savers and survivors undermines coordination, delaying search, rescue, emergency response and evacuation operations during transport-disasters (Anwer and Yousuf, 2022; Anwer et al., 2024). Despite disaster risk reduction frameworks emphasising multi-hazard resilience, transport-disaster uncertainties arising from infrastructure disruption, communication breakdown, unreliable information and limited mobility remain inadequately addressed, particularly in developing countries (Anwer et al., 2016; Anwer, 2017; Anwer and Grant-Muller, 2017a, 2017b, 2017c). Existing literature predominantly reflects institutional and policy perspectives, overlooking affected communities' information needs, capabilities, available resources, trust and potential contributions to emergency response. Furthermore, the differential uncertainties associated with unpredictable earthquakes and comparatively predictable floods, and their implications for community–authority coordination, remain underexplored. This study bridges these gaps by comparing three case studies across developed and developing countries to investigate community-generated, event-specific transport information, ICT-enabled communication linkages and barriers to effective coordination. The findings aim to inform context-specific, community-inclusive strategies for reducing uncertainties and strengthening search, rescue, emergency response and evacuation operations.

METHODOLOGY

The methodology covers piloted questionnaire design, ethical approval, selection of case-studies, disasters and communities, recruitment of subjects, data collection on the most relevant variables, sample size of the targeted population, and analysis methods leading to the interpretation of results and conclusions.

Case-studies: Three case-studies were picked: York (UK), and Islamabad and Head-Marala (HM) (Pakistan), representing evolved and evolving countries, respectively. Floods are predictable and earthquakes are unpredictable, which adds complexity to disruptions. The case-studies and disasters were selected to draw out differences in the responsive and preferential behaviors of communities from countries of different development status, with varied demographics, socio-economic and cultural values. Hence, the impact of disasters on transport-related disruptions and communities' responsive behaviors showcases the global application of the study.

York-UK: York's total population was 204,439, including urban and rural areas, until mid-2014 (Council, 2016). Floods are caused by the river Ouse, so data were collected from residences alongside the river that were prone to flooding; in total, 102 questionnaires were collected from households at the river bank. York has been prone to severe floods for a couple of decades due to climate change, rising water levels and precipitation, and floods still damage homes and businesses and delay the transport system (BBC(NEWS), 2012a, 2012b, 2012c). The Environment Agency issued many flood warnings in 2015 and onwards, and stakeholders (environment agency, city council, met department etc.) constantly work to upgrade flood defence systems and mitigate flood impacts.

Head-Marala Pakistan: HM is a barrage on the river Chenab, constructed in 1968 (Shakir and Khan, 2009). The densely populated community around HM has been massively flooded for decades, even to date (Atta Ur et al., 2015; Atta Ur and Shaw, 2015), causing extensive loss of lives, transport infrastructure, communication lines, buildings and natural habitat (NDMAP, 2010). The case is like York and the river Ouse. Monsoon and precipitation, overflowing rivers, faster glacier melt and cutting of trees and forests all contribute to floods in the area. There is a lack of significant research on floods and their impacts on the transport system, infrastructure and traffic.

Islamabad Pakistan: Margala towers and their vicinity were directly affected by the earthquake, especially in 2005 and onwards, and residents experienced the earthquake and aftershocks over an extended period. Data were collected from the directly affected residents of Margalla towers and their vicinity.

Questionnaire design, variables selection and data collection: The variables cover a wide range of transport-disaster scenarios affecting mobility in disasters due to possible failure of ICF required to sustain transport systems, from the perspective of transport-disaster affected people and management experts. Variables were selected after consulting the literature, reports, piloted questionnaires, interactions with flood- and earthquake-affected communities, news, articles, personal observations, documentaries and experts. They broadly represent awareness about transport-disaster circumstances, demographics, personal characteristics, prevailing situations, available facilities, trust in authorities, technology engagement and evacuation vehicles, and are categorical (distinct categories) or binary ("Yes or No"). In total Table 1, 19 variables were sorted to understand demographics, evacuations and technological usage under transport-disaster scenarios and community responses. Analysis showed moderate to strong severity/intensity (of flood and earthquake), moderate to highly affected residence locations and prior experience of disaster, implying that all respondents were from highly affected disastrous areas, still resided there and had been through disasters in their specific area.

Table 1: Variables, categories, variable types and categorical findings of overall table.

Variables	Category	Variables	Pak-Flood		UK-Flood		Pak-Earthquake	
			N	%	N	%	n	%
Age	18 – 25	Categorical	366	32.8	244	21.9	327	29.3
	26 – 40		527	47.3	476	42.7	525	47.1
	41 – 65		200	17.9	192	17.2	253	22.7
	65+		22	2.0	203	18.2	10	.9
Gender	Male	Binary	511	45.8	694	62.2	807	72.4
	Female		604	54.2	421	37.8	308	27.6
Education	School to college	Binary	50	4.5	337	30.2	24	2.2
	College to professional		1065	95.5	778	69.8	1091	97.8
Own vehicle	Yes	Binary	535	48.0	988	88.6	668	59.9
	No		580	52.0	127	11.4	447	40.1

(Continued)

Table 1: Continued.

Variables	Category	Variables	Pak-Flood		UK-Flood		Pak-Earthquake	
			N	%	N	%	n	%
Frequently used vehicles	Cycle/ Motorcycle/ Car	Categorical	592	53.1	898	80.5	800	71.7
	Public transport		282	25.3	59	5.3	145	13.0
	Paratransit		81	7.3	0	0	13	1.2
	All above		160	14.3	158	14.2	157	14.1
Benefited from vehicle in-built technology	Yes	Binary	414	37.1	973	87.3	729	65.4
	No		701	62.9	142	12.7	386	34.6
Technology aided to evacuate area	Do not know / None	Binary	786	70.5	192	17.2	384	34.4
	Radio / GPS / both		329	29.5	923	82.8	731	65.6
Occupation	Employed	Categorical	435	39.0	657	58.9	733	65.7
	Student / Home maker		502	45.0	147	13.2	308	27.6
	Unemployed / Retired		178	16.0	311	27.9	74	6.6
Evacuation vehicle	Not used	Categorical	273	24.5	203	18.2	268	24.0
	On foot or cycle		131	11.7	476	42.7	235	21.1
	Boat/ Helicopter/ Airplane		571	51.2	193	17.3	567	50.9
	Motorcycle or car		140	12.6	243	21.8	45	4.0
Severity/ intensity	No to light intensity	Binary	23	2.1	54	4.8	178	16.0
	Moderate to strong intensity		1092	97.9	1061	95.2	937	84.0
Prior disaster experience	Yes	Binary	995	89.2	983	88.2	979	87.8
	No		120	10.8	132	11.8	136	12.2
Location of residence	Not to least affected	Categorical	20	1.8	118	10.6	206	18.5
	Moderate to highly affected		1095	98.2	997	89.4	909	81.5
Dependency status	Alone and independent	Categorical	794	71.2	867	77.8	857	76.9
	Dependent on others		321	28.8	248	22.2	258	23.1

(Continued)

Table 1: Continued.

Variables		Category	Variables	Pak-Flood		UK-Flood		Pak-Earthquake	
				N	%	N	%	n	%
Transport-Disaster followed up		Yes	Binary	435	39.0	625	56.1	262	23.5
		No		680	61.0	490	43.9	853	76.5
Transport-Disaster authority contacted		Yes	Binary	62	5.6	354	31.7	47	4.2
		No		1053	94.4	761	68.3	1068	95.8
Shared vehicles with other to rescue		Yes	Binary	619	55.5	940	84.3	460	42.1
		No		496	44.5	175	15.7	632	57.9
Pre-Hand informed by authorities		Yes`	Binary	181	16.2	547	49.1	237	21.3
		No		934	83.8	568	50.9	878	78.7
Preferred authority transport-disaster information	Govt. Authority	Not preferred	Binary	833	74.7	64	5.7	237	21.3
		Preferred		282	25.3	1051	94.3	878	78.7
	Police	Not preferred	Binary	586	52.6	845	75.8	853	76.5
		Preferred		529	47.4	270	24.2	262	23.5
	Emergency authority	Not preferred	Binary	433	38.8	461	41.3	781	70.0
		Preferred		682	61.2	654	58.7	334	30.0

RESULTS

Behavior of people in utilizing ICTs and sharing transport-disaster information: Figure 1, 2, and 3 shows Comfort level, usage frequency under normal conditions and in emergency situations were compared among themselves and for three case-studies in seeking transport-disaster information. Also, behavior of sharing information is compared in pre, during and post-disaster phases for the three case-studies. Figures EP(a), FP(d) and FUK(g) shows that people from all three case-studies were strongly comfortable with cell phones. Landline in floods rather than in earthquakes and TV and social media webs were of strong comfortable for all case-studies. Noticeable was that FUK showed neutral behavior of comfort towards smartphones, in FP smartphones and web 2.0/3.0 and in EP newsletters/broachers. FUK were strongly uncomfortable with newspaper and newsletters/brochures, FP info webs and blogs, following newsletters and social media webs, EP showed close variance among all ICTs. FUK were not familiar with newsletters/brochures.

Figures EP(b), FP(e) and FUK(h) shows the frequency of usage if ICTs under normal circumstances in seeking transport-disaster information. Every few hourly, social websites following smartphones were used in EP, Web 2.0/3.0 in FP and laptops, mobile phones and smartphones in FUK. In contrast, newsletters and web 2.0/3.0 in EP, landline, radio and newsletters in FP, and Web 2.0/3.0 in FUK were not used at all. It was observed variations in other ICTs usage in all case-studies.

Figures (c), (f), and (i) shows frequency of ICTs usage in emergency situations to seek transport-disaster information. Frequently used was mobile phone in all three cases and smart phone as well in PUK. The percentage of never used did not show many variations for all ICTs in all cases. The situation was similar with do not know category, for EP and FP, however, four ICTs emerged in FUK i.e., mobile ph., smart ph., landline and Web 2.0/3.0 where people did not know to acquire emergency information through these ICTs.

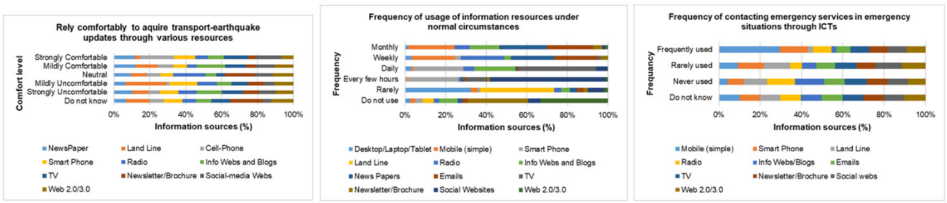


Figure 1: (a), (b), and (c) Earthquake-Pak.

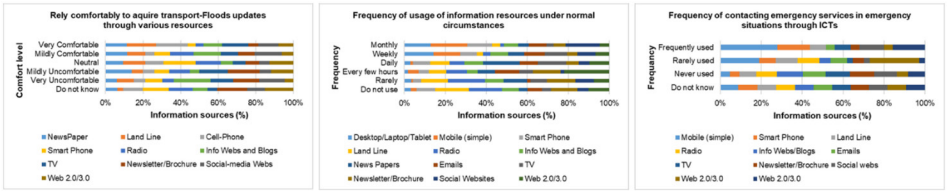


Figure 2: (d), (e), and (f) Floods-Pak.

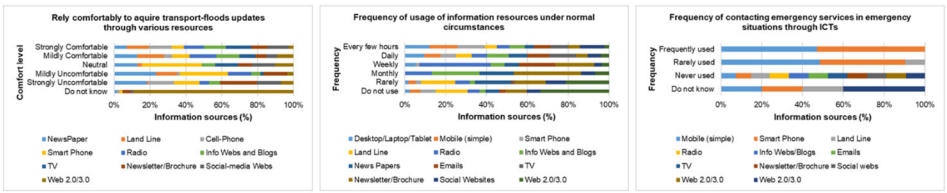


Figure 3: (g), (h), and (i) Floods UK.

The data for EQP, FP and FUK across various ICTs to exchange transport-disaster information, showed distinct patterns in the distribution of usage comfort levels among respondents Figures EP(a), FP(d) and FUK(g). These comparisons emphasized the diversity of comfort perceptions among respondents for each ICT and highlighted significant variations in comfort levels between the EQP, FP, and FUK datasets.

Do not know: Substantial uncertainty was reflected with percentage ranges for EQP: 5% social-media-webs to 19% newsletter/brochure. FP: 9.5% TV to 28.6% newsletter/brochure. FUK: 0% newspaper, landline, cellphone, smartphone, radio, Info-webs-blogs, TV, and social-media-webs to 59% web 2.0/3.0. *Strongly Uncomfortable*: It varied from EQP: 5% cellphone to 11% Info-webs-blogs. FP: 2.9% web 2.0/3.0 to 12.4% Info-webs-blogs. FUK: 0% TV to 27% newsletter/brochure. *Mildly Uncomfortable*: Responses ranged from EQP: 2% cellphone to 25% landline. FP: 1% social-media-webs to 16.2% landline. FUK: 0% social-media-webs to 16% smartphones. *Neutral*: It ranged from EQP: 12% TV to 44% radio. FP: 10.5% social-media-webs

to 33.3% smartphones. FUK: 0% cellphone and radio to 13% smartphone. *Mildly Comfortable*: The responses ranged between EQP: 11% radio to 34% Info-webs-blogs. FP: 10.5% cellphones to 31.4% Info-webs-blogs and social-media-webs. FUK: 6% cellphone to 20% radio and landline. *Strongly Comfortable*: The responses ranged from EQP: 7% landline to 48% cell phone. FP: 10.5% smartphone and radio to 41.9% cell phones. FUK: 15% web2.0/3.0 to 74% cell phone.

The data for EQP, FP and FUK across various ICTs to exchange transport-disaster information, showed distinct patterns in the distribution of usage frequency under normal circumstances among respondents Figures EP(b), FP(e) and FUK(h). These comparisons emphasized the diversity of usage perceptions among respondents for each ICT and highlighted significant variations in frequencies between the EQP, FP, and FUK datasets.

Do not know: Substantial uncertainty was reflected with percentage ranges for EQP: 0% TV to 81% newsletter/brochure. FP: 7.6% cell phone to 44.8% landline. FUK: 0% TV to 44% web 2.0/3.0. *Rarely*: It varied from EQP: 0% TV to 85% landline. FP: 1% cell phone to 21% radio. FUK: 1% emails and TV to 24% web 2.0/3.0. *Every few hours*: Responses ranged from EQP: 0% desktop/laptop/tablet, landline, and info-webs-blogs to 52% social-media-webs. FP: 1% desktop/laptop/tablet and social-media-webs to 12.4% web 2.0/3.0. FUK: 8%, web 2.0/3.0 to 48% cell phones. *Daily*: It ranged from EQP: 0% landline and newsletter/brochure to 85% TV. FP: 1.9% cell phone to 28.6% newspaper. FUK: 21% web 2.0/3.0 to 69% TV. *Weekly*: The responses ranged between EQP: 0% landline and social-media-webs to 67% cellphone, radio, newspaper, and email. FP: 13.3% landline to 61% desktop/laptop/tablet. FUK: 0% cellphone, landline, and TV to 20% radio. *Monthly*: The responses ranged from EQP: 0% landline, smartphone, and TV to 16% cellphone, newspaper, and emails. FP: 2.9% radio to 29.5% cellphones. FUK: 0% desktop/laptop/tablet, cellphone, smartphone, landline, email, and TV to 10% newsletter/brochure.

The data for EQP, FP and FUK across various ICTs to exchange transport-disaster information, showed distinct patterns in the distribution of usage frequency under emergency circumstances among respondents Figures EQP(c), FP(f), and FUK(i).

Do not know: Substantial uncertainty was reflected with percentage ranges for EQP: 72% social-media-webs to 76% emails. FP: 82% cellphone to 89% smartphone. FUK: 0% TV to 44% web 2.0/3.0. *Never used*: It varied from EQP: 6% cellphone to 20% info-webs-blogs. FP: 4.8% cellphone and smartphone to 13.3% info-webs-blogs. FUK: 1% emails and TV to 24% radio, info-webs-blogs, email, TV, newsletter/brochure, social-media-webs and web 2.0/3.0. *Rarely used*: Responses ranged from EQP: 77% landline to 100% radio, social-media-webs. FP: 1% TV, social-media-webs and info-webs-blogs to 8.6% web 2.0/3.0. FUK: 0% radio, info-webs-blogs, email, TV, newsletter/brochure, social-media-web, and web 2.0/3.0 to 15% cellphones. *Frequently used*: It ranged from EQP: 1% landline and info-webs-blogs to 13% cellphones. FP: 0% radio and info-webs-blogs to 6.7% cellphone. FUK: 0% landline, radio, info-webs-blogs, email, TV, newsletter/brochure, social-media-webs and web 2.0/3.0 to 9% smartphone.

Figure 4 shows that government authority was the most preferred source of transport-disaster help for EQP (about 79%) and especially FUK (about

94%), while FP respondents mostly did not prefer it (about 75% not preferred). Police were largely not preferred in EQP and FUK (about 77%), and emergency authorities were preferred mainly in FP and FUK (about 59-61%) but not in EQP (about 70% not preferred).

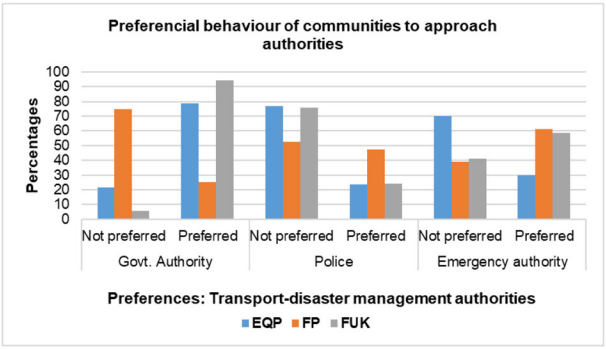


Figure 4: Preferential behaviours of earthquake and flood affected communities to approach authorities in seeking help.

Behavior before, during and after disasters: Figures 5–7 compare respondents' agreement, indifference and disagreement with ICT-related behaviors in the pre-, during- and post-disaster phases of EQP, FP and FUK.

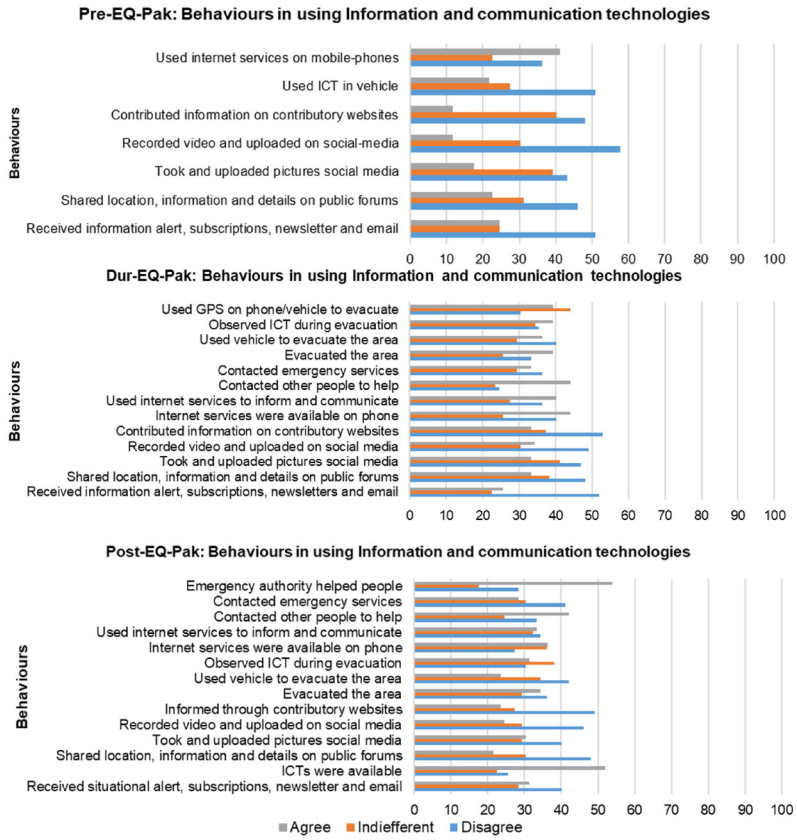


Figure 5: Behaviors in using ICTs before (top), during (middle) and after (bottom) the earthquake in Pakistan (EQP); bars show the percentage of respondents who agreed, were indifferent or disagreed.

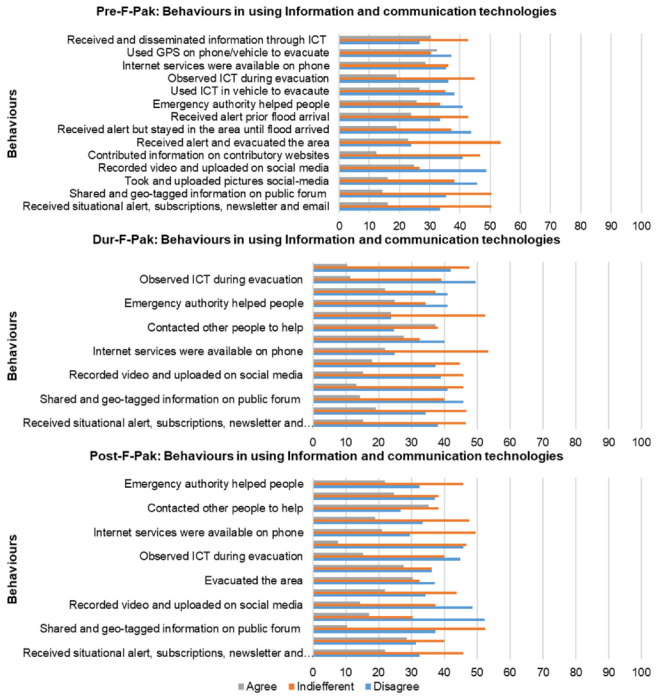


Figure 6: Behaviors in using ICTs before (top), during (middle) and after (bottom) the flood in Pakistan (FP); bars show the percentage of respondents who agreed, were indifferent or disagreed.

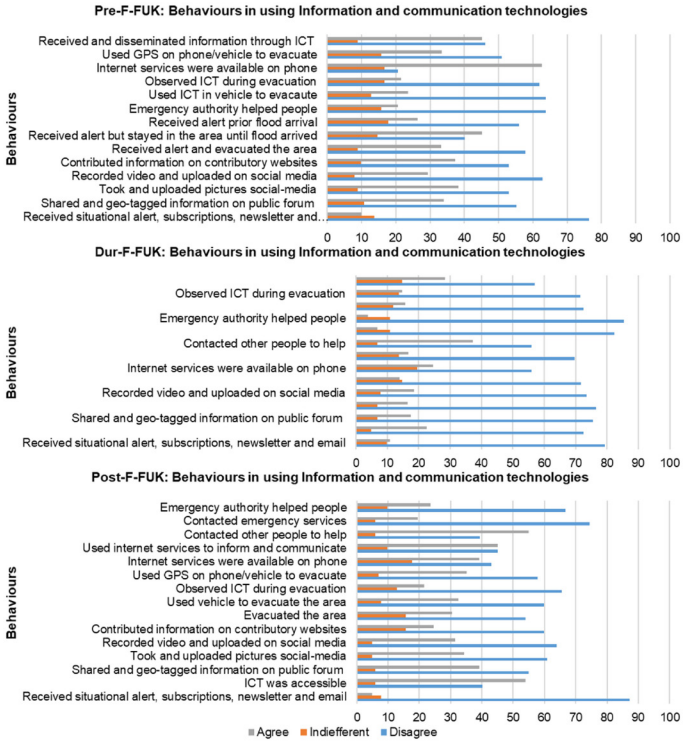


Figure 7: Behaviors in using ICTs before (top), during (middle) and after (bottom) the flood in the UK (FUK); bars show the percentage of respondents who agreed, were indifferent or disagreed.

DISCUSSION

Figures 5–7 show that ICT-related behaviors differ by disaster, country and phase. In EQP (Figure 5), disagreement dominated before the event about 58% for recording and uploading videos and about 50% for receiving alerts, consistent with an unpredictable hazard that gives no warning window. During the event, agreement rose for informal, person-to-person behaviors, such as contacting others for help and cell-phone internet availability 44%, whereas contributory websites and alerts still drew about 50% disagreement. Afterwards, the emergency authority helping people 54% and ICT availability 52% received the highest agreement in EQP.

In FP, Figure 6, indifference rather than disagreement stood out, about 50% were neutral on receiving alerts, geo-tagged sharing and evacuating after an alert, and agreement seldom exceeded about 37% in any phase. Although floods are predictable, this suggests uncertainty about, or unfamiliarity with, ICT-based flood information, leaving the warning window under-used. FUK respondents Figure 7 were far more polarized, disagreement was 60–76% before the flood, about 85% for emergency-authority help during it and about 87% for receiving alerts afterwards, while agreement concentrated on ICT availability 54–63% and contacting other people 37–55%. Table 1 adds that FUK respondents contacted authorities more often (31.7% vs 5.6% in FP and 4.2% in EQP) and preferred government authorities (94.3%), which reflects higher expectations of formal services, whereas FP respondents favoured emergency authorities (61.2%) and police (47.4%) over government (25.3%).

CONCLUSION

This study examined how communities in predictable (flood) and unpredictable (earthquake) disasters, in developing and developed contexts, use ICTs and institutions during search, rescue, emergency and evacuation operations, and where uncertainties between rescuers and survivors arise. In all three cases, informal person-to-person contact, and basic ICT availability were the most agreed-upon behaviors, while formal alerts, subscriptions and social-media sharing remained weak in every phase. The rescuer–survivor gap is therefore an information-flow gap rather than an access gap which means indifference and uncertainty in FP, post-event reliance on emergency authorities in EQP, and strong criticism of alerts and authority help in FUK despite high technology access. Bridging it requires trusted pre-event warning channels, two-way authority-community communication during evacuation, and integration of informal community networks into transport-disaster planning and futuristic smart cities.

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