

Unveiling hidden risks in healthcare from flood-induced transportation disruption: Supplement

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The following sections provide supplementary material to the manuscript *Unveiling hidden risks in healthcare from flood-induced transportation disruption*.

S1 Anecdote: Hospital evacuations during 2021 floods in Germany

In mid-July 2021, a persistent low-pressure system caused severe rainfall and widespread flooding across Belgium, Germany, and the Netherlands, particularly in Western Germany, where rivers overflowed, severely damaging infrastructure, including healthcare systems, and disrupting emergency and public health services [Koks et al., 2021, Schäfer et al., 2021, Faust, 2021]. Healthcare facilities were faced with power cuts, structural damage and significant disruption to medical services, resulting in the need to evacuate patients [Voss et al., 2022]. Table S1 summarizes the

evacuations of healthcare facilities during the event, including the number of patients moved, and the circumstances surrounding these events.

Table S1: Evacuation of healthcare facilities during the 2021 flood events

Date	Hospital	Patients Evacuated	Notes
14.07.2021	Klinikum Leverkusen	468	Patients relocated to various regional healthcare facilities. [kli, 2021]
14.07.2021	Krankenhaus Maria Hilf- Bad-Neuenahr	140	Partial operations continued; evacuation extended to Baden-Württemberg. [Wörz, 2021, mar, 2021]
14.07.2021	Dreifaltigkeitskrankenhaus Wesseling	7 ICU	Intensive care unit (ICU) patients moved due to lack of emergency power. [dre, 2021]
15.07.2021	Eschweiler St.-Antonius Hospital	298 (17 ICU)	Complete evacuation of the hospital at 3:35 AM. [Voss et al., 2022, Wagenbach, 2021]
15.07.2021	Klinikum Mutterhaus Ehrang	100	Patients transferred to other facilities within Trier. [Thome, 2021]
15.07.2021	Marienhospital Erftstadt	Unknown	All patients on lower floors transferred to upper floors or other healthcare facilities. [Jürgensonn, 2021]

S2 Methods: Flood hazard scenarios

To reduce computational load, the original 20,000 Regional Flood Model (RFM) event set needed to be trimmed while maintaining the diverse character and mechanisms of floods. The simplest approach would have been to select those flood events with the most flooded pixels from each of the five RFM basins. However, this approach only yields generally large, regional, main-stem freshet floods; omitting other sub-regional flood mechanisms represented by RFM that could pose substantial threat to infrastructure. Therefore, to maintain “extremeness” at a more local level, we sub-sample the original event set using NUTS 3 (Nomenclature of Territorial Units for Statistics) regions. NUTS is a hierarchical system used to divide the economic territory of the EU into regions of comparable size, with NUTS 3 being the smallest level, typically representing districts or counties. The event selection routine employs the following steps:

1. Raw RFM events are pre-processed, removing any empty or corrupt events.
2. For each event’s maximum WSH grid, we compute raw metrics (e.g., maximum, mode, wet pixel count, min) and similar HAND (height above nearest neighbor) normalized metrics.
3. Using the computed metrics, iterative logistic regressions are used to identify clearly erroneous events (13 for Danube and 47 for Rhine). These, along with those events with 100 or fewer wet pixels are discarded (i.e., pre-filtered).
4. Each pre-filtered event is sub-sampled to compute wet pixel count per NUTS 3 region.
5. For each NUTS 3 region, the events with the five largest wet pixel counts are selected. The union of this set is then clipped to the respective analysis basin.

This routine yields the events summarized in Table S2. Resulting events are provided in Bryant [2024a].

Table S2: Flood hazard event count summary and analysis basin metadata. See text for details and Figure S1 for analysis basins. Population, area and number of facilities relate to the buffered analysis basins (i.e., Fig. S1 basins plus a 75 km buffer) and therefore the totals are omitted as these would include some double-counting.

RFM basin	RFM event count	analysis basin	event count	population	area [km ²]	facility count
Danube Elbe	2834	Danube	37	34,980,495	172,177	780
	11,162	Lower Elbe	47	29,980,615	193,345	605
		Upper Elbe	38	18,837,118	123,029	464
Ems Rhine	60	Ems	5	19,439,900	77,223	389
	5,936	Lower Rhine	36	53,497,066	156,049	1107
		Upper Rhine	12	41,817,758	163,311	914
Weser	754	Weser	18	34,869,299	159,351	701
TOTAL	20,746		193			

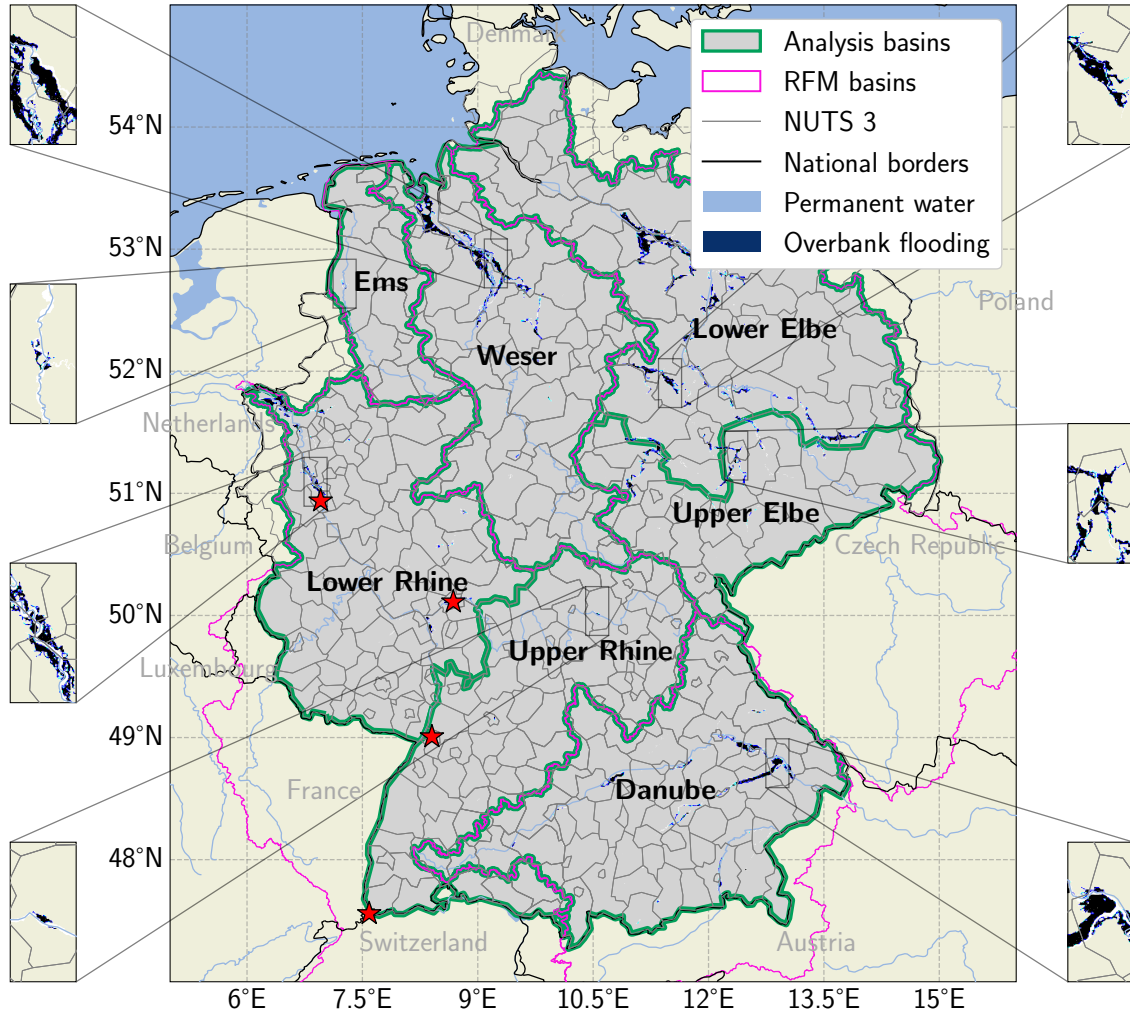


Figure S1: Overview and discretization map of Germany-wide study area showing national borders (black) and NUTS-3 (Nomenclature of Territorial Units for Statistics) regions (light grey). Also shown are the original RFM river basins (magenta) and the subdivided analysis basins used in this study (green). Maximum flood extent across all events is shown in dark blue and permanent water bodies are shown in light blue. Further shown are the locations of Cologne, Frankfurt, Karlsruhe and Basel (red stars, from top to bottom)

S3 Methods: Flood hazard data enhancement

To estimate flood-driven disruptions of the road network in the analysis, the maximum simulated flood depth above the pavement surface (pavement flood depth) for each road segment is used. This pavement flood depth is estimated by sampling those WSH grid cells intersecting the road center line. In RFM, WSH grids are computed by taking the difference between the simulated water surface elevation and the DEM (both at 100 m resolution) like most 2D grid-based models. Therefore, routines for estimating the pavement flood depth are sensitive to the DEM resolution relative to the road width. In other words, coarse DEMs (and their derivative WSH grids) provide poor representations of linear topographic features like road embankments, especially when the grid resolution is greater than the width of the linear feature (e.g., 20 m wide roads are poorly represented in 100 m DEMs).

To evaluate the sensitivity of our network disruption routine to DEM resolution, a pair of hazard events differing only in DEM resolution (RFM native 100 m and an enhanced 5 m) are applied as forcing data to a region along the Ems river (Fig. S2). This comparison shows that the native 100 m hazard resolution yielded 39 disrupted road segments while the enhanced 100 m yielded 46. Visual inspection with street-level imagery of the roadways calculated as disrupted shows the enhanced 5 m-resolution-forced network disruption routine better represents sub-100 m flood paths. This matches our intuition as roadway widths in this region are typically less than 20 m and therefore poorly represented by the 100 m resolution DEM.

Considering this issue, we enhance the native 100 m RFM WSH results to 5 m for each analysis event using a modified version of the *CostGrow* algorithm from [Bryant et al., 2024] and the *Digitales Geländemodell Gitterweite 5 m* (DGM5) DEM dataset [BKG, 2021]. The modified *CostGrow* algorithm employs four phases: 1) grid resampling; 2) least-cost mapping with distance-based decay; 3) filtering high-and-dry sub-grid cells; and 4) an isolated-cell filter. The algorithm is implemented in Python as part of the open-source FloodDownscaler2 project [Bryant, 2024b]. Resulting downscaled flood grids are provided in Bryant [2024c].

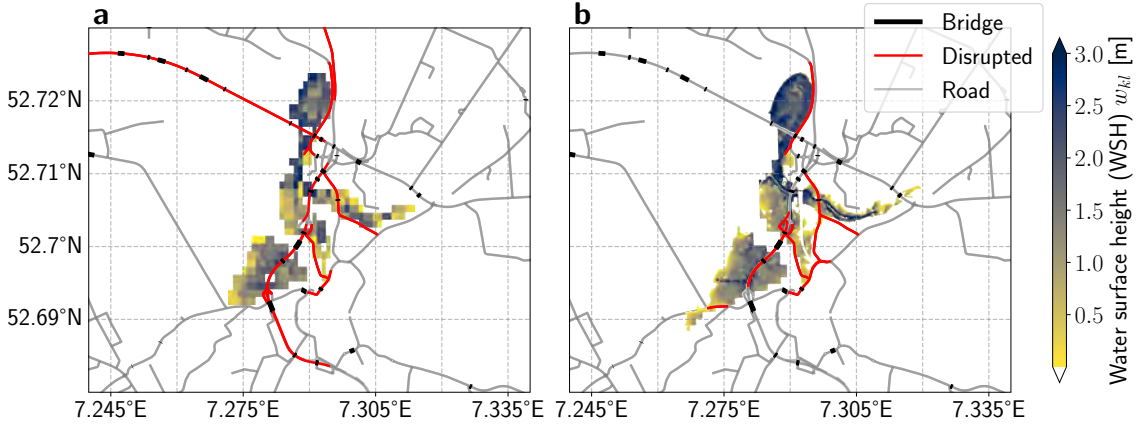


Figure S2: Example network disruption routine results for a sub-region within the Ems analysis basin showing (a) RFM native 100 m and (b) resolution enhanced 5 m hazard forcings.

S4 Methods: Identification of flooded bridges

This simple intersection of road segments with WSH values carries the implicit assumption that the elevation basis of both the road and the WSH simulation (RFM in this case) are equivalent (i.e., WSH in grid cells intersecting road segments is measured from the road surface). We feel this assumption is reasonable in a Germany-wide analysis for all but two cases: 1) roads that are narrow relative to the DEM resolution, which we address in section S3; and 2) roads that are raised above overland flowpaths (and therefore not considered in RFM's hydro-corrected DEM) like bridges and over-passes. To avoid falsely classifying the later as disrupted, we selectively remove pixels that coincide with the spatial location of a bridge from the WSH data. The locations of the bridges are taken from OSM and are shown for an example region in Fig. S3. As a result, a bridge edge in the graph is only considered compromised if the bridge's access points (which are taken as the end points of the polylines obtained from OSM) are submerged.

To demonstrate this, Fig. S3 shows the network disruption routine for a small example region. Panel **b** shows the WSH grid modification which prevents the segment disruption routine from incorrectly identifying this bridge as flooded.

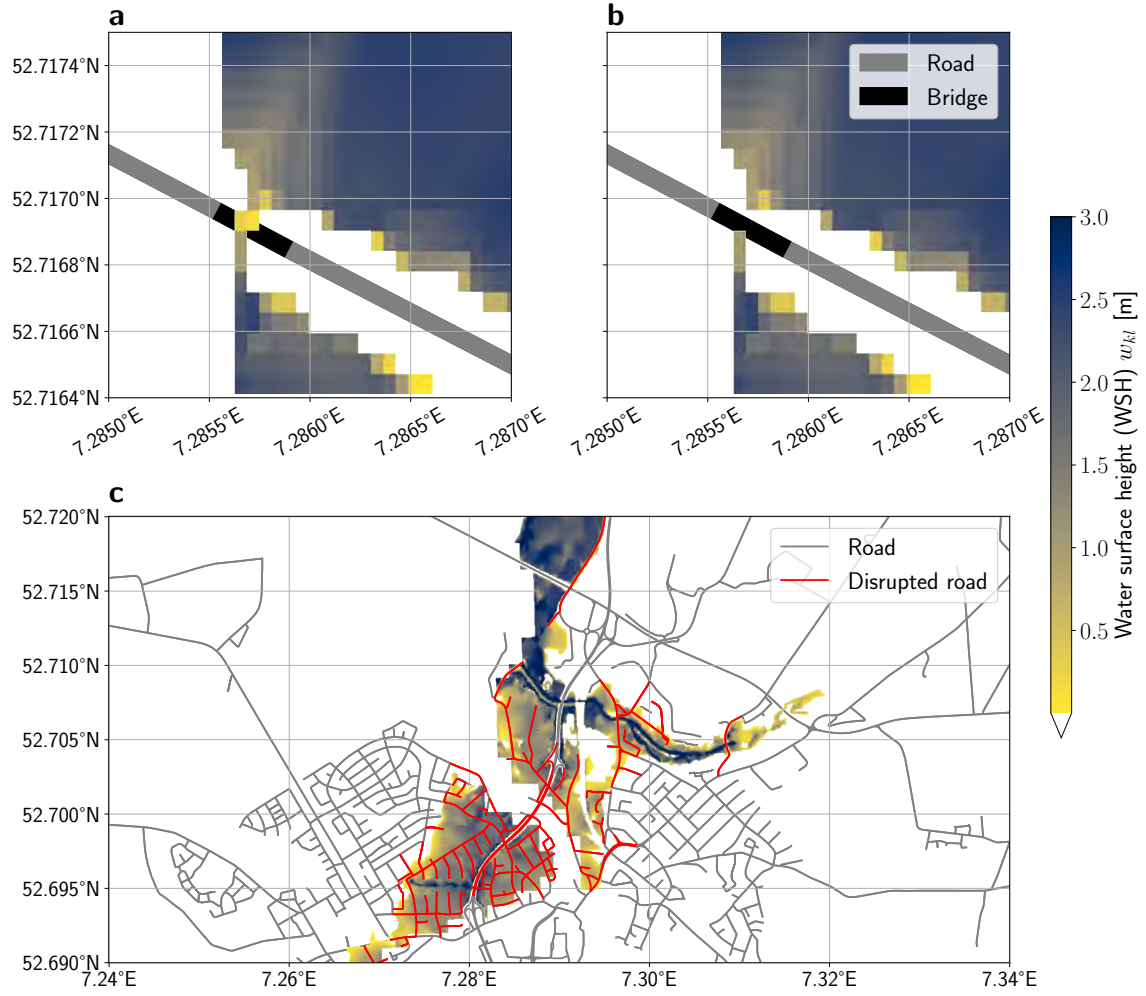


Figure S3: Road network disruption routine in an example region. (a) shows the raw WSH grid u_{kl} . (b) shows the modified WSH grid where pixels intersecting bridge segments have been removed. (c) shows the post-flood disruptions where the flooded edges E_f (red) are excluded from the graph to form the post-flood road network ($G_r(V, E \setminus E_f)$).

S5 Results: Traffic sensitivity analysis

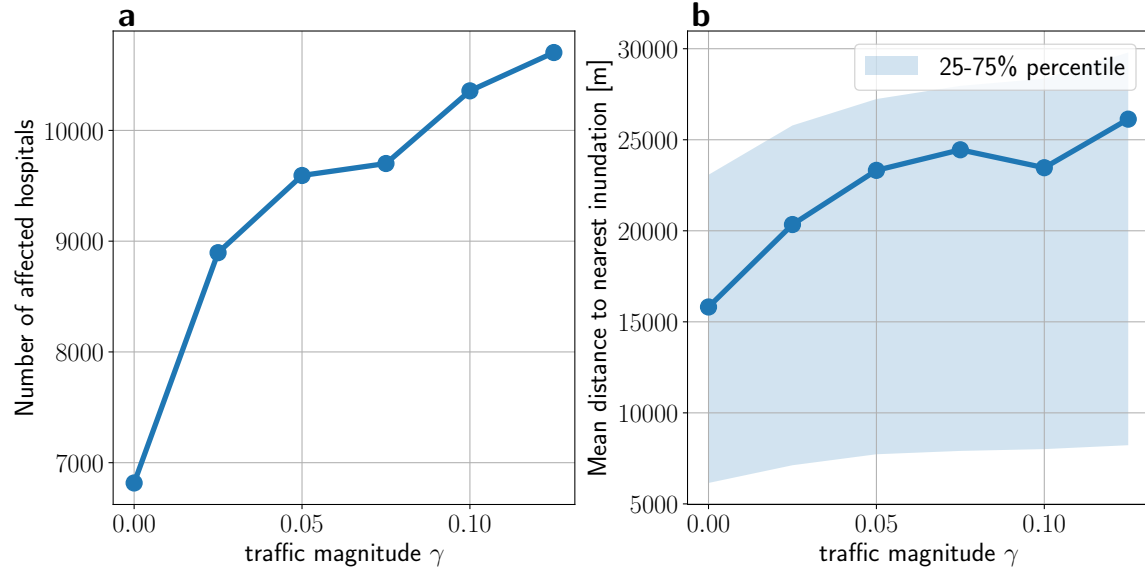


Figure S4: (a) Number of affected healthcare facilities ($\Delta N(k_h) > 0.01$) and (b) mean euclidean distance of affected facilities to nearest point of inundation against traffic magnitude γ .

Figure S5 shows how increasing traffic severity γ affects healthcare facility accessibility during a flood. Panel (a) shows that the number of healthcare facilities affected ($\Delta N(k_h) > 0.01$) increases with increasing traffic. Panel (b) shows that as traffic increases, so does the mean Euclidean distance from affected healthcare facilities to the nearest inundation point, suggesting that incorporating traffic into the analysis of emergency response after destructive events is particularly relevant for understanding healthcare facilities at hidden risk.

S6 Results: Interactive maps

321 interactive maps are available for download at Wassmer [2024] to explore the impact of flood events on specific regions and at-risk healthcare facilities. This collection includes 321 maps, each highlighting a healthcare facility where the service population change exceeds 0.3. Figure S5 provides an example screen shot of a single interactive map.

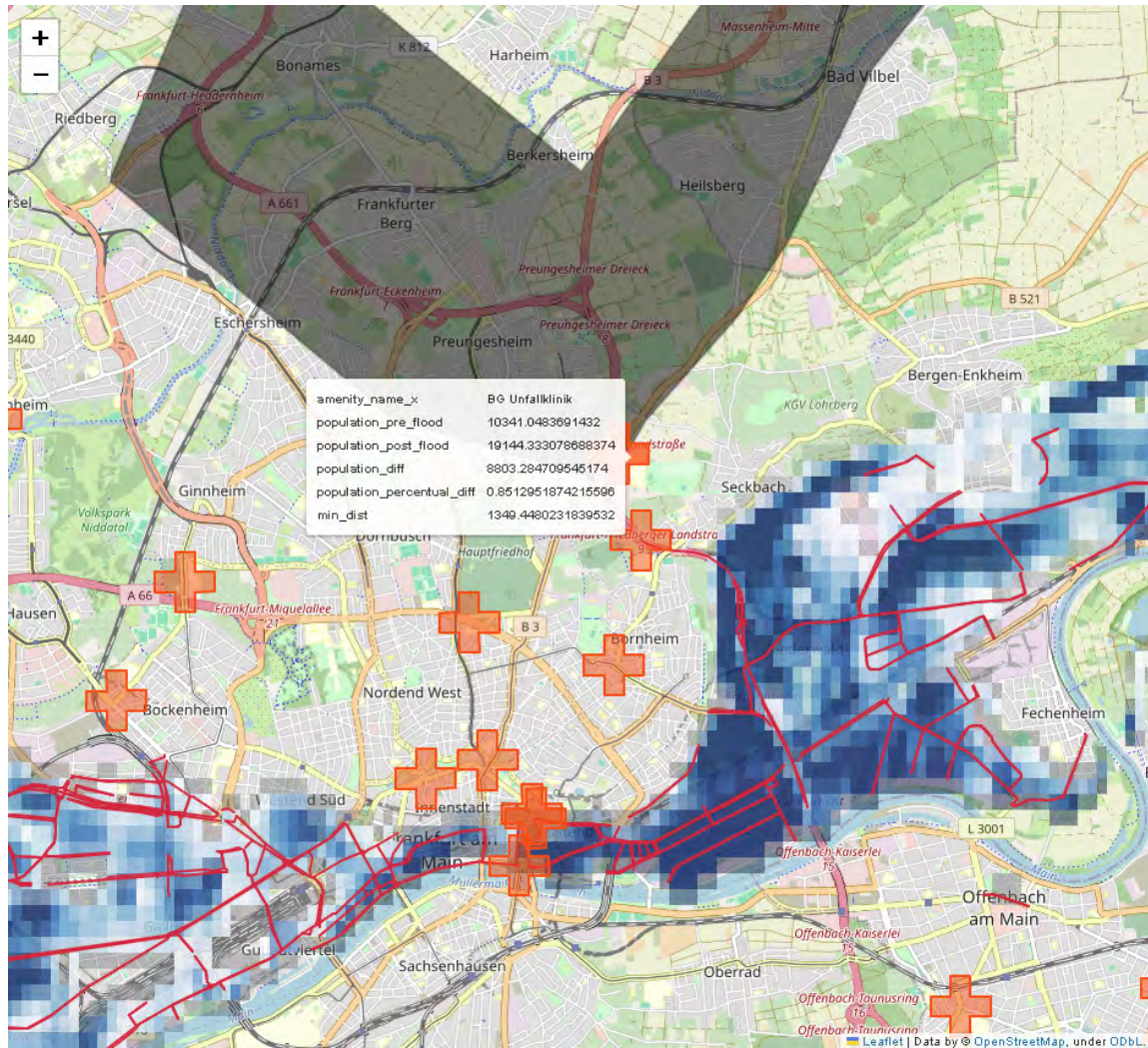


Figure S5: Screenshot of one interactive map obtained from [XXX](#).

S7 Results: Affected healthcare facilities per-basin

$\Delta N(k_h)$	Lower Rhine	Danube	Weser	Upper Elbe	Lower Elbe	Ems	Upper Rhine	TOTAL
0.1	150	68	49	33	23	4	5	332
0.3	38	20	11	6	0	0	0	75
0.5	13	9	6	3	0	0	0	31
1.0	3	1	1	0	0	0	0	5

Table S3: Number of unique affected healthcare facilities for different $\Delta N(k_H)$ thresholds for each analysis basin.

Analysis Basin	#affected Healthcare facilities ($\Delta N(k_H) \geq 0.3$)	#unique affected Healthcare facilities	#Events	$\overline{\Delta N(k_H)}$	$\overline{\text{dist}_E(k_h, u_{kl})}$
Lower Rhine	118	38	30	0.5	5844.34
Danube	119	20	27	0.44	12410.15
Weser	38	11	16	0.52	8282.15
Upper Elbe	46	6	31	0.41	3442.01
Lower Elbe	0	0	0	-	-
Ems	0	0	0	-	-
Upper Rhine	0	0	0	-	-

Table S4: Healthcare facilities that are affected with at least 30% increase of service population grouped by analysis basin.

S8 Results: Disruption frequency

To assess healthcare facilities vulnerable to multiple events, we identify those where the change in service population, $\Delta N(k_H)$, exceeds a specified threshold used to indicate the facility’s relative level of risk. We then calculate how frequently each healthcare facility surpasses this threshold as shown in Figure S6.

In Table S5 we present a list of healthcare facilities that have experienced an increase in service population of at least 50%, indicated by $\Delta N(k_H) \geq 0.5$. Additionally, the table provides information about the mean distance to the nearest inundation, the mean increase in service population, and the healthcare facility’s service area and event occurrences.

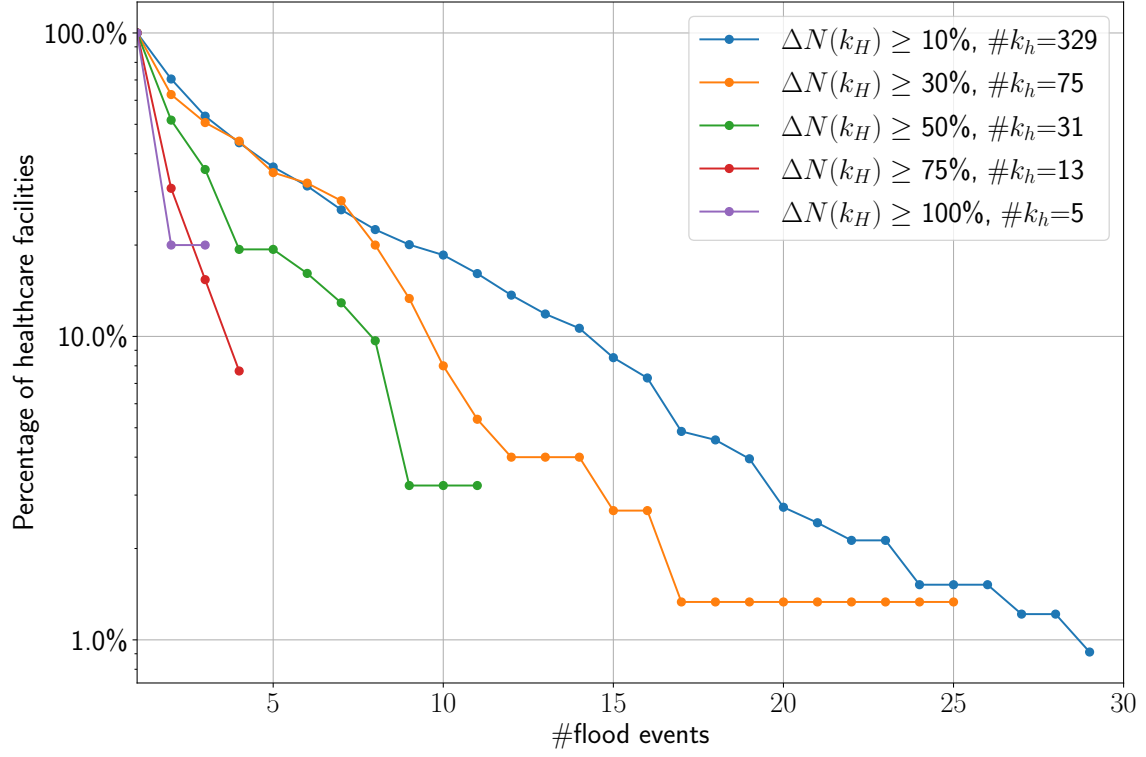


Figure S6: Portion of disrupted facilities experiencing multiple flood-induced disruptions for five $\Delta N(k_H)$ thresholds. Total counts of facilities with at least one disrupting event meeting or exceeding the $\Delta N(k_H)$ are shown in the legend as $\#k_H$. See text for details.

name	count	$\overline{d_E(u_{kl}, k_H)}$	$\overline{\Delta N(k_H)}$	event	analysis basin
Ev. Krankenhaus Bethanien	11	10347.06	0.51	8662, 3955, 11195 11439, 8334, 10237 12853, 9336, 4130 12626, 11016 9774, 9336, 10237	Lower Rhine
BG Klinikum Duisburg	8	3967.4	0.68	9992, 8662, 3913 12853, 11439 3610, 1804, 3716	Lower Rhine
Krankenhaus der Barmherzigen Brüder	8	1387.01	0.79	4409, 4650, 2916 4641, 4994 448, 484, 478	Danube
Kinderkrankenhaus Amsterdamer Straße	7	1472.98	0.98	3325, 2982, 3336 81	Lower Rhine
Johanniter-Krankenhaus Gronau	6	396.25	0.57	1103, 20, 203 686, 1060, 389	Weser
MVZ Kölleda	5	7801.45	0.58	300109, 30071, 460033 270059, 20175	Upper Elbe
Kinderkrankenhaus auf der Bult	3	473.23	1	389, 65, 20	Weser
Kreisklinik Mallersdorf	3	16431.34	0.55	3610, 4641, 1938	Danube
Krankenhaus	3	10611.3	0.75	3610, 4053, 5333	Danube
Klinikum Luitpold	3	11273.85	0.65	4053, 5333, 3610	Danube
Asklepios Zentrum für Rehabilitation	3	460.79	0.56	4994, 1938, 4641	Danube
Agaplesion Evangelisches Krankenhaus Mittelhessen	2	34.85	0.74	484, 482	Lower Rhine
St. Marien-Hospital	2	4818.97	0.55	1581, 1578	Lower Rhine
Marien-Hospital	2	2983.11	0.84	448, 482	Lower Rhine
TU München Universitätslinik für Dermatologie	2	14502.16	0.59	1938, 1571	Danube
Gesundheitscampus	2	450.44	0.53	5333, 4053	Danube

Table S5: Healthcare facilities that are affected by multiple floods, with an increase of service population greater 50%, $\Delta N(k_H) \geq 50\%$.

S9 Results: Facilities at hidden risk

Name	Analysis Basin	Count	$\overline{\text{dist}_e(k_H, u_{kl})}$	$\overline{\Delta N(k_H)}$
Klinikum Hann. Münden	Weser	16	11350.6	0.41
Klinikum Luitpold	Danube	12	16069.03	0.46
Ev. Krankenhaus Bethanien	Lower Rhine	11	10347.06	0.51
TU München Universitätsklinik für Dermatologie	Danube	10	14734.84	0.44
Schön Klinik München Schwabing	Danube	8	14128.16	0.33
Krankenhaus St. Barbara	Danube	7	22149.41	0.34
Bezirkskrankenhaus II	Danube	7	26847.49	0.37
Kreisklinik Mallersdorf	Danube	7	16429.04	0.48
Schlossklinik Rottenburg	Danube	6	19607.65	0.42
Klinik für Psychiatrie & Psychotherapie	Lower Rhine	5	21019.46	0.4
Krankenhaus	Danube	5	10690.29	0.59
Vital Klinik Alzenau	Lower Rhine	4	10613.83	0.3
Vinzenz-Pallotti-Hospital	Lower Rhine	3	10150.9	0.35
Krankenhaus Grimma	Upper Elbe	3	22182.68	0.37
Krankenhaus Burglengenfeld	Danube	3	19000.23	0.31
Gesundheitscampus	Danube	3	24502.48	0.4
Deister-Süntel-Klinik	Weser	3	18384.96	0.6
Fachkrankenhaus für Innere Medizin	Weser	2	10481.98	0.7
Krankenhaus Lindenbrunn	Danube	2	30990.38	0.45
Kreiskrankenhaus Cham	Danube	2	15697.67	0.35
Josephinum	Weser	2	18447.26	0.61
Deister Süntel Klinik Bad Münder	Lower Rhine	2	11616.23	0.32
Asklepios Klinik Lich	Lower Rhine	1	17922.49	0.42
Krankenhaus Rockenhausen	Danube	1	32058.76	0.32
Bayerwald-Klinik	Danube	1	16639.9	0.33
Medical Park Klinik Chiemseeblick	Danube	1	31281.4	0.31
Medizinisches Behandlungszentrum Cham	Danube	1		

Table S6: Healthcare facilities situated at a distance of 10km or more from the nearest point of inundation and exhibiting an increase of at least 30% in their service population are classified as being at high risk.

S10 Results: Highlighted vulnerabilities

In panel (a), we highlight the most substantial increase, which occurs at ‘Sankt Katharinen’ healthcare facility in Frankfurt, lower Rhine, located less than a kilometer from the river Main. Initially, ‘Sankt Katharinen’ has a small service population (barely visible on Figure 5a); however, due to the flood, the healthcare facility experiences a 6-fold increase in service population. This significant increase can be attributed to two main factors. First, two healthcare facilities to the south and east of ‘Sankt Katharinen’ are incapacitated by the flooding, with Sankt Katharinen being one of those not to be incapacitated. As a result, a lot of patients from these other healthcare facilities are diverted to Sankt Katharinen. Second, the bridges are inundated along the river Main. This disruption effectively isolates the regions south of the river from those to the north, funneling more patients towards Sankt Katharinen hospital. Thus, it not only faces an increased demand from its immediate vicinity but also becomes a critical care point for a broader area disconnected by the flood. Additionally, Frankfurt’s high population density exacerbates the situation, as more individuals within a confined area require emergency services, significantly increasing the demand on the remaining operational healthcare facilities like Sankt Katharinen.

Panel (b) shows the ‘Krankenhaus der Barmherzigen Brüder’ in Regensburg. There is one healthcare facility in the south which is in the direct flood zone and thus disconnected from the network. We further observe that many other healthcare facilities closer to the flooded area experience a decrease in service population, which is redirected to the Krankenhaus der Barmherzigen Brüder’. This healthcare facilities experiences an increase in its service population by more than 50% in eight different events.

Panel (c) illustrates the ‘Kinderkrankenhaus auf der Bult’ in Hannover. In this event, two healthcare facilities very close to the flood zone, resulting in a significant loss of their service population, which must be accommodated by nearby healthcare facilities.

Panel (d) highlights the ‘Kinderkrankenhaus Amsterdamer Straße’, located just a few hundred meters from the river Rhine, where the inundation approaches within 100 meters of the facility. Similar to the event in Frankfurt shown in panel (a), the flood bisects the city’s transportation network, disconnecting several nearby healthcare facilities and requiring their patients to be accommodated elsewhere. This healthcare facility experiences an increase in its service population of more than 50% in seven different events.

Similar effects occur in panel (e), which shows the ‘Marienhospital’ in Düsseldorf, but here three other close by healthcare facilities are disconnected from the network.

Panel (f) depicts the Lindenbrunn Hospital in Coppenbrügge, Lower Saxony. This facility is the first healthcare facility that is not located in a larger city and therefore has a larger area to serve. The nearby healthcare facilities in Gronau are flooded, resulting in an even larger area and a doubling of the service population. This example is particularly interesting because the healthcare facility is 10km away from the flood zone but is still severely affected.

The ‘Deister-Sünter-Klinik’ in Bad Münder, Lower Saxony, also exhibits analogous effects, as illustrated in panel (g). Moreover, the healthcare facility has two locations, one of which is situated slightly further north and displays a comparable pattern. Both facilities are situated approximately 17 km from the flood zone, thus being classified as hidden risk.

In panels (h) and (i), we present the neighboring healthcare facilities ‘Hospital zum heiligen Geist’ and ‘Klinik Rotes Kreuz’. Both of these healthcare facilities are similar to ‘Sankt Katharinen’, depicted in panel (a) located in the city of Frankfurt. Furthermore, all three facilities are affected by the same event, numbered 482, which serves to illustrate the devastating impact of this incident. The fact that three facilities in close proximity are similarly affected by the same event demonstrates the severity and widespread nature of the event, and highlights the significant strain placed on local healthcare infrastructure during such crises.

To avoid redundancy and highlight the diversity of risk, we showed only one event per healthcare facility, but if ranked by severity, some healthcare facilities, like “Ev. Krankenhaus Bethanien”, which is implicated in eleven events where its service population increases by over 50%, would appear multiple times, suggesting this facility is particularly vulnerable (see Section S8).

References

- Elco Koks, Kees Van Ginkel, Margreet Van Marle, and Anne Lemnitzer. Brief communication: Critical infrastructure impacts of the 2021 mid-july western european flood event. *Natural Hazards and Earth System Sciences Discussions*, 2021:1–11, 2021.
- Andreas Schäfer, Bernhard Mühr, James Daniell, Uwe Ehret, Florian Ehmele, Katharina Küpfer, Johannes Brand, Christina Wisotzky, Jens Skapski, Lukas Rentz, et al. Hochwasser mitteleuropa, juli 2021 (deutschland). *CEDIM Forensic Disaster Analysis Group Bericht*, na(1), 2021.
- Eberhard Faust. Überschwemmungskatastrophe mitteleuropa juli 2021. *Bamberg/München: Transformateure. Hg. v. Transformateure*, 2021.
- Martin Voss, Anja Rüger, Nicolas Bock, Cordula Dittmer, and Sara T Merkes. Die evakuierung des st.-antonius-hospitals eschweiler während der flutereignisse im juli 2021. *na*, 2022.
- Flutkatastrophe 2021: Eine ganz schwarze nacht im klinikum leverkusen. Online, 2021. URL <https://www.marburger-bund.de/nrw-rlp/meldungen/flutkatastrophe-2021-eine-ganz-schwarze-nacht-im-klinikum-leverkusen>. Accessed: 22.3.24, 11:34.
- Simon Würz. Evakuierte klinik bad neuenahr hochwasser. Online, 2021. URL <https://www.zeit.de/gesellschaft/2021-07/evakuierte-klinik-bad-neuenahr-hochwasser-azt-nabard-faiz-wasserversorgung>. Accessed: 22.3.24, 11:27.
- Klinikbetrieb nach hochwasser wiederhergestellt. Online, 2021. URL https://www.marienhaus-klinikum-ahr.de/startseite/einzelmeldung?tx_ttnews%5Btt_news%5D=9763&cHash=8e3024c599697fc9dc507bec816fd472. Accessed: 22.3.24, 11:27.
- Krankenhaus wesseling kann derzeit keine patienten aufnehmen. Online, 2021. URL <https://lokalklick.eu/2021/07/14/krankenhaus-wesseling-kann-derzeit-keine-patienten-aufnehmen/>. Accessed: 25.3.24, 10:00.
- Elmar Wagenbach. Um 3:35 uhr haben wir das krankenhaus aufgegeben. Online, 2021. URL <https://www.bibliomedmanager.de/news/um-335-uhr-haben-wir-das-krankenhaus-aufgegeben>. Accessed: 22.3.24, 11:20.
- Christian Thome. Hochwasser trier ehrang vor evakuierung, auch krankenhaus betroffen. Online, 2021. URL https://www.volksfreund.de/region/trier-trierer-land/hochwasser-trier-ehrang-vor-evakuierung-auch-krankenhaus-betroffen_aid-61363123. Accessed: 22.3.24, 13:15.
- Ulla Jürgensonn. Hochwasser in erftstadt: Marienhospital kündigt wiedereröffnung an. Online, 2021. URL <https://www.rundschau-online.de/region/rhein-erft/erftstadt/hochwasser-in-erftstadt-marienhospital-kuendigt-wiedereroeffnung-an-234715>. Accessed: 22.3.24, 16:05.
- Seth Bryant. RFM2019: Flood events spatially representative selection. <https://doi.org/10.5281/zenodo.13963065>, October 2024a.

- Seth Bryant, Guy Schumann, Heiko Apel, Heidi Kreibich, and Bruno Merz. Technical Note: Resolution enhancement of flood inundation grids. *Hydrology and Earth System Sciences*, 28(3): 575–588, February 2024. ISSN 1027-5606. doi: 10.5194/hess-28-575-2024.
- BKG. Digitales Geländemodell Gitterweite 5 m, 2021. [dataset] <https://gdz.bkg.bund.de/index.php/default/digitales-gelandemodell-gitterweite-5-m-dgm5.html>.
- Seth Bryant. Cefect/FloodDownscaler2: V2024-06-29_main. Zenodo, October 2024b. <https://doi.org/10.5281/zenodo.13963800>.
- Seth Bryant. RFM2019: Flood grids downscaled. <https://doi.org/10.5281/zenodo.13963132>, October 2024c.
- Jonas Wassmer. Interactive maps: Unveiling hidden risks in healthcare from flood-induced transportation disruption, 2024. URL <https://doi.org/10.5281/zenodo.14002296>. Accessed: 2024-10-28.