

Beyond biological threats: A global ecological study of International Health Regulations (2005) core capacities and multi-hazard disaster outcomes, 2015–2023

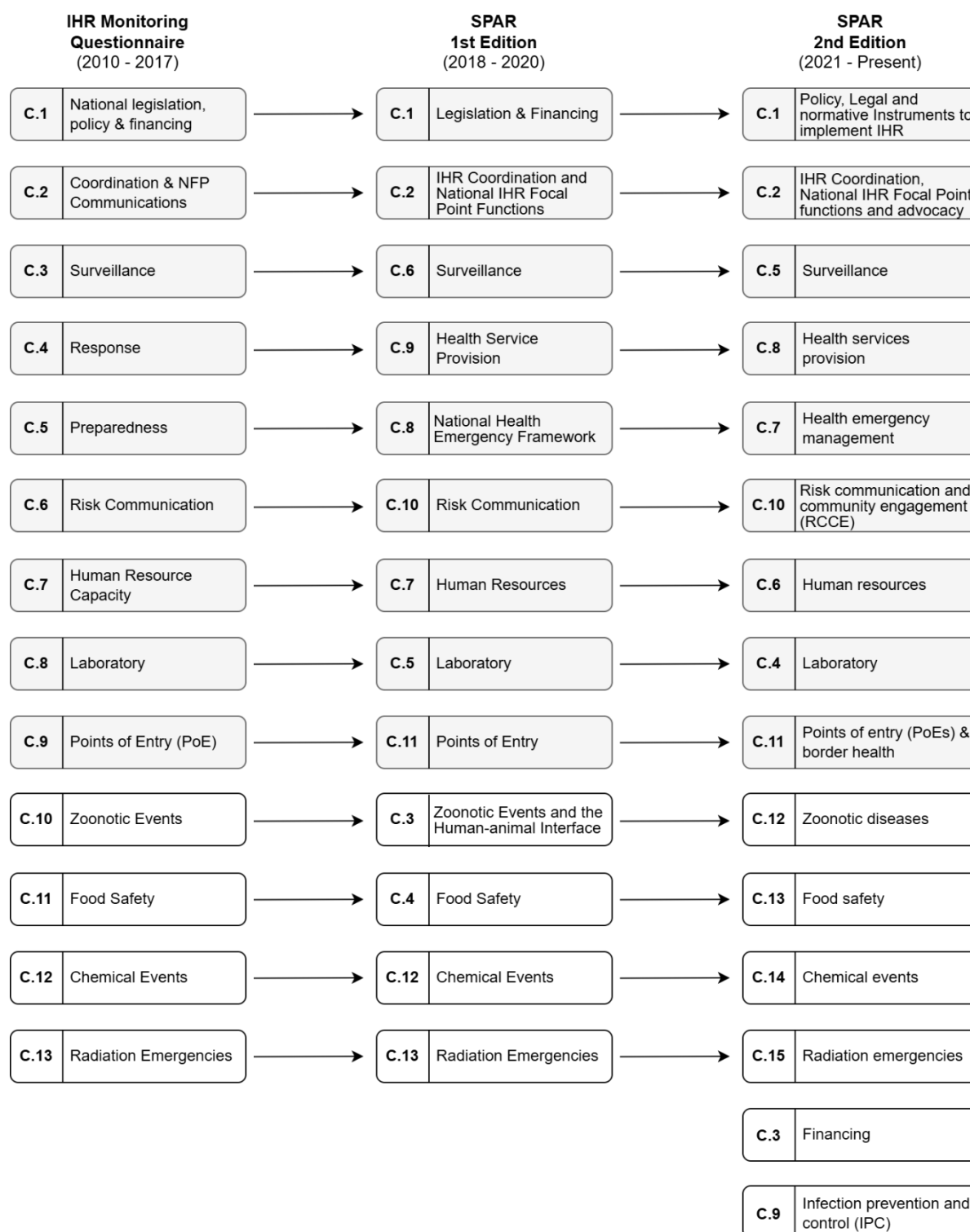
Thein Than Htay¹, Feng-Jen Tsai^{1*}

¹PhD Program in Global Health and Health Security, College of Public Health, Taipei Medical University, Taipei, Taiwan

No. 301, Yuantong Road, Zhonghe District, New Taipei City 235, Taiwan (R.O.C)

dr.theinthantay@gmail.com, jeanfjtsai@tmu.edu.tw

*Corresponding author: jeanfjtsai@tmu.edu.tw



Supplementary Figure S1. *Conceptual crosswalk across IHR (2005) Monitoring tools*

Note: Arrows indicate the mapping of each capacity across three successive WHO IHR monitoring instruments. Shaded boxes denote the nine cross-cutting capacities retained for analysis. C.3 Financing and C.9 Infection prevention and control were introduced as standalone capacities only in the SPAR 2nd edition (2021), and the four event-specific capacities (C.12–C.15) were excluded.

Supplementary Table S1. *Spearman rank correlations among IHR core capacity scores, disaster-attributed mortality and morbidity rates, and socioeconomic controls, 2015–2023*

Variable	Disaster mortality		Disaster morbidity	
IHR core capacity	SFM	EM-DAT	SFM	EM-DAT
Policy, legal and normative instruments to implement IHR	-0.090*	-0.082**	-0.075*	-0.031
IHR coordination, National IHR Focal Point functions and advocacy	-0.035	-0.040	-0.020	-0.001
Laboratory	-0.189***	-0.042	-0.148***	-0.023
Surveillance	-0.034	0.034	-0.083*	0.057
Human resources	-0.049	-0.020	-0.079*	0.040
Health emergency management	-0.149***	-0.062*	-0.134***	0.003
Health services provision	-0.184***	-0.069*	-0.100**	-0.036
Risk communication and community engagement	-0.096**	-0.076**	-0.099**	-0.012
Points of entry and border health	-0.134***	-0.105***	-0.093*	-0.061*
IHR average score	-0.133***	-0.067*	-0.109**	-0.010
Socioeconomic controls				
GDP per capita (constant 2015 USD)	-0.362***	-0.208***	-0.197***	-0.272***
Population density (people per sq. km of land area)	-0.090**	-0.091***	-0.141***	-0.070*
Urban population (% of total population)	-0.319***	-0.080**	-0.152***	-0.097***

Note. Values are Spearman's rank correlation coefficients (ρ). Disaster-attributed mortality and morbidity are expressed per 100,000 total population. Coefficients are calculated from pairwise complete observations among the 1,764 possible country-year observations, with N varying across cells from 741 to 1,540. Correlations pool observations across countries and years and are therefore not directly comparable with the within-country estimates in Tables 2 and 3. IHR refers to the International Health Regulations (2005), SFM to the Sendai Framework Monitor, EM-DAT to the Emergency Events Database, and GDP to gross domestic product.

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Supplementary Table S2. *Sensitivity analyses for the associations between the IHR average score and disaster-attributed mortality and morbidity*

	I		II		III		IV		V		VI		VII		VIII	
Variable	SFM disaster mortality		EM-DAT disaster mortality		SFM disaster morbidity		EM-DAT disaster morbidity									
Period	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023	2015–2023	2020–2023
Baseline specification																
β (SE)	-0.005 (0.021)	-0.050** (0.018)	-0.013 (0.023)	-0.052* (0.021)	-0.059* (0.029)	-0.047 (0.094)	-0.013 (0.032)	-0.039 (0.052)								
<i>N</i> (Countries)	708 (125)	273 (95)	1,180 (166)	553 (155)	611 (108)	241 (84)	769 (135)	338 (115)								
Zero outcomes (Panel used) %	20 (40)	16 (35)	27 (67)	19 (71)	19 (35)	19 (31)	26 (44)	15 (43)								
1. Two-way clustering of country and year																
β (SE)	-0.005 (0.023)	-0.050* (0.022)	-0.013 (0.025)	-0.052* (0.021)	-0.059 (0.039)	-0.047 (0.118)	-0.013 (0.028)	-0.039 (0.039)								
<i>N</i> (Countries)	708 (125)	273 (95)	1,180 (166)	553 (155)	611 (108)	241 (84)	769 (135)	338 (115)								
Zero outcomes (Panel used) %	20 (40)	16 (35)	27 (67)	19 (71)	19 (35)	19 (31)	26 (44)	15 (43)								
2. Exclusion of socioeconomic controls																
β (SE)	-0.001 (0.022)	-0.035* (0.016)	-0.012 (0.023)	-0.053** (0.018)	0.024 (0.023)	-0.185** (0.057)	-0.021 (0.033)	-0.040 (0.044)								
<i>N</i> (Countries)	709 (126)	273 (95)	1,210 (169)	566 (159)	612 (109)	241 (84)	781 (137)	340 (116)								
Zero outcomes (Panel used) %	20 (40)	16 (35)	28 (69)	19 (72)	19 (35)	19 (31)	26 (44)	15 (43)								
3. Exclusion of top 1% of outcome outliers																
β (SE)	-0.025** (0.008)	-0.038*** (0.010)	-0.003 (0.010)	-0.030 (0.018)	-0.025 (0.017)	-0.046 (0.044)	-0.034 (0.019)	0.038 (0.032)								
<i>N</i> (Countries)	698 (124)	269 (95)	1,167 (166)	546 (155)	603 (108)	234 (83)	759 (135)	333 (115)								
Zero outcomes (Panel used) %	20 (40)	17 (34)	28 (66)	19 (70)	20 (34)	18 (30)	26 (43)	15 (42)								
4. Intersection sample with complete data across all variables																
β (SE)	-0.008 (0.021)	-0.050** (0.018)	-0.016 (0.023)	-0.052* (0.021)	-0.061* (0.029)	-0.047 (0.094)	0.005 (0.033)	-0.039 (0.052)								
<i>N</i> (Countries)	685 (124)	273 (95)	1,127 (166)	553 (155)	586 (106)	241 (84)	729 (134)	338 (115)								
Zero outcomes (Panel used) %	20 (39)	16 (35)	26 (64)	19 (71)	19 (33)	19 (31)	25 (41)	15 (43)								

Note. β values are Poisson pseudo-maximum likelihood (PPML) log-rate coefficients. Standard errors clustered at the country level are reported in parentheses. Estimates discussed in the text are transformed into a 10-point increase as $RR_{10} = \exp(10\beta)$, with percentage differences calculated as $100 \times (RR_{10} - 1)$. All models include country and year fixed effects and use the natural logarithm of total population as an offset to estimate per capita rates. *N* indicates the number of country-year observations included in each model, with the number of countries shown in parentheses. The ‘Zero outcomes (panel used) %’ row reports the percentage of model observations with zero outcome values, followed by the percentage of the full 1,764-observation panel retained in the model. The baseline specification includes gross domestic product per capita, population density, and urban population. IHR refers to the International Health Regulations (2005), SFM to the Sendai Framework Monitor, and EM-DAT to the Emergency Events Database.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.