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Supplementary Materials for

Driving improvements in emerging disease surveillance through locally relevant capacity strengthening

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Table S1. Case study to show how actions to achieve control and elimination of rabies, contribute to capacity-strengthening for EID surveillance and achievement of sustainable development goals. The capacities listed in the second and third columns align to the IHR-PVS (*20*) and GHSA (*21*) frameworks respectively.
*IHR-PVS capacity on zoonoses (10.1) and GHSA Action Package on Zoonotic Diseases (Prevent 2) apply throughout.

Action on a locally relevant disease: Control and elimination of rabies	**Relevant capacities and competencies within IHR-PVS Monitoring Framework***	**Relevance to Global Health Security Action Packages***	**Interactions with Sustainable Development Goals and Targets**
Ensure notifiability of human and animal rabies	National legislation and policy, epidemiological surveillance	Detect 2,3: Real-time surveillance	SDG 3.d Early warning, risk reduction and management of national and global health risks
Training of human and animal health workers in integrated bite case management and outbreak investigation (required for all suspect exposures when aiming to verify freedom from rabies/ interruption of transmission)	Human resource capacity, including veterinary, para-professionals and other professionals; diagnostic and laboratory capacity; intersectoral coordination; emergency response; risk communication	Detect 1: National laboratory system; Detect 2,3: Real-time surveillance system, multi-sectoral surveillance data; Detect 5: Workforce development	SDG 3.c: Training, retention of health workforce; SDG 3.d Early warning, risk reduction and management of national and global health risks
Interventions: Emergency access to life-saving human vaccines; large-scale mass dog vaccination; washing of animal bite injuries to reduce rabies risk; dog population management	Management of resources and operations; consultation and stakeholder participation; disease prevention, control and eradication; management of resources and operations	Prevent-4: Immunization action package; Respond 1: Emergency operations (multi-sectoral response teams)	SDG 3.b: Access to affordable vaccines; SDG 3.8: Achieve universal health coverage, including access to safe, effective, quality and affordable vaccines for all; SDG 3.3: End epidemics of neglected tropical diseases (rabies); SDG 6.2: Achieve access to adequate and equitable sanitation; SDG 11.6: Urban waste management; SDG 15.5: Protect and prevent extinction of threatened species

Vaccine procurement, distribution and delivery	Coordination capability; management of resources and operations; operational funding; forecasting capacity	Prevent-4: Immunization action package	SDG 3.b: Provide access to affordable vaccines; 3.8: Achieve universal health coverage, including access to safe, effective, quality and affordable vaccines for all
Establishment of One Health/Zoonoses coordination units	Intersectoral coordination; disease prevention, control and eradication; emergency response; management of resources and operations	Respond 1: Emergency operations (multi-sectoral response teams)	SDG 3.c: Training, retention of health workforce; SDG 3.d Early warning, risk reduction and management of national and global health risks
Detection and diagnosis of human cases of acute encephalitis syndrome (required to validate freedom from human rabies)	Epidemiological (syndromic) surveillance; diagnostic capacity	Detect 2,3: Real-time surveillance (syndromic surveillance)	SDG 3.d Early warning, risk reduction and management of national and global health risks
Collection, management and analysis of surveillance data	Epidemiological surveillance; intersectoral coordination; diagnostic capacity	Detect 2,3: Real-time surveillance	SDG 3.d Early warning, risk reduction and management of national and global health risks

References

1. G. T. Keusch, M. Pappaioanou, M. C. Conzalez, K. A. Scott, P. Tsai, Eds., *Sustaining Global Surveillance and Response to Emerging Zoonotic Diseases*, (National Academies Press, Washington, DC, 2009).

2. D. G. Streicker, A. S. Turmelle, M. J. Vonhof, I. V. Kuzmin, G. F. McCracken, C. E. Rupprecht, Host phylogeny constrains cross-species emergence and establishment of rabies virus in bats. *Science* **329**, 676–679 (2010). doi:10.1126/science.1188836 Medline

3. J. O. Lloyd-Smith, D. George, K. M. Pepin, V. E. Pitzer, J. R. C. Pulliam, A. P. Dobson, P. J. Hudson, B. T. Grenfell, Epidemic dynamics at the human-animal interface. *Science* **326**, 1362–1367 (2009). doi:10.1126/science.1177345 Medline

4. M. E. J. Woolhouse, S. Gowtage-Sequeria, Host range and emerging and reemerging pathogens. *Emerg. Infect. Dis.* **11**, 1842–1847 (2005). doi:10.3201/eid1112.050997 Medline

5. K. E. Jones, N. G. Patel, M. A. Levy, A. Storeygard, D. Balk, J. L. Gittleman, P. Daszak, Global trends in emerging infectious diseases. *Nature* **451**, 990–993 (2008). doi:10.1038/nature06536 Medline

6. S. S. Morse, J. A. Mazet, M. Woolhouse, C. R. Parrish, D. Carroll, W. B. Karesh, C. Zambrana-Torrelio, W. I. Lipkin, P. Daszak, Prediction and prevention of the next pandemic zoonosis. *Lancet* **380**, 1956–1965 (2012). doi:10.1016/S0140-6736(12)61684-5 Medline

7. M. E. J. Woolhouse, D. T. Haydon, R. Antia, Emerging pathogens: The epidemiology and evolution of species jumps. *Trends Ecol. Evol.* **20**, 238–244 (2005). doi:10.1016/j.tree.2005.02.009 Medline

8. E. H. Chan, T. F. Brewer, L. C. Madoff, M. P. Pollack, A. L. Sonricker, M. Keller, C. C. Freifeld, M. Blench, A. Mawudeku, J. S. Brownstein, Global capacity for emerging infectious disease detection. *Proc. Natl. Acad. Sci. U.S.A.* **107**, 21701–21706 (2010). doi:10.1073/pnas.1006219107 Medline

9. S. A. Kluberg, S. R. Mekaru, D. J. McIver, L. C. Madoff, A. W. Crawley, M. S. Smolinski, J. S. Brownstein, Global capacity for emerging infectious disease detection, 1996-2014. *Emerg. Infect. Dis.* **22**, E1–E6 (2016). doi:10.3201/eid2210.151956 Medline

10. World Health Organization, International health regulations (2005) Third edition. http://apps.who.int/iris/bitstream/10665/246107/1/9789241580496-eng.pdf?ua=1 [accessed 11 April 2017].

11. F. M. Burkle Jr., Global health security demands a strong international health regulations treaty and leadership from a highly resourced world health organization. *Disaster Med. Public Health Prep.* **9**, 568–580 (2015). doi:10.1017/dmp.2015.26 Medline

12. T. L. Bogich, R. Chunara, D. Scales, E. Chan, L. C. Pinheiro, A. A. Chmura, D. Carroll, P. Daszak, J. S. Brownstein, Preventing pandemics via international development: A systems approach. *PLOS Med.* **9**, e1001354 (2012). doi:10.1371/journal.pmed.1001354 Medline

13. J. A. Patz, P. Daszak, G. M. Tabor, A. A. Aguirre, M. Pearl, J. Epstein, N. D. Wolfe, A. M. Kilpatrick, J. Foufopoulos, D. Molyneux, D. J. Bradley, D. Emergence; Working Group on Land Use Change and Disease Emergence, Unhealthy landscapes: Policy recommendations on land use change and infectious disease emergence. *Environ. Health Perspect.* **112**, 1092–1098 (2004). doi:10.1289/ehp.6877 Medline

14. P. Hitchcock, A. Chamberlain, M. Van Wagoner, T. V. Inglesby, T. O'Toole, Challenges to global surveillance and response to infectious disease outbreaks of international importance. *Biosecur. Bioterror.* **5**, 206–227 (2007). doi:10.1089/bsp.2007.0041 Medline

15. R. G. Vaz, P. Mkanda, R. Banda, W. Komkech, O. O. Ekundare-Famiyesin, R. Onyibe, S. Abidoye, P. Nsubuga, S. Maleghemi, B. Hannah-Murele, S. G. Tegegne, The role of the polio program infrastructure in response to Ebola virus disease outbreak in Nigeria 2014. *J. Infect. Dis.* **213** (suppl. 3), S140–S146 (2016). doi:10.1093/infdis/jiv581 Medline

16. J. C. Mariner, J. A. House, C. A. Mebus, A. E. Sollod, D. Chibeu, B. A. Jones, P. L. Roeder, B. Admassu, G. G. van 't Klooster, Rinderpest eradication: Appropriate technology and social innovations. *Science* **337**, 1309–1312 (2012). doi:10.1126/science.1223805 Medline

17. J. Frenk, The global health system: Strengthening national health systems as the next step for global progress. *PLOS Med.* **7**, e1000089 (2010). doi:10.1371/journal.pmed.1000089 Medline

18. K. Bardosh, Global aspirations, local realities: The role of social science research in controlling neglected tropical diseases. *Infect. Dis. Poverty* **3**, 35 (2014). doi:10.1186/2049-9957-3-35 Medline

19. R. C. Swanson, R. Atun, A. Best, A. Betigeri, F. de Campos, S. Chunharas, T. Collins, G. Currie, S. Jan, D. McCoy, F. Omaswa, D. Sanders, T. Sundararaman, W. Van Damme, Strengthening health systems in low-income countries by enhancing organizational capacities and improving institutions. *Global. Health* **11**, 5 (2015). doi:10.1186/s12992-015-0090-3 Medline

20. World Health Organization, World Organization for Animal Health, Handbook for the assessment of capacities at the human-animal interface. http://www.who.int/ihr/publications/handbook_OMS_OIE/en/ [accessed 11 April 2017].

21. Global Health Security Agenda, https://www.ghsagenda.org [accessed 11 April 2017].

22. R. D. Horan, E. P. Fenichel, Economics and ecology of managing emerging infectious animal diseases. *Am. J. Agric. Econ.* **89**, 1232–1238 (2007). doi:10.1111/j.1467-8276.2007.01089.x

23. T. N. Cason, R. M. Sheremeta, J. J. Zhang, Communication and efficiency in competitive coordination games. *Games Econ. Behav.* **76**, 26–43 (2012). doi:10.1016/j.geb.2012.05.001

24. B. White, N. Hanley, Should we pay for ecosystem service outputs, inputs or both? *Environ. Resour. Econ.* **63**, 765–787 (2016). doi:10.1007/s10640-016-0002-x

25. Z. Mtema, J. Changalucha, S. Cleaveland, M. Elias, H. M. Ferguson, J. E. Halliday, D. T. Haydon, G. Jaswant, R. Kazwala, G. F. Killeen, T. Lembo, K. Lushasi, A. D. Malishee,

R. Mancy, M. Maziku, E. M. Mbunda, G. J. Mchau, R. Murray-Smith, K. Rysava, K. Said, M. Sambo, E. Shayo, L. Sikana, S. E. Townsend, H. Urassa, K. Hampson, Mobile phones as surveillance tools: Implementing and evaluating a large-scale intersectoral surveillance system for rabies in Tanzania. *PLOS Med.* **13**, e1002002 (2016). doi:10.1371/journal.pmed.1002002 Medline

26. Z. Chisha, D. A. Larsen, M. Burns, J. M. Miller, J. Chirwa, C. Mbwili, D. J. Bridges, M. Kamuliwo, M. Hawela, K. R. Tan, A. S. Craig, A. M. Winters, Enhanced surveillance and data feedback loop associated with improved malaria data in Lusaka, Zambia. *Malar. J.* **14**, 222 (2015). doi:10.1186/s12936-015-0735-y Medline

27. World Health Organization, Ebola response: What needs to happen in 2015. http://www.who.int/csr/disease/ebola/one-year-report/response-in-2015/en/ [accessed 01 April 2017].

28. N. B. Kabatereine, M. Malecela, M. Lado, S. Zaramba, O. Amiel, J. H. Kolaczinski, How to (or not to) integrate vertical programmes for the control of major neglected tropical diseases in sub-Saharan Africa. *PLOS Negl. Trop. Dis.* **4**, e755 (2010). doi:10.1371/journal.pntd.0000755 Medline

29. P. Farmer, *Infections and Inequalities: The Modern Plagues* (University of California Press, Berkeley; London, ed. Updated ed. with a new preface, 2001).

30. UNU-IHDP, UNEP, *Inclusive Wealth Report 2014. Measuring Progress Toward Sustainability. Summary for Decision-Makers* (UNU-IHDP, Delhi, 2014).

31. M. Nilsson, D. Griggs, M. Visbeck, Policy: Map the interactions between sustainable development goals. *Nature* **534**, 320–322 (2016). doi:10.1038/534320a Medline