Scaling-up Human Resources for Health in Rural India to achieve health-related SDGs: Projections of Personnel and Costs for 2030

Siddhesh Zadey

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Association for Socially Applicable Research

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Affiliations & Disclosures

- Association for Socially Applicable Research (ASAR), India
- Department of Surgery, Duke University School of Medicine, US
- Global Emergency Medicine Innovation and Implementation (GEMINI) Research Center, Duke University, US
- Dr. D.Y. Patil Medical College, Hospital, and Research Centre, India

I serve as – the Chair of the South Asian SOTA Care Working Group at The G4 Alliance, a Fellow of the Lancet Citizens' Commission for Reimagining India's Health System, on the Drafting Committee of the Maharashtra State Mental Health Policy, and on the advisory board of Nivarana Public Health Platform.

I have received honoraria from Think Global Health, The Wire, and Harvard Public Health Magazine.

Duke Surgery GEMINI DPU Dr. D. Y. Patil Vidyapeeth, Pune (Deemed to be University) ASAR REIMAGINING INDIA'S HEALTH SYSTEM A Lancet Citizens' Commission G4 alliance surgical, obstetric, trauma & anaesthesia care

People Involved

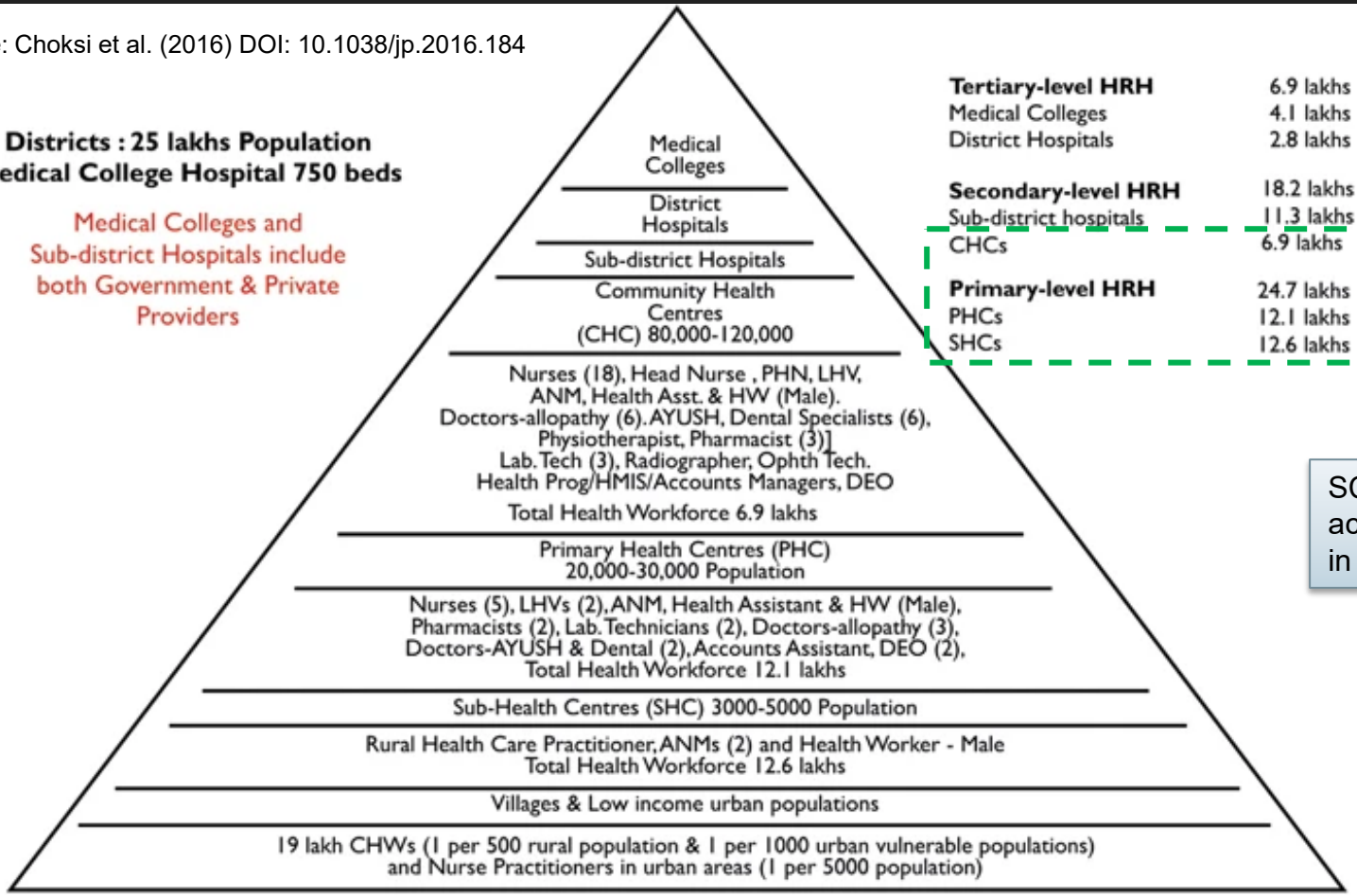
Yash Jawale
Varad Puntambekar
Vedika Sharma
Amit Sahu
Nanditha Venkat
Rachit Sekhrajka
Aatmika Nair
Sweta Dubey
Surabhi Dharmadhikari
Suraj Bhor

Indian Health System – Structure

Image: Choksi et al. (2016) DOI: 10.1038/jp.2016.184

Districts : 25 lakhs Population
Medical College Hospital 750 beds

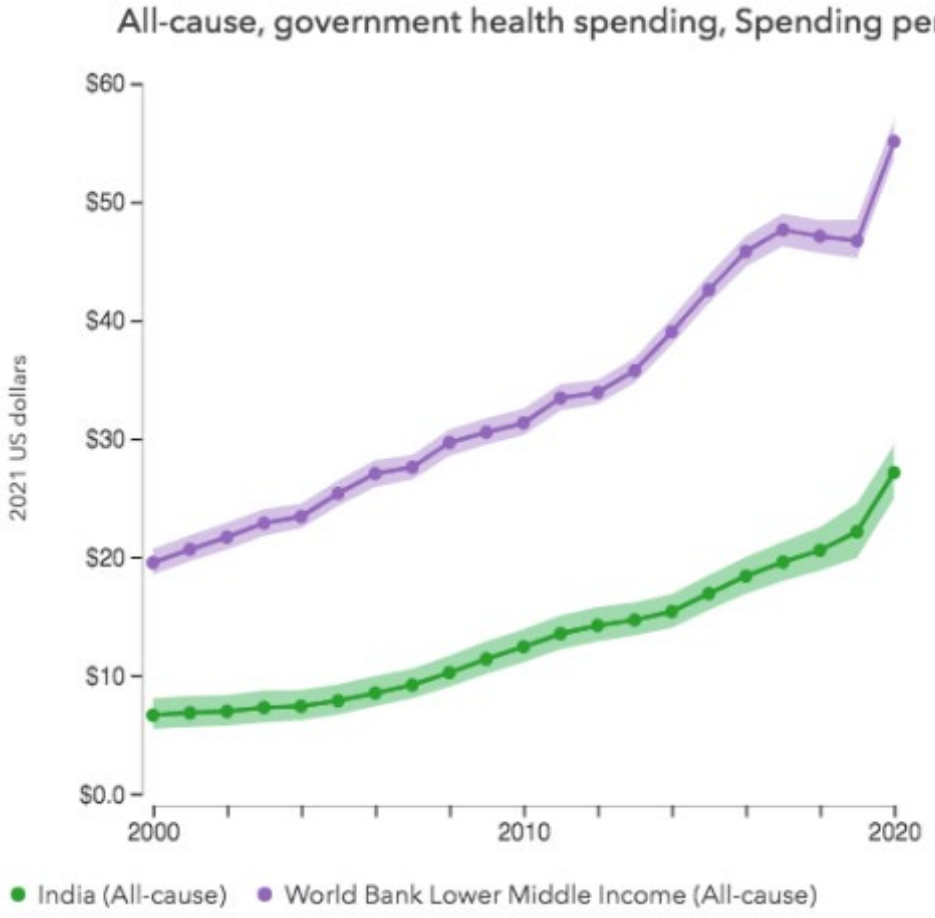
Medical Colleges and Sub-district Hospitals include both Government & Private Providers



Tertiary-level HRH	6.9 lakhs
Medical Colleges	4.1 lakhs
District Hospitals	2.8 lakhs
Secondary-level HRH	18.2 lakhs
Sub-district hospitals	11.3 lakhs
CHCs	6.9 lakhs
Primary-level HRH	24.7 lakhs
PHCs	12.1 lakhs
SHCs	12.6 lakhs

SCs, PHCs, and CHCs, account for **56.5%** of HRH in the public health system.

Indian Health System – Public Financing



- Public spending is about a fifth of total health spending in India [1].
- 52% of public spending goes to primary health care [2].

Image: IHME VizHub http://ihmeuw.org/47rx

1. IHME (2023)
2. National Health Accounts (2019)

Critical HRH shortage: Moment of Crisis

Only **1.7** essential HRH personnel (doctors, nurses, midwives) per 1000 population (WHO-SDG target: 4.4). This drops to **1.1** after adjusting the adequate qualifications [3].

The situation is worse in rural India [4] →

- Only 2-3 doctors and 3-4 nurses per 10,000 rural population
- Less than ⅓ of essential HRH serving more than ⅔ of the country's population

Crisis is greater in rural public health system at primary and secondary care levels [5].

3. Tiwari R et al. (2019) DOI: 10.4103/2224-3151.255351
4. Karan A et al. (2019) DOI: 10.1136/bmjopen-2018-025979
5. Nair A, Jawale Y et al. (2022) DOI: 10.1186/s12960-021-00687-9

Aims

- To estimate deficits in essential HRH in rural public health system India at primary + secondary care levels.
- To project for growth rates required to achieve Sustainable Development Goal (SDG) targets by 2030.
- To estimate recruitment and retention costs required for HRH scale-up.

Approach

- **Macro** but specific – Rural | Public | Primary/Secondary | State-wise
- Historic **data trends** – high value
- Prescriptions for **annual** budgeting/funding
- **Library of estimates** for decision-makers to choose from
- Awareness about **data limitations** when working in LMICs

Methods | Data Sources

- HRH annual count data (2009-2021): Rural Health Statistics (RHS)
- Rural population annual mid-year projections (2009-2030): National Commission on Population, Census of India 2001 & 2011
- Health services utilization in rural areas (2017-2018): National Sample Survey (NSS) 75th Round on Social Consumption in Health
- Cadre and State-wise HRH salary payments: National Health Mission (NHM) budgets and recruitment documents

Methods | Centre and Cadre Inclusions

Essential HRH	Community Healthcare Centres (CHCs)	Primary Healthcare Centres (PHCs)	Sub-Centres (SCs)
General Duty Medical Officers (GDMOs)	✓	✓	Not Applicable (NA)
Internal Medicine Physicians	✓	NA	NA
Surgeons	✓	NA	NA
Pediatricians	✓	NA	NA
Obstetricians & Gynecologists	✓	NA	NA
Nurses	✓	✓	NA
Auxiliary Nurse Midwives (ANMs)/ Health Workers Female (HWFs)	Data missing	✓	✓

Methods | Deficits

Two scenarios for India + 36 states & union territories -

Aspirational - serving all rural population

Realistic - based on service utilization proportions (SUPs) for public facilities

HRH density (per 1000) = Essential HRH/SUP-adjusted Population * 1000

Required HRH = Threshold x SUP-adjusted Population

Target HRH density thresholds:

Acute (based on WHO 2006 report): 2.28

WHO-SDG (based on WHO 2016 report): 4.45

Government of India or India-SDG (based on NITI Aayog 2018 SDG Baseline report): 5.55 (specific for public system HRH)

Deficit = Required HRH - Essential HRH present

Methods | Joinpoint Regression - Origin

Joinpoint regression analysis - Piecewise linear regression developed and promoted by National Cancer Institute (https://surveillance.cancer.gov/joinpoint/)

STATISTICS IN MEDICINE
Statist. Med. **19**, 335–351 (2000)

PERMUTATION TESTS FOR JOINPOINT REGRESSION WITH APPLICATIONS TO CANCER RATES

HYUNE-JU KIM[1]*, MICHAEL P. FAY[2], ERIC J. FEUER[2] AND DOUGLAS N. MIDTHUNE[3]

[1] *Syracuse University, Department of Mathematics, 215 Carnegie Building, Syracuse University, Syracuse, NY 13244-1150, U.S.A.*
[2] *National Cancer Institute, Executive Plaza North, Suite 313, 6130 Executive Boulevard, Bethesda, MD 20892, U.S.A.*
[3] *National Cancer Institute, Executive Plaza North, Suite 344, 6130 Executive Boulevard, Bethesda, MD 20892, U.S.A.*

SUMMARY

The identification of changes in the recent trend is an important issue in the analysis of cancer mortality and incidence data. We apply a joinpoint regression model to describe such continuous changes and use the grid-search method to fit the regression function with unknown joinpoints assuming constant variance and uncorrelated errors. We find the number of significant joinpoints by performing several permutation tests, each of which has a correct significance level asymptotically. Each *p*-value is found using Monte Carlo methods, and the overall asymptotic significance level is maintained through a Bonferroni correction. These tests are extended to the situation with non-constant variance to handle rates with Poisson variation and possibly autocorrelated errors. The performance of these tests are studied via simulations and the tests are applied to U.S. prostate cancer incidence and mortality rates.

Image Source

Methods | Joinpoint Regression - Basics

The data is fitted with a minimum number of linear fits of significantly different slopes called annual percent change (APC).

Intersection point of consecutive linear fits is called a joinpoint.

Average annual percent change (AAPC) - Weighted aggregation of annual percent changes (APCs)

$$AAPC = \frac{\sum_{i=1}^{n}(w_i \times APC_i)}{\sum_{i=1}^{n} w_i}, where\ w\ is\ the\ weight\ for\ the\ segment$$

AAPC gives for rate of change (r) in the past that can be used for the future

Methods | Projections

How many HRH will be present?

$$N_{(i+n)} = N_i(1+r)^n$$

e.g. $HRH_{2030} = HRH_{2019}(1+r)^{11}$

What should be the growth rate for achieving targets?

$$desired\ r = e^{\left[\frac{log\left(\frac{Desired\ HRH_{2030}}{HRH_{2019}}\right)}{11}\right]} - 1$$

Methods | Costs Framework

$$HRH\ statistical\ salary = \frac{\sum_{j=1}^{n}(N_j \times Salary_j)}{\sum_{j=1}^{n} N_j}, where\ N\ is\ available\ count\ of\ cadre\ j$$

$$yearly\ cost_i = \Delta\ HRH\ deficit_{i-(i-1)} \times (recruitment\ salary + retention\ salaries), till\ \Delta > 0$$

$$total\ cost = \sum_i yearly\ cost_i$$

$$salary = basic\ pay + allowance$$

$$allowance = 28\% \times basic\ pay$$

$$increment = 1\% \times allowance$$

Methods | Costs Models

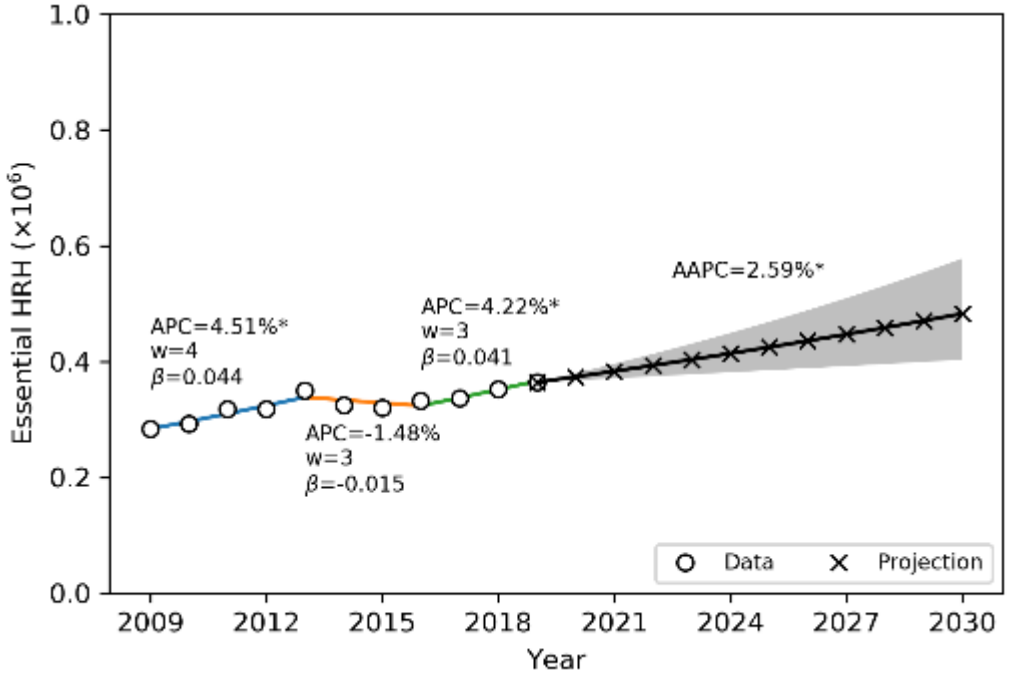
Basic Model

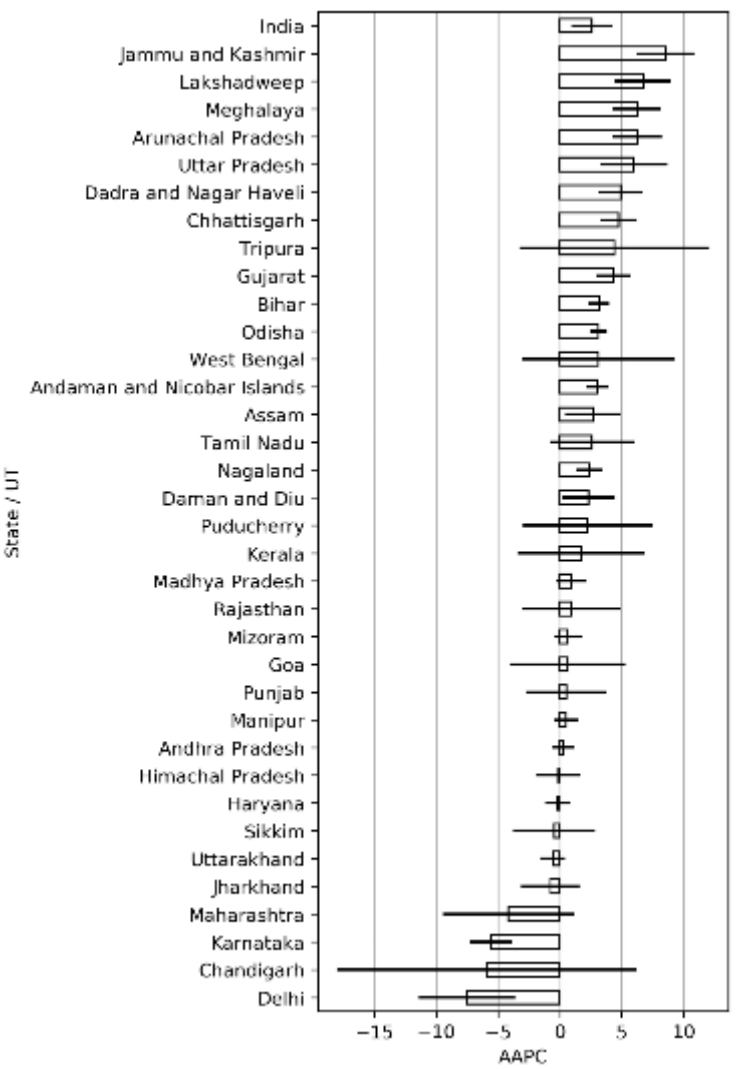
$$yearly\ cost_i = \Delta\ HRH deficit_{t-(i-1)} \times \left[(basic\ pay + allowance) + \left((basic\ pay + allowance) \times retention\ period\right)\right], till\ \Delta > 0$$

Increment Model

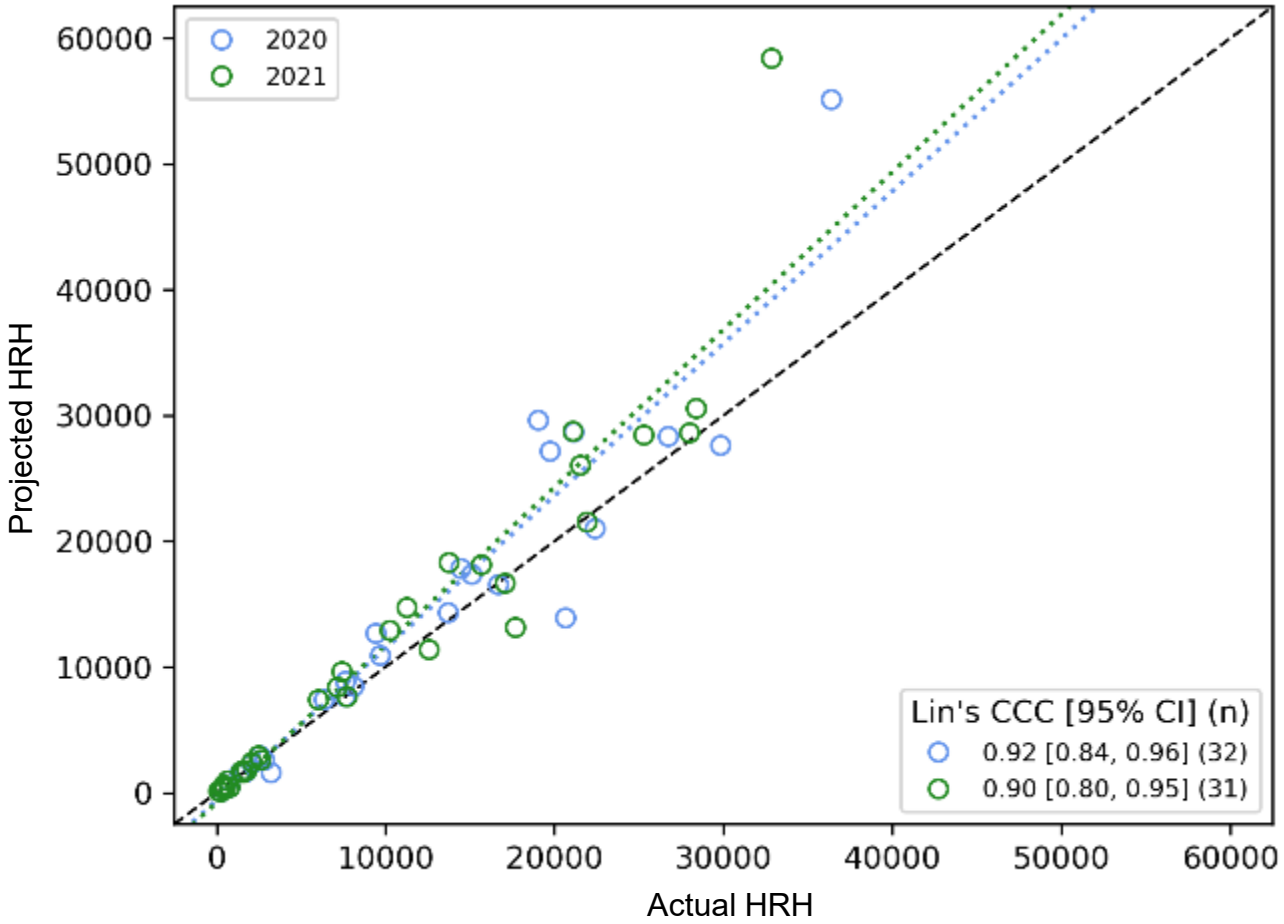
$$yearly\ cost_i = \Delta HRH deficit_{i-(i-1)} \times \left[(basic\ pay + allowance) + \left((basic\ pay + allowance) + \left(allowance \times (1 + 1\%)^{retention\ period}\right)\right)\right], till\ \Delta > 0$$

Results | AAPCs

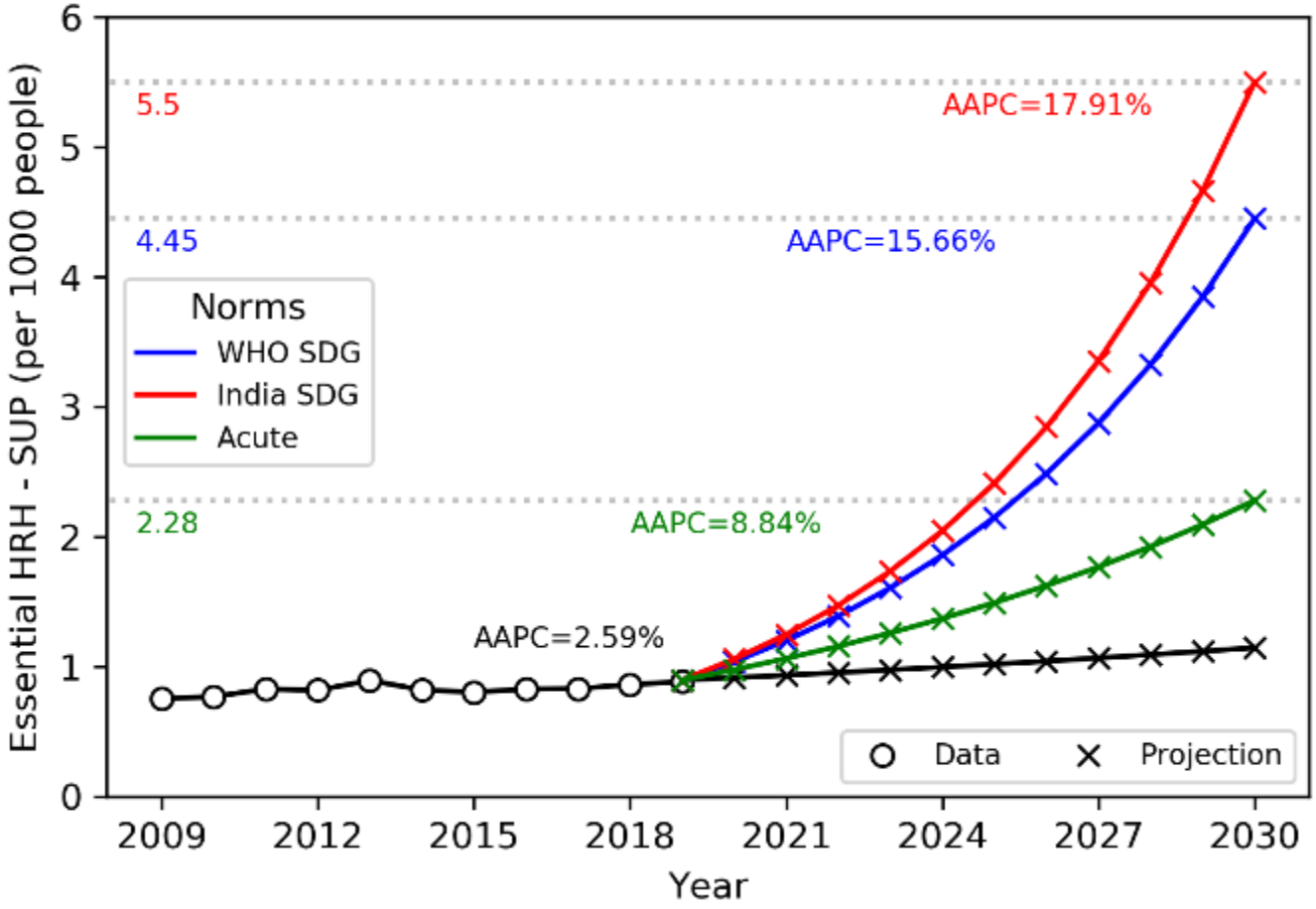




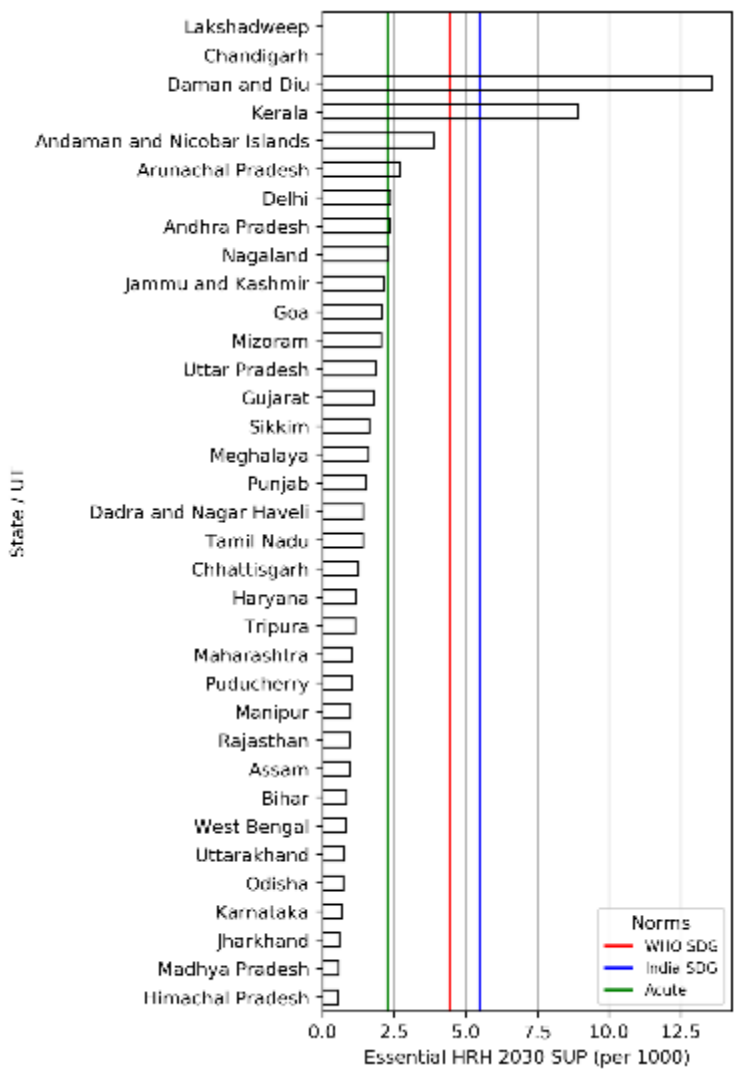
Results | Validating Projections



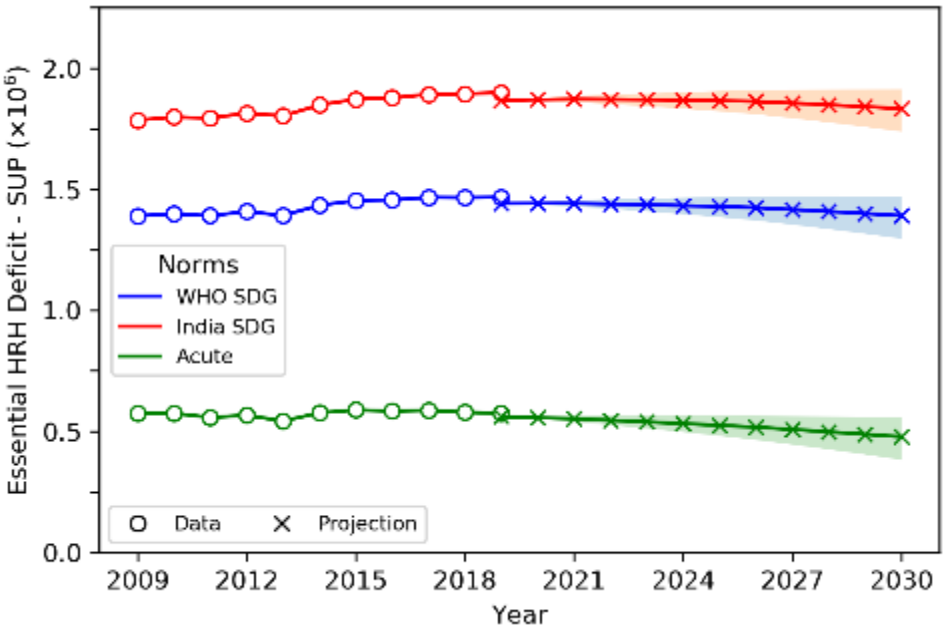
Results | Target growth rates

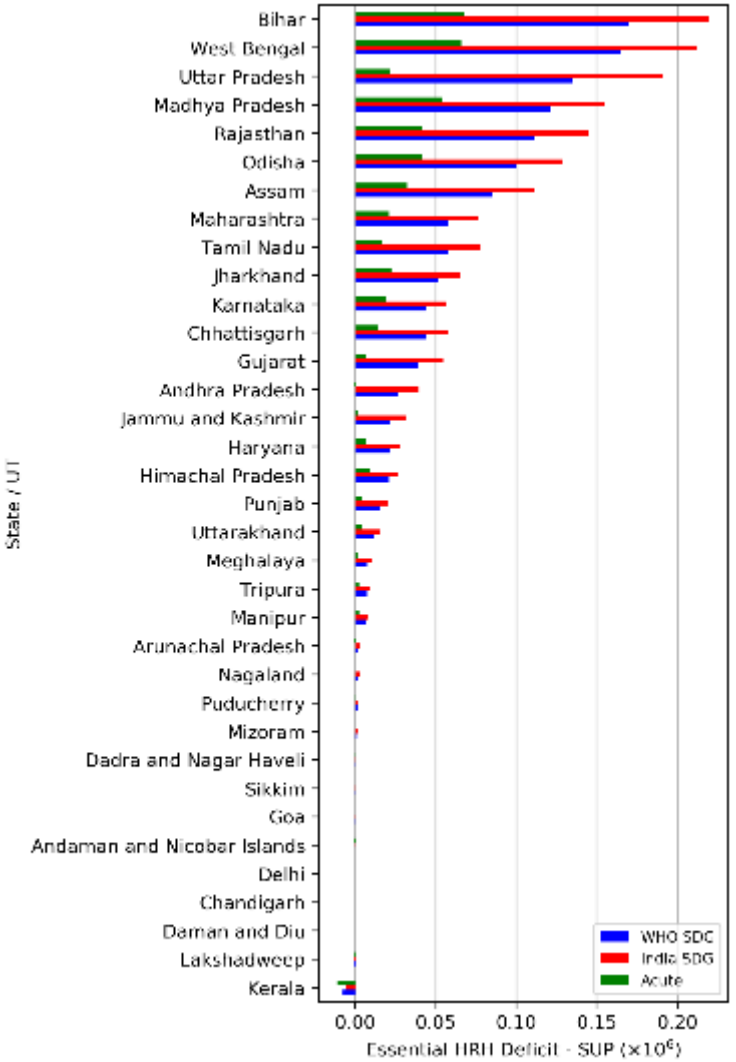


Results | Density Projections 2030



Results | HRH Deficit Projections





Results | National Scale-up Costs

Basic Model			Increment Model		
Acute	WHO SDG	India SDG	Acute	WHO SDG	India SDG
1.37T INR (18.47B USD)	3.58T INR (48.37B USD)	4.66T INR (62.91B USD)	1.38T INR (18.68B USD)	3.62T INR (48.91B USD)	4.71T INR (63.61B INR)

Budget	Basic Model			Increment Model		
	Acute	WHO SDG	India SDG	Acute	WHO SDG	India SDG
Govt. Health Spending	4.18%	10.96%	14.25%	4.23%	11.08%	14.41%
Total Health Spending	1.22%	3.19%	4.15%	1.23%	3.23%	4.20%
Gross Domestic Product	0.04%	0.12%	0.15%	0.04%	0.12%	0.15%

Results | State-level Scale-up Costs

Basic Model

All values in million USD

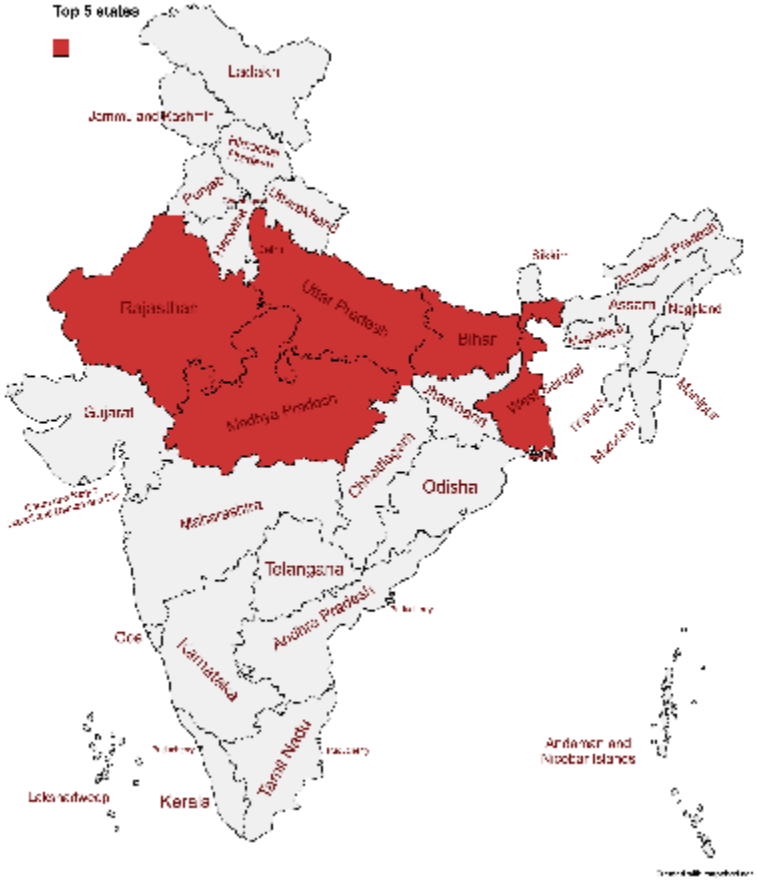
State	Acute	WHO SDG	India SDG
Uttar Pradesh	2140	6170	8120
Bihar	2220	5450	7000
Rajasthan	1920	5100	6630
West Bengal	2260	5160	6560
Madhya Pradesh	1650	3760	4780
Odisha	1610	3610	4580
Assam	1200	2990	3860
Chhattisgarh	860	2160	2800
Gujarat	680	2040	2700
Tamil Nadu	630	1720	2250
Karnataka	650	1660	2150
Jammu and Kashmir	590	1560	2030
Maharashtra	415	1340	1790
Andhra Pradesh	86	1120	1630
Haryana	287	850	1120
Himachal Pradesh	328	740	940
Punjab	165	590	790
Jharkhand	225	520	670
Uttarakhand	197	487	630
Kerala		285	476
Meghalaya	133	351	457
Manipur	92	248	323
Arunachal Pradesh	34	137	186
Goa	19	61	81
Mizoram	6	53	76
Puducherry	16	43	56
Sikkim	13	38	50
Delhi	20	40	50
Tripura	14	33	42
Dadra and Nagar Haveli	10	28	37
Andaman and Nicobar Islands		19	31
Nagaland	2	9	12
Chandigarh			
Daman and Diu			
Lakshadweep			

Limitations

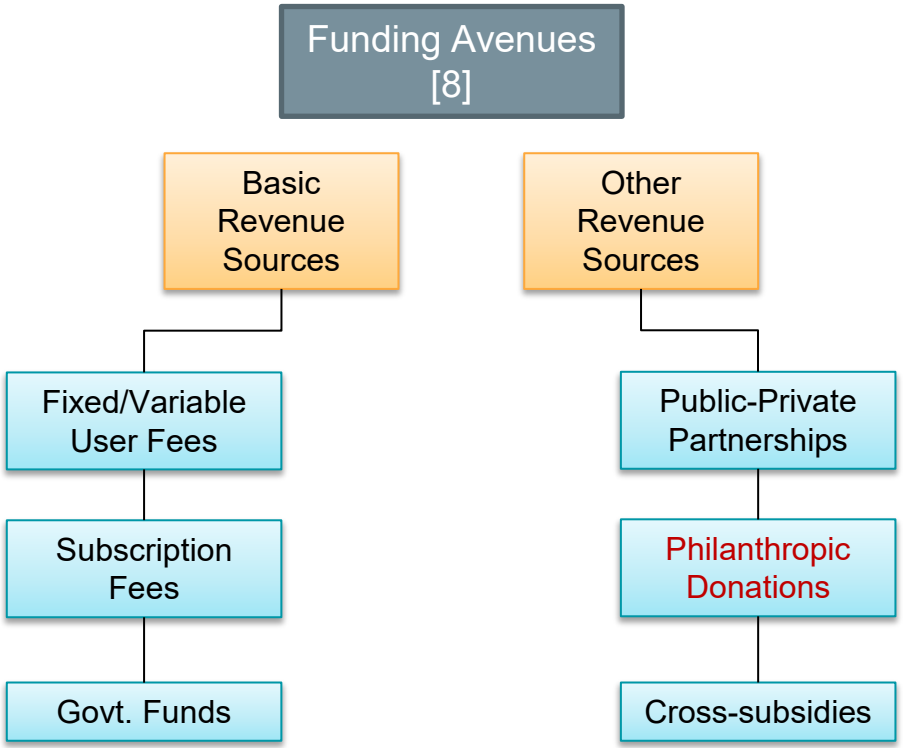
- Lack of availability of high-resolution data
- Error estimation using constant variance for several years
- Growth rate assumed to be exponential
- Simplified salary model may lead to cost misidentification
- All costs estimated at 2019 level and are not adjusted for inflation
- Service utilization proportions are based on cross-sectional estimates

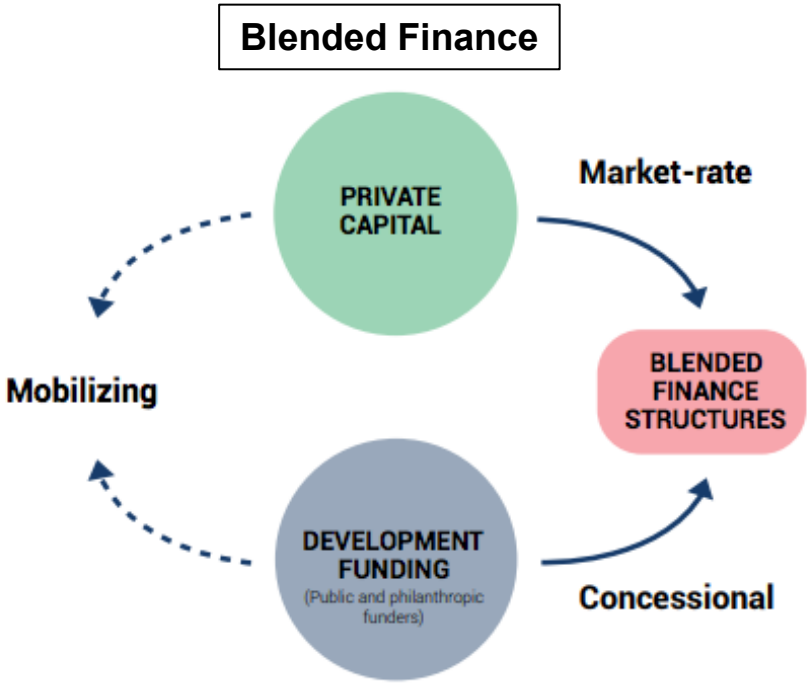
Significance

- **Data-driven** estimates for the required growth rate and target gaps for SDG 2030.
- Modeling aspirational and realistic scenarios gives **sensitivity estimates** useful for decision-makers and funders.
- Cost estimates advocate for **increased spending and appropriate allocation** for HRH in national and state budgets as part of HSS.
- Analysis at the state-level points to regions that need **immediate attention** and investments.



Potential Models of Funding HRH In Rural Primary Health Care





8. Dutta M, et al. (2020) DOI: 10.4103/jfmpc.jfmpc_1131_20
Image: NITI Aayog, SAMRIDH (2022) ISBN: 978-81-953811-8-0c

Scope for DAH for HRH funding

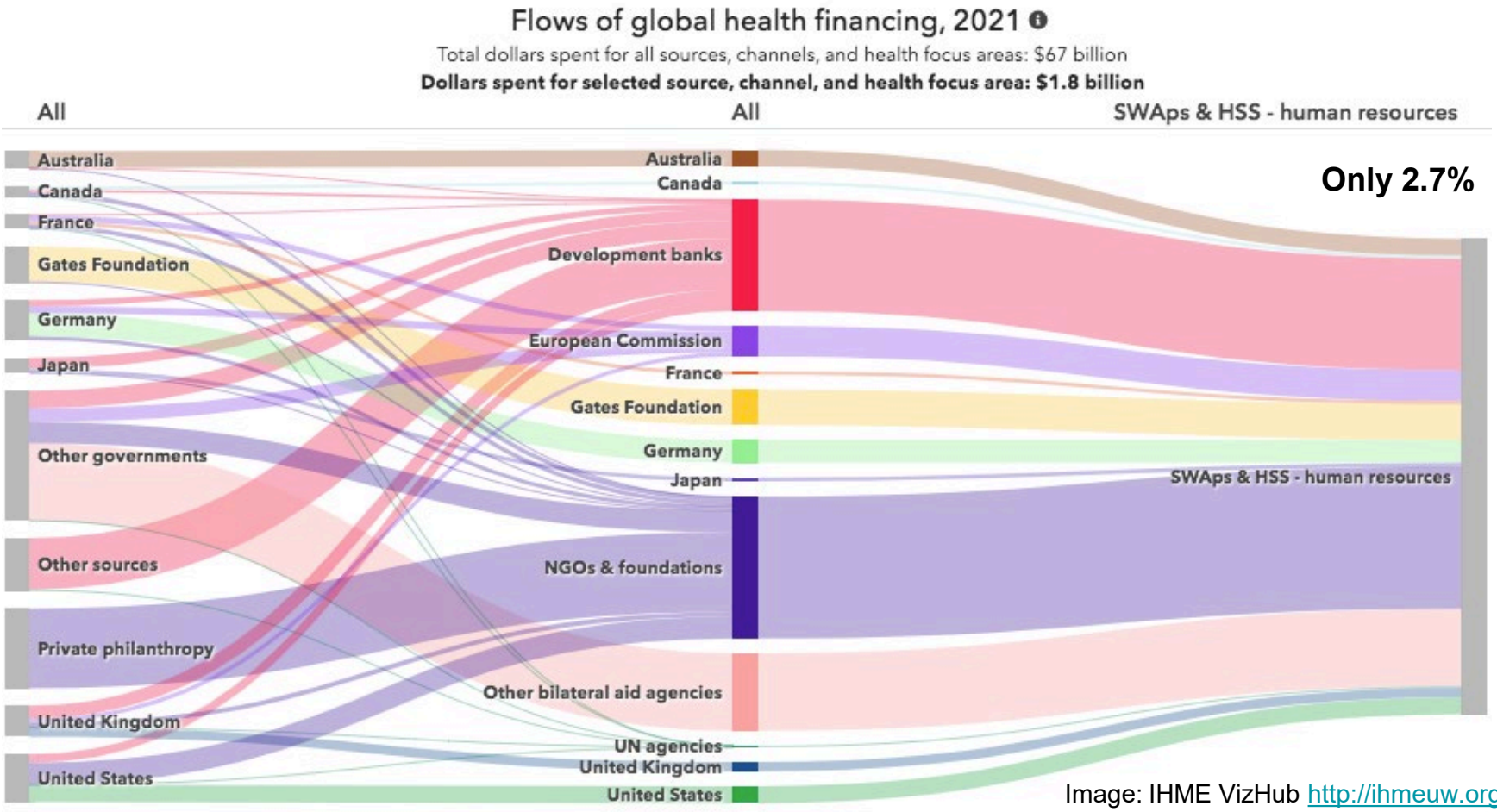


Image: IHME VizHub http://ihmeuw.org/47rx

Thank you | धन्यवाद

Connect: sidzadey@asarforindia.org

Twitter: @RantingSid

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Appendix

RESULTS FOR ASPIRATIONAL SCENARIO MODELING

Methods | Joinpoint Regression - Application

Log-transformed data with an autocorrelated error model. HRH counts with constant variance error type.

Model capped to find a maximum of two joinpoints. The model with the optimal number of changepoints selected using the permutation test for best fit from 4499 permutations with 0.05 significance level.

95% upper and lower confidence intervals (CI) for the AAPC values.

AAPCs of available HRH 2009-2019 data both at national and state-level calculated in Joinpoint (Command-Line (Batch/Callable) version 4.8.0.1).

For incomplete data at state-level, data up to most recent complete year used. Analysis performed using Python Jupyter notebooks (Python 3.7.3, Anaconda, Inc.).

Results | State-level Scale-up Costs

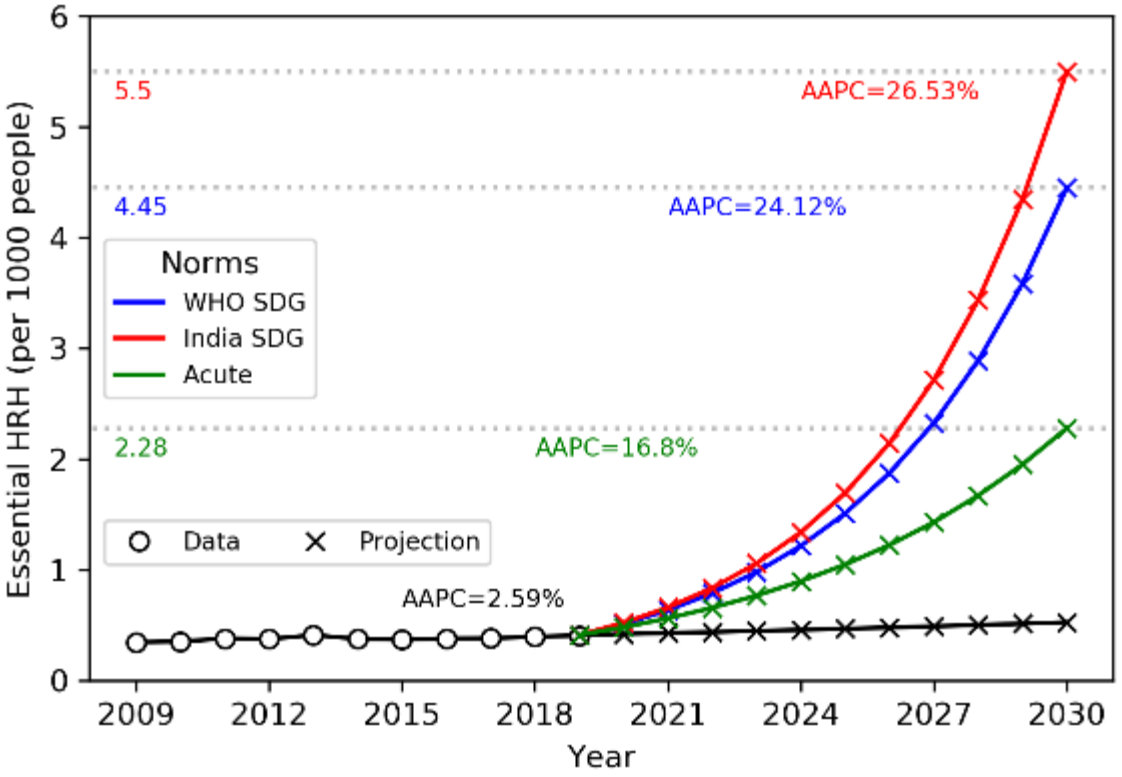
Increment Model

All values in million USD

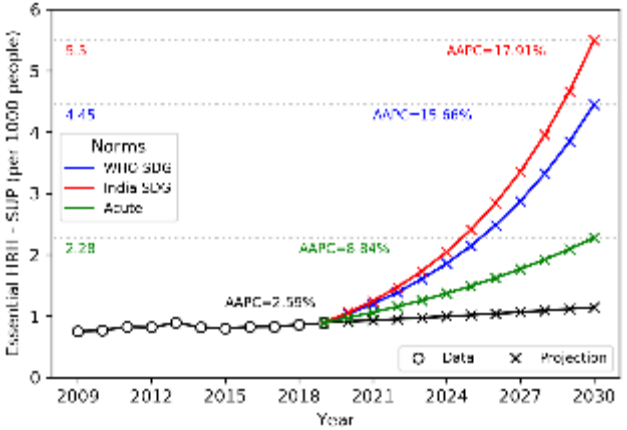
State/UT	Acute	WHO SDG	India SDG
Uttar Pradesh	2160	6240	8210
Bihar	2250	5510	7080
Rajasthan	1950	5150	6710
West Bengal	2280	5220	6640
Madhya Pradesh	1670	3800	4830
Odisha	1630	3650	4630
Assam	1210	3020	3910
Chhattisgarh	870	2190	2830
Gujarat	690	2060	2730
Tamil Nadu	640	1740	2280
Karnataka	660	1680	2180
Jammu and Kashmir	590	1580	2060
Maharashtra	419	1350	1810
Andhra Pradesh	87	1140	1650
Haryana	290	860	1130
Himachal Pradesh	332	750	950
Punjab	167	590	800
Jharkhand	228	530	670
Uttarakhand	199	493	630
Kerala		288	481
Meghalaya	135	355	462
Manipur	93	250	326
Arunachal Pradesh	34	138	189
Goa	20	62	82
Mizoram	6	54	77
Puducherry	16	44	57
Sikkim	13	38	51
Delhi	20	40	50
Tripura	14	33	42
Dadra and Nagar Haveli	10	28	37
Andaman and Nicobar Islands		20	31
Nagaland	2	9	12
Chandigarh			
Daman and Diu			
Lakshadweep			

Results | Target growth rates

ASPIRATIONAL SCENARIO

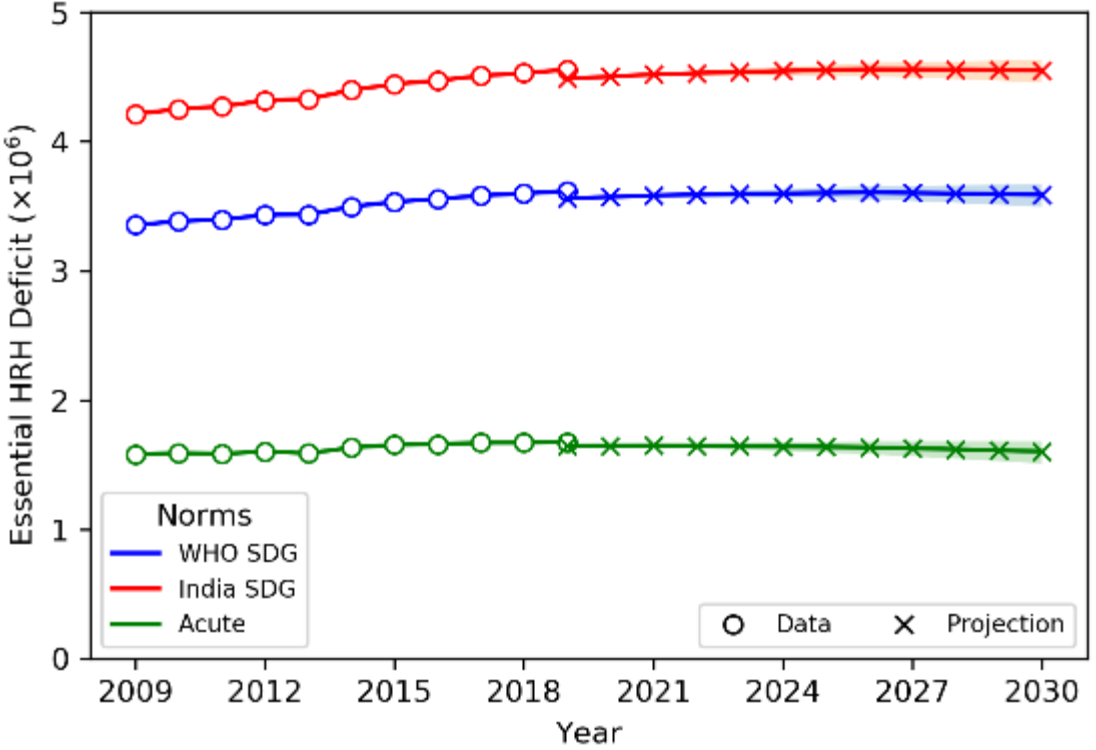


REALISTIC SCENARIO

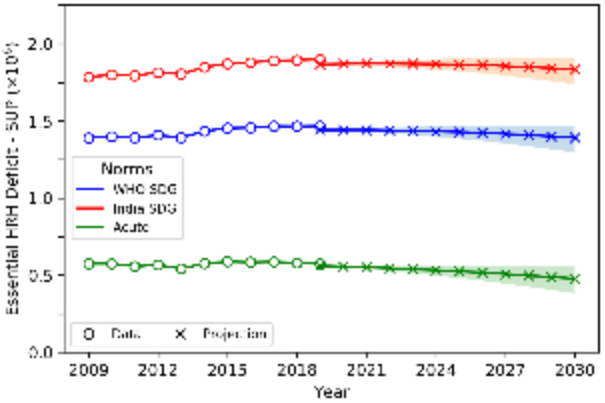


Results | HRH Deficit Projections

ASPIRATIONAL SCENARIO



REALISTIC SCENARIO



Results | National Scale-up Costs

Basic model			Increment model		
Acute	WHO SDG	India SDG	Acute	WHO SDG	India SDG
4.34T INR (58.54B USD)	9.43T INR (127.3B USD)	11.9T INR (160.64B USD)	4.39T INR (59.19B USD)	9.54T INR (128.72B USD)	12.04T INR (162.44B USD)

Budget	Basic model			Increment model		
	Acute	WHO SDG	India SDG	Acute	WHO SDG	India SDG
Govt. Health Spending	13.26%	28.83%	36.38%	13.41%	29.15%	36.79%
Total Health Spending	3.86%	8.40%	10.60%	3.91%	8.49%	10.72%
Gross Domestic Product	0.14%	0.31%	0.39%	0.14%	0.31%	0.39%