Vulnerability To Health in A Ward of Bengaluru: Insights from A Mobile-Based Survey

Ravish KS[1], Ashwini Lonimath[2], Vani HC[3], I Sushil Kumar[4], Ranganath TS[5]

[1,2,3,4,5]Bangalore Medical College & Research Institute (BMCRI), Bengaluru, India

ABSTRACT

Context/Background: Rapid urbanization has resulted in a growing number of people living in under-served areas with inadequate and overburdened infrastructure and services, worsening of environmental factors. Sustainable Development Goal 11: "sustainable cities and communities", highlights, there is an urgent need to re-orient the community development strategies by adopting economically & technologically sustainable models.

Aims/Objectives: An application-based household survey to assess the vulnerability and Health conditions among the urban poor of slums in Bengaluru.

Methodology: The tool for Vulnerability Assessment by Government of India was modified to develop a user-friendly tool for Community Health Workers in an Android–based smartphone application (Namma Samudaya). Data was collected through house-to-house survey.

Results: A total of 3165 households (HHs) were surveyed. Among these, 54.2% of the HHs belong to vulnerable category and 45.8% to highly vulnerable group.

Conclusions: Domain-wise analysis showed, Residential -25.2% of HHs were located besides polluted water Social - "No social support" and "disability" was reported by 3% of households each; Health-Related - Catastrophic Health expenditure in the past 1 year was reported by 40.4% HHs. The baseline information of slums & their geographic mapping obtained during the survey can be used as foundation for effective planning of health care services.

Key-words: Vulnerability, Health, Urban poor, Slums, Assessment

INTRODUCTION

The Slum Areas 'Improvement and Clearance' Act, 1956, defines a 'slum' as a residential area where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, design of buildings, narrowness or faulty arrangement of streets, lack of ventilation, lack of sanitation facilities or any combination of these factors which are detrimental to safety or health.[1] Rao and Thakur define the term 'vulnerability' as 'able to be easily hurt'.[2] According to Loughhead et al. 2001, 'Vulnerability' can be defined as 'a situation where some people are more prone to face adverse situations, and where there is a higher likelihood of succumbing to those situations'.[3] In the context of public health, however, it implies a situation leading to higher likelihood of morbidity and mortality.[4]

The National Urban Health Mission (NUHM) is a sub-mission of National Health Mission which envisages with a special focus on the urban poor and vulnerable addressing the health care needs and reducing out of pocket expense. The term "Vulnerability Assessment" in relation to healthcare has been defined as assessing the level of vulnerability of a slum or household towards ill-health. Vulnerability is commonly associated with poor economic and nutritional status; Overlapping social vectors - quality of housing and public services, occupation, gender, dis-

ability, marital status, age, stigmatized and debilitating ailments.[5] Apart from a strong service delivery mechanism, geographical variations, health, social & environmental determinants are essential parameters to estimate the needs, chalk-out an effective response strategy. The mapping of the HHs will provide more granularity to population data. It would also build a platform for easy planning and monitoring of outreach camps, regular health programs like Routine Immunization, Pulse Polio campaign, Leprosy Case Detection Campaign, Active Case Finding of TB, Non-Communicable Diseases mapping & many more.

International health bodies including Indian Council of Medical Research have highlighted the poor data quality in Indian health-care system.[6,7] A major source of data has been the population-based surveys that healthcare workers carry out on a regular basis since the start of National Urban Health Mission. The amount of data generated is of huge quantity. However, the overburdened health-care system does not allow for validation of the data and appropriate compilation of the same. In such situations the data quality remains questionable and the basis of the health planning as well.

The burden of multiple surveys that the community health workers face has been a common cause for health worker attrition.[8] The multiple visits to the same community with similarly designed questionnaires also cause resistance in the urban community. The monetary burden of long paper-based surveys has always been a matter of debate.[9] Data entry and compilation at UPHC level without dedicated data entry operators would make paper-based surveys wasteful. However, in spite of crossing the above hurdles, a possible compiled data would be difficult to be validated due to the sheer amount of data collected per survey. Hence, this app based integrative platform was planned and developed in the background of vulnerability assessment in a ward classified as the urban field practice area of a Government Medical College in Bengaluru city of Karnataka.

OBJECTIVE

The present study was conducted to estimate the vulnerability score among the residents in an urban ward through app-based household survey and also to represent the geo-tagged household level data as a layer of map in GIS.

METHODOLOGY

Based on the requirement from the Office of National Urban Health Mission at the Urban Local Body (ULB), in line with the directives from the Government of India and Karnataka, the Department of Community Medicine was allocated the task of "Vulnerability Assessment and Mapping" activity planning for the entire city. However, it was decided that the study will be conducted in detail in the ward, classified as Field Practice Area, under the direct supervision of the Department.

Tool revision and development: The tool for Vulnerability Assessment defined by Government of India and was revised and digitized in a two-step process as below, based on multiple meetings with all stakeholders:

I. Analysis of the existing tool for vulnerability assessment: A Questionnaire for Vulnerability Assessment tool by ASHAs had been described in the document: "Guidelines & Tools for Vulnerability Mapping & Assessment for urban health 2017"[5] & same in "Induction Training Module for ASHAs in Urban Areas".[10] The key observations noted in the tool were a) Multiple components were assessed simultaneously in one question, making it difficult for field level response marking; and b) Non-availability of the tool in the local language of Kannada.

In this regard, multiple meetings with the stakeholders were undertaken to segregate components and developed a user-friendly tool for Community Health Workers (CHWs).

II. Android-based app development: The modified vulnerability assessment tool was developed as an Android-based application named: Namma Samudaya with all ASHAs and ANMs enrolled as a user. As compared to paper-based surveys, the data captured directly through app-based surveys have the following advantages: a) cost-effectiveness; b) locating the household surveyed on to the map through GIS mapping; c) Realtime data recording; d) Correction and updation on-the-go; e) Features of drill-down and better visualization due to a more structured data collection; and f) Quick generation of reports on each of the variables as summaries.

The app-based survey form contained a total of 45 questions in the format: a) 37 parent questions and 8 linked by "if <x>, then <y>" logic; b) 7 (out of 45) open-ended questions and rest closed-ended; c) Validation checks for numeric fields; d) Unique User ID & password for each health worker/surveyor; e) All questions were marked "required" for final submission; f) Linking of Community Based Assessment Checklist for NCDs; g) Complete offline support with sync option; and h) Availability in dual language – English & Kannada

Key Considerations included - Reliability, Security, Confidentiality, Extensibility, Data Validation, Dashboard generation.

Following the tool finalisation, Institutional Ethical Committee clearance was taken and training modules were designed based on inputs from all stakeholders.
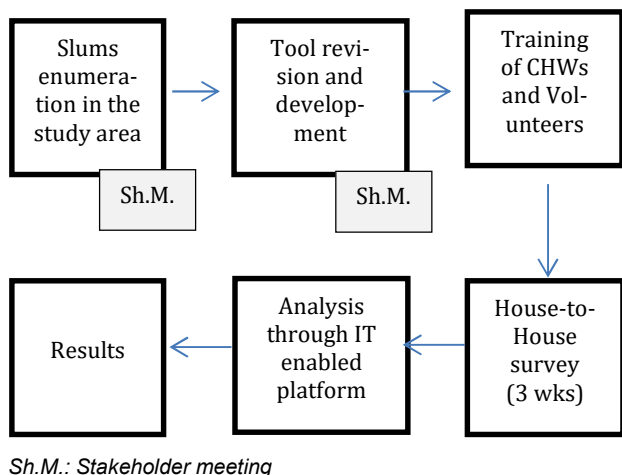
Sh.M.: Stakeholder meeting

Figure 1: Pictorial representation of the steps in study (Sh.M: Stack holder meeting)

Training of surveyors and other stakeholders: A total of 3 sessions were conducted to train the Community Health Workers, volunteers and other stakeholders involved for a period of 7 days.

House-to-house survey: A house-to-house cross-sectional descriptive study was carried out in the period of 26th July to 16th August 2019 in the ward classified as Urban Field Practice area of Bangalore Medical College & Research Institute. The target HHs being 6047 for the ward, universal sampling technique was used to cover all slum households based on a common decision from the Public Health stakeholders of the Urban Local Body (ULB). This was decided based on Pulse Polio micro plan and Active Case Finding for Tuberculosis-2019. As listed in the Pulse Polio micro plan and based on field visits, all the HHs were classified as High-Risk Area due to multiple accessibility-related issues.
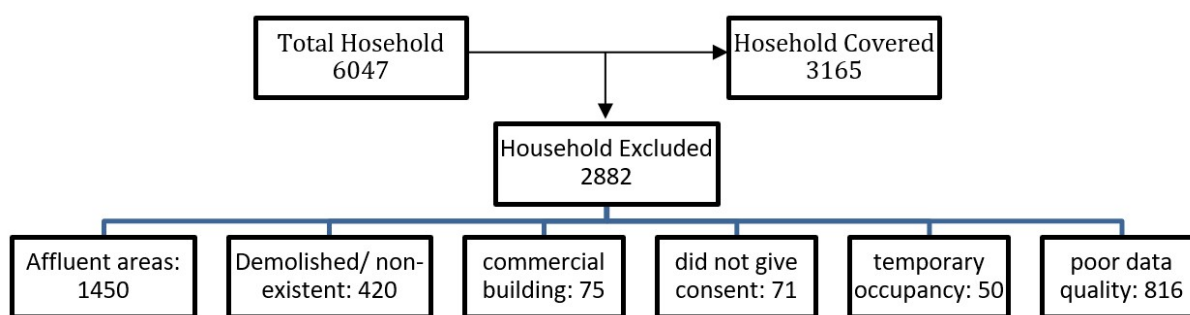
Figure 2: Households in the ward and selection of eligible data for analysis

A briefing meeting was conducted to explain the purpose of survey permission from local leaders and the jurisdictional heads of the ULB was sought in a briefing stakeholder to conduct health survey in the area and purpose of the same was explained to gain support at the community level.

Data collection was carried out by trained CHWs and Volunteers (students in the Phase III Part I of MBBS and those undergoing compulsory rotatory internship at the field practice hospital). Each team with was given a target of 15 households per day. The head of the household/informant was asked permission to collect information of family members of the household and then consent was taken on an individual basis to collect data. The HHs whose informants refused to give consent & households which were locked (not available for data collection) for two consecutive visits were excluded from the study.

RESULTS

The survey data was exported from the application database as a csv file and analysis was done using MS Excel and SPSS ver 20. The ward has been divided into 12 HRAs grouped into 3 sectors (Table 1), for ease of service delivery and monitoring. Of the 6047 HHs in the ward, the results have been analysed for 3165 HHs (causes for exclusion of 2882 HHs depicted in Figure 2)

Table 1: Sector wise coverage of HHs

Sector and Area	Target	HHs Covered
Sector I		
VN	595	491
MC & YMS	423	378
NSG	360	212
RG	334	143
Sector I-subtotal	**1712**	**1224**
Sector II		
KSG	1106	532
CKCG	1048	427
Sector II-subtotal	**2154**	**959**
Sector III		
HKG	454	94
RGG	566	499
SP	220	48
AJG	356	125
DM	585	216
Sector III-subtotal	**2181**	**982**
Total HHs	**6047**	**3165**

*VN – Vinobha Nagar, MC& YMS – Muniappa Compound & YM Shalla, NSG – Narayannswamy Garden, RG – Ramanna Garden, KSG – Khadar Shareef Garden, CKCG – CKC Garden, HKG – Hamid Khan Garden, RJG - Rajgopal Garden, SP – Shambupalya, AJG – Appajappa Garden & DM – Doddamavalli.

Note: Remaining HHs are the ones with – elite population (1450), demolished (420) and uncooperative HHs (71), commercials (75); few HHs are occupied only during elections (50). Due to poor data quality, 816 HHs were deleted from the final analysis.

Table 2: Basic Socio demographic distribution of HHs (n=3165)

Socio-demographic	Participants (%)
Gender (10927 family members)	
Male	5404 (50.55)
Female	5523 (49.45)
Religion	
Hinduism	2292 (72.42)
Islam	758 (23.94)
Christianity	109 (3.44)
Others	6 (0.3)
Caste	
General	1023 (32.32)
SC	1486 (46.95)
ST	573 (18.1)
OBC	83 (2.63)

Table 3: Distribution of HHs based on Residential Vulnerability (n= 3165)

Residential Vulnerability	Participants(%)
Slum Status	
Homeless/Temporary Shelters	7 (0.2)
Unauthorized Settlement	326 (10.3)
Registered Slum	2832 (89.5)
Migration status	
Recent /Seasonal Migration	87 (2.7)
Living in area from few Yrs (1-5 Yrs)	133 (4.3)
More than 5 years	2945 (93)
Location of the household‡	
Road side	1651 (52.2)
Polluted water	796 (25.2)
Besides dumping ground	747 (23.6)
High Tension wire	82 (2.6)
Along Railway Line	27 (0.8)
Other Hazardous area§	6 (0.2)
Toilet And Bathing Facilities	
No Toilet, Defecation in the open	11 (0.4)
Community Toilet & no bath facilities	1410 (44.5)
Private space for Bathing & Toilet	1744 (55.1)
Source Of Water	
Have Individual piped water	2206 (69.7)
Community Tap / Water Tanker	-
Regular water supply	775 (24.5)
Irregular water supply	184 (5.8)

‡multiple response questions, numbers don't add up to total HHs.
§ "Other Hazardous area" - Foothill/ Land slide prone area, Gas pipeline, Electric sources/ Electromagnetic Radiation

Table 4: Distribution of HHs based on Social Vulnerability (n= 3165)

Social Vulnerability	Participants (%)
Social Support	
Living far from the family, no social support available at all.	95 (3)
Living alone in the area but people from your community are living nearby	230 (7.2)
Not Applicable	2840 (89.7)
Episodes Of Harassment	
Very Often	25 (0.8)
Rarely	231 (7.3)
Not at all	2909 (91.9)
ID Proof	
Have all the Necessary Documents	95 (3)
Have at least one legal document	3063 (96.8)
Do not have any documents	7 (0.2)
Disability Status	
Presence of a Person with Disability	93 (3)

Out of 10927 family members among 3165 HHs, 50.5% of the population were males, 834 (7.6%) under 5 children, 1743(15.9%) adolescents (10-19 years) and 817 (7.4%) elderly >60 years). The age group of the household members ranged from new born child to 98 years old geriatric. 72.42% HHs belonged to Hindu religion and 46.95% of the HHs belong to Scheduled Caste category (Table 2).

According to "World Report on Disability" by the World Health Organization (WHO) in 2011 [11], about 15% of the world's population lives with some form of disability, of whom 2-4% experience significant difficulty in functioning. As per Census 2011, in India, out of the 121 Cr population, about 2.68 Cr persons are 'disabled' which is 2.21% of the total population [Disabled Persons in India, A statistical profile 2016][12]. The present survey also showed that prevalence of disability being 3% which was almost like that of the national average (Table 4).

HEALTH RELATED VULNERABILITY

72% of the HHs in the slums sought health care services from the Government facilities and 27.8 % from the private providers. 0.2% of them did not seek any health care facilities making them vulnerable to various Communicable and Non-Communicable Diseases (Table 6).

ANM visit to Household for Health Services

70.5% of the HHs are visited by ANM monthly or twice a month and 19% of the houses are visited once in three months. 10.5% of the houses were never visited by ANM for health care services which show that these are the HHs which need immediate focus and health care workers need to be deployed in these areas.

When enquired regarding any deaths in the HHs in the past 5 years, 71 (2.2%) reported at least 1 death. Heart attack (ischemic heart disease) accounted for 28.2% of households reporting such death (s). Debilitating illnesses were reported as a cause of death in 11 (15.5%) of HHs reporting deaths (Table 7).

Out of pocket Expenditure (Financial Vulnerability)

1380 (43.60%) and 902 (28.49%) HHs had expenditure for outpatient (in the past 1 month) and inpatient (in the past 1 year) health care services respectively.

642(40.35%) among the HHs who had expenditure on the health care services in the past 1 year had faced catastrophic health expenditure (>10% of their household income was spent on health) [13] which indicates that there is high chance of these HHs being pushed towards impoverishment.

Table 5: Distribution of individuals of HH based on Occupational Vulnerability

Occupation	Participants (%)
Unemployed	5364 (56.3)
Regular	3005 (31.5)
Irregular	1168 (12.2)

Table 6: Health care seeking among HHs of urban slum (n=3165)

Facilities sought for Health Care	Participants (%)
Government	2147 (72)
Private	828 (27.8)
Do not take treatment	7 (0.2)
Total	3165 (100)
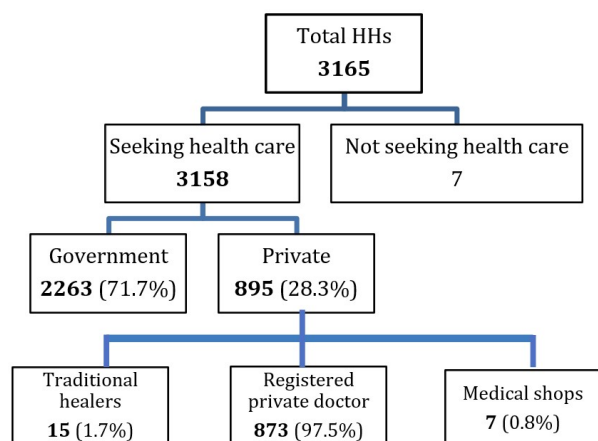
Figure 3: Pattern of Health Care Seeking according to type of facilities and practitioners (n = 3165)

Table 7: Deaths in the Past 5 Years

Category of Death	HHs reported death (% of total HHs reported deaths)
Maternal Death	3 (4.2)
Death of Child (<1year)	1 (1.4)
TB Death	6 (8.5)
Heart attack	20 (28.2)
Cancer	5 (7)
Others††	36 (50.7)
Total	71 (100)

†† Others – accidents (14), suicide (2), homicide (1) & other deaths (19)

Table 8: Proportional Morbidity Data

Disease	Cases (%)
Diabetes	415 (41.5)
Hypertension	410 (41.0)
Heart Disease	60 (6.0)
Hypothyroidism	57 (5.7)
Pneumonia	15 (1.5)
Dengue	14 (1.4)
Stroke	11 (1.1)
Diarrhoea	7 (0.7)
Cancer	5 (0.5)
Undernourished	4 (0.4)

HIV-1(0.1) & RTI – 1(0.1); Physiological Conditions - ANC – 14 and PNC-7. (‡ ‡the percentage in the table doesn't add up to 100% as there were multiple responses)

Table 9: Cumulative Vulnerability

Vulnerability (score)	No. of HHs (%)
For HHs	
Most Vulnerable (0-15)	0
Highly Vulnerable (16-30)	1452 (45.8)
Vulnerable (31-42)	1713 (54.2)
Total	**3165 (100)**
For Slum	**No. of slums (%)**
Most Vulnerable (0-15)	0
Highly Vulnerable (16-30)	6 (50%)
Vulnerable (31-42)	6 (50%)
Total	**12 (100)**

Geographic Information Systems (GIS) and the accompanying methods and data have been adopted increasingly in diverse health-related domains and national settings with the goal of improved response to public health problems.[14,15] Figure 4 shows geographic or spatial mapping of the HHs surveyed during the pilot phase of Vulnerability Assessment carried out at Urban Primary Health Centre catchment area. The objective was to get an accurate map of the HHs present within the slum with all geographic information with respect to NUHM. The base map including knowledge of location of all health facilities (public and private), their catchment areas, slums with population, Anganwadi centres, educational institutions (public and private) Municipal and ward boundaries, major road networks, major landmarks, agriculture land, major water bodies etc. were obtained through Public Health Information and Epidemiological Cell (PHIEC). The layer of the surveyed HHs was added up on the same.

DISCUSSION

The vulnerability assessment at the household level showed that 45.8% (1452) of them were highly vulnerable and 54.2% (1713) were vulnerable whereas the slum level data 50% of the slums were highly vulnerable and other 50% were vulnerable.

Among 3165 HHs - 0.2% of the HHs were staying in temporary shelters; 2.7% were seasonal migrants; 25.2% stay besides polluted water, 23.6% besides dumping ground and 2.6% near high tension wire; 0.4% have no access to toilet facilities; and 5.8% of the HHs have irregular water supply.

In a Vulnerability Assessment conducted by BT Rao, JS Thakur by using rapid survey method it was observed that 15 slums (36.6%) were highly vulnerable, 21 (51.2%) were moderately vulnerable and 5 (12.2%) were low vulnerable.[2]

Vulnerability assessment conducted in Chandigarh, India (2012) by Subhakanta Mohapatra[16] showed that - in highly vulnerable slums more than 60% of the population suffers from the lack of basic infrastructural facilities include housing structure, access to safe drinking water, poor drainage system, basic sanitation facilities, type and nature of employment and health facilities (immunization, institutionalized delivery).
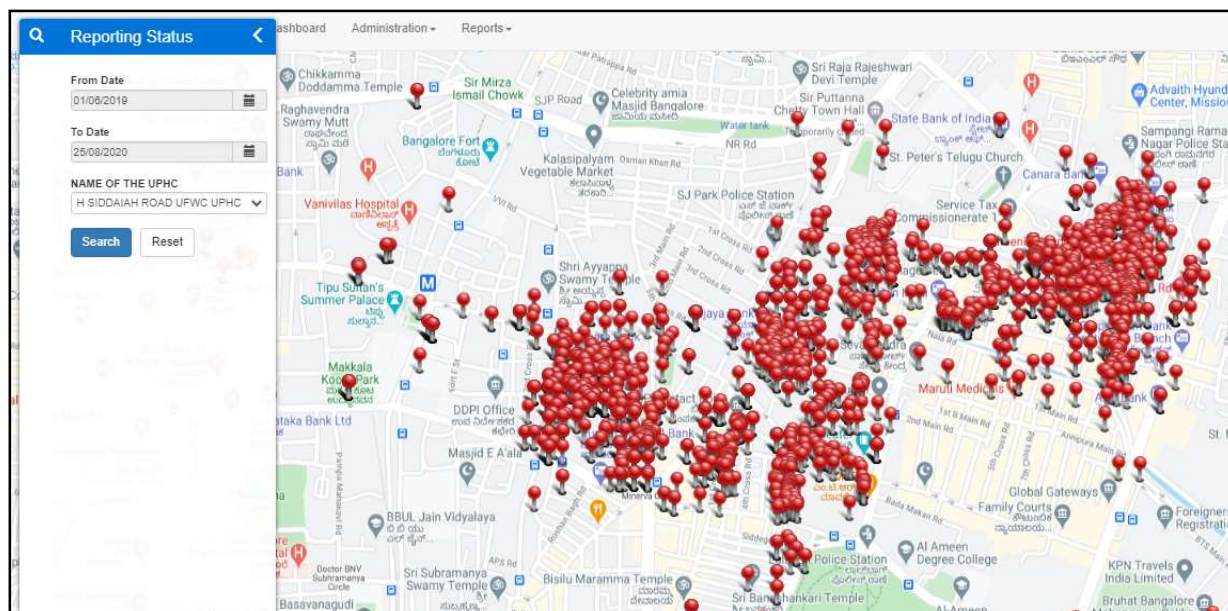
Figure 4: GIS mapping of the HHS covered during vulnerability assessment

On the other hand, in less vulnerable slums, less than 45% of the population suffers from a lack of these facilities and indicators. There exists a lack of dependable data on the various aspects of slum life. This includes the number of slums, size of slum populations, access to services like water and sanitation, livelihood, morbidity patterns etc.

Vulnerability Survey conducted by Siddharth Agarwal, Shivani Taneja, Pradeep Patra showed that - Government of India[17] study on the condition of urban slums also shows that the respective authorities notified a little more than half of the slums in the urban areas of the country. The findings in five Indian cities showing differential vulnerability status – Indore -highly Vulnerable 66 (12.24%), moderately vulnerable 92 (17.06%), less vulnerable 381 (70.68%); Dehradun - highly Vulnerable 26 (25%), moderately vulnerable 48 (46.15%), less vulnerable 30 (28.84%); Haridwar - highly Vulnerable 31 (40.78%), moderately vulnerable 35 (46.05%), less vulnerable 10 (13.15%); Bally, West Bengal - highly Vulnerable 50 (40.98%), moderately vulnerable 65 (53.27%), less vulnerable 7 (5.7%). Unregistered slums are more deprived on various counts than registered slums. a) Dehradun:14 of the 78 officially listed slums were highly vulnerable while corresponding number for unlisted slums was 12 in the located 28 unlisted areas; b) Bally: 27 of registered 75 slum, and 23 of 48 unregistered slums were assessed to be highly vulnerable. c) Agra: Uttar Pradesh (Population 12.75 lakh) 93 out of 178 unrecognized slums were highly vulnerable while 90 out of the total 215 recognized slums were belonged to the same category.

The slum assessment exercise carried out by USAID-EHP Urban Health Program in six Indian cities provides ample evidence of this. In Dehradun, 28 unlisted slums were identified against 78 listed ones, in Bally (6) 48 unlisted slums were identified against 75 listed ones, Indore the figures were 159 unlisted against 439 listed ones. Of the total 513 slums identified in Agra the urban authority listed only 219.[18]

A pilot study conducted by Centre for Education & Documentation (CED) shows that the predominant vulnerability of people living in the slums under study is water logging and flooding. Most vulnerable are those who have mud flooring, this combined with poor drainage of grey water in the neighbourhood, makes any kind of perturbation extremely intolerable. In Khader Sharif Garden, most floors would be cement and roofs tiled or of asbestos. Here there is a little mobility and excessive crowding. [19]

The study conducted by Wankhade K et al. showed that five slums (one from PNP and four from NNP) belonged to the 'moderately vulnerable' category with scores ranging between 16 and 20. The rest of the slums belong to the 'least vulnerable category' with scores ranging between 11 and 15. The scores also indicate that slums are quite homogeneous in terms of their vulnerability.[20]

CONCLUSION

The baseline information of slums, vulnerable pockets and their geographic mapping obtained during the survey can be used as foundation for effective planning of delivery of health care services for a given area population. The vulnerability mapping along with the mapping of the health facilities will complement the overall planning exercise and can be used for assistance in the Site Planning for community process activities.

RECOMMENDATION

Also the Medical Colleges can implement the platform at their Urban Health Training Centres under

their Department of Community Medicine and their respective catchment areas, which would aid in planning regular follow up visits and in providing Preventive, Promotive and Curative Health Services at the community level. "Namma Samudaya" application provides a platform for dashboard generation and monitoring the trends of Communicable and Non- Communicable diseases which can be utilized for decision making, planning and implementing disease specific programs on a long term basis & in sustainable manner. The results obtained can be easily collated through the digital platform and can be utilized for improved continuum of care.

REFERENCES

1. Census of India Website: Office of the Registrar General & Census Commissioner, India [Internet]. Censusindia.gov.in. 2022 [cited 12 June 2021]. Available from: https://censusindia.gov.in/2011-common/censusdata2011.html

2. Thakur J, Rao B. Vulnerability assessment in slums of union territory, Chandigarh. Indian Journal of Community Medicine. 2007;32(3):189.

3. Urban Poverty & Vulnerability in India. DFIDs experiences from a social policy perspective [Internet]. Ucl.ac.uk. 2001 [cited 16 June 2022]. Available from: https://www.ucl.ac.uk/dpuprojects/drivers_urb_change/urb_society/pdf_liveli_vulnera/DFID_Loughhead_Reducing

4. Agarwal S, Satyavada A, Kaushik S, Kumar R. Urbanization, Urban Poverty and Health of the Urban Poor: Status, Challenges and the Way Forward [Internet]. Papers.ssrn.com. 2022 [cited 12 June 2020]. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3133050

5. National Urban Health Mission. Guidelines and Tools for Vulnerability Mapping & assessment for urban Health [Internet]. New Delhi: Ministry of Health and Family Welfare, Government of India; [cited 12 Aug 2020]. Available from: http://nhm.gov.in/images/pdf/NUHM/Guidelines_and_tools_for_vulnerability_mapping.pdf

6. Sia W, S. S, K.A. K, S. S, N. B, I. M. India: health system review [Internet]. Apps.who.int. 2022 [cited 15 June 2022]. Available from: https://apps.who.int/iris/handle/10665/352685

7. Media report (20 July to 2 Aug Indian Council of Medical Research, Department of Health Research – Ministry of Health & Family Welfare Government of India [Internet]. 2019 [cited 2020 Aug 12] Available from: file:///C:/Users/HP/Downloads/Icmr_news.pdf

8. Castro Lopes, S., Guerra-Arias, M., Buchan, J. et al. A rapid review of the rate of attrition from the health workforce. Hum Resour Health 15, 21 (2017). https://doi.org/10.1186/s12960-017-0195-2

9. Electronic versus paper-based data collection: reviewing the debate [Internet]. World Bank Blogs. 2022 [cited 15 June 2022]. Available from: https://blogs.worldbank.org/impactevaluations/electronic-versus-paper-based-data-collection-reviewing-debate

10. Induction Training Module for ASHAs in Urban Areas (Annexure 12) [Internet]. Nhm.gov.in. 2021 [cited 19 May 2021]. Available from: https://nhm.gov.in/images/pdf/NUHM/TrainingModule/Induction_Training_Module_for_ASHAs.pdf

11. World Report on Disability [Internet]. Who.int. 2011 [cited 18 June 2020]. Available from: https://www.who.int/teams/noncommunicable-diseases/sensory-functions-disability-and-rehabilitation/world-report-on-disability

12. Disabled Persons in India: A statistical profile [Internet]. People's Archive of Rural India. 2016 [cited 19 June 2021]. Available from: https://ruralindiaonline.org/en/library/resource/disabled-persons-in-india-a-statistical-profile-2016/

13. Organization W. Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies [Internet]. Apps.who.int. 2022 [cited 18 August 2020]. Available from: https://apps.who.int/iris/handle/10665/258734

14. Ruiz MO, Sharma AK. Application of GIS in public health in India: A literature-based review, analysis, and recommendations. Indian J Public Health [Internet]. 2016 [cited 2018 Jun 10];60(1):51–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26911217

15. Musa GJ, Chiang P-H, Sylk T, Bavley R, Keating W, Lakew B, et al. Use of GIS Mapping as a Public Health Tool-From Cholera to Cancer. Heal Serv insights [Internet]. 2013 [cited 2018 Jun 11];6: 111–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25114567

16. Mohapatra S. Assessing Differential Health Vulnerability of the Slums in Chandigarh, India. Internationales Asienforum. 2012; 43(1–2): 81–98.

17. Agarwal S, Taneja S, Patra P. Health Vulnerability Assessment of Slums – A tool for better planning of health programs in urban areas [Internet]. 2005 [cited 12 Aug 2020] Available from: https://www.researchgate.net/publication/261596160_Health_Vulnerability_Assessment_of_Slums_-_A_tool_for_better_planning_of_health_programs_in_urban_areas

18. Urbanization, Urban Poverty and Health Vulnerability. USAID-EHP Urban Health Program pursuant to recommendations of the Urban Health Working Group at the RCH II consultation [Internet]. Uhrc.in. 2020 [cited 16 June 2020]. Available from: http://www.uhrc.in/uhgateway/documents/1120.pdf

19. Education CF. Vulnerability Assessment of Urban Marginalised Communities: A Pilot study in Bangalore Slum areas. Change. 2011;

20. Vulnerability Assessment of Slums in Periyanaicken-Palayam and Narasimhanaicken-Palayam – IIHS Knowledge Gateway [Internet]. Iihs.co.in. 2022 [cited 18 June 2022]. Available from: https://iihs.co.in/knowledge-gateway/vulnerability-assessment-of-slums-in-periyanaicken-palayam-and-narasimhanaicken-palayam/