Tracking Sustainable Development Goals in Urban Slums using SMAART framework

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Introduction

The Sustainable Development Goals (SDGs) are a set of global goals within a universal agreement to end poverty, protect all that makes the planet habitable, and ensure that all people enjoy peace and prosperity now and in the future (1). In September 2015, the United Nations General Assembly accepted the 2030 Development Agenda and included 17 new Sustainable Development Goals (SDGs). These goals provide the best chance to ensure the necessary collaboration and alignment as we implement global approaches to securing a fair, healthy, and prosper future for all. The UN resolution refers to five areas of critical importance known as the 5Ps including People, Planet, Prosperity, Peace, and Partnerships (1).

Currently, 54% of the world's population lives in urban areas, a proportion expected to increase to 68% by 2050 (2). As part of the post-2015 United Nations Sustainable Development Agenda, the world has, as its first urban sustainable development goal (USDG), "to make cities and human settlements inclusive, safe, resilient and sustainable". By 2030, it is projected that over fifty percent of the low- and middle-income countries' (LMICs) residents will reside in cities. Urbanization brings overcrowding, social, health, and pollution challenges (3). Urbanization cultivates inequality and exclusion creating cities and dwellings characterized by poverty, overcrowded conditions, poor housing, severe pollution, and absence of basic services like water and sanitation (4).

Slum settlement, result of the rapid worldwide urbanization, is a common site in most developing countries. Slum households lack one or more of the following: (a) durable housing of permanent nature, (b) sufficient living space, which means not more than three people sharing the same room, (c) easy access to safe water in sufficient amounts at an affordable price, (d) access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people and (e) security of tenure that prevents forced evictions (5). One-third of the developing world's population lives in urban slums. To meet the Sustainable Development Goals, low- and middle-income countries must make substantial progress in ending extreme poverty, ensuring access to essential infrastructure, curbing environmental degradation, and promoting social inclusion. Reaching these goals will require deep transformations as well as major efforts in monitoring and measuring progress in every country.

Good data and clear metrics are critical for each country to devise pathways of achieving the goals, and track progress. Three types of data challenges need to be addressed to improve baseline measurement of the SDGs and to ensure effective monitoring (6). First, some SDG priorities lack scientifically robust indicator definitions that can be applied in a broad range of countries. Second, some indicators require better and more frequent data collection and dissemination, particularly in poor countries where data is either unavailable or estimated. Third, in other areas data is collected by scientists or available through big data but is not adequately used to inform official SDG monitoring efforts at national, regional and global levels. Because of these data gaps, some SDGs remain poorly measured. There is a need for scientifically robust tools to help operationalize the SDGs at various levels in order to begin a process of data-driven and evidence-based implementation and follow-up.

In addition to requiring greater financial resources and political commitments, these transformations will also place major demands on science to devise data and monitoring frameworks. Although none of the 17 SDGs particularly refers to Information and Communications Technologies (ICTs), the 2030 Agenda for Sustainable Development still claims that the ICTs can substantially accelerate the development and progress of human beings and may greatly bridge the digital gaps to construct knowledge communities (7).

The objective of this study is to discover the correlations among various SDG indicators across urban slum settings utilizing SMAART informatics framework. The findings of this study can help inform and understand interactions between various SDG indicators; and

guide development and implementation of data driven, community based interventions to address various SDGs through evidence-based policy-making.

SMAART informatics framework
The SMAART informatics framework is designed using the combined principles of Data, Information and Knowledge (DIK), Human Centered Approach, and Information Processing Theory and Humanistic, Behavioral, and Learning theories (8). This Population Health Informatics (PopHI) framework provides a platform to collect process and present population data, in a meaningful and contextually relevant format that is easy to understand. SMAART framework utilizes DIK pathway to make data more meaningful and consists of several components (8)

- *Data sources:* Social determinants of health data are typically organized at a geospatial unit and often has 3 dimensions: (a) attribute (i.e., context), (b) spatial (i.e., geographic) and (c) temporal (i.e., time). Attribute (context) component relates to issues of interest such as social and environmental data. Spatial (geographic) component includes data with location attributes (e.g. address, region, or country) and can provide insight into how and where to obtain important services. Temporal (time) component records time of the observation and enables users to learn from the past to predict, plan, and build the future. These data courses across spatial and temporal dimensions can help to answer how, who what, when and where related questions.
- *Data Management:* This component includes data collection, validation, storage, data transformation, and making data available in a format that is readily analyzable.
- *Data Analysis:* This component includes arithmetic and comparison operators to compute means, medians, percentage distribution and 95% Confidence Intervals. The goal is to present data at both individual and aggregate levels.
- *Interactive visualization:* The goal is to display meaningful information in various formats including tables, charts, graphs and maps.
- *User Interface:* This component allows the individuals to interact with the data to conduct specific analysis and visualize the information based on their needs and the users perform.

We utilized SMAART framework to design, develop and implement an interactive, internet enabled SMAART informatics platform for collection of data on various SDG goals, and facilitating data interpretation to make information meaningful that can inform design and development of interventions, programs and policies to address SDGs across various urban slum settings.

Methods

Data Collection and Study population
A cross-sectional study was conducted between June 2016 to January 2017 to assess individuals' perception about various Sustainable Development Goals living in urban slum settings of New Delhi, India. The sampling frame utilized was the Delhi Urban Shelter Improvement Board Jhuggi-Jhopadi (JJ) Cluster List of 2015, which enumerated 675 un-notified urban slums of New Delhi. We randomly selected 38 slum sites from the 675 un-notified slums using a convenience sampling approach (8). Ten percent of the households within each slum site were sampled resulting in an initial sample of 907 participants (North zone; n=12 slums; sample size n=264; South zone; n=14 slums; sample size n=275; East zone; n=6 slums; sample size n=206; West zone; n=6 slums; sample size n=162). Individuals who were aged 18 years and above, were residing in the slum, and gave voluntary consent to participate in the study were included. One member from each household was interviewed. The study protocol was approved by the Institutional Review Board (IRB) #FHTS/041/2016.

Variables gathered

Socio-demographics: Information was collected on participant's age, gender, educational status, occupation, household size, family size, and number of earning members in the household.

Access to technology: Information was collected about household cell phone ownership, access to internet, and participants' knowledge of cell phone texting.

Sustainable Development Goals (SDG) assessment: Information was collected about individuals' perception towards coverage of their basic needs including healthcare services, educational needs, employment needs, financial needs, Water, Sanitation & Hygiene needs, drinking water needs, electricity needs, general safety, women safety needs and child's health & education needs.

- ***SDG 1 No Poverty:*** It was evaluated using self-reported assessment of the extent to which financial needs were met or not.
- ***SDG 2 Zero Hunger:*** Household Food Insecurity was assessed using the HFIAS (Household Food Insecurity Access Scale) (10). This scale consisted of nine food insecurity questions, which included participant's perception of food vulnerability, or stress within the household and about their behavioral response in case of food insecurity (10). Each of these questions enquired whether a particular condition of food insecurity occurred in the household or not accompanied with what frequency (10). Households were categorized as increasingly food insecure when they responded affirmatively to more severe conditions or had experienced these conditions more frequently. All the household hunger questions were based on a recall period of four weeks. The original food insecurity categories—Food Secure, Mildly Food Insecure, Moderately Food Insecure and Severely Food Insecure—were collapsed into binary (food secure vs insecure) pertaining to small cell sizes for the mildly and severely food insecure categories.
- ***SDG3 Good Health and Well-Being****:* It was evaluated using self-reported assessment about the extent to which healthcare service needs were met or not.
- ***SDG4 Quality education****:* It was covered by assessing individuals' current educational status and the extent to which the educational service needs were met or not.
- ***SDG5 Gender Equality****:* It was evaluated by comparing proportion of individuals who owned a mobile telephone, by sex.
- ***SDG6 Clean Water and Sanitation****:* It was evaluated using self-reported assessment of the extent to which water, sanitation & hygiene needs and drinking water needs were met or not. Participants were also asked about accessibility to a toilet facility.
- ***SDG7 Affordable and Clean Energy:*** It was evaluated using self-reported assessment of the extent to which electricity needs were met or not.
- ***SDG8 Decent work and economic growth:*** It was evaluated using self-reported assessment of the extent to which a study participant's and his/her household's employment needs were met or not.

Additional variables assessed included perceived stress (11) (scores range from 0 to 40 with higher scores indicating higher perceived stress), general safety needs, women safety and child's health and education needs.

Statistical Analysis

Univariate analysis computed the means and frequency distributions of continuous and categorical variables (Tables 1, 2, 4). Bivariate unadjusted analyses examined the relationships within demographic variables, SDG indicators and technology-related items (cell-phone ownership, text messaging, and internet access) (Table2, 5). Pearson's Chi-squared tested associations between categorical variables (Respondent Education, Household Education, Number of Working Hours (Daily), Zone, Household Food Insecurity, Text Messaging Knowledge, Internet Access, Financial Needs, Healthcare Needs, Electricity, Child Health and Education Needs, Sanitation and Hygiene Needs, Drinking Water Needs, Employment Needs, Safety Needs and Women Safety Needs). We used T-Tests to compute association between continuous predictors (Age, Number of Household Members, Number of Earning Members in Household, and Perceived Stress Score) and dichotomous 'Cell Phone Ownership' and we used ANOVA for the already mentioned categorical outcome variables.

All SDG indicators collected in the study are ordinal type and measure perception of fulfilment of the need across three levels— 'Not Met At All', 'Somewhat Met', and 'Met'. Variables that were statistically significant at five percent level of significance in the bivariate analyses were then adjusted in the Cumulative Logistic Regression models (for ordinal data) to identify the predictors of each SDG indicator (not shown). The Proportional Odds Assumption of all the models was violated and results cannot be reported. As a result, the 'Somewhat Met' and 'Met' categories for all SDG items were collapsed and modeled as binary outcome variables in the final adjusted Multivariable Logistic Regression models (Tables 3, 6). All analyses were conducted using SAS Version 9.4 (SAS Institute Inc., Cary, NC).

Results

Study participant characteristics

The average age of our study participants was 36 years (± 13). More than half of them were females (66%, n=599), and 46% had less than or equal to high school. Fifty-percent of them lived in households where the highest level of education was high school (n=453), had an average of six household members with only one earning member per household. More than one–third of them were self-employed, with incomes below INR 5000. Almost half of the study participants worked for up to 8 hours daily (49%, n=420) and had an average perceived stress score of 20 (SD=4) indicating moderate perceived stress levels. Majority of our study sample owned a cell phone (83%, n=752). About one-third of them resided in the South zone of New Delhi.

Table 1. Population characteristics of the study participants

Socio-demographics	% (n=904)
Age, years *(Mean, SD)*	36(13)
Number of earning members *(Mean, SD)*	2(1)
Total household members *(Mean, SD)*	6(3)
Gender	
Male	34(305)
Female	66(599)
Respondent Education	
No schooling	42(376)
High school	46(418)
Intermediate/Diploma	7(61)
Some College	1(12)
Graduate/Postgraduate	4(37)
Household Education	
No schooling	16(142)

High school	50(453)
Intermediate/Diploma	17(155)
Some College	5(49)
Graduate/Postgraduate	12(105)
Number of working hours (daily)	
None	6(48)
Up to 6 hours	13(113)
Up to 8 hours	49(420)
Up to 10 hours	15(132)
More than 10 hours	17(141)
Cell phone ownership	
Yes	83(752)
No	17(152)
Zone	
West	17(151)
East	23(207)
North	29(262)
South	31(284)
Occupation	
None of the family member is employed	6(45)
Self-employed e.g. shops, rehdies or petty business with income > INR5000	18(130)
Self-employed with income < INR5000 (housewife, laborer)	36(264)
Service at shops, home, transport, own land cultivation	20(146)
Service in private sector or independent business	17(121)
Service in central/state/public undertakings or company owner employing > 20 persons	3(25)
Perceived Stress Score *(Mean, SD)*	20(4)

Socio-demographic and SDG-related indicators associated with cell-phone ownership

Age, education, earning members, working hours, perceived stress and zone of residence were significantly associated with cell-phone ownership among the study participants ($p < 0.05$). Cell phone ownership was significantly higher among study participants who had obtained a high-school education (50%, n=373), as well as those who lived in households where the highest level of education attained was high-school (51%, n=382). Cell-phone ownership was also significantly higher among residents of the South zone of New Delhi (36%, n=269). Gender (p=0.3012) and number of household members (p=.2074) was not significantly associated with cell-phone ownership.

All the SDG-related needs assessed including financial needs, health, education, sanitation, water, electricity, employment, safety, women's safety needs, and food insecurity, were significantly associated with cell-phone ownership ($p < 0.0001$). Cell-phone ownership was significantly higher among study participants who reported that their SDG needs were "Met" or "Somewhat Met" ($p < 0.0001$). More than half of those who were food secure owned a cell phone (56%, n=420), compared with those who were food insecure (44%, n=326). Text messaging and internet access were significantly associated with cell-phone ownership ($p < 0.0001$). Cell-phone ownership was significantly higher among study participants who were able to send text messages (59%, n=441), compared with those that could not send text messages (41%, n=311).

However, cell-phone ownership was higher among participants with no internet access (71%, n=535), compared with those with internet access (29%, n=217).

Table 2. Cell phone ownership by demographics and SDG indicators

Cell Phone Ownership	Yes	No	p-value[b]
	% (n=752)	% (n=152)	
Age *(Mean, SD)*	36(12)	39(15)	0.0052[c]
Number of earning members *(Mean, SD)*	2(1)	1(1)	<.0001[c]
Total household members *(Mean, SD)*	6(3)	7(4)	0.2074[c]
Gender			0.2823
Male	33(248)	38(57)	
Female	67(504)	62(95)	
Respondent Education			<0.0001
No schooling	37(279)	64(97)	
High school	50(373)	30(45)	
Intermediate/Diploma	7(55)	4(6)	
Some College	1(10)	1(2)	
Graduate/Postgraduate	5(35)	1(2)	
Household Education			<0.0001
No schooling	11(84)	38(58)	
High school	51(382)	47(71)	
Intermediate/Diploma	19(143)	8(12)	
Some College	6(45)	3(4)	
Graduate/Postgraduate	13(98)	5(7)	
Number of working hours (daily)			<0.0001
None	4(25)	15(23)	
Up to 6 hours	14(97)	11(16)	
Up to 8 hours	53(377)	28(43)	
Up to 10 hours	15(103)	19(29)	
More than 10 hours	14(101)	27(40)	
Perceived Stress Score *(Mean, SD)*	20(4)	21(4)	0.0007[c]
Zone			<0.0001
West	15(115)	24(36)	
East	20(150)	37(57)	
North	29(218)	29(44)	
South	36(269)	10(15)	
Financial needs			<0.0001
Not met	12(92)	46(70)	
Somewhat met	60(449)	39(60)	
Met	28(211)	15(22)	
Food insecurity			<0.0001
No	56(420)	37(56)	
Yes	44(326)	63(95)	
Healthcare needs			<0.0001
Not met	20(153)	48(74)	
Somewhat met	38(283)	30(45)	
Met	42(316)	22(33)	

Cell Phone Ownership	Yes	No	p-value[b]
	% (n=752)	% (n=152)	
Child health and Education needs			<0.0001
Not met	9(65)	40(60)	
Somewhat met	33(253)	32(49)	
Met	58(434)	28(42)	
Education needs			<0.0001
Not met	12(92)	47(71)	
Somewhat met	30(224)	27(42)	
Met	58(434)	26(39)	
Sanitation and hygiene needs			<0.0001
Not met	33(249)	52(79)	
Somewhat met	38(286)	34(51)	
Met	29(216)	14(21)	
Drinking water needs			<0.0001
Not met	26(192)	41(63)	
Somewhat met	35(264)	35(53)	
Met	39(295)	24(36)	
Electricity			<0.0001
Not met	5(39)	31(47)	
Somewhat met	11(80)	21(32)	
Met	84(632)	48(73)	
Employment needs			<0.0001
Not met	26(194)	57(87)	
Somewhat met	39(293)	24(37)	
Met	35(264)	19(28)	
Safety needs			<0.0001
Not met	18(140)	37(56)	
Somewhat met	27(201)	33(51)	
Met	55(411)	30(45)	
Women safety needs			<0.0001
Not met	15(114)	39(59)	
Somewhat met	27(202)	29(44)	
Met	58(435)	32(49)	
Text messaging knowledge			<0.0001
No	41(311)	97(147)	
Yes	59(441)	3(5)	
Internet access			<0.0001
No	71(535)	98(149)	
Yes	29(217)	2(3)	

[a]Total n=904 [b]Chi-sq p-value [c]T-test p-value for unequal variances

Having unmet financial (OR=5.71, 95% CI: 3.28, 9.93) and educational needs (OR=4.29, 95% CI: 2.52, 7.29) were associated with greater odds of not having a cell phone. Having some college education was also associated with greater odds of lacking a cell phone (OR=2.09, 95% CI: 0.27, 16.39). However, having a graduate or postgraduate education was associated with lower odds of lacking a cell-phone (OR=0.58, 95% CI: 0.09, 3.57). Residing in the East zone of New Delhi (OR=3.65, 95% CI, 2.04, 6.52) or West slum zones of New Delhi (OR=3.84, 95% CI: 1.99, 7.41) were associated with greater odds of cell-phone ownership. Having internet access was associated with lower odds of cell-phone ownership (OR=0.075, 95% CI: 0.022, 0.259).
Table 3: Predictors of not owning a cell phone: Adjusted Odds Ratios

Cell phone ownership (Outcome=No)	Multivariable Adjusted OR (95% CI)
Respondent education	
No schooling	Ref
High school	0.37 (0.23,0.60)
Intermediate/Diploma	0.39 (0.14, 1.18)
Some College	2.09 (0.27, 16.38)
Graduate/Postgraduate	0.58 (0.09,3.57)
Zone	
North	Ref
East	3.65 (2.04,6.53)
West	3.84 (1.98, 7.41)
South	0.67 (0.31, 1.45)
Internet access	
No	Ref
Yes	0.08 (0.02, 0.26)
Financial needs	
Met	Ref
Not met	5.71 (3.28, 9.94)
Drinking water needs	
Met	Ref
Not met	0.68 (0.39,1.18)

Sustainable Development Goal (SDG) indicators

More than half of the study participants reported that their electricity needs (78%, n=705), educational needs (52%, n=473), women safety needs (54%, n=484), and child health needs (53%, n=476) had been met. Fifty percent of our study sample reported that their safety needs had been met (n=456). More than half of the study participants reported that their financial (56%, n=509) and about one-third health (36%, n=328), sanitation (37%, n=377), water (35%, n=317) and household toilet facility needs (45%, n=409) needs had been only somewhat met (Table 4).

Less than one third of them reported that their financial needs (26%, n=233), sanitation needs (26%, n=237), household toilet facility needs (13%, n=118) had been met. Less than one-third also reported that their electricity needs (12%, n=112), safety needs (28%, n=252), and women's needs (27%, n=246) had been somewhat met.

Table 4. Distribution of Sustainable Development Goal (SDG) indicators

Sustainable Development Goals	%(n=904)
SDG 1: No Poverty	
Financial needs	
Not met	18(162)
Somewhat met	56(509)
Met	26(233)
SDG 2: Zero Hunger	
Food Insecurity	
Yes	47(421)
No	53(476)

SDG 3: Good Health and Wellbeing

Healthcare needs

Not met	25(227)
Somewhat met	36(328)
Met	38(349)

Child health and education needs

Not met	14(125)
Somewhat met	33(302)
Met	53(476)

SDG 4: Quality Education

Education needs

Not met	18(163)
Somewhat met	29(266)
Met	52(473)

SDG 6: Clean Water and Sanitation

Sanitation and hygiene needs

Not met	36(328)
Somewhat met	37(337)
Met	26(237)

Drinking water needs

Not met	28(255)
Somewhat met	35(317)
Met	37(331)

Household toilet facility needs

Not met (Open defecation)	42(377)
Somewhat met (Public)	45(409)
Met (In-house)	13(118)

SDG 7: Affordable and Clean Energy

Electricity needs

Not met	10(86)
Somewhat met	12(112)
Met	78(705)

SDG 8: Decent Work and Economic Growth

Employment needs

Not met	31(281)
Somewhat met	37(330)
Met	32(292)

Other variables

Safety needs

Not met	22(196)
Somewhat met	28(252)
Met	50(456)

Women safety needs

Not met	19(173)
Somewhat met	27(246)
Met	54(484)

Bivariate associations of demographic characteristics and SDG indicators with other SDG indicators

Results showed that the study participants' age was significantly associated with having unmet financial, health and employment needs (p<0.05) (Table 5). Gender was significantly associated with unmet financial, sanitation and hygiene, and employment needs (p<0.05). The study participants' education was significantly associated with sanitation and hygiene, drinking water, household toilet facility, electricity and employment needs (p<0.05). Household education was significantly associated with financial, education, household toilet facility, electricity, safety, and child health and education needs (p<0.05). The number of earning members in a household was significantly associated with unmet needs for all the SDG indicators except household toilet facility (p=0.1796). Perceived stress was not significantly associated with healthcare and education needs (p>0.05). Text messaging was not significantly associated with healthcare needs, safety and women safety needs (p>0.05). Internet access was not significantly associated with sanitation and hygiene, electricity, safety, women safety and child health needs (p>0.05).

Table 5. Bivariate unadjusted analyses showing associations of sociodemographic and SDG indicators with other SDGs

	SDGs Indicators (p-values)										
	Financial needs	Healthcare	Child health & education	Educational needs	Sanitation & hygiene	Drinking water	HH* toilet facility	Electricity	Employment	Safety	Women safety
Age	0.0032	0.0163	0.2252	0.2066	0.1000	0.0641	0.7344	0.9360	0.0324	0.9055	0.4323
Number of earning members	<0.0001	0.0033	0.0003	0.0014	0.0029	0.0332	0.1796	0.0035	<0.0001	0.0029	0.0029
Total household Members	0.0003	0.0036	<0.0001	0.0006	0.0052	<0.0001	<0.0001	<0.0001	0.0070	<0.0001	<0.0001
Perceived stress score	<0.0001	0.1126	0.0054	0.2324	<0.0001	<0.0001	<0.0001	0.0166	<0.0001	<0.0001	0.0007
Gender	0.0028	0.0902	0.6390	0.6390	0.0180	0.3576	0.1062	0.7647	0.0008	0.9546	0.6179
Respondent education	0.0958	0.5060	0.0767	0.1690	0.0046	0.0772	0.0001	0.0046	0.0032	0.4382	0.0650
Household education	<0.0001	0.2947	<0.0001	<0.0001	0.1594	0.0655	<0.0001	<0.0001	0.1377	0.0314	0.2061
Working hours	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zone	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.1259	<0.0001	<0.0001
Financial needs		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Healthcare	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Child health and education	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Educational needs	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sanitation & hygiene	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Drinking water	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
HH toilet facility	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001
Electricity	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001

	SDGs Indicators (p-values)										
	Financial needs	Healthcare	Child health & education	Educational needs	Sanitation & hygiene	Drinking water	HH* toilet facility	Electricity	Employment	Safety	Women safety
Employment	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001
Safety	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Women safety	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Food insecurity	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cell phone ownership	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Text messaging knowledge	<0.0001	0.1615	<0.0001	<0.0001	0.0030	0.0014	<0.0001	<0.0001	0.0080	0.5700	0.5707
Internet access	<0.0001	0.0072	0.0522	<0.0001	0.2758	0.0199	0.0030	0.0504	0.0002	0.1180	0.4658

- HH*: Household

Multivariable adjusted associations of demographics and SDG indicators with other SDG indicators

Results of the multivariable regression analysis showed that demographics including age, gender, number of earning members in the household and household education were not predictive of the SDG indicators assessed. The number of daily working hours were predictive of unmet sanitation needs, electricity, employment and safety needs (Table 6).

The predictors of unmet financial needs in the multivariable analysis included perceived stress, unmet electricity, employment and child health needs, household toilet facility, cell phone ownership and zone of residence. Having unmet electricity needs (OR=22.4, 95% CI: 8.64, 58.04), unmet employment needs (OR=6.24, 95% CI: 3.60, 10.81), unmet child health needs (OR=2.83, 95% CI: 1.43, 5.59) and perceived stress (OR=1.21, 95%CI: 1.13, 1.29) were associated with higher odds of unmet financial needs (Table 5). Owing a cell phone (OR=0.43, 95% CI: 0.23, 0.80), having an in-house toilet facility (OR=0.35, 95% CI: 0.15, 0.79) and residing in the west and south zone of New Delhi were associated with a lower odds of unmet financial needs. Having unmet health needs (OR=10.09, 95% CI: 6.05, 16.83), educational needs (OR=6.54, 95% CI: 3.38, 12.65) and financial needs (OR=3.83, 95% CI: 2.06, 7.12) were associated with a greater odds of unmet employment needs. Having unmet healthcare needs (OR=13.5, 95% CI: 7.56, 24.18), employment needs (OR=7.05, 95% CI: 3.83, 12.97), child health needs (OR=4.12, 95% CI: 2.19, 7.73), and food insecurity (OR=2.37, 95% CI: 1.35, 4.18) were associated with greater odds of unmet educational needs. Owning a cell phone was associated with lower odds of unmet educational needs.

Having unmet educational needs (OR=13.00, 95% CI: 7.03, 24.06), unmet employment needs (OR=10.02, 95% CI: 6.13, 16.37), unmet women's safety needs (OR=4.63, 95% CI: 2.55, 8.40) and unmet drinking water needs (OR=2.38, 95% CI: 1.42, 4.00) were significantly associated with a greater odds of unmet health needs. Having unmet safety needs (OR=64.9, 95% CI: 30.64, 137.69), child health and education needs (OR=38.21, 95% CI: 16.74, 87.18), healthcare needs (OR=4.23, 95% CI: 1.96, 9.14) and being food insecure were associated with a greater odds of unmet women needs (OR=5.22, 95% CI: 2.68, 10.18). Having unmet women's safety needs (OR=41.6, 95% CI=18.37, 94.30), electricity needs (OR=7.85, 95% CI: 2.97, 20.80), educational needs (OR=4.6, 95% CI: 2.20, 9.61), water needs (OR=4.04, 95% CI: 2.11, 7.73), and employment needs (OR=3.56, 95% CI: 1.70, 7.45) were associated with a greater odds of unmet child health needs. Working for more than 10 hours a day was associated with a greater odds of unmet safety needs (OR=12.37, 95% CI: 2.62, 58.31). Having unmet electricity (OR=24.09, 95% CI: 6.82, 85.08) and women needs (OR=40.21, 95% CI: 20.64, 78.31) were also associated with a greater odds of unmet safety needs.

Having unmet safety needs (OR=31.14, 95% CI= 8.58, 113.0), being food insecure (OR=13.74, 95% CI: 2.97, 63.6), having unmet financial needs (OR=13.13, 95% CI: 4.23, 40.72), drinking water needs (OR=6.43, 95% CI: 2.10, 19.69), education needs (OR=4.31, 95% CI: 1.39, 13.38), and child health needs (OR=3.98, 95% CI: 1.37, 11.61) were associated with a greater odds of unmet electricity needs. Having unmet water needs (OR=17.74, 95% CI: 11.15, 28.23), safety needs (OR=5.02, 95% CI: 3.02, 8.35), and financial needs (OR=2.61, 95% CI: 1.48, 4.59) were associated with a greater odds of unmet sanitation needs. Having unmet sanitation and hygiene needs (OR=16.01, 95% CI: 10.2, 25.13), electricity needs (OR=8.36, 95% CI: 2.91, 24.00), child health needs (OR=4.02, 95% CI: 1.83, 8.85), and owing a phone (OR=2.04, 95% CI: 1.07, 3.92) were associated with a greater odds of unmet drinking water needs.

Table 6. Logistic regression analysis predicting the odds of unmet needs for all SDG indicators

	Multivariable Adjusted OR (95% CI)- Need Not Met									
	Financial needs	Healthcare	Educational needs	Sanitation & hygiene	Drinking water	Electricity	Employment	Safety	Women safety	Child health & education
Household members						1.11 (0.99,1,24)				
Perceived Stress Score	1.21 (1.13,1.29)						0.93 (0.88,0.97)			
Working hours										
None				Ref		Ref	Ref	Ref		
More than 10				1.48 (0.48,4.54)		0.45 (0.07,2.95)	1.03 (0.37,2.88)	12.36 (2.62,58.31)		
Up to 10				1.76 (0.57,5.49)		0.79 (0.10,6.09)	1.78 (0.63, 5.02)	3.02 (0.62,14.71)		
Up to 8				1.98 (0.68,5.77)		0.12 (0.01,0.97)	0.75 (0.28,2.03)	2.51 (0.55,11.42)		
Up to 6						3.83 (0.42,34.83)	0.28 (0.09,0.89)	1.48 (0.27,7.96)		
Zone										
North	Ref	Ref		Ref	Ref				Ref	
East	1.12 (0.58,2.17)	0.84 (0.43,1.63)		1.08 (0.63,1.87)	0.99 (0.59,1.70)				1.06 (0.49,2.55)	
South	0.84 (0.43,1.65)	1.69 (0.90,3.19)		1.28 (0.77,2.12)	0.26 (0.15,0.46)				2.05 (0.97,4.34)	
West	0.14 (0.05,0.39)	0.56 (0.25,1.28)		0.51 (0.26,1.03)	0.30 (0.14,0.64)				0.26 (0.05,1.28)	
Healthcare										
Not met vs. Met			13.52 (7.56,24.18)				10.09 (6.05,16.83)		4.23 (1.96,9.14)	

	Multivariable Adjusted OR (95% CI)- Need Not Met									
	Financial needs	Healthcare	Educational needs	Sanitation & hygiene	Drinking water	Electricity	Employment	Safety	Women safety	Child health & education
Child health & education										
Not met vs. Met	2.83 (1.43,5.59)		4.12 (2.19,7.73)		4.02 (1.83,8.85)	3.98 (1.37,11.61)	2.20 (0.99,4.86)		38.21 (16.74,87.18)	
Educational needs										
Not met vs. Met		13.00 (7.03, 24.06)				4.31 (1.39,13.38)	6.54 (3.38,12.65)			4.60 (2.20.9.61)
Financial needs										
Not met vs. Met					2.61 (1.48,4.59)	13.13 (4.23,40.72)	3.83 (2.06,7.12)			
Sanitation & Hygiene										
Not met vs. Met					16.01 (10.2,25.13)			4.34 (2.34,8.05)		
Drinking water										
Not met vs. Met		2.38 (1.42,4.00)		17.74 (11.15,28.23)		6.43 (2.09,19.68)		2.34 (1.25,4.40)	0.24 (0.11,0.53)	4.04 (2.11,7.73)
Household toilet facility										
In-house vs open-defecation	0.35 (0.15,0.79)			0.65 (0.32,1.35)						
Public place vs open defecation	0.98 (0.45,2.15)			1.49 (0.72,3.06)						

	Multivariable Adjusted OR (95% CI)- Need Not Met									
	Financial needs	Healthcare	Educational needs	Sanitation & hygiene	Drinking water	Electricity	Employment	Safety	Women safety	Child health & education
Electricity										7.85 (2.97,20.80)
Not met vs. Met	22.4 (8.64,58.04)				8.36 (2.91,24.00)			24.09 (6.82,85.08)	0.48 (0.17,1.37)	
Employment										
Not met vs. Met	6.24 (3.60,10.81)	10.00 (6.13,16.37)	7.05 (3.83,12.97)						0.30 (0.13,0.67)	3.56 (1.70,7.45)
Safety										
Not met vs. Met				5.02 (3.02,8.35)	1.92 (0.95,3.87)	31.14 (8.58,113.0)			64.95 (30.64,137.69)	0.31 (0.13,0.72)
Women needs										
Not met vs. Met		4.63 (2.55,8.40)			0.32 (0.14,0.72)		0.28 (0.14,0.56)	40.21 (20.64,78.31)		41.62 (18.37,94.30)
Food insecurity (Yes)		0.54 (0.33,0.91)	2.37 (1.35,4.18)	0.56 (0.36,0.85)		13.74 (2.97,63.60)		0.42 (0.23,0.8)	5.22 (2.68,10.18)	
Cell phone (Yes)	0.43 (0.23,0.80)		0.43 (0.23,0.81)		2.04 (1.07,3.92)					
Internet access (Yes)							0.51 (0.30,0.85)			

Discussion

Results showed that demographics including age, gender, number of earning members in the household and household education were not predictive of the SDG indicators assessed. The number of daily working hours were predictive of unmet sanitation needs, electricity, employment and safety needs.

Our study findings showing that around 10% of the study participants had unmet electricity needs were consistent with findings from prior literature. According to a study assessing resource requirements across 10 Indian cities, around 6% of households lack electricity and about 14-71% of households utilize below the International Energy Agency benchmark of 25kWh capital-month (12). Rising demand and pressure on supply are key constraints on power supply in India, with the burden disproportionately affecting the poor (12). This is consistent with our study findings showing that having unmet financial needs were associated with a 13 times greater odds (OR=13.13, 95% CI: 4.23, 40.72) of unmet electricity needs.

More than one-third of our study participants had unmet sanitation needs. This is consistent with findings showing that an average of 33% of households across 10 Indian cities lack connection to a sewage system (12). Drainage issues are predominant in the literature around urban slum challenges (13). These conditions are often exacerbated during natural disasters or extreme rainfall and frequently affect both the urban poor and non-poor. This is consistent with our study findings showing the impact of unmet financial needs on sanitation (OR=2.61, 95% CI: 1.48, 4.59). A key predictor of unmet sanitation needs in our study was unmet drinking water needs (OR=17.74, 95% CI: 11.15, 28.23). Access to water is linked to multiple dimensions of human well-being. In particular, poor access to safe, adequate and affordable water sources promotes negative health outcomes and other aspects of wellbeing such as education and electricity. According to an excerpt from a qualitative study linking water services and human wellbeing in India:

> "[t]he people over here are poor. They make maybe around 100-200 INR per day. However, just imagine that they are going to be paying INR rupees for this water, for drinking water. Therefore, this causes many problems for us. It is not just the drinking water; they are also paying for the water from the bore well. They are paying for drinking water; they are paying for bore water. They must look after their families, they must look after the health issues, and they have to pay electricity. So, there is a lot of problems that we face." (14)

Such high out-of-pocket spending on water can have severe implications on the ability of households to provide essential services such as healthcare. Our study showed that unmet water needs was a significant predictor (OR=2.38, 95% CI: 1.42, 4.00) of unmet healthcare needs. Healthcare services in India are financially demanding and predominantly require out-of-pocket payments. These high healthcare costs have been indicated as the leading cause of impoverishment among Indians. The present study did not find a significant association between financial needs and unmet healthcare needs. However, unmet child health needs (OR=2.83, 95% CI: 1.43, 5.59) was a significant predictor of financial needs.

Safety remains a major challenge facing urban slum populations, which are home to an increasing female population. Two-thirds of our study participants were females. The safety and security of young girls and women in urban slums are frequently compromised by the lack of adequate water, sanitation and hygiene infrastructure (WASH), requiring them to travel longer distances in search of water for cleaning, and cooking or in search of safety and privacy for bathing or sanitation (15). Female reproductive needs in slum settings are further compromised by inadequate WASH infrastructure during their menstrual cycles. Subsequently, slum residents are subjected to open defecation practices thereby promoting poor health outcomes and contaminating their surrounding environments. (15). These findings are consistent with our study results showing that women's healthcare needs were a strong predictor (OR= 4.23, 95% CI: 1.96, 9.14) of unmet safety needs.

Individual health (OR=10.09, 95% CI: 6.05, 16.83) and educational needs (OR=6.54, 95% CI: 3.38, 12.65) were key predictors of unmet employment needs. Slum residents predominantly migrate to urban settings in search of better employment opportunities. Education is strongly associated with health inequities since it provides a main route out of poverty and empowers people—financially, psychologically, and politically. (16). Higher educational attainment subsequently improves health both directly and indirectly through provision of access to better work and economic conditions, social–psychological resources, and information management that allows disadvantaged individuals to make better choices and achieve healthier lifestyles (17). Employment availability, salaries, and working conditions affect health equity through material and social empowerment.

Cell-phone ownership was associated with a greater odds of unmet water needs (OR=2.04, 95% CI: 1.07, 3.92), but associated with a lower odds of unmet financial and educational needs (OR=0.43, 95% CI: 0.23, 0.80). However, internet access was only predictive of unmet employment needs (OR=0.51, 95% CI: 0.30, 0.85). Urban slums has been referred to as "collaborative environments for building digital literacies. However, technologies such as internet access are often leveraged for financial gain rather than educational gain in such settings. The mobile internet in the wild and every day: Digital leisure in the slums of urban India). For instance, a prior study indicated that mobile stores in Mumbai slums make more money from downloading audio-visual content rather than selling SIM cards. This is consistent with our study findings showing lower odds of unmet financial needs with cellphone ownership (OR=0.43, 95% CI: 0.23, 0.80).

Findings of our study show how the SDG indicators assessed are inter-related in their scope of influence. Attaining the goals of these SDGs requires a background on how these indicators interact with one-another in various settings. Our study provides a good background for further research in this area. By using a SMAART framework, we show how various SDG indicators can be measured across urban slum settings. Key findings from our study suggest that popular demographics factors such as age, gender, number of earning members in the household, may not always predict SDG-related needs. Further research is needed to understand their impact on the SDG indicators in other settings.

Bibliography

1. Morton Stephen, Pencheon David, Squires Neil. Sustainable Development Goals (SDGs), and their implementation: A national global framework for health, development and equity needs a systems approach at every level. Br Med Bull. 2017 124(1):81-90
2. United Nations, Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: Economic & Social Affairs. New York: 2014. 1–32. Available from: https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.pdf.
3. Omulo Godfrey, Muhsin Musinguzi, Kasana Ismail, Nabaterega Resty. A proposal for empowering slum dwellers as a viable way of addressing urbanization challenges in Katanga slum, Kampala, Uganda. 2017. Environ Eng Res. 22 (4)
4. de Snyder VN, Friel S, Fotso JC, Khadr Z, Meresman S, Monge P, Patil-Deshmukh A. Social conditions and urban health inequities: realities, challenges and opportunities to transform the urban landscape through research and action. J Urban Health. 2011;88(6):1183-93
5. UN-Habitat. State of the World's Cities 2012/2013: Prosperity of Cities. Routledge. 2013. Available from: https://unhabitat.org/books/prosperity-of-cities-state-of-the-worlds-cities-20122013/ Cited 31 Jul 2019
6. Schmidt-Traub, G., Kroll, C., Teksoz, K., Durand-Delacre, D. and Sachs, J. (2017): National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. Nature Geoscience 10 (8), 547-555.
7. Transforming Our World: The 2030 Agenda for Sustainable Development, New York, NY, USA: UN Gen. Assembly, 2015.
8. Joshi A, Arora M, Malhotra B. Usability Evaluation of a Portable Health Information Kiosk Using a SMAARTTM Intervention Framework. Glob J Health Sci. 2017;9(8):153
9. Saunders MN. Choosing research participants In: Simon G and Cassell C, editors. The practice of qualitative organizational research: core methods and current challenges. London: Sage; 2012. April 5 pp 35–52
10. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2007. Available from: http://www.fao.org/fileadmin/user_upload/eufao-fsi4dm/doc-training/hfias.pdf Cited 31 July 2019.
11. "Perceived Stress Scale." accessed 08/01, 2019, https://das.nh.gov/wellness/Docs/Percieved%20Stress%20Scale.pdf.
12. Nagpure, Ajay Singh, Mark Reiner, and Anu Ramaswami. "Resource Requirements of Inclusive Urban Development in India: Insights from Ten Cities." *Environmental Research Letters* 13, no. 2 (2018): 025010.
13. Yu, Jessica, Harry Shannon, Andrea Baumann, Lisa Schwartz, and Mihir Bhatt. "Slum Upgrading Programs and Disaster Resilience: A Case Study of an Indian 'Smart City'." *Procedia Environmental Sciences* 36 (2016): 154-61.
14. Gimelli, Francesco M, Briony C Rogers, and Annette JJ Bos. "Linking Water Services and Human Wellbeing through the Fundamental Human Needs Framework: The Case of India." *Water Alternatives* 12, no. 2 (2019): 715.
15. Klett-Davies, Martina. *Young Female Adolescents in Urban Areas of the Global South, the Challenges of Slums and Potential Solutions - Rapid Evidence Review.* 2017. doi:10.13140/RG.2.2.15036.54408.

16. de Snyder, V. Nelly Salgado, Sharon Friel, Jean Christophe Fotso, Zeinab Khadr, Sergio Meresman, Patricia Monge, and Anita Patil-Deshmukh. "Social Conditions and Urban Health Inequities: Realities, Challenges and Opportunities to Transform the Urban Landscape through Research and Action." [In eng]. *Journal of urban health : bulletin of the New York Academy of Medicine* 88, no. 6 (2011): 1183-93.

17. "Why Education Matters to Health: Exploring the Causes." 2015, accessed 08/01, 2019.