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Synergies and trade-offs between energy-efficient urbanization and health

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Abstract

Energy-efficient urbanization and public health pose major development challenges for India. While both issues are intensively studied, their interaction is not well understood. Here we explore the relationship between urban infrastructures, public health, and household-related emissions, identifying potential synergies and trade-offs of specific interventions by analyzing nationally representative household surveys from 2005 and 2012. Our analysis confirms previous characterizations of the environmental-health transition, but also points to an important role of energy use and urbanization as modifiers of this transition. We find that non-motorized transport may prove a sweet spot for development, as its use is associated with lower emissions and better public health in cities. Urbanization and improved access to basic services correlate with lower short-term morbidity (STM), such as fever, cough and diarrhea. Our analysis suggests that a 10% increase in urbanization from current levels and concurrent improvement in access to modern cooking and clean water could lower STM for 2.4 million people. This would be associated with a modest increase in electricity related emissions of 84 $ktCO_2e$ annually. Promoting energy-efficient mobility systems, for instance by a 10% increase in bicycling, could lower chronic conditions like diabetes and cardio-vascular diseases for 0.3 million people while also abating emissions. These findings provide empirical evidence to validate that energy-efficient and sustainable urbanization can address both public health and climate change challenges simultaneously.

Introduction

India is projected to add 400 million new urbanites to its existing 410 million by 2050, doubling its urban population within one generation (UN-DESA 2014). Urbanization offers the chance of a better life for many, providing improved access to infrastructure and living conditions (UN Habitat 2009). Yet, when public policy lags behind urbanization, as is currently the case in India and other emerging economies, it results in a new set of challenges. Where urban growth proceeds unplanned, dismal living conditions and inadequate infrastructure lead to growing inequities and an urbanization of poverty (McGranahan and Satterthwaite 2014, Ravallion *et al* 2007). In 2011, an estimated 17.2 percent of urban Indians were living in slums under detrimental public health conditions (Census of India 2011). Improving health and wellbeing of these populations requires rapid infrastructure development and extending modern services and amenities to all. However, rapid expansion of infrastructure in cities and rising personal incomes can, in turn, result in growing environmental footprints and associated health impacts. On average, household greenhouse gas (GHG) and pollutant emissions from urban areas already exceed those from rural areas (Donglan *et al* 2010, Krey *et al* 2012, O'Neill *et al* 2012).

Nonetheless, urban infrastructures are also at the center of demand-side action for climate change mitigation (Creutzig *et al* 2016a, Creutzig *et al* 2016b) and provide opportunities for improving social stability and economic well-being (Bongardt *et al* 2010).

Of total household emissions in urban India, three-fourth are from electricity and private transport energy use (Ahmad *et al* 2015). A significant fraction of urban populations in developing countries today thus face multiple overlapping environmental health risks and opportunities concurrently (Kjellstrom *et al* 2007, Marcotullio and Lee 2003).

Energy, transport, climate, and building policies all offer significant potential to improve the sustainability of cities (Creutzig 2016, Grubler *et al* 2012, Lucon *et al* 2014, Kahn Ribeiro *et al* 2012). But understanding of the potential health co-benefits and risks of these policies remains limited, especially at the level of individuals and households. The few studies that assess the health burdens of specific transport and energy policies do so at an aggregate level (Wilkinson *et al* 2009, Woodcock *et al* 2009). Yet understanding of the differential health outcomes and vulnerabilities of urban populations in developing countries and the multiple energy, transport and infrastructural correlates and confounders of these has not received adequate attention. Here we contribute to improving this understanding empirically using microdata from two rounds of the most recently available nationally representative longitudinal surveys from India (Desai *et al* 2010, 2015). We assess if there is a sweet spot in specific urban development measures that maybe associated with lower GHG emissions and better public health. We focus on understanding differences in traditional disease, labeled short term morbidity, and modern disease, labeled major morbidity, prevalence among Indians, as well as their residential and transport energy spending that correlate with emissions. We find significant differences in energy and transport spending and morbidity patterns among rural and urban households, about half of which can be attributed to differences in socioeconomic conditions and endowments. Our analyses suggest that access to clean cooking, water, and improved sanitation is correlated with lower short term morbidity. At the same time access to active (non-motorized) and public transit mobility options is associated with lower chronic disease morbidity, as well as more efficient energy use and lower emissions. Thus sustainable infrastructure development in cities can be an effective means to achieve public health as well as local and global environmental objectives and goals. This requires multi-sector integrated approaches to urban policies and planning to realize the greatest gains to human and environmental health and to improve livability in cities.

Methods

This section presents the data employed and describes the health measures, energy and transport spending based emissions measures, and other explanatory variables used in this study. We also present the statistical methods and tests for model validation applied in our analysis.

Data sources

This paper uses the Indian Human Development Surveys (IHDS) I (2004–05) and II (2011–12), both of which are nationally representative and multi-topic surveys (Desai *et al* 2010, 2015). While IHDS I surveyed 41 554 households (215 754 individuals), IHDS II re-interviewed 83% of the original households surveyed in IHDS I, as well as additional samples, so that a total of 42 152 households (204 568 individuals) were surveyed in this round. The samples are nationally representative, spread across 33 (now 34) states and union territories over rural and urban areas, covering questions on health, education, employment, expenditures, economic status, marriage, fertility, gender relations, and social capital.

Health measures

The health measures covered by the surveys are based on information collected at the individual level, where individuals are classified as either having short-term morbidity (STM), or major morbidity (MM), or neither. An individual is assumed to have STM also referred to as traditional diseases or communicable diseases if s/he had fever, cough, or diarrhea in the last 30 days. An individual is assumed to have MM also referred to as modern diseases or non-communicable diseases if s/he has been diagnosed with high blood pressure, heart disease, diabetes, or asthma ever. Figure S1 available at stacks.iop.org/ERL/12/114017/mmedia presents distribution of these morbidities.

Energy and transport spending based emissions measures

The dataset includes detailed household consumption expenditures over the past 30 days, including data on electricity spending, and private transport spending (expenditures on diesel, petrol, CNG, and maintenance of owned vehicle). These spendings are a proxy for household energy use. These spendings may vary slightly spatially and in scale of consumption (for electricity), given differences in prices. The mean spending on electricity and private transport in 2012 are 58 ₹/capita and 76 ₹/capita respectively. Employing the data on household consumption expenditure on electricity and private transport, we estimate emissions from electricity and private transport using the methodology described in Box S1. The annual per capita emissions from electricity and private transport are estimated to be 0.282 tCO_2e and 0.052 tCO_2e respectively in 2012, corresponding to 21% of economy-wide per capita emissions (including the burning of fossil fuels and the manufacture of cement) (World Bank 2012).

Explanatory variables

We group these variables into four categories—built environment, basic services, energy and transport, and other control variables that consist of socioeconomic and demographic characteristics of households. The built environment consists of location of settlements (megacity, urban (non-megacity), and rural), basic services include modern stove, piped water, flush toilet, separate kitchen, and overcrowding (i.e. three or more persons living in a room). Here, individuals living in the six largest metropolitan areas (Mumbai, Delhi, Kolkata, Chennai, Bangalore, and Hyderabad) are defined as megacity dwellers. The geographical boundaries include census 'urban agglomeration' for each of the six areas with the exception of Delhi, where Gurgaon district (Haryana) and Gautam Buddha district (UP) are also included. The variables related to energy and transport consist of electricity spending, private-transport spending, and vehicular ownership. The variables related to socioeconomic and demographic characteristics include household size, age, gender, highest adult education level (male and female), and income. Tables, S1–S3, present descriptive statistics of these variables, and table S4 presents the correlation coefficients among the variables of interest.

Statistical methods

Multivariate regressions are employed to understand the factors underlying emissions from electricity and private transport based energy spending at the household level, and health (likelihood of having short term and major morbidity) at the individual level, following other empirical studies (Ahmad *et al* 2015, Lenzen *et al* 2006). Some of the household-level attributes (i.e. sanitation facilities) are assigned to the individual-level, and vice versa. We perform panel regressions using 2005 and 2012 data to get robust estimates.

For emissions (electricity and private transportation), which are continuous variables, we use linear models, whereas for the prevalence of STM (or MM) relative to neither, we use logit models using Stata 14.1 (Stata Corp. College Station TX, USA). Pooled OLS regressions are run to estimate constant coefficients, under the usual assumption for cross-sectional analysis that regressors are uncorrelated with the error term. To account for individual heterogeneity, we estimate fixed and random effect panel models (Wooldridge 2012).

To decide between the fixed or random effects model, we run a Hausman test (Greene 2011). This basically tests whether the unique errors are correlated with the regressors, assuming under the null hypothesis that they are not. Based on the Hausmann test, we conclude that the coefficients estimated by the efficient random effects are not the same as the ones estimated by the consistent fixed effects estimator. Therefore, it is not appropriate to use the random effects model. In addition, we test for time fixed effects, a joint test to see if the dummies for years (2005 and 2012) are equal to 0. In our case, we rejects the null hypothesis that the coefficients for all years are jointly equal to 0, and therefore retain time fixed effects in the model.

Using the results from our multivariate regression models, we also estimate the changes in our dependent variables—emissions and prevalence of morbidity—resulting from a change in some of our key explanatory variables, like urbanization in a comparative static analysis (for details of the methods employed for these computations see Box S2).

Descriptive statistics

Our investigation of the patterns of individual morbidity and energy spending at a household-level in India shows that the prevalence of MM is higher whereas that of STM is lower in urban centers and for households with higher incomes in line with the environmental health transition literature (Smith and Ezzati 2005). Per capita electricity and private transport energy consumption (both continuous variables that are a proxy for emissions) are also higher for households with higher income and that live in urban areas (figure 1). Between 2005 and 2012, both morbidity and energy consumption increased, albeit energy consumption has increased at a faster pace.

Other infrastructural characteristics are also correlated with STM, MM, and spending on electricity and transport (figure 2). Households with higher STM live in dwellings that have poorer quality drinking water and sanitation facilities (figure 2 and table S1). In contrast, households that use better quality cooking fuels, have higher electric spending, and that use motorized vehicles for personal transportation (i.e. own more two-wheelers and four-wheelers) have higher MM. Notably, households that own vehicles have several times higher MM as well as energy consumption.

Multivariate regression results

To analyze these differences further and test the statistical significance of various household characteristics in affecting traditional disease (STM) and modern disease (MM) prevalence, as well as electricity and transport energy spending, we present here the fixed effect model results organized by the following categories of explanatory variables: built environment, basic services, energy and transport, and socio-economic and demographic characteristics of households (tables 1 and 2).

Built environment

We find that inhabitants of megacities have lower odds (0.68 times) of STM than rural inhabitants. But unlike other findings from low-income countries (van der Sande *et al* 2000) we do not observe statistically significant higher MM in cities, after controlling for other variables as shown in table 1. Moreover, we do not find statistically significant differences in STM and MM between smaller cities (urban category) and rural inhabitants, contrary to the hypothesis that urban inhabitants have lower incidence of STM and higher incidence of MM (Agarwal 2011, Gupta *et al* 2009).

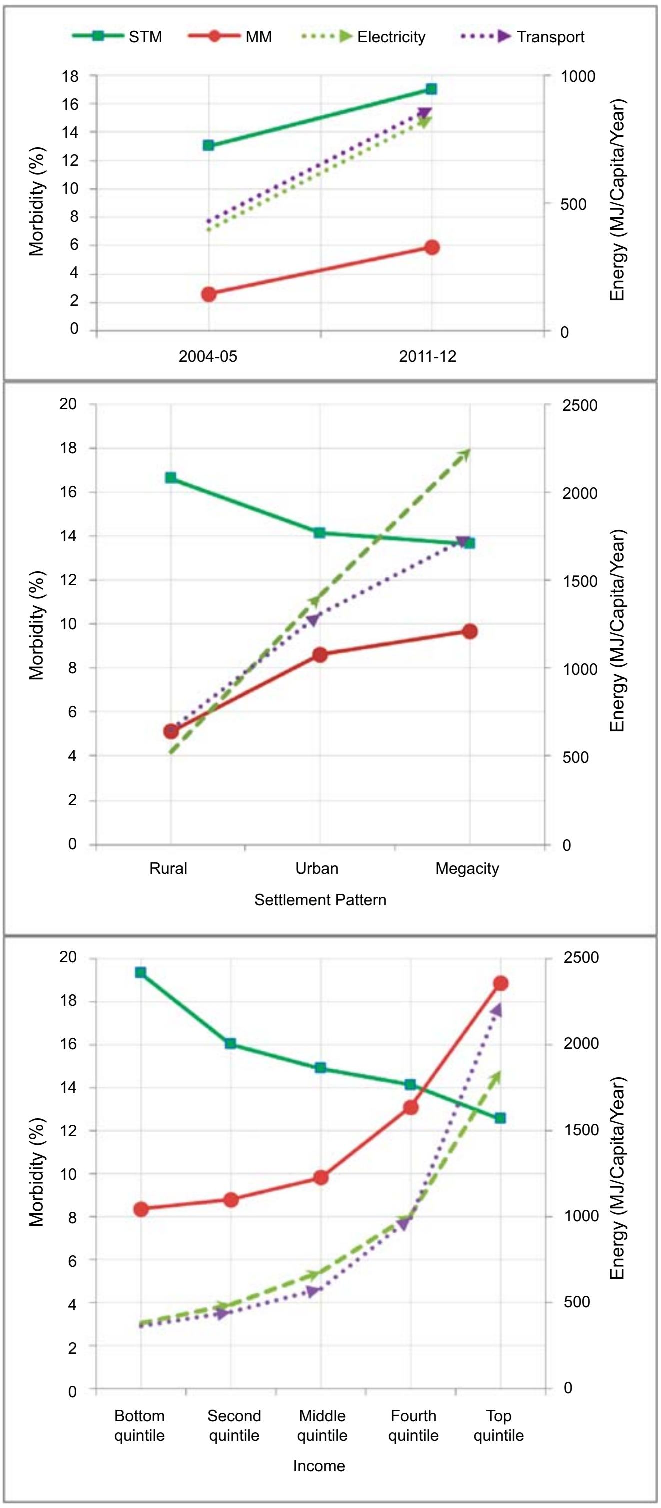

Figure 1. Morbidiy prevalence and energy consumption by income (bottom panel), settlement type (middle panel) and over time (top panel) in Indian households. All graphs use 2012 survey data, except for the top panel, which relies on survey data from both rounds.

Households in smaller cities spend more on transport and electricity than rural households. After controlling for other variables, including income, we find electricity spending in megacities is lower than in other areas, suggesting possible efficiencies of scale (Bettencourt *et al* 2007). The lower electricity spending among megacity inhabitants could also be explained by other household characteristics e.g. family work pattern and density of human settlement (Makido *et al* 2012), which are not controlled for here. Individuals in megacities have lower traditional disease prevalence and household electricity spending (use), but higher utilization of private transport, and consequently higher emissions of air pollutants and greenhouse gases than those living in other urban areas, when controlling for all other variables.

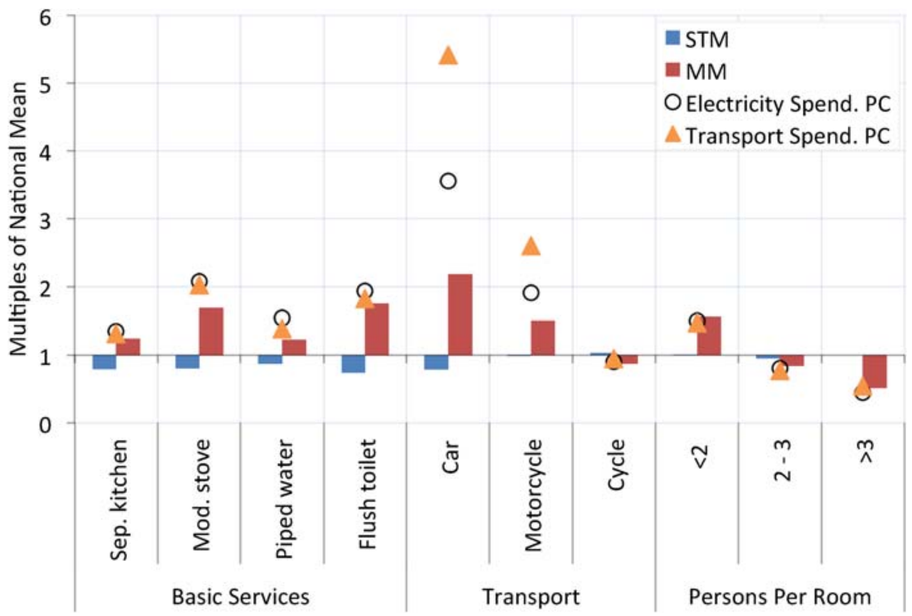

Figure 2. Comparing prevalence of morbidity and energy spending (times) to the national average, by basic services, vehicle ownership and living space in India for 2005 and 2012. The national averages: STM (15%), MM (5%), electricity spending 524₹ capita yr^{-1}, and transport spending 880₹ capita yr^{-1} (spending in 2005 ₹).

Basic services

Access to basic services, specifically to modern stoves, piped water, and flush toilet, lower the odds of STM, but have no significant effect on the odds of MM. Our results echo previous findings that show that switching from traditional to modern non-solid cooking fuels brings about large reductions in household smoke, therefore improving health (Wilkinson *et al* 2009). Households with access to these basic services also show higher expenditures on energy. However, households with access to piped water spend 4.2% less on electricity, ceteris paribus.

Housing space provides the immediate environment where individuals spend two-thirds of their time (Brasche and Bischof 2005). It also provides an environment for the household economy. Therefore, it is likely to play an important role in overall morbidity outcomes (Krieger and Higgins 2002, Shaw 2004) as well as energy spending, required for lighting and space conditioning. We examine the relationship between dwelling space using two proxy variables—separate kitchen and room per capita—on morbidity and energy spending. Dwelling units with a separate kitchen are less exposed to smoke, resulting in reduced disease prevalence. Previous studies have shown that lower room per capita, resulting in inadequate space or overcrowding, is associated with a lack of privacy and stress, which contribute to both physical and mental illness, transmission of tuberculosis and respiratory infections (Krieger and Higgins 2002), and increased incidents of accidents.

Our results reveal that inhabitants living in dwelling units with a separate kitchen have lower STM ($p < 0.01$) and MM ($p < 0.1$) compared to those without a separate kitchen. We also find that STM and MM are positively associated with room per capita (figure 2). These findings are against intuition, as more space ought to reduce STM. The average room per capita in urban smaller city households (0.59) is higher than in megacities (0.53) and rural (0.52) households. It is likely that households with higher room per capita are located in peripheral urban areas, which could have poorer access to certain municipal services, which are not controlled for here, e.g. solid waste management, that could be associated with higher STM. Moreover living in peripheral urban areas might be associated with longer commute times (more exposure to air pollution) and/or more sedentary livestyles that could also be related to higher prevalence of MM.

Electricity and transport

Increased electricity spending is correlated with lower STM, whereas private-transport spending is positively correlated with higher MM. Interestingly, we do not find a statistically significant influence of electricity spending on MM and transport spending on STM, ceteris paribus. These findings suggest that adequate access to electricity maybe associated with lower STM, whereas the use of non-motorized personal transport maybe associated with lower MM.

Owning a bicycle is associated with lower STM as well as MM ($p < 0.1$), everything else held constant. This finding complements our earlier one that indicates a correlation between transport spending and MM. Ownership of vehicles also explains variations in electricity and transport spending. We find that households with a motorcycle, compared to those without one, spend 11% and 102% more on electricity and transport, respectively, ceteris paribus. Similarly, households with a car, compared to those without one, spend 7% and 63% more on electricity and transport, respectively.

Table 1. Likelihood of the prevalence of morbidity at the individual-level in India 2005 and 2012.

Variables	STM	MM
Megacity (ref: rural)	0.686***	0.697
	(0.0625)	(0.155)
Urban (ref: rural)	1.079	0.951
	(0.0866)	(0.144)
Kitchen separate	0.914***	0.903*
	(0.0201)	(0.0509)
Stove modern	0.932**	1.082
	(0.0288)	(0.0675)
Piped water	0.927***	1.053
	(0.0267)	(0.0665)
Flush toilet	0.946**	1.105*
	(0.0244)	(0.0583)
Room pc	1.164***	1.185**
	(0.0426)	(0.0789)
Electricity pc (log)	0.974***	0.982
	(0.00760)	(0.0193)
Transport pc (log)	0.994	1.036**
	(0.00616)	(0.0144)
Cycle (ref: Ø)	0.949**	0.913*
	(0.0218)	(0.0460)
Motor cycle (ref: Ø)	1.064**	1.029
	(0.0329)	(0.0649)
Car (ref: Ø)	1.007	1.130
	(0.0640)	(0.120)
Household size	0.914***	0.969**
	(0.0049)	(0.0123)
Age	0.890***	1.081***
	(0.00552)	(0.0176)
Ageˆ2	1.001***	1.000***
	(4.54e–05)	(0.000127)
Female	0.793	0.733
	(0.136)	(0.371)
Highest edu male	1.006	0.993
	(0.00365)	(0.00816)
Highest edu female	0.997	1.013*
	(0.00344)	(0.00735)
Income pc (log)	0.958***	0.957
	(0.0121)	(0.0267)
Year 12 (ref:05)	1.792***	2.947***
	(0.0661)	(0.196)
Observations	54 116	15,322
F statistics	1953.74***	3079.52***
Number of individuals	27,058	7,661
Individual FE	Yes	Yes

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; standard errors in parentheses.

Table 2. Determinants of energy spending at the individual-level in India 2005 and 2012.

Variables	Electricity PC (log)	Private transport PC (log)
Megacity (ref: rural)	−0.080**	0.347***
	(0.0374)	(0.0441)
Urban (ref: rural)	0.063**	0.194***
	(0.0265)	(0.0366)
Kitchen separate	0.141***	0.043***
	(0.00857)	(0.0104)
Stove modern	0.075***	0.128***
	(0.0103)	(0.0142)
Piped water	−0.041***	−0.003
	(0.0104)	(0.0134)
Flush toilet	0.035***	0.102***
	(0.00873)	(0.0120)
Room pc	0.311***	0.126***
	(0.0126)	(0.0171)
Cycle (ref: Ø)	0.090***	0.055***
	(0.00827)	(0.0106)
Motor cycle (ref: Ø)	0.112***	1.025***
	(0.0103)	(0.0135)
Car (ref: Ø)	0.073***	0.630***
	(0.0183)	(0.0274)
Household size	−0.018***	−0.024***
	(0.00180)	(0.00216)
Age	0.003	0.007**
	(0.00226)	(0.00286)
Ageˆ2	−1.22e−05	−2.25e−05
	(1.62e–05)	(2.10e–05)
Female	−0.054	0.048
	(0.0617)	(0.0776)
Highest edu male	0.011***	0.017***
	(0.00132)	(0.00169)
Highest edu female	0.002	0.004**
	(0.00117)	(0.00156)
Income pc (log)	0.073***	0.151***
	(0.00447)	(0.00601)
Year12 (ref:05)	0.522***	0.515***
	(0.0129)	(0.0165)
Constant	1.192***	0.529***
	(0.0717)	(0.0912)
Observations	267,560	267,683
R-squared	0.153	0.192
F statistics	1249.86***	1652.72***
Number of individuals	147, 552	147,563
Individual FE	Yes	Yes

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; standard errors in parentheses.

Socioeconomic and demographic variables

Our study controls for socioeconomic and demographic characteristics that partially explain prevalence of STM and MM, as well as energy spending. Notably, we find higher income is associated with lower STM but is unrelated with MM. Moreover, we find electricity and transport spending is inelastic in income, as has been shown in previous studies (Ahmad and Puppim de Oliveira 2016, Lenzen *et al* 2006). A 10% increase in income is associated with 0.7% increase in electricity spending and 1.5% increase in transport spending. Thus, given similar increases in income, we find transport spending rises twice as fast as electricity spending.

Higher education levels among female members is related to higher prevalence of MM, according to our analysis. Possibly, changing activity patterns that accompany higher educational attainment might explain this finding. We also find that with age, STM is lower but MM is higher. This suggests that women and seniors might deserve special attention in designing policies to moderate morbidity incidences.

Comparative static analysis

We assess the potential implications for public health and energy use of specific interventions that have an important relationship with these outcomes based on a comparative static analysis. The potential effects on health and energy of specific interventions are determined assuming a change in the value of one factor, while all other independent variables are held constant. These results provide further insight on the relative importance of various factors that we find are associated with morbidity and energy use (figure 3). All the interventions we tested are associated with lower STM, albeit with a minor increase in electricity emissions, whereas only a shift from private transport to public transport and cycling is associated with lower MM,

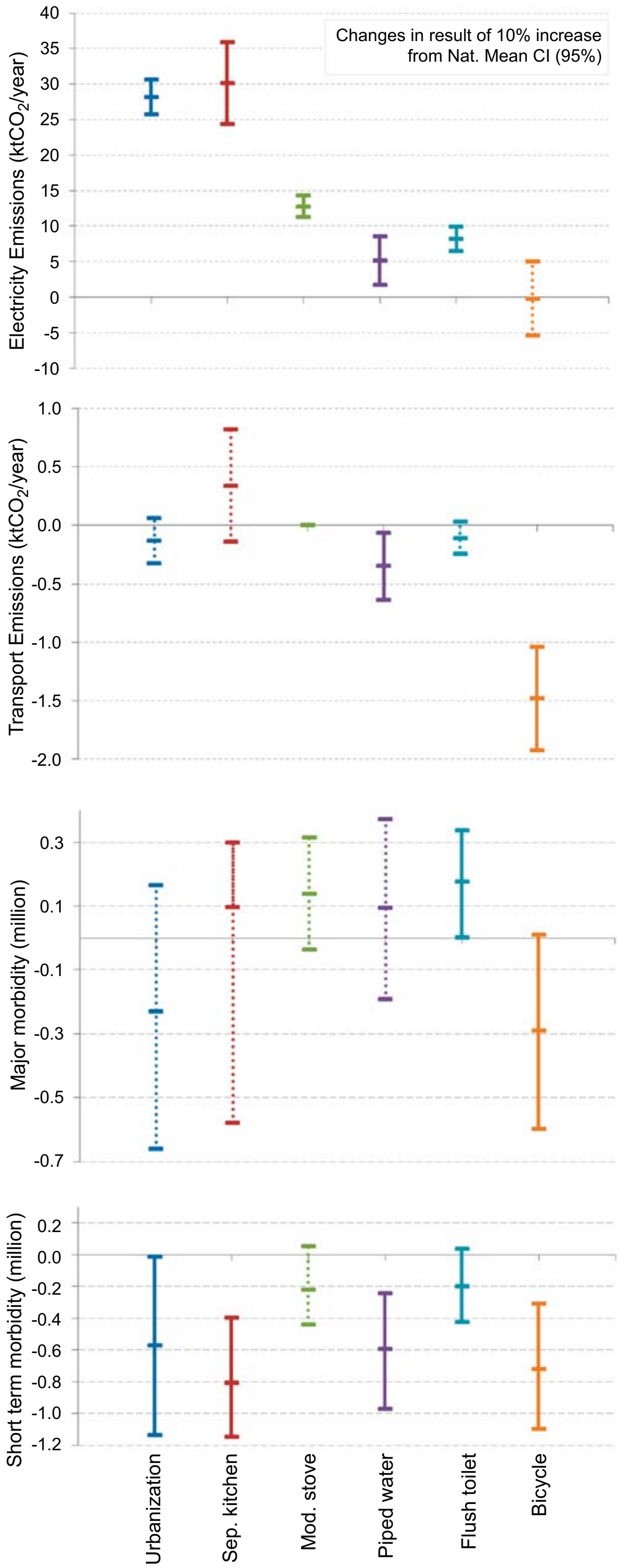

Figure 3. Changes in morbidity and emissions due to selected interventions in India, represented by a 10% change relative to the 2012 national average values (dotted lines represent results that are not statistically significant in our models). The ranges represent the 95% confidence intervals of parameter estimates.

significantly. Hence, we find both potential tradeoffs and synergies between reductions in morbidity and GHG emissions from energy use (figure 3).

As traditional diseases remain widespread (≈16% of population), our analysis suggests that structural interventions may have a large potential to lower STM. We find that a 10% increase in urban population (with 2012 data as the baseline) would be associated with lower STM for 0.55 million people. At the same time, this magnitude of urbanization is also associated with an increase in household electricity emissions by 28 $ktCO_2\ yr^{-1}$. Alternatively, greater provision of basic services, such as a seperate kitchen, modern stove, piped water, and flush toilet by a similar magnitude of 10% above 2012 levels, could lower STM by as much as 1.8 million, while increasing electricity emissions by about 56 $ktCO_2\ yr^{-1}$.

Lowering private transport spending, through an associated shift from private motorized to public transit modes and non-motorized transport (e.g. bicycling) could be associated with lower major morbidity as well as energy emissions. Specifically, we estimate that an increase of 10% in bicycle ownership could lower major morbidity for 0.29 million people, and private transport emissions from households by as much as 1.5 $ktCO_2\ yr^{-1}$.

Discussion and conclusions

Our analysis provides empirical evidence that energy-efficient and sustainable urbanization can address both public health and climate change challenges simultaneously. Three specific findings emerge from our empirical study that can inform sustainable urbanization policies: 1) the provision of non-motorized transport (NMT) may be a sweet spot for sustainable development that is associated with better health and lower GHG emissions; 2) urbanization and better access to household infrastructure can be a means to lower short-term morbidity; 3) other socio-economic developments and built environment interventions, except in the case of the transport sector, remain rather unrelated with major morbidity prevalence.

The promotion of non-motorized and public transit options, through its affect on private transport spending and bicycle use is associated with lower major morbidity as well as transport related emissions. However, trends in India and other developing economies indicate that the share of bicycles is declining and private motorized vehicle ownership is rising with economic development ((Pucher *et al* 2005), see also table S5). Beyond higher modern disease prevalence, private motorized transport also augments the risk of road traffic injuries, air and noise pollution, which pose a major global public health challenge (Garg and Hyder 2006, Sharma 2008). Hence, the provision of efficient and clean transport systems—through a combination of high-quality mass transit and safe bicycle infrastructures (Bongardt *et al* 2013)—could be highly beneficial for both public health and climate change mitigation.

Mitigation effects of cycling are rather low in absolute numbers, and one order of magnitude smaller than emission increases in electricity required to increase access to basic services. Nonetheless, the effect is prospectively relevant, as the transport share of emissions increase with development and structural change (Schäfer 2005). Moreover, incentivizing car transport also leads to sprawled urban form and long-term lock-in into car dependency and transport energy use (Borck and Brueckner 2016, Creutzig 2014, Seto *et al* 2016). Neither too dense slums, nor too sprawled suburbs are likely to help India towards sustainable urbanization. Instead medium-dense suburbs with public transit and bicycle access can best negotiate the trade-offs associated with urban form (Lohrey and Creutzig 2016).

Other than these transport related interventions, our study did not find any evidence of the effect of other socio-economic or built environment related factors on major morbidity, which has increased significantly between 2005 and 2012. This also suggests that solutions to reduce major morbidity might lie in measures beyond those studied here, such as better diets and physical activity.

Our study also provides empirical evidence of the potential role of urbanization and access to basic amenities on short term morbidity. We find that interventions to improve access to clean water and sanitation systems are strongly associated with lower STM as opposed to urbanization alone (figure 3).

In contrast to other studies, we rely on micro-data from nationally representative household surveys to analyze the prevalence of morbidity at an individual level, and transport and energy related emissions at a househehold level, while controlling for socio-economic and built environment related variables. Methodologically, we use cross-sectional and panel regressions to identify significant relationships, and provide evidence of potential interventions that may improve quality of life in cities. Some caveats of our analysis are the relatively short time span of seven years (2005 and 2012) between the two surveys employed, and the use of subjective measurements of morbidity as captured in the surveys. Future work can build on this analysis by taking a wider systems perspective and uncovering the underlying causal mechanisms behind rising morbidity and emissions in cities. The availability of longer panel series and better data, such as objective measurement of individuals' health status rather than reported health status alone, could also inform more spatially differentiated analysis, and allow for other important health and emissions drivers such as nutrition (food demand) and physical activity patterns to be incorporated. Transport-related information was also limited to the variables included in the survey. In the future more detailed information such as on individuals' travel patterns (typical transportation mode and distance) could be of great use in carrying out more detailed assessments.

Our results have important implications for policy, particularly for the nexus between energy-efficient urbanization, climate change mitigation, and sustainable development. With urbanization, directed energy use from cities is expected to more than triple between 2005 and 2050 globally (Creutzig *et al* 2015). However, smart urbanization strategies, such as those that rely on higher transport fuel prices, could reduce energy demand by 25% (Creutzig *et al* 2015). For no world region is this result more relevant than for India that is expecting the highest absolute urbanization among all countries. Our analysis of households in India shows that a shift in transport spending from private motorized means to clean mass transit and more bicycles could also benefit public health by reducing the prevalence of modern diseases like diabetes. Thus, higher taxes on gasoline and diesel to finance clean mass transit could benefit public health and the climate. The opposite is likely to be true for electricity, however. We find that an increase in electricity spending is associated with greater utilization of clean cooking and water infrastructures, and a significantly lower traditional disease prevalence. Hence, a blunt tax increase on electricity for climate change mitigation might hinder the achievement of other sustainable development goals, and in particular, improved public health. Significantly, previous research suggests that expanding electricity access to households has a relatively marginal contribution to national greenhouse gas emissions increases (Pachauri 2014). On the other hand, climate mitgiation policies in South Asia that lead to higher fossil fuel costs could slow down clean cooking fuel uptake if not compensated for by other social protection measures (Cameron *et al* 2016). Climate policies hence need to shield the poor and be cognizant of the potential public health benefits of higher energy and electricity use, especially when starting from very low levels.

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