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Impact of household air pollution exposure on rural India: A systemic review

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Abstract

All in developing nations about 50% population rely on solid unclean fuel in the form of animal dung cake, crop residue and wood for household energy and cooking. Solid biomass fuel is typically burnt in traditional cooking stove or chulha without chimney with incomplete combustion. As well as in rural areas children and women must go through the drudgery and health risk of collecting crop residue and fire wood. So the scheme of "Ujjwala Yojana" was commenced by the Prime Minister of India in 2016 and Rs. 8000 Cr. has been granted for the Yojana. The aim of this scheme was to provide safety for children and women in rural areas from health risk by furnishing with clean and safe cooking energy Liquid Petroleum Gas (LPG), so that they don't have to deal their health issues in poor ventilated and smoky, blackish kitchen. Villagers were used traditional biomass stoves or chulha without chimney for cooking, boiling water and used for cooking cattle food. Aim of this review was to find out household air quality of rural areas using different solid unclean biomass fuel for example cow dung cake, crop remains and wood in terms of gaseous pollutants and particulate matter in kitchen area so the higher concentration of different gaseous pollutants i.e. carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) were reported in the kitchen area during cooking hours. It can be concluded based on literature reviews that, there is significant health risk associated with increased concentration of gaseous pollutants and suspended particulate matters.

Key words: ***Gaseous pollutants, health risk, household air quality, indoor air pollution, particulate matter, solid biomass fuel and traditional cooking stove or chulha.***

Introduction

Household air pollution is now seems to be a significant rural public health problem. This is responsible for the growing range of adverse health effects that are subjected from the results of an extensive research work conducted in different regions of the world. 80 to 90% exposure of indoor air pollution found in the rural population and about 50 to 60% urban population were effected from indoor air pollution, on a national basis (Mondel *et al*., 2011). Rural household air pollution owing to unprocessed solid unclean biomass combustion is the matter of concern because of exposure of large number of pollutants and combustion of unprocessed solid biomass fuel from cooking activities has adverse effects on ambient household air quality and human health. Unclean solid fuel combustion in form of firewood, dung cake and crop residues all are also the major sources responsible for indoor air pollution in rural environment. We watched, indoor and outdoor individual experience to air pollution, collective, contain the major environmental threat for transience, accountable for 6.4 million fatalities in 2015 (Cohen *et al.*, 2017). World Health Organization (WHO) was conducted CRA (Comparative Risk Assessment) in year 2002 (Fig.1), then they estimates the exposure of indoor burn from unclean biomass fuel possibly answerable for premature death about 1.6 million and about 2.6 percent of global burden of diseases in almost developing countries. Unprocessed solid biomass fuels such as cow dung cake, firewood and crop residues are the most hazardous bio fuels, are used mostly by poor rural women for cooking, boiling water and cooking cattle food. It has been estimated that these fuels on combustion produce at least 50 times more noxious gaseous pollutants then LPG (Smith, 2003). Some Asian

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and European countries have highly destructive damage to the environment and to the health of human as well as animal population health owning to many years of rigorous coal flaming or coal mining and associated metallurgy in the past (Helios, 1996; Sofilic *et al.,* 2013; Oliveira *et al.,* 2014; Banerjee *et al.,* 2016; Naik, 2016).

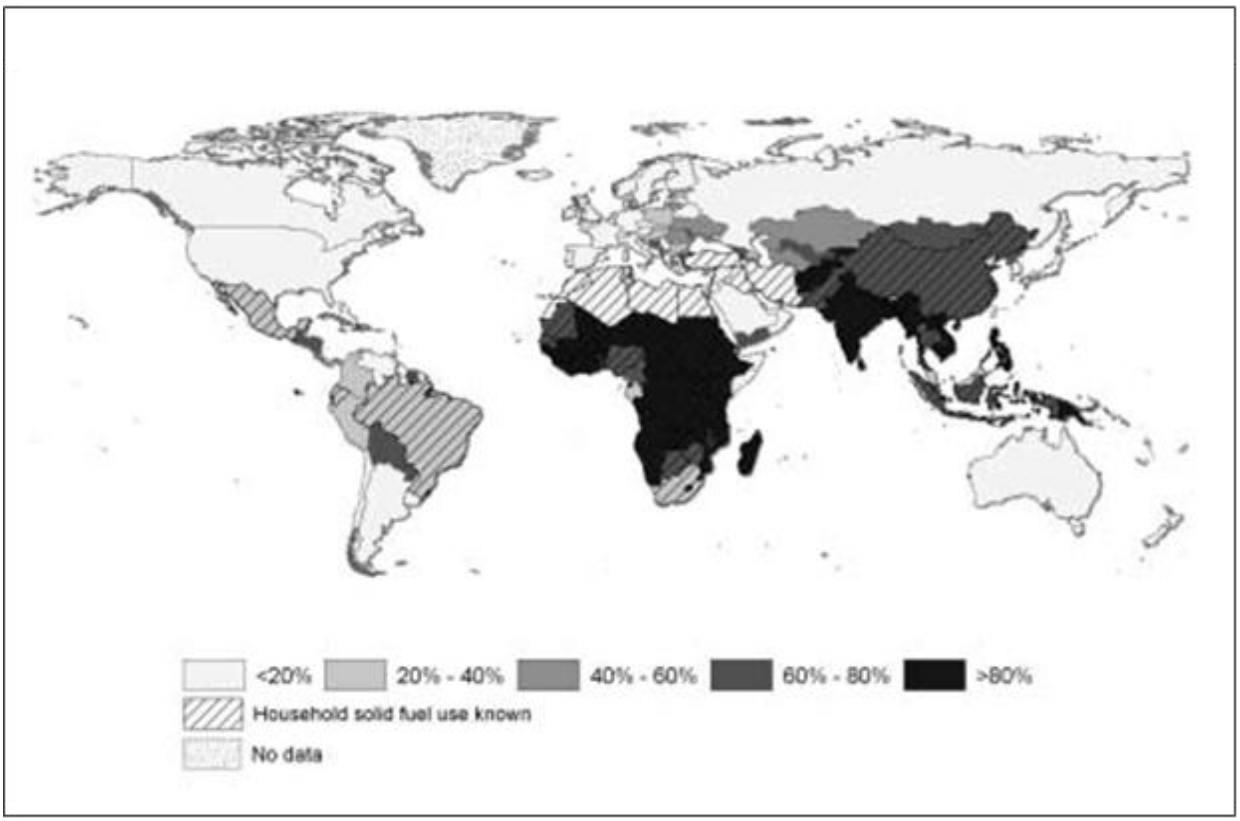


Fig 1. Household fuel use transversely world constituency (Source: Mehta, 2002).

Throughout the world, household air pollution is determined as a considerable cause of probable health risk to showing population. In the world, main causes of household air pollution is incineration of solid biomass fuels such as coal, fuel wood, cow dung cake and tobacco, furnishing and ventilation systems (Table -1). In Varanasi, UP Jain *et al.,* 2017 identified an increase level of particulate matter 2.5 (PM) about 45% in ambient air over the 15 years (2001-2015). Toxicological and epidemiological study showed that the mass of particulate matter (PM_{10} and $PM_{2.5}$) comprises fractions and sources with varying types of health effects to exposed population (Kelly and Fussell, 2012).

Status of household air pollution in India

In rural areas of India the largely main household pollutants are combustion of unclean solid biomass fuels by the rural population especially women for food preparation. For rural population indoor air pollution is a key and increasing risk factor in India, it is contributing notably to the country's burden of many diseases. Household air pollution studies has been ignored so far in India, although the estimates reveals that 88% of VOCs, 38% of NO_X, 96% PM_{10} and $PM_{2.5,}$ 82% SO_X and 88% of VOCs and emissions appear from the domestic sector (Parikh, 1999). Almost 75% of Indian households, as well as up to 90% of households use unprocessed solid biomass fuels such as fire wood and cow dung in rural places (Prasad *et al.,* 2012) illustrated in Fig. 2. The largely main indoor air pollutants are burning products in India which is used by the poor rural population for domestic cooking (ICMR Bulletin, 2001) and is responsible for the

Table - 1: Main health destructive pollutants produced from indoor sources.

S. No.	Pollutants	Indoor sources
1.	Carbon monoxide	Tobacco combustion/fuel
2.	Nitrogen oxides	Fuel combustion
3.	Sulphur oxides	Coal combustion
4.	Fine particles	Cleaning operations, tobacco smoke/fuel/cooking
5.	Aldehydes	Cooking, construction materials, furnishings
6.	Polycyclic aromatic hydrocarbons	Fuel/tobacco combustion, cooking
7.	Pesticides	Dust, consumer products
8.	Arsenic and fluorine	Coal combustion
9.	Lead	Demolition of painted surfaces/remodelling
10.	Radon	Construction material, soil under building
11.	Asbestos	Demolition of construction materials/remodelling
12.	Volatile and semi - volatile organic compounds	Cooking, fuel/tobacco combustion, construction materials, consumer products, furnishings
13.	Radon	Construction materials, soil under building
14.	Biological pollutants	Ventilation systems, moist areas, furnishings
15.	Free radicals and other short lived, highly reactive compounds	Indoor chemistry

death of about half a million children and women each year (Smith, 2000). Studies by NFHS-3, 2007 show that, eight out of ten rural households and three out of ten urban households using open fires for food preparation therefore, monitor the household air quality of kitchens of rural areas is required (Fig. 3).

(a) (b)

Fig. 2. (a) Rural women using a traditional mud chulha (b) Smokey indoor kitchen due to burning of solid biomass fuel (Photographs taken during survey)

Air Quality Index

The index of air pollutants has been used for about last 25 years to obtain the ratio of concentration of pollutants for the eminence of ambient air in places (Zlauddin and Siddiqui, 2006; Joshi and Semwal, 2011). The giving subtraction was indicated to make the AQI of the sites under reflection:

$AQI = {}^{1}/_{4} \times (ISPM / SSPM + IRSPM / SRSPM + ISO_2 / SSO_2 + INO_X / SNO_X) \times 100$

Where, ISPM, IRSPM, ISO_2 and INO_X = Individual values of SPM (Suspended Particulate Matter), respirable particulate matter, sulphur dioxide and oxides of nitrogen respectively. SSPM, SRSPM, SSO_2 and SNO_X = Standards of ambient air quality. The main five different levels of AQI are listed in Table - 2.

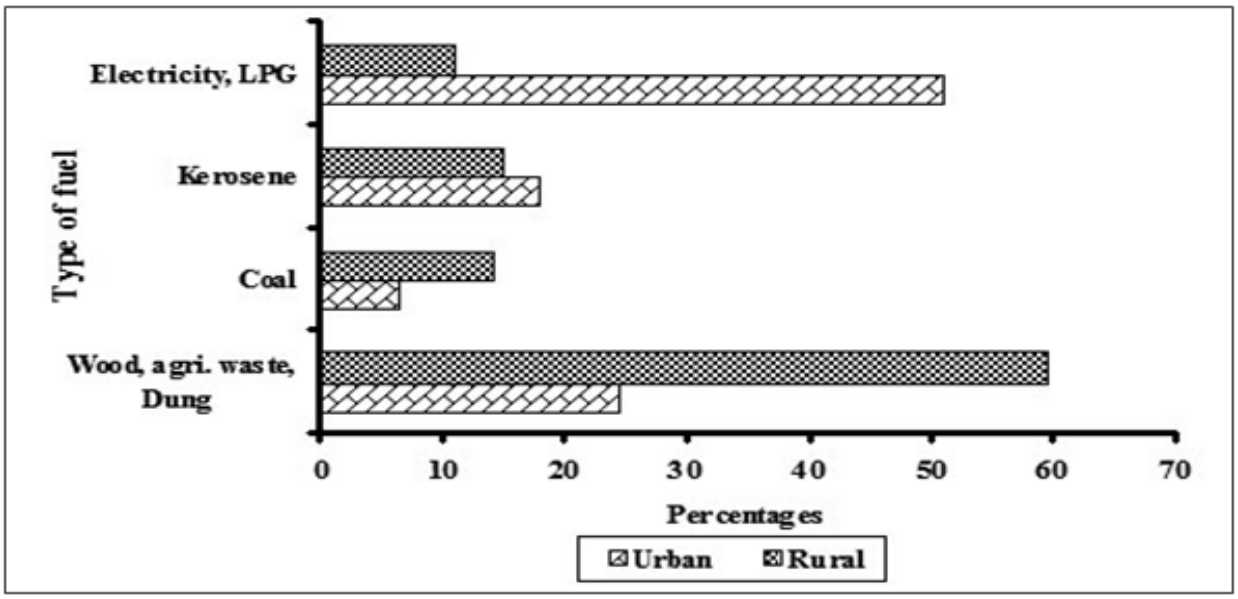


Fig 3. Graph indicating comparative fuel use pattern between urban and rural areas of India (Source: NFHS-3, 2007)

Table - 2: Table showing the index value of air quality index calculation (Source: Rao and Rao, 1989).

Index values	Remarks
Between 10-25	Clean air
Between 26-50	Light air pollution
Between 51-75	Moderate air pollution
Between 76-100	Heavy air pollution
Above 100	Severe air pollution

World Health Organization (WHO) focuses on mainly four air pollutants, sulphur dioxide, particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide and ozone. The main focal point on these air pollutants is for the sake of monitoring the state of air quality and it doesn't signify the other air pollutants don't impact human health as well as environment (WHO, 2006) shown in Table -3.

Government initiatives for rural population

It has been estimated that exercise of open fires with these biomass fuels depictions approx 2 billion individuals in the world to improved deliberations of particulate matter and different gases, up to 10–20 times elevated than health based parameter ethics existing for usual urban outdoor (Barnes *et al.,* 1994; Reddy *et al.,* 1996; WHO, 1999). According to the 55th encircling of the National Sample Survey performed in 1999–2000 (NSS, 2000) covering 120,000 family circles, 86% of pastoral families and 24% of urban families rely on solid biomass as their major fuel in food preparation. In rural regions of India, the mainly essential indoor air pollutants are ignition products of unrefined solid biomass energy used by the poor rural inhabitants for familial cooking. In developing nations, the most considerable indoor air quality concern is coverage to pollutants released throughout burning of unrefined solid biomass energy used for food preparation and heating in the dwellings (Wylie *et al.,* 2017; Pope *et al.,* 2010). They rely on unclean solid biomass in the type of wood, dung cake and crop rests for primary source of household energy and heating. These resources are usually burnt in traditional cooking stove or chulha without chimney with very incomplete combustion. In adding up, the smoulder from flaming such unclean coal causes frightening domestic effluence and harmfully concerns the physical condition of women and children causing numerous respiratory illnesses. Seeing that report of WHO, smoke gulped by women from solid

Table 3. The data of ambient air quality in different cities in India for the year 2012 (Source: CPCB, 2014).

State	Cities	SO_2	NO_2	PM_{10}
Andhra Pradesh	Chitoor	4	9	40
	Guntur	5	11	75
	Hydrabad	4	28	79
	Kakinada	5	11	63
	Kothagudem	4	9	74
	Kurnool	4	15	79
	Nalgonda	5	11	62
	Nellore	6	22	108
	Patencheru	6	11	82
	Ramagundam	4	9	37
	Tirupati	6	12	97
	Vijaywada	3	11	49
	Warangal	12	13	65
	Vishakhapatnam	5	11	63
Assam	Daranga	5	13	56
	Dibrugarh	6	13	56
	Guwahati	6	14	92
	Margherita	6	15	54
	Lakhimpur	2	2	45
	Nagaon	6	13	79
	Nalbari	6	15	82
	Sibsagar	7	15	109
	Silchar	6	14	91
	Tezpur	3	9	11
	Tinsukia	5	12	57
Bihar	Patna	N.A.	36	166
Chandigarh	Chandigarh	2	19	110
	Bhillai	8	22	103
Chhatisgarh	Bilaspur	6	20	N.A
	Korba	12	19	81
	Raipur	14	40	N.A
Dadra and Nagar Haveli	Silvassa	8	20	N.A.
Daman & Diu	Daman	8	20	N.A.
Delhi	Delhi	5	59	237
	Panaji	9	14	67
	Marmagao	6	19	112
Goa	Vasco	7	20	84
	Curchorem	15	20	112
	Codli	16	21	121
	Bicholim	10	18	119
	Amona	10	12	90
	Assanora	9	12	84
	Usgao	10	18	121
	Margao	9	17	67
	Tilamol	15	20	114
	Mapusa	7	9	82
	Sanguem	14	19	100
	Ponda	9	16	60

	Kundaim	**9**	**16**	**63**
Gujarat	**Ahmedabad**	**12**	**24**	**83**
	Anklesvar	**18**	**27**	**99**
	Jamnagar	**12**	**25**	**101**
	Rajkot	**13**	**17**	**99**
	Surat	**16**	**26**	**97**
	Vadodara	**16**	**33**	**102**
	Vapi	**19**	**30**	**100**
Haryana	**Faridabad**	**12**	**38**	**184**
	Hissar	**6**	**8**	**111**
	Yamunanagar	**N.A**	**N.A**	**N.A**
Himachal pradesh	**Baddi**	**2**	**23**	**99**
	Damtal	**2**	**12**	**97**
	Kala Amb	**2**	**16**	**165**
	Nalagarh	**2**	**23**	**89**
	Parwanoo	**2**	**8**	**79**
	Paonta Sahib	**2**	**15**	**153**
	Una	**N.A**	**N.A**	**69**
	Sunder Nagar	**2**	**11**	**94**
J&K	**Jammu**	**6**	**12**	**119**
Jharkhand	**Dhanbad**	**17**	**40**	**178**
	Jamshedpur	**37**	**49**	**149**
	Jharia	**17**	**40**	**212**
	Ranchi	**18**	**35**	**202**
	Saraikela Kharsawan	**39**	**51**	**160**
	Sindri	**17**	**40**	**170**
	West Singhbhum	**19**	**27**	**153**
Karnataka	**Bangalore**	**14**	**28**	**121**
	Gulburga	**3**	**11**	**65**
	Hassan	**5**	**17**	**36**
	Hubli-Dharwad	**5**	**14**	**77**
	Mandya	**10**	**24**	**49**
	Mangalore	**6**	**7**	**31**
	Mysore	**11**	**23**	**56**
	Devanagere	**5**	**10**	**75**
Kerala	**Alappuzha**	**2**	**5**	**50**
	Kochi	**3**	**10**	**70**
	Kollam	**4**	**19**	**41**
	Kottayam	**6**	**16**	**56**
	Kozhikode	**2**	**8**	**56**
	Malapuram	**2**	**5**	**36**
	Palakkad	**3**	**7**	**37**
	Pathanamthitta	**2**	**15**	**23**
	Thissur	**2**	**15**	**73**
	Wayanad	**2**	**8**	**33**
	Thiruvananthapuram	**9**	**22**	**55**
Madhya Pradesh	**Bhopal**	**3**	**21**	**173**
	Dewas	**18**	**23**	**92**
	Gwalior	**13**	**27**	**329**
	Indore	**12**	**20**	**143**
	Jabalpur	**2**	**24**	**75**

	Nagda	**26**	**27**	**103**
	Sagar	**3**	**13**	**120**
	Singrauli	**24**	**25**	**64**
	Ujjain	**12**	**13**	**80**
Maharashtra	**Dombivali/Ambernath**	**52**	**87**	**114**
	Amravati	**11**	**13**	**100**
	Aurangabad	**9**	**32**	**80**
	Badlapur	**6**	**86**	**124**
	Chandrapur	**11**	**19**	**148**
	Jalgaon	**19**	**44**	**130**
	Latur	**8**	**20**	**117**
	Lote	**25**	**14**	**40**
	Mumbai	**5**	**20**	**117**
	Nagpur	**10**	**32**	**103**
	Nashik	**24**	**27**	**95**
	Navi Mumbai	**17**	**43**	**120**
	Pune	**22**	**45**	**92**
	Sangli	**11**	**40**	**80**
	Solapur	**17**	**35**	**83**
	Thane	**20**	**12**	**72**
	Ulhasnagar	**46**	**79**	**111**
	Jalna	**9**	**30**	**109**
	Akola	**9**	**10**	**139**
	Nanded	**30**	**30**	**53**
Meghalaya	**Byrnihat**	**35**	**20**	**138**
	Dawki	**2**	**8**	**44**
	Tura	**2**	**5**	**52**
Nagaland	**Dimapur**	**2**	**7**	**90**
Orissa	**Angul**	**6**	**19**	**106**
	Balasore	**3**	**14**	**82**
	Berhampur	**2**	**18**	**80**
	Bhubneshwar	**2**	**18**	**81**
	Cuttack	**2**	**17**	**68**
	Rayagada	**3**	**22**	**54**
	Rourkela	**5**	**11**	**98**
	Sambalpur	**3**	**15**	**53**
	Talcher	**8**	**19**	**116**
	Kalinga Nagar	**3**	**9**	**52**
Punjab	**Amritsar**	**15**	**39**	**202**
	Dera Bassi	**9**	**28**	**129**
	Pathankot/Dera Baba	**7**	**12**	**68**
	Gobindgarh	**9**	**35**	**201**
	Jalandhar	**13**	**26**	**136**
	Khanna	**10**	**26**	**213**
	Ludhiana	**11**	**27**	**228**
	Naya Nangal	**7**	**19**	**89**
	Patiala	**5**	**13**	**62**
	Batala	**8**	**14**	**42**
Puducherry	**Puducherry**	**9**	**52**	**187**
Rajasthan	**Jaipur**	**6**	**24**	**189**
	Jodhpur	**6**	**31**	**155**
	Kota	**8**	**14**	**42**

	Udaipur	**9**	**52**	**187**
Tamil Nadu	**Chennai**	**12**	**21**	**57**
	Coimbatore	**3**	**27**	**68**
	Madurai	**14**	**30**	**48**
	Salem	**9**	**22**	**60**
	Tuticorin	**14**	**14**	**134**
	Trichy	**11**	**17**	**76**
Uttar Pradesh	**Allahabad**	**4**	**32**	**317**
	Anpara	**17**	**31**	**134**
	Bareily	**12**	**24**	**231**
	Gajraula	**19**	**29**	**158**
	Ghaziabad	**30**	**34**	**248**
	Jhansi	**8**	**21**	**110**
	Kanpur	**8**	**34**	**215**
	Khurja	**25**	**25**	**168**
	Lucknow	**8**	**32**	**211**
	Meerut	**4**	**43**	**129**
	Muradabad	**13**	**23**	**165**
	Noida	**9**	**35**	**136**
	Varanasi	**18**	**21**	**138**
	Unnao	**10**	**32**	**98**
	Saharanpur	**11**	**29**	**186**
	Raebareli	**11**	**15**	**163**
	Mathura	**23**	**29**	**208**
	Gorakpur	**18**	**35**	**123**
Uttarakhand	**Haldwani**	**N.A**	**N.A**	**137**
	Haridwar	**28**	**32**	**149**
	Kashipur	**N.A**	**N.A**	**180**
	Rudrapur	**N.A**	**N.A**	**158**
West Bengal	**Asansol**	**10**	**37**	**111**
	Barrackpore	**13**	**48**	**130**
	Durgapur	**13**	**48**	**108**
	Haldia	**13**	**41**	**238**
	Howrah	**13**	**40**	**186**
	Kolkata	**12**	**70**	**135**
	Raniganj	**14**	**45**	**125**
	South Suburban	**8**	**59**	**119**

unrefined fuel is equal to burning 400 cigarettes in an hour. According to another report of WHO, approximate 5 lakhs deaths in India only as a result of unrefined cooking fuels. So Pradhan Mantri Ujjwala Yojana (PMUY) plan to protect the fitness of women and children by given them by means of a hygienic cooking fuel - LPG (Liquid Petroleum Gas), so that they do not have to compromise their health in grey and smoky kitchens or wander in dangerous regions accumulating firewood. Pradhan Mantri Ujjwala Yojana was commenced by Hon'ble Prime Minister Shri Narendra Modi on May 1st, 2016 in Ballia, Uttar Pradesh. PMUY has also been commenced in numerous districts in UP & Bihar. The 1.2 billion USD dedicated to the PMUY program is a small division of other chief national subsidy programs, for example the rural service proposal and the food subsidy proposal (Bose, 2017; Chakrabarti *et al*., 2016).

Target beneficiaries:

In this proposal, 5 Cr. LPG connections will be afforded to BPL families with a support of Rs.1600 per connection in the subsequently 3 years for women's empowerment, chiefly in rural India, the associations will be subjected in the name of women of the house (Fig. 4). The governmental

cost of Rs. 1600 per connection, which comprises a cylinder, pressure regulator, booklet, safety hosepipes, etc., would be borne by the Government. Rs. 8000 Cr. has been to be paid on the way to the functioning of the proposal. Recognition of the BPL family units will be done via Socio Economic Caste Census (SECC) - 2011 database. PMUY is probably to consequence in a supplementary service of around 1 lakh and offer dealing prospect of at least Rs. 10,000 Cr. over the subsequently 3 Years (Fig. 5) to the Indian business. Initiate of this proposal will also supply an enormous boost up to the 'Make in India' operation as the entire producer of cylinders, gas stoves, regulators, and gas hosepipes are domestic. The plan would be executed over three years, namley, 2016-17, 2017-18 and 2018-19 across the country.

Uttar Pradesh leads the state, with maximum LPG connections given under the Ujjwala scheme. Although Ujjwala has covered all states of India, prominent LPG distribution has taken place in 15 states (Fig. 6).

Biomass smoke characterization

Smoulder from wood fiery stoves has been publicized to enclose 17 pollutants nominated as

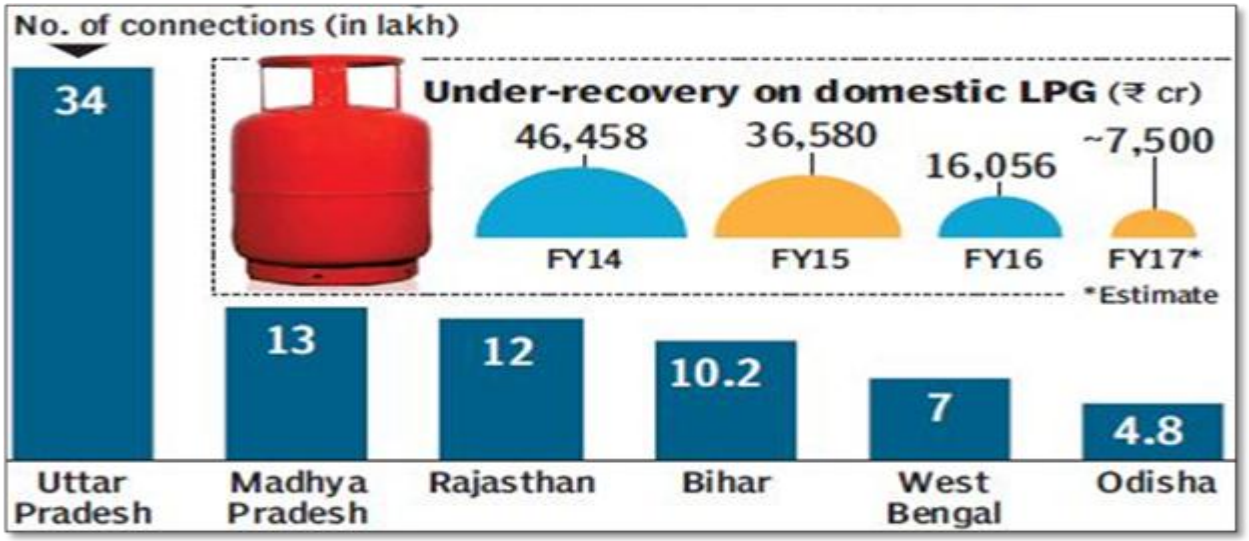
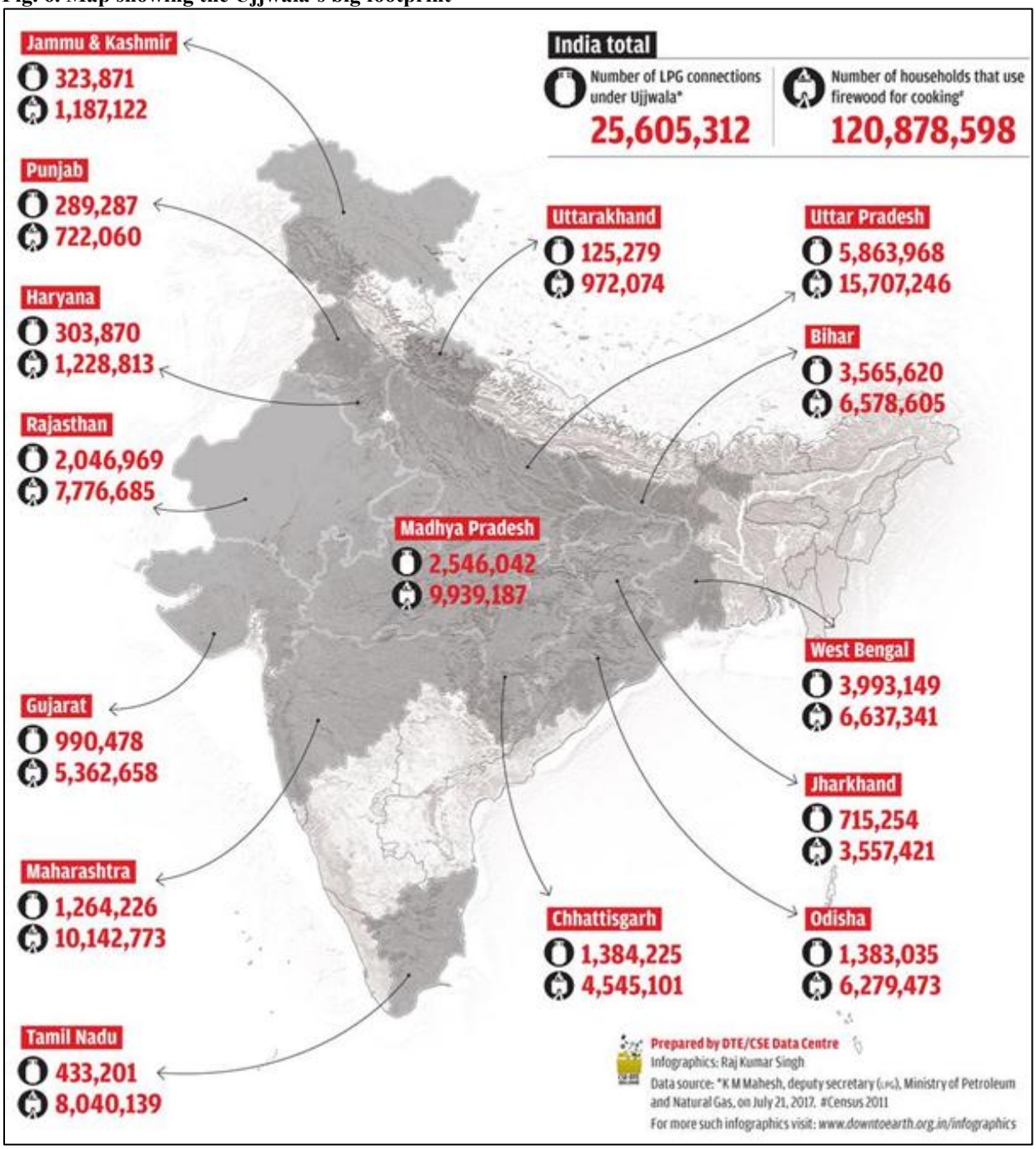


Fig 4. Graph showing the no. of states leading in adding new LPG connections under PMUY scheme
(Source: Petroleum Planning & Analysis cell (PPAC), India)

Fig 5. Graph showing the number of LPG connections of year 2005-2015
(Source: Petroleum Planning & Analysis Cell (PPAC), India).

Fig. 6. Map showing the Ujjwala's big footprint



(Source: K.M. Mahesh, deputy secretary (LPG), Ministry of Petroleum and Natural Gas, On 21 July 2017).

priority pollutants by the United States Environmental Protection Agency (USEPA, 1997) because of their toxicity in animal studies (Cooper, 1980; Smith and Liu, 1993). These pollutants consist of carbon monoxide (CO), small amounts of nitrogen dioxide (NO_2), aerosols (called particulates in the air pollution narrative) in the series (0.1–10 µm in aerodynamic distance), and other organic substance as well as polycyclic aromatic hydrocarbons for example benzo [a] pyrene, and other volatile organic complexes such as benzene and formaldehyde (Table 4).

Table - 4: Table showing toxic pollutants from biomass ignition and their toxicological features

Pollutant	Known toxicological characteristics
1. Particulates (PM_{10}, $PM_{2.5}$)	Bronchial irritation, inflammation increased reactivity, reduced muco ciliary clearance, reduced macrophage reaction
2. Carbon monoxide	Reduced oxygen delivery to tissues due to formation of carboxy haemoglobin
3. Nitrogen dioxide (relatively small amounts from low temperature incineration)	Bronchial reactivity, enhance vulnerability to bacterial and viral lung infections
4. Sulphur dioxide (relatively small amount from most biofuels)	Bronchial reactivity (other toxic end points common to particulate fractions)
5. Organic air pollutants	
Formaldehyde	Carcinogenicity/mutagenecity
1,3 butadiene	Co-carcinogenicity
Benzene	Cilia toxicity, leukemia
Acetaldehyde	Increased allergic sensitization
Phenols	Increased airway reactivity
Pyrene Benzopyrene	
Benzo(a)pyrene	
Dibenzopyrenes	
Dibenzocarbazoles	
Cresols	

(Sources: Cooper, 1980; Smith, 1987; Smith and Liu, 1993; Bruce, 2000)

Unrefined biomass burning, involved in preparing food and warming exercises, is the major resource of Household air pollution (HAP) in India. According to the 55th round of the National Sample Survey accomplished in 1999 - 2000 and covering 120,000 family circles, 86% of rustic family units and 24% of urban family units rely on unrefined solid biomass as their primary catering energy (NSS, 2000). More than 70% of the residents in India depends on conventional energy i.e. firewood, crop remains, cow droppings, coal and lignite (Fig. 7) for preparing of food and almost 32% depend on kerosene for illumination intentions. About 3 billion folks in the world (above 40% of the worldwide inhabitants) rely on conventional unrefined biomass for the use of cooking and an approximate 500 million houses rely on kerosene and comparable for the function of lighting (WHO, 2015). About 75% of Indian households exploit raw fuels (primarily wood and cow dung), as well as up to 90% of households in several rural regions. Fuel wood, roots, agricultural remains and animal dung all generate towering discharges of carbon monoxide (CO), hydrocarbons and particulate matter (PM) (Smith *et al.,* 2000).

Exposures of indoor air pollutants level in household

A number of the initial revisions to conclude stages of household air pollutants related with solid biomass burning and their belongings on health were passed out in the early 1980s (Smith *et al.*, 1983). Preliminary learning determined stages of overall suspended particulates and disclosures for cooks through cookery periods. Nearly 60% of Indian households use unrefined biomass (in the variety of fire wood, charcoal, dung, and crop remains) as their major energy basis for food preparation, whereas, about 30% use LPG. According to census 2011, total 67% households in which 87% rural and 26% urban households use firewood/crop remains, cow dung /coal etc., total 29% households in which 12% rural and 66% urban households use kerosene (Fig. 8), so the data indicate major variations in biomass fuel use pattern between rustic and city houses (Table 5). The study says that, the rural population is highly effected by burning of biomass fuel in cooking and other household activities.

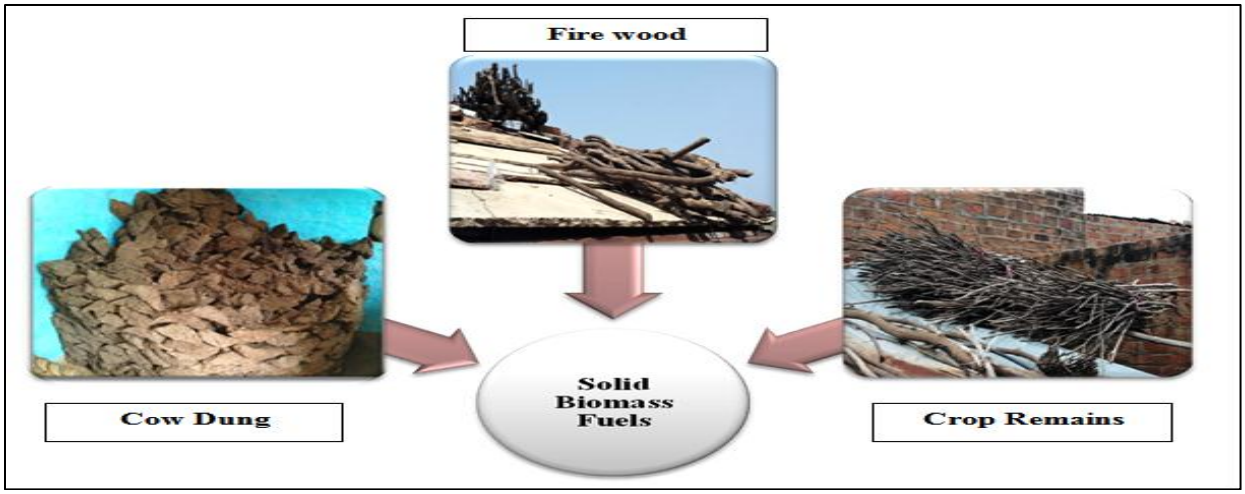


Fig 7. Picture showing the different type of solid biomass fuels which is used in the food preparation in rural regions

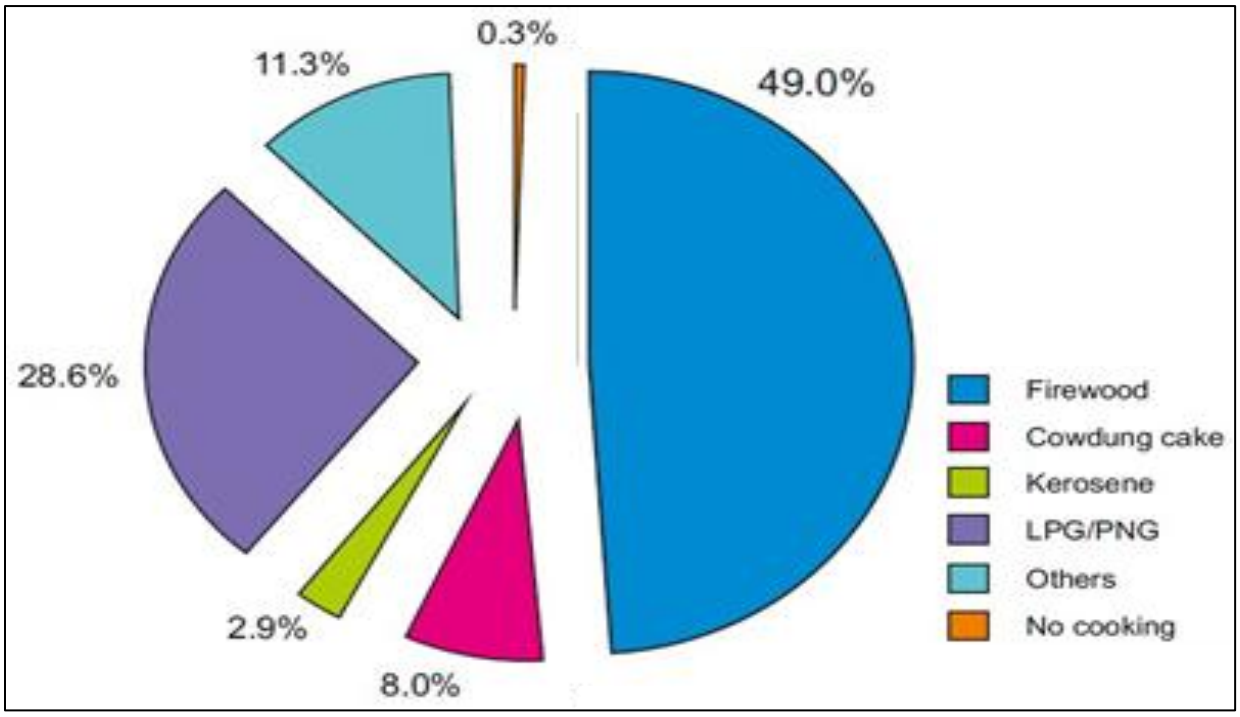


Fig 8. Presentation of household fuel use pattern of rural and urban areas (Source: Census, 2011).

Adverse health effects on women & children

According to World Health Organization (WHO, 2012) indoor smoke from unrefined solid biomass positioned as one of the top ten threat aspects for the global load of diseases, accounting for 4.3 million early fatalities every year (Fig. 9). Amongst main health threat aspects in India, ambient air pollution (AAP) is positioned 5th in death and 7th in overall fitness trouble. According to the World Health Organisation (WHO), 10 of the 20 mainly polluted capitals in the world are in India, including Delhi, Patna, Gwalior, Raipur etc. In rural regions chulha (traditional stove) is principally used for food preparation uses, which enhance the probability of indoor air pollution in the region. Numerous latest revisions have exposed strong links between raw biomass fuel ignition and increased frequency of chronic bronchitis in women

Table 5. Data showing the variations in fuel use pattern between rural and urban households

S. No.	Fuel used for cooking	Total	Rural	Urban
1.	Fire-wood	49.0	62.5	20.1
2.	Crop residue	8.9	12.3	1.4
3.	Cow dung cake	8.0	10.9	1.7
4.	Coal, Lignite, Charcoal	1.4	0.8	2.9
5.	Kerosene	2.9	0.7	7.5
6.	LPG/ PNG	28.5	11.4	65.0
7.	Electricity	0.1	0.1	0.2
8.	Biogas	0.4	0.4	0.4
9.	Any other	0.5	0.6	0.2
10.	No cooking	0.3	0.2	0.5

(Source: Census, 2011).

and acute respiratory infections in children in developing nations. Disclosure to unclean solid fuel combustion indoors has also been related with tuberculosis (TB) (Jafta *et al.*, 2015; Lin *et al.*, 2014), cataract (Ravilla *et al.*, 2016) and undesirable birth conclusions (Wylie *et al.*, 2017; Pope *et al.*, 2010). In accumulation, confirmation is now promising of associates with a figure of other situations, as well as low birth weight, asthma, tuberculosis, cataracts and cancer of the superior airways (Bruce *et al.*, 2000). Disclosure to air pollution, both household and ambient, is linked with a wide series of acute and chronic health belongings from slight physiologic disorders, to

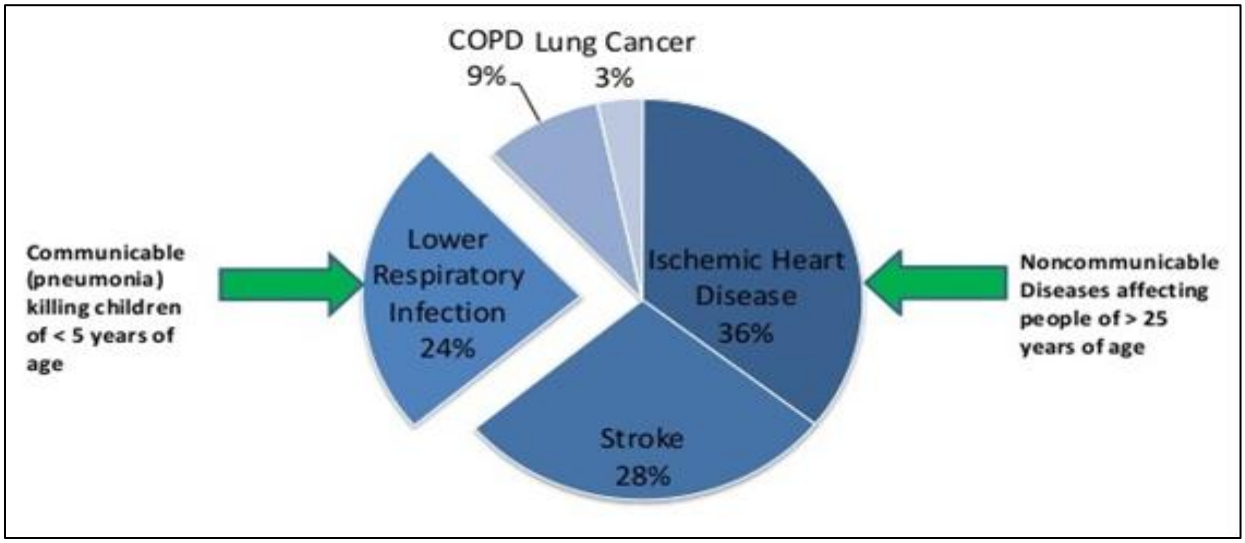


Fig 9. Proportion of overall worldwide fatalities due to cause that are recognized to air pollution
(Source: WHO, 2012).

fatality from respiratory and cardiovascular illness. Longer term experience to $PM_{2.5}$ has been linked with Acute Lower Respiratory Infection (ALRI) in children, developmental disorders, cardiovascular death, reduced lung function, Chronic Obstructive Pulmonary Disease (COPD), diabetes, and lung cancers. Largely women and young children in developing nations are at superior threat due to their masculinity functions and household tasks and behaviours; food preparation and spending loads of time inside the house and keeping children with them while food preparation resultant in elevated contact to indoor air pollution. Approximations point towards that indoor air pollution is connected with 1.5 million fatality yearly and 2.7% of the worldwide trouble of sickness (Table - 6). Of exacting fear is the association linking indoor air pollution and child Acute Respiratory Infections (ARI).

Table 6. Records for each five years from 1990 to 2010 for the proportion of entire worldwide deaths caused by recognized to air pollution characterized under three major diseases (Source: WHO, 2015).

Year	Chronic Obstructive Pulmonary Disease	Lower Respiratory Infections	Pneumoconiosis	Other Chronic Respiratory Disease	Total
1990	6.7	7.3	0.4	0.6	15
1995	6.3	6.7	0.3	0.6	13.9
2000	5.7	6.1	0.3	0.5	12.6
2005	5.4	5.5	0.2	0.5	11.6
2010	5.5	5.3	0.2	0.6	11.6

This is estimated that indoor air pollution sources nearly 36% of lower respiratory infections and 22% of chronic respiratory disease (UNEP, 2006). On fire unclean solid biomass in conventional cooking stoves, open fire three stone ‘‘stoves’’, or other stoves of little effectiveness, and frequently with slight aeration releases smoke having huge amount of detrimental pollutants Cooper, 1980; Smith, 1987, Smith and Liu, 1994 with serious health consequences for those exposed, mainly female involved in cookery and young kids spending time around their mother (Smith *et al.,* 2000; Bruce *et al.*, 2000). HAP is reported to increase annoyance of the airways, coughing, irregular heartbeat, difficulty in breathing and early fatality in persons with heart and lung syndrome (Gurley *et al.,* 2013; Laumbach and Kipen, 2012; Ritz and Wilhelm, 2008). Reviews of the load of illness attributable to exploit of unclean solid biomass fuel use in India have set the figure at 4-6% of the nationwide load of illness (Smith, 2000; Smith and Mehta, 2003). Disclosure to household air pollution from domestic unclean solid fuel exploit grounds over 4 million fatalities per year, and is the most major environmental threat issue for disability adjusted life years international. An approximate 400000 fatalities in India occur as a result of acute lower respiratory infection (ALRI) in children under five years of age, with a third of the danger attributable to HAP exposures. According to the newest World Health Organization (WHO) account, 8 million folks expire each year worldwide as a result of air pollution. Along with these, 4.3 million expire due to air pollution from household sources and 3.7 million expire as a result of ambient air pollution (Fig. 10).

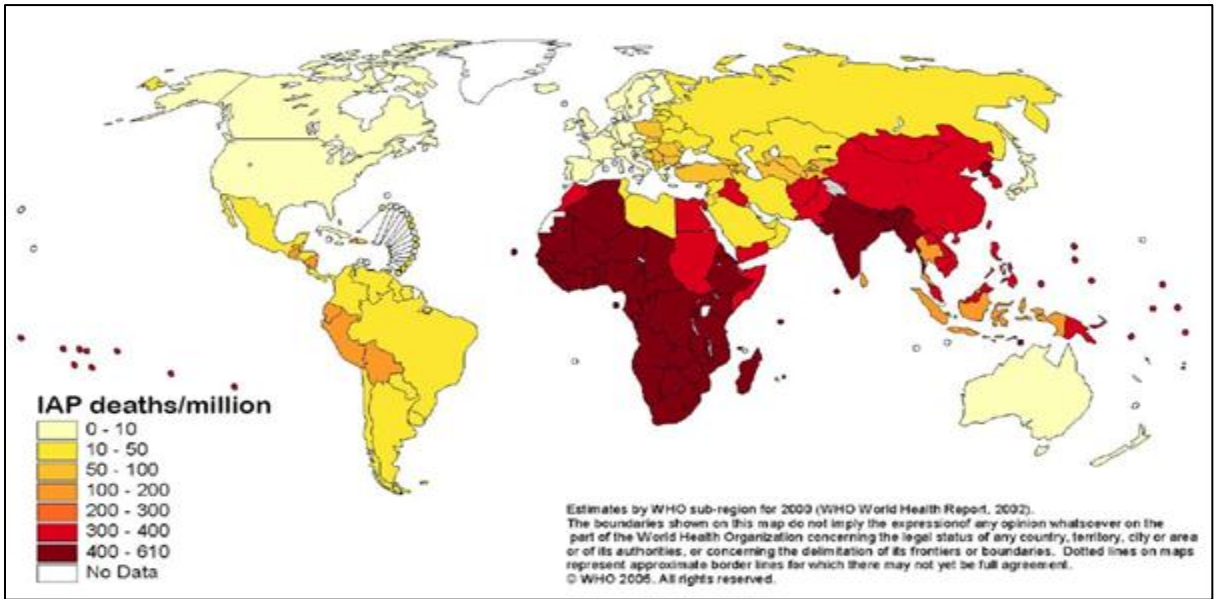


Fig 10. Worldwide indoor air pollution (IAP) death per million populations
(Source: Reprinted with authorization from WHO website: http://www.who. Int/heli/risks/indoor air/en/iapmap.pdf (admittance on 12th Oct 2016).

Awareness

Wakefulness amongst the common community with reference to air pollution and fitness dangers related with it has commonly been low in India. Elevated pollution stages in Beijing observe citizens wearing air filter masks, which hasn't essentially been the case in New Delhi. Almost all the female investigated believed that smoke from cookery harmfully affects their health and the health of their children; nevertheless, they were not conscious of precise health effects. Kitchen smoke was measured to be detrimental for the eyes and to cause headaches, shortness of breath, coughs, and other diseases. Nearly 21% of women declared they had experienced from extreme phlegm production for 10-12 days during the prior year (2006), and about a quarter of the children experienced signs of pneumonia during the similar phase. Rural inhabitants were found to be less conscious and aware in comparison the urban inhabitants in consider to air pollution and interrelated regulations.

Control measures and recommendations for improving Household Air Quality (HAQ)

According to the Air Quality Life Index, every person's life has decreased by 1.8 years due to air pollution. According to this report, the WHO guideline will be applicable to the Indians for up to 4.3 years. There is a critical require to implement a range of policies to recover rural household air quality. To get better air quality and decrease the weight of diseases, numerous intercessions have been approved in India to condense household air pollution. The Central Pollution Control Board (CPCB) and public health research body, ICMR required the setting up assignment to be in agreement for national indoor air pollution customs for the duration of the 12^{th} five years preparation. The National Biomass Cook stove Initiatives (NBCI) of the Central Government which is currently being executed in the "Unnat Chulha Abhiyan" targeted spreading of 27.5 lakh improved cook chulhas in the leftovers of the 12^{th} Five Year Plan phase. In initiate to manage the indoor air pollution through stipulation of uncontaminated or clean energy admittance, government has commenced a range of proposals that would aid clean energy entrance such as; "Pradhan Mantri Ujjwala Yojana" was commenced by Hon'ble Prime Minister of India, Shri Narendra Modi on May 1^{st}, 2016 in Ballia, Uttar Pradesh. In this proposal, 5 Cr. LPG connections will be afforded to BPL families with a support of Rs.1600/- per connection in the subsequently 3 years. Aim of this initiative is to provide safeguard for rural women and children from household air pollution which is generated through burning of solid biomass fuel on chulha. The plan would be executed over three years, namley, 2016-17, 2017-18 and 2018-19 across the country. Some indoor plants are useful in improving household air quality. Indoor plants can be proving to be helpful in preventing this problem from growing indoor air pollution such as: *Sansevieria trifasciata* (Snake Plant), *Spathiphyllum* (Piece Lily), *Chlorophytum comosum* (Spider Plant), *Colocasia* (Elephant Ear) and *Asparagus aethiopicus* (Asparagus Fern). These indoor plants are helpful in reducing toxins and gaseous pollutants such as NO_X, SO_X, CO, CO_2, VOC_S, Benzene and Formaldehyde by their higher absorption efficiency.

By taking those into consideration indoor air quality can be improved:

- Rural kitchens along with better ventilation system.
- Improve LPG accessibility in rural regions and encourage optional fuels for food preparation along with higher competence cook stoves.
- Expose awareness and induce behavioural change.
- By using improved cooking stoves instead of traditional cooking stoves without chimney.

Conclusion

Conventional use of solid biomass fuels exposure shows hazardous effect on all members of the family unit especially women and children on a regular basis at different stages of indoor air pollution. Since improved cooking stoves look to propose one of the greatest near term alternatives for reducing the women and children health impact of domestic solid unrefined biomass energy use, it would be significant to focus on this matter in future hope researches in India. It was estimated that, the rural population rely more on cow dung and fuel wood as a solid biomass fuel for preparing food and other household activities like boiling water and cooking cattle food and lightening

purposes, whereas, urban population use only LPG gas cylinders for cooking activities. So the study proves that indoor air pollution experiences are extensive among the rural poor and those female and children experience maximal potentials for elevated exposures. The studies on household air pollution (HAP) and respiratory health outcomes do provide some evidence of the serious impacts of HAP and especially the use of unclean biomass fuels in the home for preparing food, on respiratory health in the country, but the studies are few and limited. Hence, encouragement to use cleaner fuels will support in shortening this threat to a narrow level.

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