Original Research Article

Belief and Plausibility of UK Pulmonologists' on *Health Effects* Due to *Air Pollution*: Revisited

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ABSTRACT

Decision making process in a real world is invariably based on perception/belief expressed in words or sometimes in numeric terms and not in probability terms. Therefore, the expert's knowledgebase assumes significant importance in quantification of health effects. WHO Centre for Environment and Health, Europe in its 2005 document states: "There is little evidence for a causal relationship between asthma prevalence/incidence and air pollution in general, though the evidence is suggestive of a causal association between the prevalence/incidence of asthma symptoms and living in close proximity to traffic". The attempts made in the past in this direction used statistical mechanics in modelling epidemiological data, population characteristics, and pollution parameters. The paper is an attempt to rank respiratory diseases, based on health effects due to indoor and outdoor air pollutants, using combined belief/plausibility/ignorance for all the possible combinations of identified respiratory diseases by UK pulmonologists. The mathematical formulations used in the study are: Fuzzy Relational Algebra and Evidence Theory. The approach outlined in this paper, is based on belief or basic evidence assignment (Bea) of experienced pulmonologists only and there is no need to collect epidemiological data accumulated over a period of years to quantify health effects. The overall outcome of the study reveals that the combined belief of Pulmonologists for Simple Bronchitis Chronic Obstructive Pulmonary Disease (COPD) with lung cancer as the sub set of COPD or Asthma or Heart Attack is 0.68 with possibility 0.95.

Keywords: Air pollutants, respiratory diseases, pulmonologists, fuzzy relational calculus, evidence theory, combined belief and plausibility measures, ignorance.

INTRODUCTION

Air is prime resource for sustenance of life. Every day, an average person inhales about 20,000 liters of air. Every time we breathe, we risk inhaling dangerous chemicals. The health effects due to outdoor vehicular pollution in cities and indoor air pollution in homes are reflected by the hospital records of increasing incidences of cough, headache, nausea, irritation of eyes etc.

Human exposure to air pollutants may result in a variety of respiratory diseases depending on the type of pollutant, the magnitude, duration and frequency of exposure, and the toxicity of the specific pollutant. There are six common criteria pollutants viz. Particulate matter (PM_{10}, $PM_{2.5}$), Ground-level Ozone, Carbon monoxide, Sulphur Oxides, Nitrogen Oxides, and Lead. Some of the hazardous air pollutants include: Asbestos, Benzene,

Carbon Tetrachloride, Chlordane, Chloroform, Formaldehyde, Heptachlor, Hydrochloric Acid, Mercury, Methanol, Phenol, and Toluene.

After high blood pressure, indoor air pollution, tobacco smoking and poor nutrition with about 0.62 million premature deaths per year, occurring from air pollution related diseases (WHO 2004), air pollution has become the *fifth* leading cause of death in India. In fact air pollution in India is restricted mostly to urban areas, where automobiles are the major contributors, and to some other areas with a concentration of industries and thermal power plants. Also, major industries and automobiles emit tonnes of pollutants every day, putting citizens at a great health risk (Mukhopadhyay 2005).

Quantifying health risks associated with exposure to air pollution considering the uncertainties involved, can be an important guide for policy-makers. In this quest, researchers realized the need for employing different mathematical paradigms (Yadav 2013). The estimates, based on these approaches, will indicate the magnitude of the problem and could serve as a guideline in deciding air pollution control strategies.

The objectives of the paper include:
➢ Model belief of experienced Pulmonologists from UK to arrive at their combined belief in relation to ranking of respiratory diseases using Fuzzy Relational Calculus and Evidence Theory.
➢ Compare respiratory disease ranking results with the belief of Indian Pulmonologists.

The remaining part of the paper is organized as follows: Section 2 refers to brief literature review on health effects studies while mathematical preliminaries are detailed in Section 3. In Section 4 the study methodology is briefly described. Section 5 refers to the comparison of UK Pulmonologists' Combined Belief/evidence and plausibility on Health Effects Due to Air Pollution with Indian Pulmonologists while Section 6 presents discussion based on the study results. Section 7 covers concluding remarks.

A Brief Literature Review

Schwartz and Marcus (1990) were one of the first to carry out a time-series study of the health risks of air pollution using a normal linear model to analyze data. However, the mortality or morbidity data are daily counts and often include small numbers, therefore, Poisson regression techniques such as generalized linear (McCullagh and Nelder (1989)) or additive (Hastie and Tibshirani (1990)) models were used as these are considered as more appropriate. In all these studies, the researchers collected epidemiological data for over a decade for establishing the association between respiratory diseases and polluted air.

To estimate health risks of chronic exposure a cohort study is typically used. For example Dockery et al. (1993) examined the output of a cohort study in which over 8000 adults in six U.S. cities were followed for a period of 14-16 years. American Cancer Study (Pope III et al. (1995) and Pope III et al. (2002)) collected data on 1.2 million adults in 1982. Millennium Cohort Study (Violato et al. (2009)) in the U.K. sampled nearly 19,000 babies born in England and Wales between 2000 and 2002.

There are uncertainties involved at every stage of relevant data collection. The hospital staff might not have collected adequate time series numeric data to arrive at meaningful conclusion using statistical methods. Sometimes, data is collected for something and used for something else-known as happenstance data. To collect data is labor intensive and time consuming. Therefore, there is a need to devise a suitable formulation in quantifying the belief/evidence of the pulmonologists. In this paper, the authors have revisited the

formalism developed earlier, for the quantification of the combined belief of UK pulmonologists.

MATHEMATICAL PRELIMINARIES
Similarity Measure using Cosine Amplitude Method

This similarity metric method makes use of a collection of data samples, *n* data samples in particular. If these data samples are collected they form a data array, $\mathbf{X} = \{\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n\}$. Each of the elements, $\mathbf{x}_i$, in the data array $\mathbf{X}$ is itself a vector of length m, i.e. $\mathbf{x}_i = \{\mathbf{x}_{i1}, \mathbf{x}_{i2}, \ldots, \mathbf{x}_{im}\}$.

Hence, each of the data samples can be thought of as a point in m-dimensional space, where each point needs *m* coordinates for a complete description. Each element of a relation, r_{ij}, results from a pair wise comparison of two data samples, say $\mathbf{x}_i$ and $\mathbf{x}_j$, where the strength of the relationship between data sample $\mathbf{x}_i$ and data sample $\mathbf{x}_j$ is given by the membership value expressing that strength, i.e., $r_{ij} = \mu_R(x_i, y_j)$. The relation matrix will be of size n × n and, as will be the case for all similarity relations, the matrix will be reflexive and symmetric − hence a tolerance relation. The cosine amplitude method calculates r_{ij} in the following manner, and guarantees, as do all the similarity methods, that $0 \le r_{ij} \le 1$:

$$r_{ij} = \frac{\left| \sum_{k=1}^{n} x_{ik} x_{jk} \right|}{\sqrt{\left(\sum_{k=1}^{m} x_{ik}^2 \right)\left(\sum_{k=1}^{m} x_{jk}^2 \right)}}$$

where i, j = 1..n (1)

Fuzzy Relational Calculus
Definition
Let U be a universe set. A fuzzy set A of U is defined with a membership $\mu_A(x) \rightarrow [0,1]$, where $\mu_A(x), \forall x \in U$, indicates the degree of x in A.

Definition
Let R be a fuzzy relation on $X \times Y$, i.e. $R = \{((x, y), f_R(x, y)) \mid (x, y) \in X \times Y\}$, the α-cut matrix R_α is denoted by:

$$R_\alpha = \{((x, y), f_R(x, y)) \mid f_R(x, y) = 1, if \_ f_R(x, y) \ge \alpha;$$
$$f_R(x, y) = 0; if \_ f_R(x, y) < \alpha, (x, y) \in X \times Y, \alpha \in [0,1]\}$$
(2)

Definition
Let $R \subset X \times Y$ and $S \subset Y \times Z$ be fuzzy relations, the max-min composition $R \circ S$ is defined by:

$$R \circ S = \{((x, z), \max_y \{\min_{x,z} \{f_R(x, y), f_S(y, z)\}\})$$
$$\mid x \in X, y \in Y, z \in Z\}$$
(3)

Definition
A fuzzy relation R on $X \times X$ is called a fuzzy equivalence relation if the following three conditions are true [4-6]:
1. R is reflexive, if $f_R(x, x) = 1, \forall x \in X$ (4)
2. R is symmetric, if $f_R(x, y) = f_R(y, x), \forall x, y \in X$ (5)
3. R is transitive, if $R^{(2)} = (R \circ R) \subset R$, or more explicitly using definition 3.2.5 (6)

Definition
The transitive closure, R_T of a fuzzy relation R is defined as the relation that is transitive, contains R and has the smallest possible membership grades. It can be transformed into a fuzzy equivalence relation by at most (n-1) compositions, just as a crisp tolerance relation can be reformed into a crisp equivalence relation. That is −
Fuzzy $R^{n-1} = R_1 \circ R_1 \circ \ldots \circ R_1 = R$ (7)

A Commentary on Monotone Measures: Belief, Plausibility, Probability, Possibility and Evidence Theory

A monotone measure describes the vagueness or imprecision in the assignment of an element '*a*' to two or more crisp sets. Figure 1 shows this idea. In the figure the universe of discourse comprises of a collection of sets and subsets, or the power set. In a monotone measure what we are trying to describe is the vagueness or imprecision in assigning this point to any of the crisp sets on the power set. This notion is not random; the crisp sets have no uncertainty about them. The uncertainty is about the assignment. This uncertainty is usually associated with evidence to establish an assignment. The evidence can be

completely lacking - the case of total ignorance - or the evidence can be complete - the case of a probability assignment. Hence, the difference between a monotone measure and a fuzzy set on a universe of elements is that, in the former, the imprecision is in the assignment of an element to one of two or more crisp sets, and in the latter the imprecision is in the prescription of the boundaries of a set.
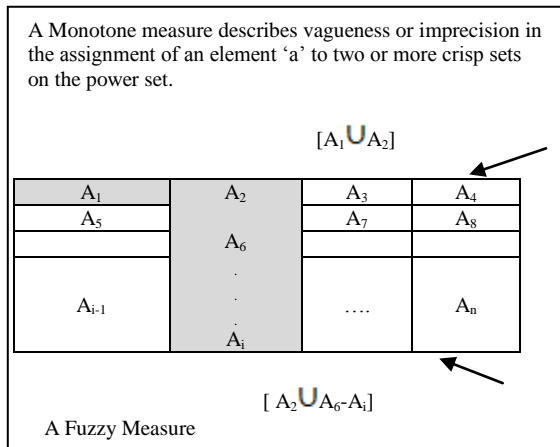
A Monotone measure describes vagueness or imprecision in the assignment of an element 'a' to two or more crisp sets on the power set.

$[A_1 \cup A_2]$

A_1	A_2	A_3	A_4
A_5		A_7	A_8
	A_6		
A_{i-1}	. . . A_i	....	A_n

$[A_2 \cup A_6 - A_i]$

A Fuzzy Measure

Figure 1: Monotone Measures

Following are the Special Forms of Monotone Measures:

Belief Measure
A form associated with preconceived notions, is called a belief measure.

$$Bel\ (A) = \sum_{B|B \subseteq A} m(B) \qquad (8)$$

Plausibility Measure
A form associated with information that is possible or plausible, is called Plausibility measure.

$$Pl(A) = \sum_{B|B \cap A \neq \emptyset} m(B) \qquad (9)$$

Certain forms of belief measures and plausibility measures are known as certainty and possibility measures, respectively.

Belief $\cap$ plausibility measures (where belief equals plausibility) = Probability

Monotone measures are defined by weaker axioms than probability theory, thus assuming probability measures as specific form of monotone measure.

pl (A) = 1- bel (Ā) (10)

where: bel (A) is a belief measure (a quantity) that expresses the degree of support, or evidence, for a collection of elements defined by one or more of the crisp sets existing on the power of a universe.

Evidence Theory

The material presented in the preceding section now sets the stage for a more complete assessment of evidence, called evidence theory. Suppose the evidence for certain monotone measures come from more than one source, say two experts. Evidence obtained in the same context (e.g., for sets A_i on a universe X) from two independent sources (e.g., two experts) and expressed by two *bea's* (e.g., m_1 and m_2) on some power set P(X) can be combined to obtain a joint *bea*, denoted m_{12}, using Dempster's rule of combined evidence The equations for combined evidence are as follows:

$$m_{12}(A) = \frac{\sum_{B \cap C = A} m_1(B)m_2(C)}{1-K} \qquad (11)$$

$\forall\ A \neq \emptyset, \text{and}\ m_{12}(\emptyset) = 0$ where

$$K = \sum_{B \cap C = \emptyset} m_1(B).m_2(C) \qquad (12)$$

Study Methodology

The detailed exposition of multifaceted mathematical framework for establishing the possible association between inhaling polluted air and respiratory diseases is depicted in Figure 2.

The stepwise brief description of the activities is described below:

Identify as many pulmonologists as feasible and obtain their evidence/belief on association between inhaling polluting air (indoor or outdoor exposure) using any type of format such as: personal interviews, via email, telephonic conversion, and alike. This is termed as Basic Evidence/belief Assignment (*bea/bba*) denoted by m.

1. Construct (m x n), matrix [power sets of respiratory diseases as m (row), and the pulmologists as n (column)]. The

elements of this matrix are on two universes. Therefore, compute similarity coefficient between the experts using cosine amplitude method (Eq.1).

2. Carry out max-min compostion/resemblance (Eq. 2-7).
3. Transform the matrix to fuzzy equivalence matrix.
4. Fuzzy to crisp conversion and the defined cut levels and plotting of dendrogram.

5. Identify the pulmonologists with defined α-level cut/possibility. This possibility or α-level cut will depend upon the severity of the diseases.
6. Work out their individual belief/evidence and plausibility (Eq. 8-10).
7. Estimate their combined belief/evidence, plausibility and ignorance (Eq. 11-12).
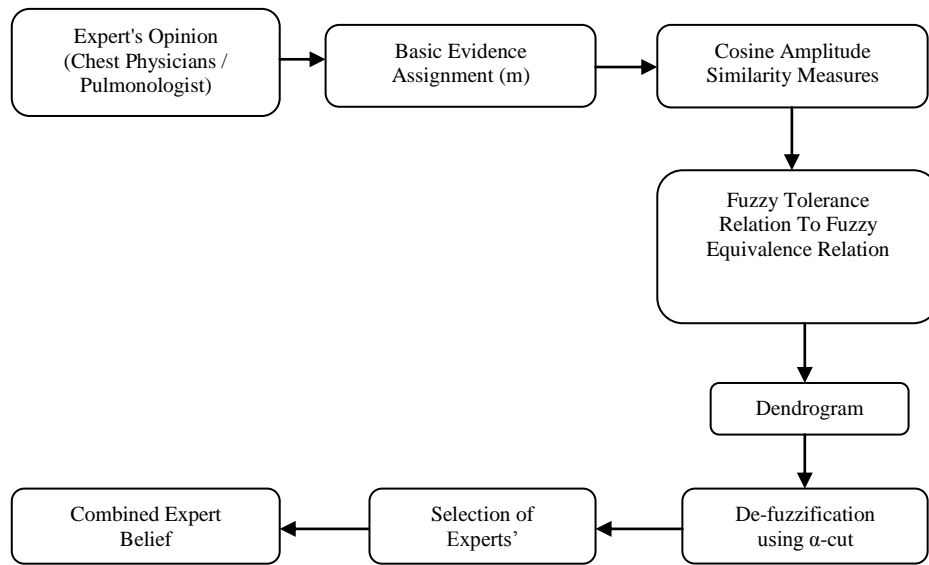

Figure 2: Framework for Estimating the Combined Belief In Respect Of Air Pollution and Respiratory Diseases

Table 1: The normalised values of the belief function of UK Pulmonologists

Sr. No.	Diseases	E1	E2	E3	E4	E5	E6	E7
1	A	0.04	0.15	0.15	0.04	0.09	0.10	0.10
2	B	0.08	0.12	0.05	0.07	0.08	0.08	0.08
3	C	0.01	0.03	0.14	0.01	0.02	0.03	0.02
4	D	0.02	0.00	0.03	0.01	0.01	0.01	0.02
5	A∪B	0.09	0.14	0.07	0.09	0.10	0.10	0.10
6	A∪C	0.05	0.09	0.15	0.04	0.05	0.08	0.07
7	A∪D	0.05	0.08	0.05	0.06	0.06	0.06	0.04
8	B∪C	0.08	0.08	0.08	0.08	0.08	0.06	0.05
9	B∪D	0.09	0.06	0.02	0.08	0.04	0.05	0.05
10	C∪D	0.02	0.02	0.04	0.02	0.02	0.02	0.02
11	A∪B∪C	0.09	0.10	0.10	0.10	0.10	0.10	0.10
12	A∪B∪D	0.10	0.07	0.03	0.10	0.11	0.12	0.10
13	A∪C∪D	0.09	0.03	0.05	0.09	0.09	0.05	0.10
14	B∪C∪D	0.10	0.02	0.03	0.09	0.03	0.03	0.04
15	A∪B∪C∪D	0.10	0.02	0.01	0.10	0.11	0.12	0.10

The Study

What causes what is a difficult question to be answered, especially when there are multi-causes. It is heartening to note that in the past sizeable efforts were made in establishing relationship between inhaling polluted air and its health effects. In these studies, the emphasis was on epidemiological data and its statistical interpretation. Realizing the limitations of data collection and statistical techniques, in this paper the authors have approached the problem of the association between respiratory diseases and inhaling polluted air, using the knowledgebase of pulmonologists/Chest Physicians.

In order to establish the combined belief, seven Chest Physicians/ Pulmonologists from United Kingdom were identified for the study. On the basis of their several years of experience and expertise, they categorized respiratory diseases into four groups: *A. Simple Bronchitis and Chronic Obstructive Pulmonary Disease (COPD) with lung cancer as the sub set of COPD B. Asthma C. Allergic Rhinitis and Conjunctivitis, and D. Heart Attack.* The experts' were further interviewed for their opinion on diseases caused/exacerbated due to increase in concentrations of air pollutants like RSPM (such as PM_{10}, $PM_{2.5}$), NO_X, and SO_X and other criteria air pollutants. The experts have communicated their evidence/belief for the diseases in the questionnaire specially designed for the purpose which is termed as Basic Evidence Assignment.

Table 1 presents the belief of the seven pulmonologists from UK who has several years of experience in dealing with the patients who were exposed to indoor or outdoor air pollution. The normalised values of the belief function of the experts are presented in Table 1. $E_1, E_2,.. … E_7$ are UK pulmonologists
A. Simple Bronchitis and Chronic Obstructive Pulmonary Disease (COPD) with lung cancer as the sub set of COPD
B. Asthma
C. Allergic Rhinitis and Conjunctivitis, and
D. Heart Attack.

RESULTS AND DISCUSSIONS
The similarity of experts was worked out using cosine amplitude method as the elements of the matrix (Table 2) are on two different universes. Sometimes, it is fuzzy tolerance relation which was transformed to fuzzy equivalent relation using equations 4-7.
Table 2 is already fuzzy equivalent relations as:
(E_2,E_3)=0.86 and (E_3,E_5)=0.74
but (E_2,E_5)=0.88 $\geq$ min[0.86,0.74]
(E_1,E_5)=0.95 and (E_5,E_4)=0.94

but (E_1,E_4)=1$\geq$ min[0.95, 0.94]
(E_2,E_1)=0.80 and (E_1,E_7)=0.93
but (E_2,E_7)=0.88 $\geq$ min[0.80, 0.93]
Therefore, it is a fuzzy equivalence relation.

Table 2: Fuzzy Equivalence relation using transitivity closure

Experts'	E1	E2	E3	E4	E5	E6	E7
E1	1.00	0.80	0.64	1.00	0.94	0.92	0.93
E2	0.80	1.00	0.86	0.79	0.88	0.90	0.88
E3	0.64	0.86	1.00	0.64	0.74	0.77	0.77
E4	1.00	0.79	0.64	1.00	0.94	0.92	0.93
E5	0.94	0.88	0.74	0.94	1.00	0.98	0.99
E6	0.92	0.90	0.77	0.92	0.98	1.00	0.97
E7	0.93	0.88	0.77	0.93	0.99	0.97	1.00

Using α- cut level for defuzzifcation method for fuzzy to crisp converse, we will get similar pulmonologists at the desired α-cut levels which is portrayed in Figure 3 as a dendrogram. Pulmonologists E_1 and E_4 could be classified in one group with possibility (α- cut level 1.0), while E_1, E_4 , E_5 and E_7 are in one group with possibility (α- cut level 0.99) and E_1, E_4, E_5, E_7 and E_6 are in one group with possibility (α- cut level 0.97). It can be inferred that out of 7, E_7 and E_5 experts' agree with one another with possibility of 0.97. We live in uncertain or fuzzy world. All the experts' might not agree with one another which is in line with Consistency Principle.
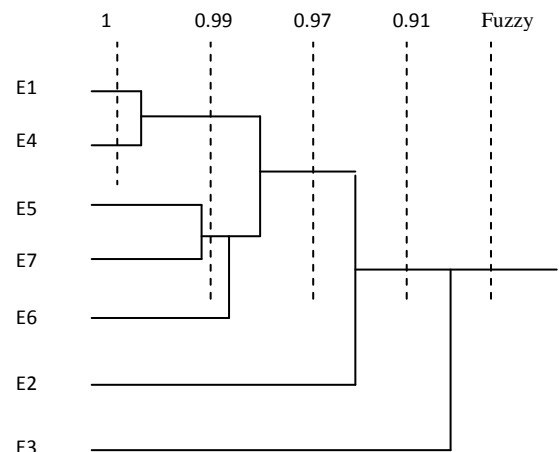

Figure 3: Dendrogram with α-cut 1, 0.99, 0.97, 0.91 and 0.64

The combined belief of pulmonologists E1 and E4 is 0.68 moderate with plausibility very high value 0.95 for A OR B OR D. Their belief for only one single disease, asthma [B] is 0.21 with plausibility 0.58 (Table 3).

Diseases	Expert E_1		Plausibility	Expert E_4		Plausibility	Combined Evidence		Plausibility
	m_1	bel_1		m_2	bel_2		$m_{1,2}$	$bel_{1,2}$	
A	**0.04**	0.04	0.61	**0.04**	0.04	0.63	0.12	0.12	0.44
B	**0.08**	**0.08**	**0.72**	**0.07**	**0.07**	**0.72**	**0.21**	**0.21**	**0.58**
C	**0.01**	0.01	0.54	**0.01**	0.01	0.54	0.06	0.06	0.33
D	**0.02**	0.02	0.56	**0.01**	0.01	0.56	0.07	0.07	0.36
A ∪ B	**0.09**	0.21	0.95	**0.09**	0.20	0.96	0.09	0.43	0.85
A ∪ C	**0.05**	0.10	0.82	**0.04**	0.09	0.83	0.06	0.23	0.64
A ∪ D	**0.05**	0.11	0.83	**0.06**	0.11	0.84	0.06	0.26	0.66
B ∪ C	**0.08**	0.17	0.89	**0.08**	0.16	0.89	0.08	0.35	0.75
B ∪ D	**0.09**	0.18	0.90	**0.08**	0.17	0.91	0.08	0.37	0.77
C ∪ D	**0.02**	0.05	0.79	**0.02**	0.04	0.80	0.03	0.16	0.58
A ∪ B ∪ C	**0.09**	0.44	0.98	**0.10**	0.44	0.99	0.03	0.65	0.94
A ∪ B ∪ D	**0.10**	0.46	**0.99**	**0.10**	0.46	**0.99**	0.03	0.68	**0.95**
A ∪ C ∪ D	**0.09**	0.28	0.92	**0.09**	0.28	0.93	0.03	0.43	0.80
B ∪ C ∪ D	**0.10**	0.39	0.96	**0.09**	0.37	0.96	0.03	0.57	0.89
A ∪ B ∪ C ∪ D	**0.10**	1.00	1.00	**0.10**	1.00	1.00	0.01	1.00	1.00
Total	1.00								

The combined belief of pulmonologists E5 and E7 is 0.76 high with plausibility very high value 0.98 for A OR B OR C. Their belief for only one single disease, Simple Bronchitis and Chronic Obstructive Pulmonary Disease (COPD) with lung cancer as the sub set of COPD [A] is 0.23 with plausibility 0.62 (Table 4).

Table 5 presents summary of the ranking of individual disease. It can be conclusively stated that Asthma [B] ranks first while COPD [A] is ranked as second respiratory disease due to traffic pollution. Similar conclusion was drawn by the earlier researchers but without assigning the belief/evidence and plausibility of the expert pulmonologists.

Somewhat similar study was carried out in India by first and third author of this paper. The overall conclusion is almost similar. The combined belief of pulmonologists E1 and E2 is 0.68 high with plausibility very high value 0.91 for A OR B OR C. (Yadav, 2013).

A gas emitted from tailpipes and power plants, nitrogen oxide contributes to the formation of ground-level ozone and smog. It also reacts with other air pollutants to form small particles that can cause breathing difficulties, especially in people with asthma. Exposure to high levels of nitrogen dioxide early in life could increase risk of developing asthma. In UK, nitrogen oxide concentration levels are higher than the permissible limits. The result of the present study also ranks nitrogen oxide as the topmost criteria pollutant which might cause asthma.

Diseases	Expert E_4		Plausibility	Expert E_7		Plausibility	Combined Evidence		Diseases
	m_1	bel_1		m_2	bel_2		m_1	bel_1	
A	**0.09**	0.09	0.72	**0.10**	0.10	0.72	0.23	0.23	0.62
B	**0.08**	0.08	0.66	**0.08**	0.08	0.62	0.19	0.19	0.48
C	**0.02**	0.02	0.50	**0.02**	0.02	0.51	0.07	0.07	0.31
D	**0.01**	0.01	0.47	**0.02**	0.02	0.47	0.05	0.05	0.27
AυB	**0.10**	0.28	0.95	**0.10**	0.28	0.93	0.11	0.53	0.90
AυC	**0.05**	0.17	0.86	**0.07**	0.19	0.85	0.08	0.38	0.76
AυD	**0.06**	0.17	0.82	**0.04**	0.16	0.84	0.07	0.35	0.73
BυC	**0.08**	0.18	0.83	**0.05**	0.16	0.84	0.05	0.30	0.68
BυD	**0.04**	0.14	0.83	**0.05**	0.15	0.81	0.04	0.27	0.65
CυD	**0.02**	0.05	0.72	**0.02**	0.07	0.72	0.02	0.13	0.50
AυBυC	**0.10**	0.53	0.99	**0.10**	0.53	0.98	0.04	0.76	0.98
AυBυD	**0.11**	0.50	0.98	**0.10**	0.49	0.98	0.04	0.72	0.96
AυCυD	**0.09**	0.34	0.92	**0.10**	0.38	0.92	0.03	0.55	0.84
BυCυD	**0.03**	0.28	0.91	**0.04**	0.28	0.90	0.01	0.41	0.80
AυBυCυD	**0.11**	1.00	1.00	**0.10**	1.00	1.00	0.01	1.0	1.0
Total	1.00								

Table 5 Average evidence/ belief and Average Plausibility of six pulmonologists with similarity

Sr.No	Respiratory Disease	Average Belief/ evidence	Average Plausibility	Rank of Disease if any
1	**A [Simple Bronchitis and Chronic Obstructive Pulmonary Disease (COPD) with lung cancer as the sub set of COPD**	**0.04**	**0.68**	**2**
2	**B [Asthma]**	**0.07**	**0.68**	**1**
3	C [Allergic Rhinitis and Conjunctivitis,]	0.01	0.51	3
4	D [Heart Attack]	0.01	0.50	4

CONCLUDING REMARKS

The experienced pulmonologists believe that the diseases can be either a cause of vehicular pollution, and could be aggravated or triggered. Outdoor air pollution control has been the emphasis in many countries in the world with focus on reduction in vehicular pollution.

The two studies carried by the authors conclusively infer that there is a need to bring down air pollution. Especially in case of asthma, the authors believe that the disease gets aggravated in patients who are already suffering from that disease, and healthy people are likely to become asthmatic because of long-term exposure to vehicular pollution. Furthermore, the researchers justify the disease as pathophysiological and relate asthma to the functional changes that can be caused in the respiratory tract. Experienced pulmonologists are of the view that the Respiratory Suspended Particulate Matter (RSPM-PM_{10}, $PM_{2.5}$) is important in triggering exacerbation of COPD/Asthma. Untreated asthma gets converted to COPD and might lead to lung cancer. This is in line with the results obtained by Pope et al. in their exhaustive study. The toxic pollutants emitted from two/three diesel or petrol driven two/three wheel vehicles along with four wheelers act as allergens which may lead to irritation of eyes and resulting in conjunctivitis.

To communicate the effects of toxic air pollutants on human health through scientific studies to the decision makers, scientific community and public at large assumes importance, especially when the vehicular traffic in many cities is on increase.

The approach presents in the paper is of general nature and could be applicable in many other cause-effect relational studies wherein domain expert knowledgebase based on their evidence/ belief. What is more important is to suggest a policy framework to bring down especially vehicular pollution in urban settings in all the countries.

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