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Do perception factors affect adaptation behaviours against air pollution among vulnerable occupation groups? evidence from chittagong and dehradun

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Abstract

Air pollution is a key environmental issue affecting the urban population in the urban cities of Hindu Kush Himalaya (HKH) countries. It is particularly detrimental to marginalized occupation groups like street vendors, labourers and drivers who work outdoors for their livelihood. There are mitigation strategies to reduce the brunt of air pollution that work in the long run. However, these strategies will need time to implement and operationalize. Adaptation behaviours and measures, in this context, are urgently required and become vital to cope with the impacts of air pollution exposure especially for highly exposed informal workers who have very little means of avoiding it. Adaptation behaviour is very complex and depends on socioeconomic and psychological factors. In this paper, we assess the impact of psychological factors like perception and motivation on the adaptive behaviour of the informal workers using Protection Motivation Theory (PMT). Our findings from Dehradun show that concern behaviour towards air pollution was strongly affected by motivation and perception factors. Adaptive behaviour in the form of both concern behavior and the extent of use of additional protective measures is dependent on how the risks of air pollution and related adaptation measures are perceived by the workers. In addition to this, certain adaptation behaviours like changing or adjusting the daily normal behaviour to avoid air pollution exposure are not feasible as they have direct implications on daily wage earnings.

1. Introduction

Rapid urbanization fuelled by economic growth and disorganized industrialization albeit increasing the socioeconomic status has worsened the air quality in the South Asian developing countries (Shi *et al* 2020). According to the data from State of Global Air, the annual PM 2.5 concentrations for the entire South Asia is 5–9 times higher than the WHO annual ambient PM2.5 standards (Health Effects Institute 2020). Moreover, most of the polluted cities (49 out of 50) fall in four Hindu Kush Himalayan (HKH) countries - India, China, Bangladesh, and Pakistan (IQAir 2020). Exposure to such high levels of pollution has a negative impact on human health, as pollution is considered the fifth-leading risk factor for mortality at a global scale coupled with increased harmful short-and long-term effects (Masiol *et al* 2014, Boogaard *et al* 2019).

The study sites—Chittagong in Bangladesh and Dehradun in India—are two such cities with high levels of pollution. The port city is the second largest city in the country and has a rich socio-political history. Being the second largest city and a major business hub of Bangladesh, the city is densely populated and amongst the most populated city in South Asia. Major sources of emissions emanate from various kinds of diesel vehicles and automobiles, biomass/coal burning for cooking and brick kilns, a massive undertaking of construction works, re-suspended road dust particles, etc (Hossen amd Hoque 2016). The air quality in the city has been steadily declining over the years with the average Air Quality Index (AQI) showing a steady increase from 127 to 133 during the 2013–2015 period (Hossen and Hoque 2016). The assessment carried out by Masum and Pal (2020) in selected locations in the city over the period of 2012–2019 show that the air quality turns from unhealthy (AQI > 150) to extremely unhealthy (AQI > 200) every year during the dry season (November to February). Similarly, Dehradun city in India has also experienced an increase in air pollution over the last decade because of haphazard urbanization, and industrialization. City covers an area of 64.4 sq. km. and has a population of 569,578 (2011 census). Physical topography of Dehradun is diversified, spanning from the plains to mountains. Dehradun's economy is mainly service sector based but rapid industrialization has taken place in the outskirts of the city over the last 2 decades. Being the gateway to the Himalayan region of the State, the city also attracts a large number of tourists on their onward journeys to different hill destinations. In 2019, migration data revealed that Dehradun had not only a significant influx of people from the hilly regions of the state but also from other states of the country. Being declared as an ad-hoc capital of the Himalayan state Uttarakhand the city experienced a huge influx of individuals and a rise in the number of vehicles. Today, vehicular emission is one of the biggest sources of air pollution in Dehradun. According to the road transport authority, only 10,000 vehicles were registered in Dehradun between 1937 and 1967. But at present, there are more than 126,452 vehicles are registered, and a large proportion of registrations happened post the year 2000. This rapid urbanization and unwanted development are adversely affecting the air quality of the city.

Emissions through automobile, industry and burning of fossil fuels are the major contributors. AQI measures show unhealthy air conditions at various parts of the city including the city centre (Ghantaghar) and bus station. The 2011–2014 trend of AQI in major city centres and bus stations was measured to be very unhealthy (AQI > 200) (Deep *et al* 2019).

This trend of decreasing air quality in these cities has affected the daily lives of the residents in the cities. The informal workers like street vendors, labourers and drivers are most vulnerable to air pollution exposure because of the nature of their job that requires them spending long hours outdoors. Migrants from rural areas with low educational qualifications form a large portion of informal urban workers.

Adaptation behaviour is very complex and depends on socioeconomic determinants and psychological factors such as motivation and perception (Bamberg and Moser 2007, Helm *et al* 2018). In our context, as the informal workers primarily shared very similar socioeconomic conditions, an assessment of psychological factors that affect the adaptation behaviour were of interest. Hence, the main objective of the research was to assess the impact of psychological factors like perception and motivation on the adaptive behaviour of these informal workers. The motivation to focus on and explore these factors comes from the fact studies related to adaptation behaviours to cope with air pollution in the context of urban informal workers are limited.

Mitigation strategies like reduction of energy use in the household environment, better urban planning, provision of renewable energy, use of electric vehicles, etc and pro-environmental behaviour to improve the air quality in the city can go a long way in reducing the brunt of air pollution (Sofia *et al* 2020). However, these strategies will need time to implement and operationalize. Adaptation behaviours and measures, in this context, are urgently required and become vital to cope with the impacts of air pollution exposure especially for highly exposed informal workers who have very little means of avoiding it. Therefore, this study contributes significantly by exploring linkages between the psychological factors and adaptive behavior to cope with air pollution exposure among informal workers. It is a novel contribution to the existing literature as very less has been researched on the topic for informal workers in the urban areas in a developing country context of South Asia. Moreover, the study also plays a vital role in guiding customized interventions and strategies that foster sustained adaptive behavior while addressing the unique challenges faced by the informal workers.

2. Literature review

Several studies have explored the linkages between psychosocial factors and health protective behavior. The psychosocial factors have been found to be stronger predictors of protective behavior than sociodemographic factors (Al-Rasheed 2020, Zickfeld *et al* 2020, Batra *et al* 2021, Yıldırım *et al* 2021). This has shed light on the importance of exploring into these factors to assess the protective behavior. In this regard, impacts of psychological factors using social cognitive models of behavioral change like health belief model (HBM), the protection motivation theory (PMT) and the extended parallel process model (EPPM) have been prominent (Radisic *et al* 2016, Covey *et al* 2019, Xu *et al* 2020). These models depended primarily on cognitive assessment of risk perception, severity, and vulnerability.

One of the best predictors of protective behavior among the cognitive factors is efficacy beliefs. Both efficacy for protective behavior and self-efficacy when engaging in protective behavior have been shown to be predictors of health protective behavior in cases of pandemic (Bish and Michie 2010, Kim and Niederdeppe 2013, Yoo *et al* 2016, Ahmad *et al* 2020, Al-Rasheed 2020, Lin *et al* 2020, Bronfman *et al* 2021, Scholz and Freund 2021, Kojan *et al* 2022). In some studies, the link between protective behaviour and perceived self-efficacy (Yıldırım *et al* 2021) and response efficacy (Al-Rasheed 2020) were found to be very weak. Similarly, it is also found from the empirical literature that perceived risk also relates positively to protective behavior intention (Tooher *et al* 2013, Ferrer and Klein 2015, Williams *et al* 2015).

There have been a few studies exploring into determinants of protective and/or adaptive behavior in relation to air pollution exposure. These studies have tested the effects of perceived threats and response efficacy on adaptation to smog episodes and have found positive relationships (Johnson 2012, Lin and Bautista 2016, D'Antoni *et al* 2017, Covey *et al* 2019, Mehiriz and Gosselin 2022). In some studies, self-efficacy was found to be statistically significant factor in predicting adaptive or protective behavior (Hansstein and Echegaray 2018, Sahrir 2019). At the same time, the findings from the empirical literature also show a positive effect of the perception of threats towards adaptation to smog (Johnson 2012, Ban *et al* 2017, Covey *et al* 2019, Qin *et al* 2020, Xu *et al* 2020).

3. Conceptual framework

Protection Motivation Theory (PMT) has been used as the conceptual framework to understand the adaptation behaviours of the vulnerable occupation groups in the urban centres in Chittagong, Bangladesh and Dehradun, India. PMT has been used in the health sector and is based on the health belief model of Rogers *et al* (Rogers 1975, Maddux and Rogers 1983). It has been widely adopted in research to understand the pro-environmental behaviour in the fields of environmental risk and natural disaster response. (Mulilis and Lippa 1990, Bubeck *et al* 2012, Floyd *et al* 2000, Ghanian *et al* 2020). The theory stipulates that when faced with potential threats, people tend to conduct two psychological assessments: threat appraisal and coping appraisal. Threat appraisal consists of an individual's perceived severity of and vulnerability to a risk. Coping appraisal includes the perceived capability to engage in and perceived effectiveness of the coping responses and behaviours constituting self-efficacy and response efficacy. These, in turn, determine the adaptive behaviours of the individuals concerned. There have been several studies that have researched into self-efficacy and response efficacy and its effect on adaptation behaviour. Among them, some have explored into pro-environmental behaviour (Kim *et al* 2013, Zhao *et al* 2016, Rainear and Christensen 2017, Xue *et al* 2021) while others have focused on health-related behaviour (Floyd *et al* 2000, Milne *et al* 2000).

In the context of air pollution, we define threat appraisal as 'risk appraisal' and coping appraisal as 'adaptation appraisal' following the terminology used by Xue *et al* (2021). During the risk appraisal process, the workers assess the vulnerability to, and severity of the risks associated with air pollution. Perceived severity is measured by assessing an individual's association of negative health consequences to air pollution exposure. The perceived severity is measured for two locations - workplace and during commutation. Perceived vulnerability is measured by assessing an individual's belief about the likelihood of developing a health risk and working capacity in the future due to air pollution exposure. In addition to this, mental vulnerability is also factored looking at the linkages between mental distress and annoyance to air pollution exposure. The adaptation appraisal consists of indicators measuring self-efficacy i.e., the perceived capability of the workers to engage in protective behaviour and response efficacy i.e., the perceived effectiveness of the protective behaviour/measures to cope with air pollution exposure. Adaptive behaviour, in our context, relates to the use of additional protective measures and concern behaviour towards the risks associated with air pollution exposure (Ban *et al* 2017). As the workers had little to no flexibility in adjusting their duration of work or timing of their work schedules, they were not taken as part of the relevant adaptation measures. The framework is illustrated in figure 1.

3.1. Hypotheses

We test a few hypotheses in relation to the conceptual framework of PMT outlined above. The hypotheses are as follows:

Hypothesis 1: Risk appraisal of air pollution exposure will affect the workers' intention to conduct adaptive behaviour. The higher the risk is perceived to be, the stronger the adaptive behaviour.

In the risk appraisal process, if the risk is adjudged to have high perceived severity and vulnerability, then, it is believed that the workers will be motivated to adopt adaptation behaviours. In other words, the hypothesis states that there is a positive relationship between perceived severity of the workers towards the risk of air pollution and adaptive behaviour. Similarly, there is a positive relationship between perceived vulnerability and adaptive behaviour. For the purposes of our hypothesis testing, the perceived vulnerability and severity are combined to reflect the assessment of risks of air pollution exposure for the workers.

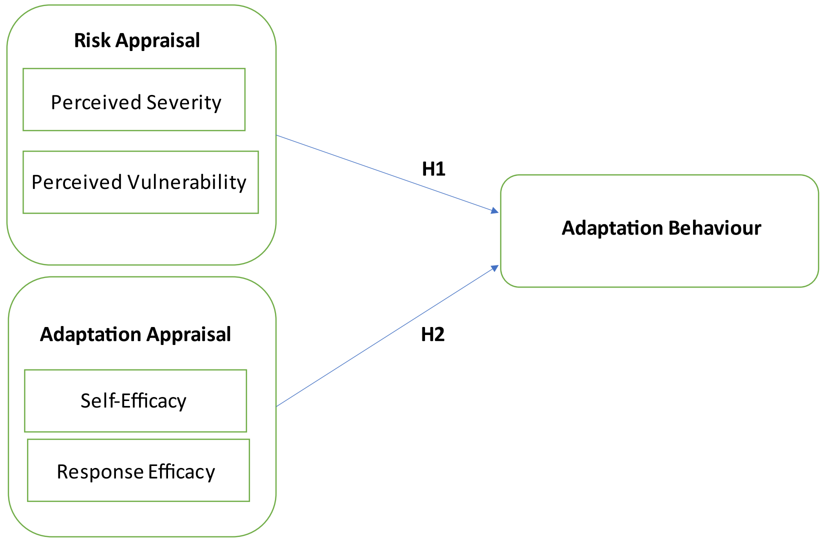

Figure 1. Protection Motivation Theory (PMT).

Hypothesis 2: Adaptation appraisal conducted by the workers to cope with air pollution exposure will affect their adaptation behaviour. The higher the perceived adaptive capacity (assessed by self and response efficacy), the stronger the adaptive behaviour.

In the adaptation appraisal process, the workers usually engage in adaptation appraisal that consists of self-efficacy and response efficacy to determine the extent to which they can deal with the risks associated with air pollution exposure. If the workers feel that they have higher adaptive capacity, they will engage in adaptive behaviour. In other words, the hypothesis states that there is a positive relationship between the workers' perception of their own ability to undertake adaptation behaviour and conducting the adaptation behaviour. Similarly, there is a positive relationship between the workers' perception of the effectiveness of an adaptation behaviour and conducting the adaptation behaviour.

4. Data and methods

4.1. Study areas

Chittagong is the second largest city of Bangladesh which has been recognized as the commercial capital of the country. It is a major seaport and an industrial hub that has seen a host of infrastructure development activities in the recent years (Hossen *et al* 2023). Hundreds of brick kilns, cement factories, and iron industries exist in the city and the outskirts to support the construction and infrastructure development activities. Mostly unregulated industries such as steel mills, brick kilns and cement manufacturing factories located in the commercial and residential regions contribute to significant particulate levels (Begum *et al* 2009, Mia *et al* 2015). Energy consumption, industrialization, and construction activities have been the major contributors to ambient air pollution in the city.

Dehradun city located in Doon Valley, is the interim capital of the Indian Himalayan state of Uttarakhand. The city covers an area of 64.4 sq. km., is divided into 100 wards, and has a population of 569,578 as per the 2011 census. Dehradun is rapidly urbanizing; the city is experiencing growth in residential as well as commercial areas. Designated as an interim capital of the state and conducive policies to increase business opportunities, Dehradun attracted industries from different parts of the country. In order to meet the demands of a growing population, construction and industry a huge influx of migrants from remote hills, parts of eastern Uttar Pradesh and Bihar entered the city as informal workers. The current population as per the state government records is around 967,000 (United Nations World Population Prospects 2022). The city's population density is 8633/km2 with a decadal population growth rate of 37.4% (Uttarakhand Pollution Control Board 2021a). According to the road transport authority, only 10,000 vehicles were registered in Dehradun between 1937 and 1967. But at present, there are more than 1,26,452 vehicles are registered, and a large proportion of registrations happened post the year 2000. This rapid urbanization and unwanted development are adversely affecting the air quality of the city (Uttarakhand Pollution Control Board 2021b).

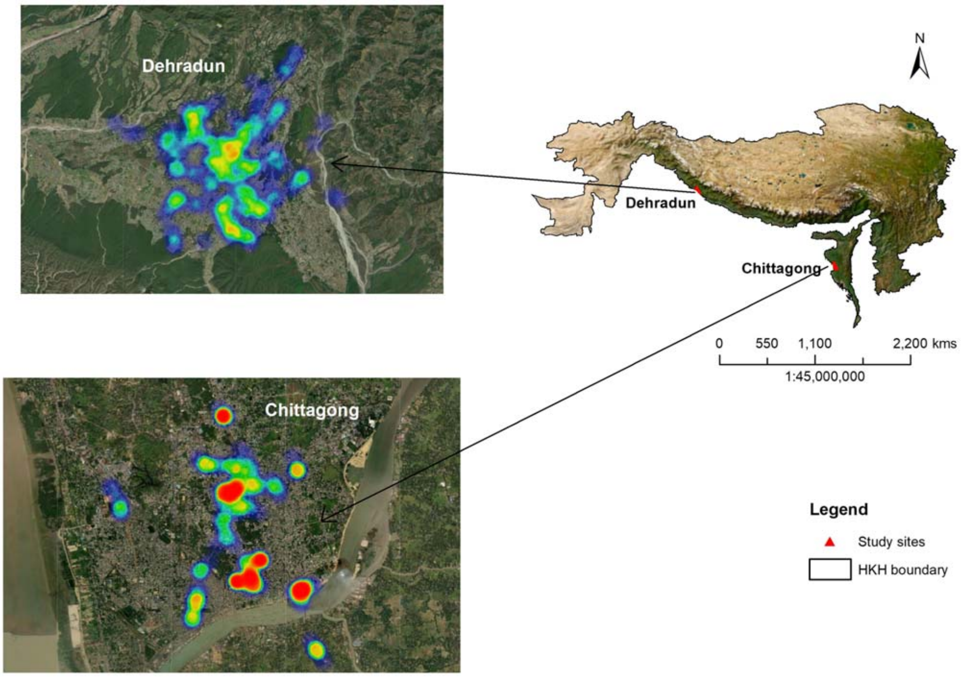

Figure 2. Map of the study areas showing the 'centres of aggregation'. Source: Maps prepared by Sunil Thapa, ICIMOD.

4.2. Data and measurement variables

The study is based on the primary data collected through a survey with a cross-sectional design. A sampling method introduced by Cochran (1977) was used to determine the sample required for an unknown population. A total of 770 participants (385 from each city) were required to gain a 95% confidence interval with a margin of error of ±5%. 800 participants were surveyed in total to cater for some loss in respondents owing to attrition during surveying.

The study used the 'centres of aggregation' strategy to create a list of locations in the urban centres where the target population of workers concentrates as illustrated in figure 2. This list of non-residential locations where target population concentrates is produced through ethnographic scoping. These centres of aggregation are then provided to interviewers randomly with final respondents also being selected at random at different times. This method of time-location sampling (TLS) is an alternative strategy to sample sub-populations when a set sampling frame is difficult to acquire. (Reichel and Morales 2017). This strategy allows for representative samples of hard-to-reach populations for whom there are no sample frames (Quaglia and Vivier 2010). TLS used in the study is held to approximate random cluster sampling where everyone attending the cluster (location) has an equal chance of inclusion but are sampled as a group. Carefully compiled universe of locations serves as the foundation for the sampling frame as well as ensures representativeness. Hence, the workers have been selected randomly from these universes of locations where they aggregate as known by the scoping exercise.

The workers perform informal outdoor work that constitutes of street vending, construction labor, driving, etc On an average, drivers, street vendors and day laborers spent 12, 11 and 8 h per day working outdoors respectively in Dehradun. Similarly, drivers, street vendors and day laborers in Chittagong spent 13, 12 and 10 h per day respectively. This showed that the workers were highly vulnerable to the effects of air pollution as they spend an exorbitant amount of time outdoors. Hence, adaptation to the exposure to air pollution is a dire need. In this context, the adaptation behavior that consisted of concern behavior and the use of additional protective measures have been explored. Additional protective measures consisted of the use of masks, home remedies, air purifier/conditioners, etc About 60 per cent of workers in Chittagong and about half of the workers interviewed in Dehradun used masks varyingly during their workdays.

So, a questionnaire was administered to the workers to assess their perceptions relating to the risks of air pollution exposure in the urban centres of Chittagong, Bangladesh and Dehradun, India. The questions have been designed in Likert scale to collect a greater degree of nuanced perceptions. The indicator variables were measured using a seven-point Likert type scale for most of the variables with some being measured in four- and five-point scales. The scale and description of the indicators of interest are listed in table 1.

Table 1. Description of the indicators under each of the latent variables.

Latent variables, associated indicators, and scale descriptions	1	2	3	4	5	6	7	Mean	SD
Risk Appraisal									
RA1: Mental Vulnerability 1 (prone to mental distress due to air pollution) [Have you felt mental distress due to air pollution?] (1-Not at all distressed; 2-Slightly distressed; 3-Somewhat distressed; 4-Moderately distressed; 5-Very distressed)	45 (29)	77 (76)	83 (112)	78 (65)	18 (18)			2.82 (2.89)	1.15 (1.04)
RA2: Mental Vulnerability 2 (prone to annoyance due to outdoor air pollution from traffic and other sources) [Have you been annoyed by outdoor air pollution due to traffic and other sources?] (1-No, never; 2-Rarely; 3-Occasionally; 4-A moderate amount; 5-A great deal)	111 (65)	80 (80)	54 (89)	41 (54)	16 (12)			2.24 (2.56)	1.22 (1.13)
RA3: Severity 1 (severity of health risk associated with air pollution) [In your opinion, is the health risk associated with air pollution serious?] (1-Not serious at all; 2-Low serious; 3-Slightly serious; 4-Neutral; 5-Moderately serious; 6-Very serious; 7-Extremely serious)	26 (16)	37 (20)	31 (57)	22 (11)	81 (82)	99 (79)	8 (35)	4.39 (4.66)	1.73 (1.69)
RA4: Severity 2 (severity of air pollution at the workplace) [Do you think air pollution is a serious issue at the workplace?] (1-Not serious at all; 2-Low serious; 3-Slightly serious; 4-Neutral; 5-Moderately serious; 6-Very serious; 7-Extremely serious)	31 (10)	27 (21)	31 (50)	18 (16)	87 (113)	97 (63)	12 (27)	4.45 (4.66)	1.76 (1.53)
RA5: Severity 3 (severity of air pollution during commute) [Do you think air pollution is a serious issue during commute?] (1-Not serious at all; 2-Low serious; 3-Slightly serious; 4-Neutral; 5-Moderately serious; 6-Very serious; 7-Extremely serious)	44 (151)	42 (67)	65 (34)	39 (10)	57 (27)	46 (11)	6 (0)	3.61 (2.09)	1.71 (1.46)
RA6: Vulnerability 1 (vulnerable to the effects of air pollution—in terms of health) [In your opinion, how vulnerable are you to the effects of air pollution—in terms of health?] (1-Not vulnerable at all; 2-Low vulnerability; 3-Slightly vulnerable; 4-Neutral; 5-Moderately vulnerable; 6-Very vulnerable; 7-Extremely vulnerable)	10 (8)	39 (32)	16 (73)	52 (41)	94 (94)	77 (41)	13 (11)	4.54 (4.16)	1.51 (1.44)
RA7: Vulnerability 2 (vulnerable to air pollution affecting the working capacity in the future) [In your opinion, do you think a severe smog or air pollution problem will affect your working capacity in the future?] (1-Strongly disagree; 2-Disagree; 3-Somewhat disagree; 4-Neither agree nor disagree; 5-Somewhat agree; 6-Agree; 7-Strongly agree)	24 (0)	50 (26)	52 (51)	26 (34)	82 (50)	64 (90)	6 (49)	4.01 (4.91)	1.68 (1.58)
Adaptation Appraisal									
AA1: Belief that changing daily normal behaviour can lead to avoiding air pollution impacts. [In your opinion, do you believe changing your daily normal behavior can lead to avoiding air pollution impacts?] (1-Very untrue of what I believe; 2- Untrue of what I believe; 3- Somewhat untrue of what I believe; 4- Neutral; 5- Somewhat true of what I believe; 6- True of what I believe; 7- Very true of what I believe)	24 (5)	41 (21)	25 (46)	116 (23)	66 (123)	26 (72)	4 (10)	3.83 (4.64)	1.41 (1.35)
AA2: Belief that protective measures can protect you from air pollution. [In your opinion, do you believe that protective measures can protect you from air pollution?] (1-Very untrue of what I believe; 2- Untrue of what I believe; 3- Somewhat untrue of what I believe; 4- Neutral; 5- Somewhat true of what I believe; 6- True of what I believe; 7- Very true of what I believe)	16 (7)	27 (22)	20 (35)	85 (21)	86 (116)	61 (81)	6 (16)	4.34 (4.75)	1.43 (1.41)
AA3: Belief that using air filtering masks would help in coping with air pollution problem. [In your opinion, do you believe using air filtering masks would help in coping with air pollution?] (1-Very untrue of what I believe; 2-	8 (10)	14 (24)	15 (25)	54 (19)	107 (109)	96 (91)	9 (22)	4.85 (4.84)	1.27 (1.49)

Table 1. (Continued.)

Latent variables, associated indicators, and scale descriptions	1	2	3	4	5	6	7	Mean	SD
Untrue of what I believe; 3- Somewhat untrue of what I believe; 4- Neutral; 5- Somewhat true of what I believe; 6- True of what I believe; 7- Very true of what I believe)									
AA4: Belief that filtering mask will reduce the risk of respiratory diseases. [Do you agree with the following statement—'If I use a filtering mask, I will reduce my risk for respiratory diseases'] (1-Strongly disagree; 2- Disagree; 3-Somewhat disagree; 4-Neither agree nor disagree; 5-Somewhat agree; 6- Agree; 7- Strongly agree)	7 (16)	20 (31)	16 (10)	38 (29)	75 (76)	127 (109)	20 (29)	5.02 (4.87)	1.41 (1.66)
Adaptation Behaviour									
AB1: Extent of protective measure use to cope with increasing level of air pollution. [Have the use of protective measures increased, decreased, or remained unchanged as the air pollution has risen?] (1-Protective measure not used; 2-Reduced; 3-Remain unchanged; 4-Increased)	230 (128)	1 (1)	20 (36)	54 (135)				1.66 (2.59)	1.19 (1.41)
AB2: Concern behaviour: concerned about the risks associated with air pollution. [In your opinion, are you concerned about the risk associated with air pollution?] (1-Not concerned at all; 2- Low concern; 3-Slightly concerned; 4-Neutral; 5-Moderately concerned; 6-Very concerned; 7-Extremely concerned)	38 (6)	72 (36)	50 (67)	38 (30)	71 (98)	30 (49)	3 (14)	3.44 (4.27)	1.63 (1.48)
AB3: Concern behaviour: Extent of concern about the increase in air pollution. [Has the concern increased or decreased or remained unchanged as the pollution became worse?] (1-Not concerned; 2-Concern reduced; 3-Concern remained unchanged; 4-Concern increased)	118 (49)	10 (1)	55 (63)	122 (187)				2.59 (3.29)	1.34 (1.09)

* Note: The initial values in the columns correspond to the frequencies of responses in Chittagong and the ones in parentheses correspond to the ones in Dehradun.

4.3. Statistical procedures

The indicators for the latent variables in table 1 are used in the Partial Least Square Structural equation Modelling (PLS-SEM) methodological framework to test the conceptual theory of PMT among the workers using SmartPLS4. The PLS-SEM modelling approach has been used for several reasons. First, SEM is well recognized among social science researchers as many concepts can be measured mainly through latent variables and observed indicators (Hair *et al* 2017, 2019). Second, SEM is more powerful than factor analysis, path analysis, or multiple regression when done for similar studies assessing adaptation behaviours (Hansstein and Echegaray 2018, Sahrir 2019, Xue *et al* 2021). Finally, SEM gives a complete picture of the entire model regardless of the complexity of the relationships and can accommodate several explanatory constructs. As the principle focus groups for us were outdoor workers, office workers who were also interviewed were removed for the PLS-SEM analysis that amounted to 300 from each city totalling to 600 respondents from both cities.

5. Results

5.1. Socioeconomic status of the workers

The socioeconomic status of the workers in the two sites have some similarities in terms of their characteristics. A majority of the workers that were available for survey were male in both cities. About 97% of respondents were male in Chittagong and 83% in Dehradun. The patriarchal structures and cultural norms are the major reasons for more male workers in the selected occupation. The average age of the respondents was in the range of 37–39 years in both sites. However, they differed in other characteristics like education level, migration status and income/savings information. On average, the highest education level achieved by the workers in Chittagong was 4th grade and 10th grade in Dehradun. About 66% of the workers surveyed in Chittagong had migrated to the city in comparison to around 49% in the case of Dehradun. Average self-reported income per month is found to be higher for Dehradun as compared to Chittagong workers with the amount saved by the workers showing the opposite trend (table 2).

5.2. Assessment of the measurement model

To validate the results obtained from the measurement model in PLS-SEM that has tested the PMT theoretical framework, the internal consistency, convergent validity, and discriminant validity of the model need to be established. Initial step would be to investigate the factor loadings where the loadings of 0.7 and higher is considered ideal (Hair *et al* 2017). However, loading values equal to and higher than 0.5 are acceptable if other items have high scores or loading to complement Average Variance Extracted (AVE) scores greater than 0.5 (Byrne 2016). Hence, factor loadings of 0.5 and above have been retained in the model as a result.

To examine the internal consistency reliability, we used Cronbach's alpha and composite reliability for all the constructs. When assessing the Cronbach's alpha coefficient, the values between 0.65 and 0.7 are acceptable, values between 0.7 and 0.8 are good and so on (Xue *et al* 2021). As the values for Cronbach's alpha is above 0.65 for each index, the instrument is considered reliable. The composite reliability value should be above 0.7 to be considered reliable. This is being met by all the constructs with values well above 0.7.

Similarly, we assess the convergent validity from the Average Variance Extracted (AVE) measure. The value for AVE exceeds cut-off point of 0.500 for all of the constructs ensuring convergent validity (Latan and Noonan 2017). These have been listed in tables 3 and 4. Heterotrait-monotrait ratio (HTMT) was used to establish discriminant validity. If the value of HTMT is lower than the threshold value of 0.85, discriminant validity is established (Henseler *et al* 2014). Table 5 shows that the HTMT ratios among the constructs are all below the cut-off point and hence discriminant validity is established.

Following an exploratory factor analysis in STATA, perceived severity and perceived vulnerability are combined into one latent variable construct named 'risk appraisal'. Similarly, self-efficacy and response efficacy were also combined into one latent variable named 'adaptation appraisal'. This has been consistent with the common factor analysis performed by Xue *et al* (2021) where these items are combined after the factor analysis.

5.3. Analysis of research hypotheses

The hypotheses were tested applying the PLS-SEM algorithm using the SmartPLS 4 software. Figures 3 and 4 depict two latent variables in Risk appraisal and Adaptation appraisal with their respective indicator variables as well as the dependent latent variable of Adaptation behaviour. It shows the path model with the factor loadings and Beta values. The estimated results of the PLS-SEM model are shown in table 6 with the use of PLS-SEM algorithm and bootstrapping methodology to obtain the results.

The results show that risk appraisal has a significant and positive impact on the workers' adaptation behaviour to cope with air pollution exposure ($\beta = 0.477$ & 0.585, $p < 0.000$). This suggest that higher the risk assessment of the workers towards air pollution exposure, greater the inclination for the workers to adopt

Table 2. Socioeconomic status of the workers in chittagong and dehradun.

Variables	Obs	Mean		Standard deviation		Min		Max	
		Chittagong	Dehradun	Chittagong	Dehradun	Chittagong	Dehradun	Chittagong	Dehradun
Gender (Male = 1; Female = 0)	300	0.97	0.83	0.156	0.373	0	0	1	1
Age	300	39.5	37.02	14.8	10.4	16	19	82	77
Education level	300	4.2	10.3	4.2	3.1	0	0	16	16
Migration status (Yes = 1; No = 0)	300	0.66	0.49	0.47	0.50	0	0	1	1
Savings amount	300	2777	1628	3164	2439	0	0	20000	15000
Income per month	300	16753	19500	8356	10795	1500	2500	70000	70000

Note: The unit of measurement for savings amount and income per month is INR for Dehradun and Taka for Chittagong.

Table 3. Measurement model for chittagong.

Variables	Items	Cross-loadings	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE) value
Adaptation Behaviour	AB1	0.674	0.65	0.805	0.582
	AB2	0.856			
	AB3	0.745			
Adaptation Appraisal	AA1	0.593	0.70	0.815	0.528
	AA2	0.738			
	AA3	0.727			
	AA4	0.830			
Risk Appraisal	RA1	0.702	0.83	0.874	0.501
	RA2	0.596			
	RA3	0.845			
	RA4	0.634			
	RA5	0.647			
	RA6	0.724			
	RA7	0.776			

Table 4. Measurement model for dehradun.

Variables	Items	Cross-loadings	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE) value
Adaptation Behaviour	AB2	0.914	0.68	0.86	0.755
	AB3	0.821			
Adaptation Appraisal	AA1	0.811	0.76	0.80	0.505
	AA2	0.742			
	AA3	0.673			
	AA4	0.598			
Risk Appraisal	RA1	0.586	0.74	0.82	0.501
	RA2	0.687			
	RA3	0.818			
	RA6	0.685			
	RA7	0.719			

Table 5. Discriminant validity (HTMT).

Heterotrait-monotrait ratio (HTMT)	Chittagong	Dehradun
Adaptive behaviour <-> Adaptation appraisal	0.577	0.402
Risk appraisal <-> Adaptation appraisal	0.276	0.298
Risk appraisal <-> Adaptive behaviour	0.66	0.847

adaptive behaviours. Looking into the individual items, the findings further indicate that the higher the perceived vulnerability and severity of the risks associated with air pollution exposure, inclination towards adaptive behaviour is increased verifying Hypothesis 1.

Similarly, the results also show that an adaptation appraisal has a highly significant positive effect on adaptation behaviour ($\beta = 0.818$ & 0.527, $p < 0.000$). The findings show that the self-assessment of workers' adaptability significantly affect the inclination towards adaptive behaviour, in turn, verifying Hypothesis 2. This assessment includes self-assessment of adaptability in the form of self-efficacy and response efficacy.

However, the measurement model for Dehradun contained few items that had factor loadings of below 0.4 (that were removed from the model) that included perceived severity of risks indicators and extent of use of protective measures. The risk appraisal indicators relating to perceived severity of air pollution at work and commute have low factor loadings indicating that they do not significantly affect the overall risk appraisal construct. In other words, this shows that the severity of air pollution at work and commuting are not perceived as a significant risk factor. Additionally, low factor loadings for adaptation behaviour indicator means that the composition of the latent variable for adaptation behaviour consists only of concern behaviour associated with the risks of increase in air pollution. The likely reasons for this could be that workers in Dehradun do not directly link air pollution with their workplace or mode of commute and subsequently do not see the need for the use of protective measures as part of the adaptation behaviour. As over more than half of the workers were migrants,

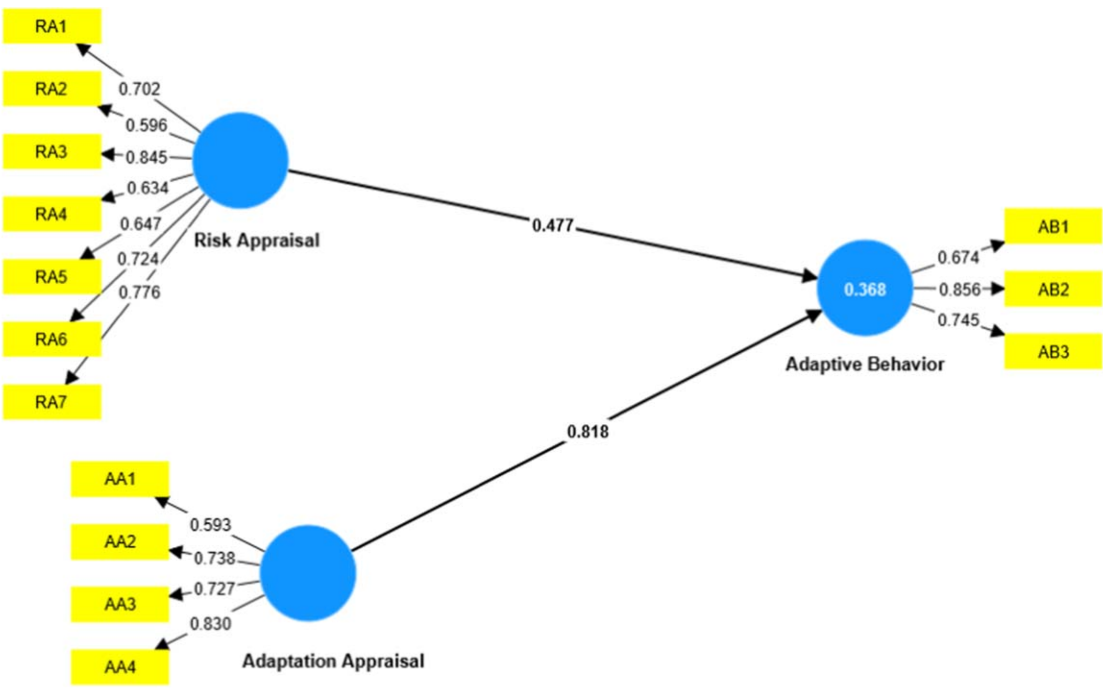

Figure 3. Route model created by SmartPLS using PLS-SEM algorithm for Chittagong.

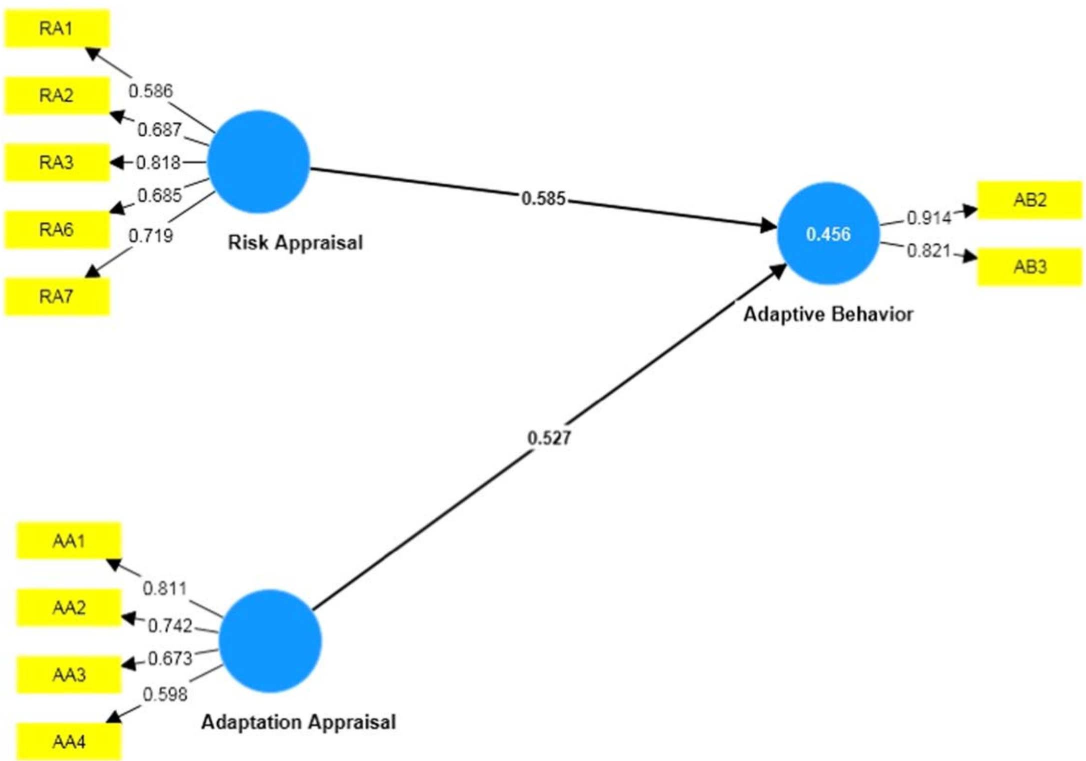

Figure 4. Route model created by SmartPLS using PLS-SEM algorithm for Dehradun.

their perception of risks may have been shaped by the relatively high level of air pollution in their origin villages and cities. Also, Dehradun lies in close proximity to Delhi, which is constantly in the news (print and electronic) for poor air quality, and respondents believe that the air quality in Dehradun is better and also the bad air is attributed to pollution transported from Delhi. This might explain the respondents not linking air pollution with local sources and not thinking it important to use protective measures.

Table 6. Hypothesis testing.

Hypothesis	Relationship	Beta, β	t-value	p-value	Decision
H1	Risk appraisal <-> Adaptive behaviour	0.477 (0.585)	15.8 (15.2)	0.000	Supported
H2	Adaptation appraisal <-> Adaptive behaviour	0.818 (0.527)	8.9 (4.48)	0.000	Supported

Note: Beta and t-values in parentheses are values for Dehradun and without parentheses are for Chittagong.

6. Discussion

Understanding the adaptation behavioural responses to air pollution among the vulnerable occupation groups in an urban centre was the key objective of this study with a focus on perception and motivation-based factors—risk appraisal and adaptation appraisal - as adjudged through PMT framework. The findings suggest that individual items in risk appraisal (i.e., perceived severity and perceived vulnerability) as well as in adaptation appraisal (i.e., self-efficacy and response efficacy) have a significant and positive impact on the workers' adaptation behaviour to reduce the risks associated with air pollution. The higher the perceived severity and vulnerability towards these risks, the greater their adaptation behaviour conduct. Similarly, if the workers of the vulnerable occupation groups think that they can and have the ability to carry out (assessing through the process of adaptive appraisal) adaptive behaviours, then, they are more likely to engage in such behaviour. This can be corroborated by several studies that have observed a positive statistically significant relationship between perceived severity, perceived vulnerability, self-efficacy, response efficacy and adaptive behaviour. (Cismaru *et al* 2011, Kim *et al* 2013, Koerth *et al* 2013). However, a similar study done in the context of air pollution with the residents of an urban centre in Malaysia find that perceived severity and response efficacy does not have a statistically significant relationship towards adaptive behaviour. (Sahrir 2019). As there is a dearth of studies that have explored this relationship among vulnerable groups in the air pollution context, there aren't comparable studies.

Additionally, we also find that the influence of adaptation appraisal on the workers' inclination to engage in adaptive behaviour was larger than the risk appraisals for Chittagong. In other words, when the workers face the risks of air pollution, prior to undertaking an adaptive behaviour, they tend to focus more on the effectiveness of the adaptive behaviour and whether they can effectively conduct such a behaviour. This finding is consistent with the analysis and conclusion by Xue *et al* (2021), Dang *et al* (2014), Floyd *et al* (2000), Milne *et al* (2000) in the context of climate change adaptation. In the case of Dehradun, the adaptation appraisal and risk appraisal assessment showed that both had almost equal influence on the adaptation behavior (that mostly consisted of concern behavior). These results point towards equal importance placed on both aspects by the workers as concern behavior is influenced and shaped by both risk perception and adaptation appraisal.

Our finding adds to the existing body of literature on the importance of an individual's risk perceptions in influencing adaptive behaviour (Bubeck *et al* 2012, Azadi *et al* 2019, Xue *et al* 2021). When we unpack the findings, it shows that the perception factors like perceived severity of the risks from air pollution, perceived vulnerability—both mental and physical susceptibility to the risks associated with air pollution, self-capability to assess and engage in adaptation behaviour are the key determinants in conducting adaptation behaviours. In particular, we are able to delve into the factors that affect the adaptive behavioural responses of vulnerable informal worker groups. They cannot avoid air pollution risks in their daily work lives as their main source of livelihoods involve spending majority of time outdoors in the urban centres. While adopting protective measures like wearing masks, using home remedies, applying cloth masks, etc are feasible for these groups of workers, conducting other behaviours like changing their daily normal behaviour becomes a challenge. By the nature of their jobs, informal workers like street vendors, laborers, and drivers have very little flexibility in choosing their working hours or timing of their work. Hence, adjusting their daily normal behaviour like changing the duration of their work outdoors or even the timing of the work hours outside becomes difficult and unfeasible for the most part. Moreover, the informal workers are not able to adjust their work routines more actively as 'air pollution exposure' is just one of the many issues that they are facing in their daily lives. Their struggle to manage their daily basic needs like food, shelter, education, health, etc still remain a major priority, above the risk of air pollution exposure. This is a common issue in many of the urban centres in the HKH countries as pointed out by Maharjan *et al* (2022).

7. Conclusion

Air pollution has adverse effects on society—faced more acutely by the most marginalized and vulnerable groups of informal workers. The informal worker groups like street vendors, labourers and drivers constitute most of the urban poor and are usually the most exposed due to the nature of their work. It is important that these workers engage in adaptation behaviour to cope with the adverse impacts. While long-term mitigation measures are required, these adaptation behaviours can partially reduce, the adverse impact of exposure to air pollution of urban workers in the short and medium term. This study focuses on the understanding of the psychological factors that influences the adaptation behaviour of the workers and hence needs to be incorporated in any effort towards behavioural change.

Adaptive behaviour is contextual and influenced by concern towards the risks associated with air pollution exposure. Concern behaviour, therefore, constitutes one of the adaptive behaviour responses towards air pollution exposure. Our findings from Dehradun have shown that concern behaviour as an adaptation behavior was strongly affected by risk appraisal and adaptation appraisal. The findings from Chittagong show that adaptive behaviour (both in the form of the extent of use of additional protective measures and concern behavior) is dependent on how the risks of air pollution and related adaptation measures are perceived by the workers. In addition, our study also shows that certain adaptation behaviours like changing or adjusting the daily normal behaviour to avoid air pollution exposure is not a feasible option as it has direct implications on daily wage earnings. Therefore, any behavioural change interventions to promote the use of protective measures should focus on increasing awareness of air pollution impacts and the efficacy of adaptation measures. However, more efficient avoidance behaviour (such as changing duration and time of exposure) requires interventions to offset the daily wage consequences for the workers.

Insights from the study can contribute to the development of occupational health and safety guidelines, specifically designed to protect the vulnerable occupation groups from air pollution exposure. The findings can help the policy makers and implementation agencies to go beyond generic recommendations and offer practical, occupation-specific measures to change behaviour of workers towards protection against negative impact of air pollution.

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Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Ethics declarations

There is no institutional review board in Nepal to review and approve non-medical research with human subjects, but that research team have obtained consent for use of data from the workers, and other ethical standards have been upheld including: that no children were involved, that the work has not been published previously, and that this work does not reproduce any figure or table from previously published work.

Declaration of conflict of interest

The authors declare no competing interests.

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