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ABSTRACT

Air Quality and Conferences' Engagement*

There is limited evidence on the non-health impacts of air pollution, including productivity in the workplace and behavior. We examine the effect of air pollution on participation, collaboration, and feedback provision in a workplace setting. Our experiment randomly assigns air purifiers to rooms at three large academic conferences to investigate the causal impact of air pollution on participants' engagement behavior. We construct a participant engagement index based on 12 presentation-level behavioral outcomes directly measured by conference observers through an online form and weigh each behavioral outcome using weights elicited from an expert survey. Conference rooms treated with air purifiers exhibit 48% less PM2.5 concentration compared to control rooms. However, we do not find a statistically significant change in engagement. Communication in the workplace might not be a large driver of the empirical relationship between air quality and productivity, albeit more research is needed across workplaces and measures of communication.

JEL Classification: Q53, J24
Keywords: indoor air quality, engagement, workplace, field experiment

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1 Introduction

Air pollution exposure has been shown to have wide-ranging negative consequences not just for individuals' health and well-being, but also for their cognitive ability and productivity (Aguilar Gomez et al. (2022); Bedi et al. (2021); Chang et al. (2019a); Dechezlepretre et al. (2019); Roth (2018)). Pollution has also been shown to increase stress hormones (cortisol) (Li et al., 2017), which are associated with changes in competitiveness (Esopo et al., 2019), aggression (Barlett and Anderson, 2014), and ethical behavior (Lu et al., 2018). Pollution has also been directly associated with violent crime (Burkhardt et al. (2019); Herrnstadt et al. (2021)), and, to a lesser extent, property crime (Chen and Li, 2020), although the mechanisms behind these relationships remain speculative.

This existing research points to mechanistic channels through which pollution may negatively impact participation, collaboration, and feedback in a workplace setting, which is the focus of this study. Inspired by past work that uses academic conferences as a setting to explore behavior in the workplace (Dupas et al., 2025), we ran a randomized control trial in three academic conferences, two in Colombia—where, on average, $PM_{2.5}$ measured $8.92 mg/m^3$ in our conference rooms at baseline—and India—where $PM_{2.5}$ measured $187.69 mg/m^3$. Sessions were randomly assigned to have an air purifier or a placebo device. Research assistants recorded outcomes including engagement in the session, aggressive behavior, and presentation quality to identify whether improved air quality leads to more effective participation and engagement in the sessions. Understanding the impacts of air pollution on conference participation can provide insights into the role of air quality in affecting effective communication and collaboration in the workplace. Specifically, we hypothesize that hindered communication might be a channel through which poor air quality reduces productivity in teams (Holub and Thies, 2023).

Across our three experiments, we document a strong "first stage" effect of air purifiers on air pollution: purifiers reduce $PM_{2.5}$ concentration by 48%. The reduction is larger in India, which has higher baseline levels of air pollution, than in Colombia, but in all three conferences treated sessions experienced economically and statistically significant improvements in indoor air quality. The reduction we estimate is larger than the reduction observed in other studies that provide air purification to schools and households (Kremer et al., 2025; Chowdhury et al., 2025), plausibly because our research assistants operated the purifiers and ensured that windows and doors stayed closed, thus maximizing purifier effectiveness.

However, this large reduction in air quality does not translate into improvements in our conference participation outcomes. Across our three experiments, treated rooms see only a small improvement of 0.012 standard deviations (s.e. 0.049) in our index including engagement, behavior, and presentation quality. Furthermore, looking at individual outcomes, we find no evidence for treatment effects for any specific aspect of conference attendance. Interestingly, treatment effects are directionally (but imprecisely) positive in both conferences in Colombia but negative in India. Consistent with this, we see that, across our data, treatment effects

are larger at low pollution levels.

Our noisy null effects could be due to measurement error introduced by the research assistants, as well as to different social norms regarding engagement across the countries in our sample. Alternatively, it might take longer than the duration of a conference session for air purification to affect behavior in a workplace setting like ours. Taken at face value, our findings suggest that that the productivity effects of air quality in the workplace found in the literature (Chang et al., 2019b; He et al., 2019; Sarmiento, 2022; Garg and Lozano-Gracia, 2025) might be driven by individual effects on cognition (Meyer and Pagel, 2024; La Nauze and Severnini, 2025; Krebs and Luechinger, 2024) rather than hindered communication and teamwork. However, further research is warranted to confirm the external validity of our findings.

2 Context

2.1 Pollution in Colombia

In 2024, Colombia ranked 82nd in the World Air Quality Index, with a national average concentration of 13.8 $\mu g/m^3$ of $PM_{2.5}$ (IQAir, 2024). Despite not being among the most polluted countries globally, air quality in Colombia's major cities remains a significant public health concern, especially in densely populated urban areas.

In the city where Conference 1 (C1) took place, the average concentration of $PM_{2.5}$ exceeds four times the World Health Organization (WHO)'s annual guideline of 5 $\mu g/m^3$. The main sources of pollution include re-suspended dust from construction activities and unpaved roads, as well as emissions from vehicles, particularly heavy-duty freight trucks, which account for a substantial share of $PM_{2.5}$ emissions (Durán et al., 2022). These pollution levels tend to worsen during the first months of the year, when meteorological conditions limit atmospheric dispersion in the city (Mura et al., 2020).

Similarly, in Medellín, the city where our second conference took place, $PM_{2.5}$ levels have also reached up to four times the WHO recommended limit. This is mainly due to emissions from outdated vehicles and dust from unpaved roads. The city's location in a narrow valley, only 7 kilometres wide, worsens the situation by trapping polluted air. In addition, thermal inversions further limit the vertical dispersion of pollutants in the city (IQAir, 2024).

2.2 Conferences in Colombia

The first part of our study was conducted in Colombia during the final months of 2023 and took place across two academic conferences. C1 was held on a university campus. It brought together a broad community of economists from Latin America and beyond, and offered a diverse schedule composed of five types of presentations: invited sessions, keynote lectures, plenary lectures, social events, and contributed sessions. Among these, the contributed

sessions represented the core of the academic agenda and were the primary setting for our study.

A total of 312 scholars participated as presenters across the different session formats. Over the course of three days, 116 contributed sessions were held. These sessions were organized into different thematic tracks covering a wide range of fields, including but not limited to applied microeconomics, behavioral economics, econometrics, economic history, macroeconomics, and political economy.

Each contributed session was chaired by a designated academic responsible for moderating the discussion and ensuring the smooth flow of presentations. Sessions typically featured between two and four research papers, and each speaker was allocated up to 30 minutes to present their work and engage with the audience. As a result, sessions generally lasted between 1.5 and 2 hours.

The 116 contributed sessions were distributed across three days: 38 on Day 1, 40 on Day 2, and 38 on Day 3. These sessions were scheduled in parallel time blocks throughout the day and held in classrooms or auditoriums across the university campus. Specifically, the parallel blocks were divided into morning and afternoon segments. Morning sessions typically ran from 10:30 a.m. to 11:30 a.m. or 12:00 p.m., while afternoon sessions were scheduled from 4:30 p.m. to 6:00 p.m. On average, half of the sessions for each day took place in the morning and the other half in the afternoon.

The second conference was the 20th World Congress of the International Economic Association (IEA), held in Medellin from December 11 to 15 at Universidad EAFIT. The event brought together over 700 international scholars and featured a diverse program that included plenary talks, policy sessions, academic panels, and contributed sessions. As with C1, our study focused primarily on the contributed sessions. These typically lasted one hour when featuring two to three research papers, or up to ninety minutes when four papers were scheduled. Each session was moderated by a chair who managed the schedule and facilitated the discussion. Presenters were generally given 15 minutes to share their work, followed by around 5 minutes for questions, usually addressed immediately after each presentation.

A total of 402 papers distributed in 154 contributed sessions were scheduled throughout the conference. Specifically, 34 sessions were held on day 1, 27 on day 2, 40 on Day 3, 38 on Day 4, and 15 on Day 5. These sessions were distributed across three daily time blocks: morning, midday, and afternoon. Morning sessions typically ran from 8:15 a.m. to 9:15 a.m., midday sessions from 12:00 p.m. to 1:00 p.m., and afternoon sessions from 4:45 p.m. to 5:45 p.m.

2.3 Pollution in India

India ranked fifth among the most polluted countries globally, with an average $PM_{2.5}$ concentration of 50.6 $\mu g/m^3$ in 2024—more than ten times the WHO's recommended annual limit (IQAir, 2024). While high pollution levels are observed across the country, the problem

is especially severe in Northern India.

Delhi, the setting of our third conference, ranked second among the world's most polluted capital cities, with annual $PM_{2.5}$ levels of approximately 91.6 $\mu g/m^3$—more than 18 times the WHO guideline (IQAir, 2024). Pollution levels in the city are driven by a combination of factors, including vehicular emissions, industrial discharges, and dust from construction activities. Seasonal agricultural stubble burning in neighboring states, particularly during November, can contribute up to 60% of observed $PM_{2.5}$ levels. The problem is exacerbated during the winter months, when thermal inversions and stagnant atmospheric conditions trap pollutants near the surface, leading to prolonged episodes of poor air quality.

These winter pollution episodes pose severe public health risks across northern India. In several affected cities, daily $PPM_{2.5}$ concentrations often exceed 250 $\mu g/m^3$. In 2021, approximately 1.2 million deaths were linked to exposure to air pollution in India (State of Global Air, 2024).

2.4 Conference in India

The final part of the study was conducted at the Annual Conference on Economic Growth and Development, organised by the Indian Statistical Institute, Delhi, from December 19-21, 2024. The conference coincided with a period of poor air quality in the city, when the average $PM_{2.5}$ was around 300-450 $\mu g/m^3$. The conference brought together over 380 participants from around the world, including leading academics and early-career researchers. The conference program included several plenary talks and parallel sessions. The study primarily took place in parallel sessions.

The experiment was conducted in a total of 56 parallel sessions, which were distributed across thematic tracks covering diverse fields within economics. These parallel sessions were scheduled in three daily time slots: 11.15 am to 1 pm, 2.15 pm to 4 pm, and 4:30 pm to 6:15 pm. During each time slot, seven sessions ran simultaneously in different rooms.

A total of 166 papers were presented. Sessions typically lasted 105 minutes and included three research papers.[1] Each presenter was allocated 30 minutes for their presentation, followed by 5 minutes for audience questions, moderated by a session chair responsible for managing time and facilitating discussion.

The opening day featured an exception to this schedule: the first set of seven sessions began at 11:50 and included only two papers in each session, resulting in a shorter duration. Day 2 also differed from the general pattern, with sessions held only in the two afternoon time slots. Of the 56 parallel sessions, 21 were held on Day 1, 14 on Day 2, and 21 on Day 3. The sessions were hosted in classrooms and seminar rooms, which were of uniform size and facilities. This standardized setup ensured consistent presentation conditions throughout the event.

[1] In 5 sessions, 4 research papers were presented.

3 Experimental Design

Our pre-registered experiment (AEARCTR-0011400) involved randomly assigning conference sessions to have an air purifier or a placebo device.[2] Randomization was performed within each block of parallel sessions held concurrently at the same conference. For example, in the morning of Day 3 of the Delhi conference there were 7 parallel sessions. We randomly selected 3 of those sessions to receive air purifiers. For C1, within each block, randomization was further stratified by floor and room orientation (either facing east or west). This additional stratification accounted for the layout of the venue, as rooms facing east overlook a mountain range that can influence natural ventilation and indoor air quality.

Overall we have 162 treatment sessions and 164 control sessions: 59 treatment and 57 control sessions in C1, 79 treatment and 75 control sessions in Medellin, and 24 treatment and 32 control sessions in Delhi.

Based on the randomization procedures described for each conference, the following treatment and control conditions were assigned:

- *Control*: Rooms assigned to the control group reflected the status quo, with no further air purification. Placebo purifier equipment without filter pads were placed in the rooms and turned on to obfuscate treatment assignment for participants as well as research assistants. The noise produced by the purifiers' fan is similar to the treatment filters. Air purifiers were run on the medium setting, which generates a quiet but noticeable "whirring" comparable to white noise.

- *Treatment*: Rooms assigned to treatment had an air purifier with a filter pad. These purifiers are designed to remove particulate matter (PM), but not carbon dioxide (CO_2). About 15 minutes before each session, research assistants entered the classroom to close the windows when possible and turn on the purifier. The purifier remained on throughout the session. Once the session ended, the research assistants packed the air purifier and proceeded to the next classroom to repeat the procedure.

In addition, we placed air quality monitors in both treatment and control rooms. The monitors measure $PM_{2.5}$, PM_{10}, CO_2, temperature and humidity in all rooms. Research assistants recorded readings at the start and end of each presentation.

3.1 Data

We collected data for each paper presented in treatment and control sessions, and the questions asked. Research assistants were assigned to each room to record a host of measures using a laptop/mobile phone survey template in Qualtrics. They recorded session and presentation characteristics as well as the engagement and the tone of the interactions. They also collected environmental data produced by the air monitor, and indicators for windows

[2]Appendix Section 7 discusses deviations from our pre-analysis plan.

and doors left vented or entirely open. Session characteristics include number and gender of audience members at session start, presentation start time, speakers' names, and session norms, e.g., whether all questions were at the end.

Our main measure of air quality (air pollution) in sessions, is particulate matter ($PM_{2.5}$) at the end of each presentation, measured in units of $\mu g/m^3$. Since we record environmental variables between the start and end of each presentation during the same session, we take the air pollution at the start of the current presentation as the same as that at the end of the previous presentation. For example, the air pollution measure at the start of the second presentation is the same recorded at the end of the first presentation. We also measure them at the end of the last presentation (i.e. the end of the whole session). We impute the missing values of these environmental variables using conference-specific means.[3]

In addition, the research assistants recorded measures of engagement, politeness, and quality of sessions. Using these measures, we created the following standardized indices, the components of each of which are detailed below. Specifically, we "flipped" the sign of the questions where higher values indicated worse outcomes (e.g., lower engagement), then standardized each component at the conference level. The indices were constructed by taking the average of the standardized components. After computing these averages, the resulting indices were again standardized at the conference level.

Engagement measures:

E1 Fraction of people **leaving** the room during each presentation and discussion (flipped)

E2 The audience frequently checks their **phones** during the presentation. Likert scale from (1) strongly disagree to (7) strongly agree (flipped)

E3 The audience seems **engaged** overall. Likert scale from (1) strongly disagree to (7) strongly agree

E4 Number of **questions** asked

E5 Fraction of questions that generate a **back-and-forth**.

E6 Audience members with **open laptop**: None, 1-2, 3-5, More than 5 (Coded as a 1-4 scale, flipped)

Politeness measures:

P1 The **tone of the question** is generally polite. Likert scale: from (1) strongly disagree to (7) strongly agree

P2 The speaker's tone is generally polite when **answering** individual questions. Likert scale: from (1) strongly disagree to (7) strongly agree

[3]There are some zero values of the temperature and CO_2 measures in the third presentations, for which we impute using a linear projection approach from the first and second presentations.

P3 The **presenter's tone** is generally polite. Likert scale: from (1) strongly disagree to (7) strongly agree

P4 Fraction of questions where the person **raised their hand**

Quality measures

Q1 The presenter was **clear**. Likert scale from (1) strongly disagree to (7) strongly agree

Q2 The presenter kept to their allotted **time**. Likert scale from (1) strongly disagree to (7) strongly agree:

Our main outcome of interest is a single index summarizing the engagement, politeness, and quality sub-indices, to mitigate issues around multiple hypotheses testing. We construct this index by taking the simple average of the three standardized sub-indices. In addition, we conducted an expert survey to gather perceptions of which outcomes in our experiment are most closely linked to air quality in conferences. The survey asked how different outcomes should be weighted in the analysis, focusing on three pre-registered categories: engagement, politeness, and quality. For example, "checking one's phone" may be less indicative of overall engagement than a "self-reported engagement level." To address this, our survey aimed to "crowdsource" the weights through the expert survey. Survey weights are reported in Appendix Table A1.

Table 1 presents summary statistics for each component of the index outcome of session quality and the measures of environmental quality we use in the empirical analysis. We present these pooled, as well as by conference. Strikingly, while session outcomes are relatively similar across settings, environmental outcomes differ quite substantially. All conferences present relatively high levels of engagement, quality, and politeness overall. $PM_{2.5}$ at the start of papers is lowest in the C1 conference, double at Medellin, and orders of magnitude higher at Delhi. CO_2 is more comparable at the two Colombian conferences, but double in India, where humidity is also higher.[4]

[4]In the regression analysis, we control for environmental characteristics other than PM as measured at the beginning of each paper presentation, winsorized at the 1st and 99th percentile, and standardized relative to the conference-specific control group.

Table 1: Summary statistics

Panel A: Engagement measures

	Pooled			C1			Medellin			Delhi		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Leaving (Fraction people)	761	0.03	0.07	272	0.02	0.06	344	0.04	0.07	145	0.04	0.07
Check Phone (1−7 scale)	800	2.82	1.45	284	2.57	1.39	374	3.01	1.48	142	2.85	1.42
Engagement Level (1−7 scale)	870	5.57	1.17	306	5.82	1.02	398	5.43	1.21	166	5.45	1.29
Question (N questions)	820	4.74	2.66	311	5.97	2.64	346	3.43	1.99	163	5.16	2.68
Back and Forth (Fraction questions)	818	0.32	0.29	311	0.32	0.24	344	0.31	0.33	163	0.36	0.29
Open Laptop (1−4 scale)	868	0.76	0.74	306	0.54	0.64	396	0.91	0.77	166	0.83	0.71
Question Tone (1−7 scale)	818	5.11	0.99	311	4.94	0.84	344	5.04	1.08	163	5.58	0.93
Answer Tone (1−7 scale)	819	5.40	0.93	312	5.28	0.89	344	5.31	0.97	163	5.82	0.82
Presenter Tone (1−7 scale)	867	6.15	0.97	306	6.26	0.87	396	6.10	1.02	165	6.07	1.01
Raise Hand (N people)	820	0.65	0.32	311	0.64	0.29	346	0.71	0.34	163	0.56	0.32
Presenter is Clear (1−7 scale)	863	5.96	1.11	305	6.12	1.02	392	5.88	1.13	166	5.86	1.17
Keep to Time (1−7 scale)	851	5.89	1.51	301	5.88	1.57	389	5.77	1.48	161	6.20	1.42

Panel B: Environmental Measures

	Pooled			C1			Medellin			Delhi		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
PM2.5 at Start of Paper	880	36.07	69.20	312	4.74	5.34	402	9.96	6.05	166	158.18	82.76
PM2.5 at End of Paper	880	30.97	59.33	312	4.11	4.88	402	9.37	5.88	166	133.74	74.13
CO2 at Start of Paper	880	1385.86	813.77	312	1293.82	655.44	402	1111.00	476.85	166	2224.45	1121.58
CO2 at End of Paper	880	1742.51	915.38	312	1714.45	724.19	402	1328.44	491.79	166	2798.00	1160.83
Temperature at Start of Paper	880	23.36	2.59	312	23.67	1.87	402	24.18	2.39	166	20.81	2.63
Temperature at End of Paper	880	23.84	2.23	312	24.80	1.59	402	23.96	1.96	166	21.73	2.48
Humidity at Start of Paper	880	59.41	9.75	312	53.55	5.89	402	58.36	7.34	166	72.95	7.65
Humidity at End of Paper	880	59.37	9.84	312	53.52	6.47	402	58.22	7.15	166	73.15	7.33

Note: This table shows summary statistics of the component outcomes of interest and environmental characteristics of sessions, pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Panel A reports the 12 individual component outcomes: the fraction of people who left the conference room during each presentation, how frequently the audience checks their phones, the number of people with laptop open, audience engagement level, the number of questions asked, the fraction of questions that generate a back-and-forth, the fraction of cases where the person asking the question raised their hand, the tone of the question asked, the tone of the speaker answering the questions, the general tone of the speaker, how clear the presentation is, and whether the speaker kept to their allocated time respectively. Panel B reports the environmental measures: $PM_{2.5}$ ($/m^3$) at the start and end of each presentation, CO_2 (parts per million) at the start and end of each presentation, temperature (Celsius) at the start and end of each presentation, and humidity (percent) at the start and end of each presentation.

4 Empirical Strategy

We use regression analysis to assess the impact of air filtration on the extent and quality of engagement in conference settings. We estimate the following equation:

$$Y_i = \beta_0 + \beta_1 T_{s(i)} + \delta_{r(i)} + X'_{is} + \epsilon_{sr}$$

where Y_i is the outcome of interest for speaker i, session s, randomization strata r; $T_{s(i)}$ is an indicator equal to one if the speaker is in a session randomly assigned to the treatment group; $\delta_{r(i)}$ are strata fixed effects; X'_{is} is a vector of controls capturing the number of audience members at the start of the talk, gender composition at the start of the talk, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Standard errors are clustered at the room-day level. Note that we do not include conference day fixed effects as the randomization strata are finer units of analysis, that would result in co-linearity.

In Appendix Table A2, we also present a secondary instrumental variables analysis for our engagement index where we instrument air quality with the randomly assigned treatment.

5 Results

5.1 Effects of air purification on air quality in conference sessions

Air purification is remarkably effective at improving air quality even in conference settings when people might open doors, e.g., to leave or come in. Specifically, the pooled specification in Table 2 Panel A, Column 1 suggests that air purification almost halves $PM_{2.5}$ concentrations in treated sessions relative to controls. This effect is driven by the India conference, where baseline $PM_{2.5}$ levels are much higher. Still, in the two Colombian conferences, air purification reduces $PM_{2.5}$ levels by 36% on a mean of 5.5 and 21% on a mean of 10.6, respectively. Moreover, these effects manifest quickly, already during the first presentation. Indeed Panel B of Table 2 shows very similar reductions in $PM_{2.5}$ after the first presentation and after subsequent ones in all conferences.

The air purifiers we used should not affect other aspects of environmental quality in conference sessions. For example, they do not remove CO_2 and do not work as dehumidifiers. Appendix Table A3 shows that, indeed, air purification did not affect other environmental characteristics of conference sessions, such as CO_2, temperature, and humidity, overall. It appears that CO_2 levels were higher in treated session during the C1 conference, possibly due to doors and windows being less likely to be opened in these sessions. Unfortunately, we do not know what led to this different behavior in C1 treated sessions.

Table 2: Air Purification and Conference Air Quality

Dep Var: Pollution (PM2.5 mg/m3)				
	(1) Pooled	(2) C1	(3) Medellin	(4) Delhi
Panel A: Baseline				
Air Purifier	-20.993***	-1.968***	-2.240***	-94.569***
	(3.883)	(0.483)	(0.553)	(10.677)
Panel B: By Paper Order				
Air Purification × First Paper	-19.096***	-2.129***	-1.877***	-88.957***
	(3.597)	(0.568)	(0.611)	(10.108)
Air Purification × Second Paper	-20.864***	-2.099***	-2.003***	-101.207***
	(3.956)	(0.547)	(0.601)	(12.405)
Air Purification × Third or Later Paper	-23.845***	-1.531***	-3.244***	-91.124***
	(5.114)	(0.488)	(0.730)	(14.928)
Observations	880	312	402	166
Control Group Mean	43.72	5.53	10.64	176.68

Note: This table shows the impact of air purificaiton on indoor air quality at different conferences. The dependent variable in all columns is $PM_{2.5}$ at the end of a presentation. All regressions include strata fixed effects and control for the number of audience members at the start of the presentation, fraction of women in audience at the start of the presentation, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Columns (1)-(4) report the coefficient estimates pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Panel A reports the baseline treatment effect of air purification on session air quality. The independent variable is an indicator for sessions with air purification. Panel B reports the heterogeneous treatment effect of air purification on session air quality by paper order. The independent variables are interactions between an indicator for sessions with air purification and indicators for the order of each paper. Standard errors clustered at the room-day level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5.2 Effects of Air Purification on Conference Outcomes

Table 3 reports our main reduced form estimates of the effects of air purification on a standardized index of conference engagement, politeness, and quality. Using either the expert-weighted index or the unweighted index, we cannot reject the null hypothesis that air purifiers do not improve conference outcomes.[5] In particular, we estimate effects of different signs across contexts, with seemingly negative (albeit statistically insignificant) effects in Delhi, where air quality was worse to start with. Appendix Tables A4 and A5 similarly find no evidence that air quality affects specific domains of conference participation. Indeed Table A4 shows results for the different components of engagement, politeness, and quality, while Table A5 finds similar results for both more objective (e.g., number of audience members leaving a session) and more subjective measures of engagement (e.g., the research assistants' assessment of overall engagement), suggesting that changes in research assistants' perceptions do not drive our findings.[6]

We can only speculate as to what explains our lack of definitive evidence on the effects of air purification on conference outcomes across contexts. While we cannot rule out the role of different cultural norms across contexts, one plausible explanation is the concavity of the cognitive and non-cognitive effects of poor air quality. We investigate these patterns in Figure 1, which plots treatment effects of air purification by average $PM_{2.5}$ concentrations in contemporaneous control sessions belonging to the same strata. This figure shows a clear pattern where treatment effects are larger at low pollution levels and get smaller and even marginally negative at higher pollution levels, consistent with a concave pollution damage function. However, we caveat these findings by noting that we cannot disentangle high pollution levels from the specific Indian conference where we saw such high pollution levels. Finally, Appendix Table A3 does not show evidence of air purification effects on other environmental characteristics of session, especially in Delhi, ruling out potential counterproductive effects of air purification as an explanation of our overall null effects.

5.3 Question-level Results

We explore the air purifiers effect at the level of each question each paper received in Table 4. Recall that for each question we recorded four variables: (1) question tone, (2) answer tone, (3) whether the audience member asking the question raised the hand, and (4) whether there was back and forth with the speaker. The pooled effects are statistically indistinguishable from zero for all four variables. There are positive effects for the question and answer tone

[5] Appendix Table A2 reports estimates of the effects of poor air quality on conference outcomes where we instrument $PM_{2.5}$ concentrations in conference sessions with our randomized treatment. We note that in the two Colombian conferences, the instrument appears weak at conventional levels.

[6] Table 4 replicates this analysis for the measures of politeness at the question level and finds similar null effects overall. However, in the C1 conference, we find large, positive and highly statistically significant (at the 1% level) effects of air purification on question tone and answer tone, which is consistent with the pattern in Table A4 where air purification improves question and answer tones (but less statistically significant), suggesting the increase in sample size improves the preciseness of the estimates.

Table 3: Effects of Air Purification on Conference Outcomes

	Dep Var: Single Index			
	(1) Pooled	(2) C1	(3) Medellin	(4) Delhi
Panel A: Weighted				
Air Purifier	0.012	0.127	0.038	-0.158
	(0.049)	(0.091)	(0.069)	(0.115)
Panel B: Unweighted				
Air Purifier	0.006	0.122	0.034	-0.161
	(0.056)	(0.091)	(0.086)	(0.116)
Observations	880	312	402	166

Note: This table shows the reduced form treatment effects of the air purifiers in conference room on the single conference outcomes index, standardized relative to the conference-specific control groups and constructed as the mean of the 12 standardized component variables. The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effects and control for the same variables as in Table 2. Panel A reports the reduced form regressions of the air purifier treatment on the expert survey-weighted single index. Panel B reports the reduced form regressions of the air purifier treatment on the unweighted single index. Columns (1)-(4) report the treatment effects pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Robust standard errors clustered at the room-day level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

in C1, the conference with low levels of pollution.

Table 4: Question-level Results (Reduced Form)

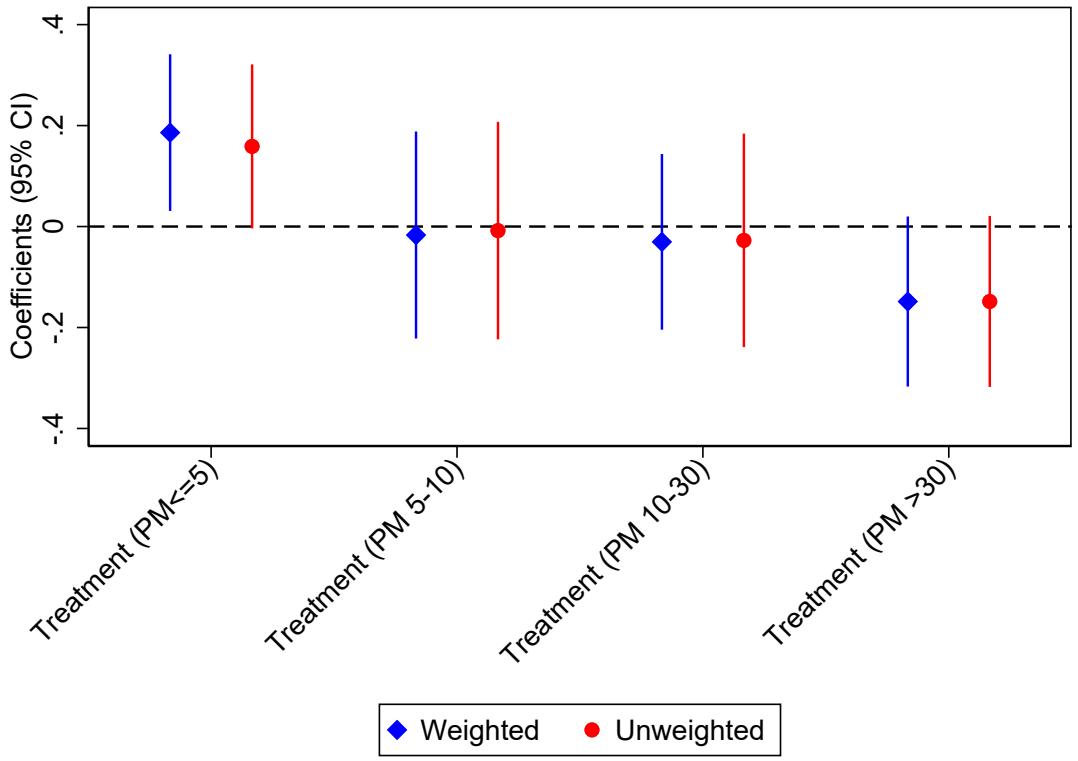
Dep Var:	(1) Politeness Index	(2) Question Tone	(3) Answer Tone	(4) Raise Hand Indicator	(5) Back and Forth Indicator
Panel A: Pooled					
Air Purifier	0.055	0.098	0.120	-0.008	0.014
	(0.038)	(0.077)	(0.084)	(0.029)	(0.023)
Observations	3533	3985	3984	3561	3822
Panel B: C1					
Air Purifier	0.177***	0.354***	0.423***	-0.074	0.018
	(0.059)	(0.132)	(0.119)	(0.055)	(0.034)
Observations	1664	1911	1912	1681	1831
Panel C: Medellin					
Air Purifier	0.022	0.034	0.082	0.011	0.008
	(0.060)	(0.113)	(0.129)	(0.041)	(0.040)
Observations	1102	1205	1205	1110	1161
Panel D: Delhi					
Air Purifier	0.002	-0.029	0.015	-0.060	0.018
	(0.080)	(0.149)	(0.199)	(0.062)	(0.055)
Observations	767	869	867	770	830

Note: This table shows the reduced form treatment effects of the air purifiers in conference room on question-level politeness outcomes. The dependent variables in columns (1)-(5) are the question-level standardized politeness index and its components: the tone of the question asked, the tone of the speaker answering the questions, a dummy variable indicating raised hands when asking the question, and a dummy variable indicating whether the question generates a back-and-forth. The politeness index is standardized with respect to the conference-specific control groups and constructed as the mean of the four standardized component variables in columns (2)-(4). The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effect and control for the number of audience members at the start of the presentation, fraction of women in audience at the start of the presentation, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Panel A reports the reduced form results pooling across the C1, Medellin, and Delhi conferences. Panel B reports the reduced form results on the C1 conference. Panel C reports the reduced form results on the Medellin conference. Panel D reports the reduced form results on the Delhi conference. Robust standard errors clustered at the room-day level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6 Conclusion

This paper studies whether installing air pollution filters in conferences affected engagement, politeness, and quality of presentation and communication. The filters reduced pollution in the treatment rooms where they were placed. However, we do not detect statistically significant changes in any of the behavioral outcomes we measured. One possibility for the lack of effects is non-linear effects of pollution reductions at different levels, although we cannot rule out measurement error in our outcome of interest and that the behavioral effects of pollution might take longer than an hour or two to manifest. As such, future research is warranted to better understand the behavioral effects of indoor air quality and air purification across different workplaces.

Figure 1: Treatment Effect Heterogeneity by $PM_{2.5}$ Level



Note: This figure shows estimates of the effect of air purification on our index outcome by average $PM_{2.5}$ level in contemporaneous control group sessions. The independent variables shown in the x-axis are the indicator for air purifier treatment interacted with indicators of $PM_{2.5}$ levels less than or equal to 5 ($/m^3$), between 5 and 10 ($/m^3$), between 10 and 30 ($/m^3$), and larger than 30 ($/m^3$). All regressions include strata fixed effects and control for the same variables as in Table 2. The blue lines represent estimates and 95% confidence intervals on the weighted single index, and the red lines represent estimates and 95% confidence intervals on the unweighted single index.

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Appendix

6.1 Additional Results

Table A1: Expert Survey Weights

Panel A: Engagement

	N	Mean	SD	Min	Max
Open Laptop	76	11.3	9.9	0	50
Leaving	76	16.9	12.8	0	70
Back and Forth	76	15.1	10.9	0	45
Check Phone	76	14.9	8.7	0	40
Question	76	23.0	14.4	3	80
Engagement Level	76	18.8	11.4	0	55

Panel B: Politeness

	N	Mean	SD	Min	Max
Presenter Tone	76	18.8	11.4	0	45
Raise Hand	76	25.3	19.8	0	100
Answer Tone	76	24.1	9.1	0	50
Question Tone	76	31.7	14.6	0	80

Panel C: Quality

	N	Mean	SD	Min	Max
Keep to Time	76	33.8	18.6	0	80
Presenter is Clear	76	66.2	18.6	20	100

Note: This table shows the summary statistics of the elicited expert survey weights. Panel A reports the survey weights on the engagement outcomes (the fraction of people who left the conference room during each presentation, how frequently the audience checks their phones, the number of people with laptop open, audience engagement level, the number of questions asked, the fraction of questions that generate a back-and-forth), Panel B reports the survey weights on the politeness outcomes (the fraction of cases where the person asking the question raised their hand, the tone of the question asked, the tone of the speaker answering the questions, the general tone of the speaker), Panel C reports the survey weights on the quality outcomes (how clear the presentation is, and whether the speaker kept to their allocated time respectively).

Table A2: Effects of Air Pollution on Conference Outcomes (IV)

	Dep Var: Single Index			
	(1) Pooled	(2) C1	(3) Medellin	(4) Delhi
Panel A: Weighted				
Air Pollution	-0.001	-0.065	-0.017	0.002
	(0.002)	(0.051)	(0.032)	(0.001)
Panel B: Unweighted				
Air Pollution	-0.000	-0.062	-0.015	0.002
	(0.003)	(0.050)	(0.039)	(0.001)
Observations	880	312	402	166
Cragg-Donald Wald F statistic	140.6	28.9	41.2	207.9
Kleibergen-Paap rk Wald F statistic	29.2	16.6	16.4	78.5
Anderson-Rubin Wald F statistic	0.0	1.8	0.2	1.9

Note: This table shows the effects of air pollution, instrumented with the air purifier treatment, on the single conference outcomes index, standardized relative to the conference-specific control groups and constructed as the mean of the 12 standardized component variables. The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effects and control for the number of audience members at the start of the presentation, fraction of women in audience at the start of the presentation, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Panel A reports the IV results on the survey-weighted single index. Panel B reports the IV results on the unweighted single index. Columns (1)-(4) report the IV coefficients pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Robust standard errors clustered at the room-day level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Effects of Air Purification on Environmental Variables

Dep Var:	(1) CO2	(2) Temperature	(3) Humidity
Panel A: Pooled			
Air Purifier	101.439*	0.223	-0.910
	(56.189)	(0.169)	(0.617)
Observations	880	880	880
Control Group Mean	1731.61	23.75	59.99
Panel B: C1			
Air Purifier	271.838**	0.225	0.417
	(114.614)	(0.213)	(1.103)
Observations	312	312	312
Control Group Mean	1596.87	24.84	53.17
Panel C: Medellin			
Air Purifier	20.997	0.168	-2.554***
	(58.211)	(0.283)	(0.886)
Observations	402	402	402
Control Group Mean	1342.66	23.92	59.32
Panel D: Delhi			
Air Purifier	56.135	0.349	1.125
	(160.957)	(0.321)	(1.224)
Observations	166	166	166
Control Group Mean	2774.45	21.55	72.70

Note: This table shows the reduced form treatment effects of air purification on environmental variables (CO_2, temperature, humidity) at the end of presentation. The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effects. Panel A reports the reduced form results polling across C1, Medellin, and Delhi conferences. Panel B reports the reduced form results on the C1 conference. Panel C reports the reduced form results on the Medellin conference. Panel D reports the reduced form results on the Delhi conference. Robust standard errors clustered at the room-day level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
Note that in the Delhi conference, windows were always closed.

Table A4: Effects of Air Purification on Each Component of the Index

	Engagement						Politeness				Quality	
	(1) Leaving (Fraction people)	(2) Check Phone (1-7 scale)	(3) Open Laptop (1-4 scale)	(4) Engagement Level	(5) Question	(6) Back and Forth	(7) Raise Hand	(8) Question Tone	(9) Answer Tone	(10) Presenter Tone	(11) Presenter is Clear	(12) Keep to Time
Panel A: Pooled												
Air Purifier	-0.008	0.240	0.051	0.058	0.015	0.079	-0.003	0.044	0.090	0.080	0.022	-0.050
	(0.007)	(0.157)	(0.067)	(0.107)	(0.095)	(0.101)	(0.101)	(0.104)	(0.099)	(0.100)	(0.099)	(0.096)
Observations	761	800	868	870	820	818	820	818	819	867	863	851
Panel B: C1												
Air Purifier	-0.012	-0.170	-0.097	0.243	0.054	0.085	-0.263	0.278	0.388**	-0.065	0.218	0.032
	(0.012)	(0.318)	(0.102)	(0.175)	(0.181)	(0.202)	(0.232)	(0.228)	(0.168)	(0.167)	(0.172)	(0.165)
Observations	272	284	306	306	311	311	311	311	312	306	305	301
Panel C: Medellin												
Air Purifier	-0.015	0.287	0.027	0.140	0.008	0.053	0.074	0.082	0.095	0.141	0.048	-0.002
	(0.010)	(0.240)	(0.083)	(0.154)	(0.125)	(0.141)	(0.136)	(0.139)	(0.146)	(0.145)	(0.135)	(0.141)
Observations	344	374	396	398	346	344	346	344	344	396	392	389
Panel D: Delhi												
Air Purifier	0.015	0.789**	0.175	-0.637***	-0.102	-0.009	-0.099	0.005	0.151	0.162	-0.210	-0.249
	(0.014)	(0.321)	(0.163)	(0.213)	(0.248)	(0.259)	(0.188)	(0.249)	(0.247)	(0.298)	(0.231)	(0.242)
Observations	145	142	166	166	163	163	163	163	163	165	166	161

Note: This table shows the reduced form treatment effects of air purification on each of the 12 individual outcomes standardized with respect to the conference-specific control groups. The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effects and control for the number of audience members at the start of the presentation, fraction of women in audience at the start of the presentation, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Panel A reports the reduced form results polling across C1, Medellin, and Delhi conferences. Panel B reports the reduced form results on the C1 conference. Panel C reports the reduced form results on the Medellin conference. Panel D reports the reduced form results on the Delhi conference. Columns (1)-(12) report the reduced form coefficients on outcomes: the fraction of people who left the conference room during each presentation, how frequently the audience checks their phones, the number of people with laptop open, audience engagement level, the number of questions asked, the fraction of questions that generate a back-and-forth, the fraction of cases where the person asking the question raised their hand, the tone of the question asked, the tone of the speaker answering the questions, the general tone of the speaker, how clear the presentation is, and whether the speaker kept to their allocated time respectively. Robust standard errors clustered at the room-day level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5: Effects on Objective and Subjective Indices

Dep Var:	Objective Index				Subjective Index			
	(1) Pooled	(2) C1	(3) Medellin	(4) Delhi	(5) Pooled	(6) C1	(7) Medellin	(8) Delhi
Panel A: Weighted								
Air Purifier	-0.030	0.016	0.011	-0.283**	0.066	0.359*	0.107	-0.190
	(0.050)	(0.113)	(0.070)	(0.119)	(0.118)	(0.206)	(0.168)	(0.278)
Panel B: Unweighted								
Air Purifier	-0.024	0.034	0.008	-0.225**	0.061	0.229*	0.098	-0.108
	(0.039)	(0.088)	(0.051)	(0.094)	(0.082)	(0.126)	(0.128)	(0.176)
Observations	878	311	401	166	880	312	402	166

Note: This table shows the reduced form treatment effects of air purification in conference rooms on two sub-indices: an index of more objectively-measured behaviors and an xindex of more subjectively-measured behaviors, both standardized with respect to the conference-specific control groups. The objective index is constructed as the mean of seven standardized component variables: the fraction of people who left the conference room during each presentation, how frequently the audience checks their phones, the number of people with laptop open, the number of questions asked, the fraction of questions that generate a back-and-forth, the fraction of cases where the person asking the question raised their hand, and whether the speaker kept to their allocated time. The subjective index is constructed as the mean of five standardized component variables: audience engagement level, the tone of the question asked, the tone of the speaker answering the questions, the general tone of the speaker, and how clear the presentation is. The independent variable in all panels is an indicator for sessions with air purification. All regressions include strata fixed effect and control for the number of audience members at the start of the presentation, fraction of women in audience at the start of the presentation, room temperature at the start of the session, CO_2 levels at the start of the session, humidity levels at the start of the session, whether the door was opened during the session, and whether the window was opened during the session. Panel A reports the reduced form regressions of the air purifier treatment on the survey-weighted indexes. Panel B reports the reduced form regressions of the air purifier treatment on the unweighted indexes. Columns (1)-(4) report the treatment effects on the objective index pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Columns (5)-(8) report the treatment effects on the subjective index pooling across conferences, and separately for C1, Medellin, and Delhi respectively. Robust standard errors clustered at the room-day level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

7 Pre-Analysis Plan Deviations

In this section, we outline the deviations from our pre-analysis plan, which is pre-registered on AEARCTR-0011400. We separately pre-registered each of our experiments; all experiments are hosted on the same AEA RCT Registry page.

Our deviations from the pre-analysis plan are as follows:

1. Most importantly, we ran an initial arm of our experiment in Cyprus as part of the 2023 European Association of Environmental and Resource Economists. This arm was intended to be included in our final analysis. However, there were concerns regarding data quality, and the study hypothesis was mistakenly communicated to a subset of conference attendees. Consistent with data quality concerns, we were not able to detect a first-stage effect on pollution ($p = 0.22$). As a result, we did not include this initial trial in our analysis, but used it to inform best practices for future implementation.

2. Our pre-analysis plan for the arm of our experiment in Delhi included the following note: "To create indices for the remaining outcomes, we will "flip" the signs of any questions where higher values signal a negative outcome (for instance, less engagement) and weight them according to expert preferences elicited in a Social Science Prediction that we ran July 30-September 1, 2024." Our pre-analysis plans for earlier conferences did not include a note indicating that we will weight outcomes according to expert preferences. We decided to run the expert survey midway through our studies, as a way to impose more structure on our data analysis.

3. We pre-registered accounting for multiple hypothesis testing by applying a bootstrap-based procedure to control the Family-Wise Error Rate. We do not include this in the paper simply because we are already reporting null results, as the rationale for including FWER corrections is to limit the chance of reporting a false positive.

4. For C1, the pre-analysis plan referenced a survey that would be run among participants at the end of the study, to further investigate perceptions of air pollution. This survey was not implemented.

5. There exist a number of differences between our pre-registered and actual specifications.

First, we added three additional controls:

1. *Humidity levels at the start of the session:* The monitors unexpectedly captured this data, and so we decided to include it as well.
2. *Whether a window was open during the session:* There was imperfect compliance in terms of windows always being kept closed during sessions, and so we thought this would be important variation to account for.
3. *Whether a door was open during the session:* There was imperfect compliance in terms of doors always being kept closed during sessions, and so we thought this would be important variation to account for.

We also do not include the following controls specific to the type of session or speaker characteristics, which were not captured directly in our survey. There was sufficient variation

in session topics and speaker backgrounds across conferences that we thought this would best be captured by conference fixed effects, when pooling data:

1. Session topic
2. Session type (policy/thematic/contributed)
3. Speaker gender
4. Speaker citation count
5. Rank of the speaker's home institution
6. Whether the speaker has been an editor