# Data Detective:

## Investigating the Human Health Effects of Air Pollution in Washington State

### *Middle School Version*

**STEM Global Teacher Workshop**

**IHME | healthdata.org**

**LESSON OVERVIEW**

**Time:** 3 50 minute class periods, if taught during synchronous, in-person instruction. Adaptations for remote learning may change this time estimate.

**Subject & Grade Level(s)**

MS Earth and Space Sciences (Grades 6-8). This lesson incorporates mathematics and computational thinking concepts and practices.

**Brief Overview**

In this data science lesson, students practice analyzing and interpreting data in order to answer an investigative question about air pollution in Washington. Student groups first collaborate to graph air pollution data from a city in Washington State. They then compile data as a class in order to observe trends and patterns across cities to make a claim about whether the time of year affects the amount of air pollution in Washington. Through this lesson, students will develop an understanding of foundational data science principles and recognize techniques for manipulating and analyzing data. Students will also gain skills in interpreting trends and patterns in data and writing evidence-based claims. In addition, students will gain an understanding of how air pollution affects human health and the global epidemiology of outcomes attributed to air pollution.

This lesson was originally developed by the Institute for Health Metrics and Evaluation (IHME), an institute affiliated with the University of Washington focused on health metrics sciences (this middle school adaptation of the lesson by Laughing Crow Curriculum). As such, this lesson attempts to introduce students to fundamental data sciences practices that are the work of scientists across fields, including global health. (Image credit: Wikipedia).

**Remote Learning Adaptations:** Integrated into this lesson plan are suggestions for adapting the activities for remote teaching and learning settings. For remote instruction, this lesson assumes students have computer and internet access at home.

**STUDENT UNDERSTANDINGS**

**Anchoring Phenomenon**

Exposure to outdoor (ambient) air pollution is a major risk factor for disease for people around the world. There is a wide array of health effects which are believed to be associated with air pollution exposure. Among them are respiratory diseases (including asthma and changes in lung function), cardiovascular diseases, adverse pregnancy outcomes (such as preterm birth), and even death. While air pollution is a global phenomenon, it has very local impacts that can profoundly affect communities in unique and profound ways. In Washington State for instance, increasing temperatures, rapid urbanization, increased manufacturing, and natural disasters can affect the region's air quality which, in turn, can contribute to poorer health outcomes for residents. In order to alleviate/mitigate the consequences of air pollution in Washington State, we must assess and understand levels and trends of exposure to air pollution to better identify solutions and interventions.

**Driving Questions**

- How can data be used to understand changing levels of air pollution exposure in the State of Washington?
- How can we present air pollution data in a way that reveals patterns or relationships?
- What are the health effects from outdoor air pollution exposure to Washington residents?
- How can data be used to make predictions and recommendations about air pollution and human health?

**Learning Objectives/Success Criteria**

*Students will be able to…*

- Recognize and explain how air pollution affects human health.
- Graph data in order to observe trends and patterns.
- Make a claim about whether the time of year affects the amount of air pollution in Washington and support it with data.
- Generate basic descriptive statistics using a set of data including mean, median, min, and max.
- Interpret trends and patterns of health outcomes related to air pollution by using various forms of data visualization.

**Mathematical and Computational Thinking**

This lesson was designed to introduce students to data science. It engages students in fundamental data science practices, including manipulating, analyzing, and visualizing data. For each of these steps, students are encouraged to engage in sensemaking around why data is important and how graphing and doing statistical analyses of data extracts meaning from it. The following linked teacher resource may be helpful for framing your approach to computational thinking in the science classroom:

- **STEM Teaching Tools Practice Brief #56:** Engaging students in computational thinking during science investigations.

**NEXT GENERATION SCIENCE STANDARDS**

This lesson builds toward the following bundle of middle school level Performance Expectations (PEs). Standards marked with an asterisk (*) are concepts or practices aligned to this lesson, but not included in the PE bundle. Hyperlinks direct to relevant sections of the Next Generation Science Standards and *A Framework for K-12 Science Education.*

| **NGSS Performance Expectations** | | |
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| **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. | | |
| **Disciplinary Core Idea(s)** | **Crosscutting Concepts (CCCs)** | **Science and Engineering Practices (SEPs)** |
| ESS3.C Human Impacts on Earth Systems | Systems and systems models<br><br>*Patterns<br><br>*Stability and change | Using mathematics and computational thinking<br><br>Influence of science, engineering, technology, and applications of science<br><br>*Analyzing and interpreting data |

Connections to Common Core State Standards in Mathematics include the following mathematical practices:

- MP.2 Reason abstractly and quantitatively
- MP.4 Model with mathematics

## TEACHER PREPARATION

### Materials

| Material | Description/Source | Quantity |
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| Classroom Computer | Computer with internet access, projector, and speakers | 1 |
| Student Computers | Computers need to have access to internet for the last topic/step of the lesson.<br>• **Remote Instruction:** Each student will need a computer with internet access. | 1/student or group of students |
| Student Handout | Make copies of the student handout, one of each handout for each group of students.<br>• **Data Science in Global Health** (1/student or group) | 1/student or group of students |
| Student Handout | Print this Excel spreadsheet and cut out the different cities so that each group can have the data for just their city. If you want a more simplified version of the data, use the Air Pollution by City Spreadsheet offered as a resource for remote learning.<br>• **Excel spreadsheet:** "WA_Air_Pollution_Student.xlsx"<br><br>**Remote learning:** For remote learning contexts, instead use the spreadsheet "Air Pollution by City_Remote.xlsx".<br>• This Microsoft Excel spreadsheet could be posted to your classroom learning system as-is, or could be converted into a Google Sheet. Each tab in this spreadsheet contains city-specific data students will need for completing the Student Handout. | 1/student or group of students |
| Teacher Slide Deck | Air Pollution slide deck (elements of slide deck below)<br>• Part I: Introduction to Air Pollution (Slides #1-6)<br>• Part II: Air Pollution and Human Health (Slides #7-9)<br>• Part III: Data Science and Air Pollution in Washington State (Slides #10-12)<br>• Part IV: How Air Pollution is Measured (Slides #13-16)<br>• Part V: Compiling Data Across Cities in Washington (Slides #17-22)<br>• Part VI: Generating Basic Statistics (Slides #23-30) | 1 |
| Student Slide Deck (remote only) | **Remote Learning:** For remote learning contexts, students will need collaborative access to this slide deck, and the ability to edit it, for Part IV of the Student Handout<br>• Slide deck: "Data Driven_Part IV_Slides_Remote.pptx" | 1 |
| Data: Instructor version | https://docs.google.com/spreadsheets/d/11sJUkHGd2DdOZnsnYDb3J_eFhlP9bKT7wskeji-4B8Y/edit#gid=0<br>This is the full data set from which the city data for this lesson was excerpted. It is for instructor reference only and should not be shared with students. | 1 |

**Notes to Teacher for Preparing to Teach this Lesson**

- Computers are required for the last topic/step of this lesson.
    - **Remote instruction:** Students will need computers and internet access throughout this lesson in order to access the digital versions of the student handouts and to submit their work to the teacher.
- Make copies of the student handouts, as indicated in the materials table above.
    - **Remote instruction:** Make digital copies of handouts available to students via your learning management system.
- Print out the Excel spreadsheet "WA_Air_Pollution_Student.xlsx" (Data for Students tab) and cut out the different cities so that each student group will have the data for just their city.
    - **Remote instruction:** Post the spreadsheet file "Air Pollution by City_Remote.xlsx" to your learning management system. Each tab in the file has the data for one of the nine cities.
- Decide how to divide the class into groups of 2 or 3 students. Each group will be assigned a city. There are 9 cities, so divide groups accordingly:
    - Anacortes
    - Bremerton
    - Darrington
    - Kent
    - Methow
    - Mountlake Terrace
    - Scotch (Creek) Basin
    - Seattle
    - Tacoma
- Review the slide deck and speaker's notes.
    - **Remote Instruction:** Upload copies of the two slide decks to your learning management system.
    - **Remote instruction:** Consider recording a video of you presenting the slides in the Air Pollution slide deck (i.e., by using Peardeck for Google Slides or ScreenCast O Matic) for students to view from home.
- An important component of engaging in data practices is having students pause during their computational work to engage in sensemaking together. This teacher resource on science talk and the embedded Student Talk Flow Chart provides ideas of how to structure student-to-student talk and teacher-student talk in equitable ways.
    - **STEM Teaching Tools Practice Brief #35:** How can I foster curiosity and learning in my classroom? Through talk!

**ADAPTATIONS FOR REMOTE INSTRUCTION**

This lesson plan has been updated to include adaptations for remote instruction settings. As written, the lesson is intended for in-person, live, classroom-based instruction. Suggestions are summarized in the table below for hybrid and fully remote teaching and learning settings. **Hybrid instruction** assumes several days each week of live, in-person, classroom-based instruction paired with several days of asynchronous, home-based, remote learning. **Asynchronous remote instruction** assumes no in-person, class-based instruction with all learning taking place in students' own homes. Suggestions focus on asynchronous learning. Teachers who can provide synchronous, live video conference meetings with students may sample from the original lesson plan or the hybrid setting suggestions. The adaptations described below should be considered in addition to the directions in the Instructional Procedure section of the lesson plan, which begins on page 11.

| Learning Activity | Adaptations for Hybrid Instruction | Adaptations for Asynchronous Remote Instruction |
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| **Teacher Prep for Lesson** | Decide what students will do during in-class days and what they will do from home during remote days.<br><br>Make digital copies of handout and spreadsheet available to students via your learning management system.<br><br>Focus in-person time in the classroom on group work, group discussion, and interaction between students. | Consider recording a video of you presenting the slides (i.e., by using Peardeck for Google Slides or ScreenCast O Matic) for students to view from home.<br><br>Make digital copies of handout and spreadsheet available to students via your learning management system.<br><br>Consider using digital bulletin boards (i.e., Padlet, Google Jamboard app, or FlipGrid) as a way for students to communicate, share, and increase interaction, as suggested throughout the procedure below. |
| **Warm-up Questions and Investigative Question #1** (1.1-1.2) | If you will present the slide deck in class, follow the instructions as written in the Procedure.<br><br>If students will review the slide deck on their own during a remote instruction day, follow the instructions in the column to the right. Discussion questions could be reviewed together during the next in-class session. | *Optional:* As an optional way to open the lesson which leverages that students are engaged in learning from home, students could be asked to engage in a self-documentation activity around sources of ambient air pollution in their own community and lives. Students could take photos using a cell phone and/or add text to a collaborative digital space using technology such as Padlet, Google Jamboard app, FlipGrid or Google Slides. This resource provides an overview of how to engage in this kind of culturally-responsive launch to the lesson.<br>**STEM Teaching Tool #31:** *How to Launch STEM Investigations That Build on Student and Community Interests and Expertise.* |

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| | | Create a padlet or other digital bulletin board so that students can respond to Investigative Question #1 (see Slide #1) and share their own hypothesis and ideas. |
| **Introduction:** Presentation on Air Pollution (2.1) | If you will present the slide deck in class, follow the instructions as written in the Procedure.<br><br>If students will review the slide deck on their own during a remote instruction day, follow the instructions in the column to the right. You might consider using the chat feature for capturing students responses to the questions posed at the beginning of each mini-presentation.<br><br>Discussion questions could be reviewed together during the next in-class session. | (Slides 1-16) Have students review the slide deck and speaker's notes or view a video of you presenting the slide deck (preferable). See Procedure section as written for more information about the mini-presentations in the slide deck.<br><br>At the beginning of each mini-presentation, engage students in sensemaking. Students could be asked to respond in writing to the following questions to submit to the teacher. Another option to promote student interaction is to use a digital bulletin board for students to post responses to the prompts and comment on each other's responses.<br><br>• **Intro to Air Pollution (Slides 2-3):** *What is air pollution? What causes it? Why is it a problem? Where have you seen it or heard about it? Does Seattle (or your own community) have a problem with air pollution? How do you know?*<br>• **Air Pollution and Human Health (Slide 7):** *How does air pollution affect human health?*<br>• **Data Science and Air Pollution in Washington State (Slide 10):** *What is data science and why is it important?*<br>• **How Air Pollution is Measured (Slide 13):** *How is air pollution measured?*<br>• **Investigative Question #1 (Slide 16):** *Is there a relationship between the time of year (or season) and the amount of air pollution in Washington?* |
| **Investigable Questions and Identifying Variables** (3.1-3.2) | If students will be able to work in groups on data analysis during an in-classroom day, follow the instructions as written in the Procedure. Divide students into groups of 2 or 3. | Decide if students will be able to work remotely in pairs, or if they will need to work individually on the data analysis project. If working in pairs, consider what technologies are available to your school/district that would allow students to virtually meet-up to complete the assignment together. If this isn't possible, then adapt the lesson for independent work.<br><br>**Option A: Working Remotely in Pairs** |

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| | If students will need to work on data analysis from home during a remote instruction day, follow the instructions in the column to the right. | Follow the directions in the Notes to Teacher for Preparing to Teach This Lesson section of this lesson plan. Assign groups to one of the nine cities.<br><br>**Option B: Working Remotely as Individuals**<br>Follow the directions in the Notes to Teacher for Preparing to Teach This Lesson section, except do not break students into groups. Instead, assign each individual student to a city and data set. There are 9 cities with datasets. As needed, you may assign multiple students to a dataset.<br><br>Students will need access to a digital version of Student Handout: *Data Science in Global Health.* Assign Part I of the handout. |
| **Graphing Data to See Patterns** (4.1-4.7) | If students will be able to work in groups on data analysis during an in-classroom day, follow the instructions as written in the Procedure. This is encouraged if possible because it allows for collaborative group work and also makes the instructor available for just-in-time troubleshooting assistance.<br><br>If students will need to work on data analysis from home during a remote instruction day, follow the instructions in the column to the right. | Students will need access to a digital version of the data from their assigned city from the **Excel spreadsheet:** "Air Pollution by City_Remote.xlsx"<br>As written in the Procedure, depending on students' prior experience interpreting and creating graphs, they may need some support. Consider providing an example graph, or a video about how to create line graphs.<br><br>Assign Part II of the Student Handout. Students should work in their pairs or independently to create a line graph of their city's air quality data across all years and to answer the data analysis questions.<br><br>(Slides 17-22) Have students review the slide deck and speaker's notes or view a video of you presenting the slide deck (preferable).<br><br>For Slide 18, students will need to share out the months with the highest air pollution and the months with the lowest air pollution for each year for their city (they will have already identified this information in Part II of the Student Handout). If using Google Slides, they can add this information directly into Slide #18. If not, you may create a different digital document in which students can add this information. Alternatively, have them email this information to you so you can create a slide that tallies this information and post it to your digital classroom. Students will need access to this information in order to complete Part III of the Student Handout. |

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| **Making a Claim and Supporting it with Data** (5.1) | If students will be able to work in groups on data analysis (encouraged) during an in-classroom day, follow the instructions as written in the Procedure.<br><br>If students will need to work on data analysis from home during a remote instruction day, follow the instructions in the column to the right. | Assign Part III of the Student Handout. Students will need access to the class data from Slide #18 in order to write their claims and evidence.<br><br>Determine how students will submit their Claims-Evidence statements. Consider creating a digital assignment with the sentence frames provided in the lesson Instructional Procedure. |
| **Generating Basic Statistics to Answer a New Investigative Question** (6.1-6.6) | | (Slides 23-30) Have students review the slide deck and speaker's notes or view a video of you presenting the slide deck (preferable).<br><br>Individual students, from home, will use the dataset for their assigned city to find the mean, median, min, max, and variance in the data for their city. Instructions on the data analysis task are provided in Part IV of the Student Handout. Students may choose to use a calculator or spreadsheet software to help calculate their statistics, or calculate them by hand. Teacher may want to provide an example of how to calculate each statistic with a mock data set. Students will document the findings for each metric on Column 1 of the table in Part IV of the handout.<br><br>If working in pairs, consider what technologies are available to your school/district that would allow students to virtually meet-up to complete the assignment together and discuss their results.<br><br>Also consider how students will get help if they encounter problems while engaged in data analysis from home. Consider if drop-in office hours via videoconference are a possibility on the day(s) students are likely to work on Part IV of the Student Handout.<br><br>In order to complete Part IV, students will also need to share the basic statistics that they calculated for their assigned city. Create a Google Slide version of the slide deck "Data Driven_Part IV_Slides_Remote.pptx" and post it in your learning management system for students to share their |

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| | | statistics with one another. Students should find the slide with their assigned city name on it, and then add their statistics to the table on that slide. Remind students to add their name to the column in which they record their data. That allows an opportunity for the teacher to review the data by city, and determine if there are any inconsistencies due to mathematical error.<br><br>Students can then choose a comparison city (or you can assign one) and use the data contributed by classmates to complete Column 2 of the table in Part IV of their handout. |
| **Observing and Asking Questions about the State of Global Air Pollution**<br>(7.1-7.2) | Part V of the handout should work well for students to complete at home on a remote learning day. If so, follow the instructions in the column to the right.<br><br>If students will be able to work on Part V during an in-classroom day, follow the instructions as written in the Procedure. | Assign Part V of the Student Handout.<br><br>Students will independently explore the State of Global Air online map and record their observations and investigable questions they are curious about. |
| **Discussion & Wrap-up**<br>(8.1-8.2) | If the discussion will be happening during a live, in-class day, engage the students in a whole class discussion to wrap-up what they have learned about air pollution and human health, both locally, across our region, and globally. Ask students what we can do with this data and results to improve air quality/pollution in the state. Student groups can report out and teacher will write ideas on the board. In addition, ask students to submit their completed **Student Handout** for grading/credit. | One option for remotely sharing students' findings from the State of Global Air map is to create a digital document in which they can share their observations (i.e., via Padlet, Google Jamboard app, FlipGrid, etc.). Students can be encouraged to review each other's posts.<br><br>A digital Exit Ticket could be assigned at this point asking students to:<br>• Summarize what they have learned about air pollution and human health, both locally, across our region, and globally.<br>• Summarize what they learned from exploring the State of Global Air webpage and reviewing other students' posts. Did they see any patterns or trends?<br><br>In addition, ask students to submit their completed Student Handout for grading/credit through your classroom learning management system. |

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| | If the wrap-up will occur during a remote instruction day, follow the instructions in the column to the right. | |

**INSTRUCTIONAL PROCEDURE**

*The procedure below assumes an in-person, in-class learning context.*

| Topic | Teaching Activities | Student Activities |
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| Warm-up Questions and Investigative Question #1 | 1.1 Teacher asks students:<br>• What they know about air pollution or where they have observed air pollution in their community.<br>• What they know about how air pollution affects human health. Can the students think of any specific instance/event they know of where air pollution impacted human health?<br>• Ideas students have about how they think air pollution might be measured.<br><br>1.2 Teacher reads aloud investigative question (#1) on Slide #1 and has students Turn and Talk to discuss their hypotheses and ideas. | 1.1 Students provide answers to the warm-up questions.<br><br>1.2 Students do Turn and Talk. |
| Presentation on Air Pollution | 2.1 Power Point presentation on air pollution, divided into following parts:<br>• Part I: Introduction to Air Pollution (Slides #1-6)<br>• Part II: Air Pollution and Human Health (Slides #7-9)<br>• Part III: Data Science and Air Pollution in Washington State (Slides #10-12)<br>• Part IV: How Air Pollution is Measured (Slides #13-16) | 2.1 Students listen and ask questions. |
| Investigable Questions and Identifying Variables | 3.1 Teacher divides class into groups of 2 or 3 students (there are 9 cities, so divide groups accordingly) and assigns a city to each group. Distribute copies of the **Student Handout: Data Science in Global Health.**<br><br>3.2 Read overview for Part I on the Student Handout as a class. Give groups a few minutes to write answers to the questions for Part I. Depending on students' familiarity with variables, the teacher may need to provide more support in identifying variables, possible controls, and making a hypothesis. Part I could be done as a class, if necessary. | 3.1 Students sit with their groups.<br><br>3.2 Groups write their answers to the questions for Part I on the handout. |
| Graphing Data to See Patterns | 4.1 Teacher distributes hard copies of city data from the **Excel spreadsheet: WA_Air_Pollution_Data,** making sure to give each group only the data for their assigned city. Read overview for Part II as a class. | 4.1 Groups use Excel spreadsheet of Washington air pollution for their city to make a graph. |

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| | Note: Optional Slide #31 provides a Washington State map with an approximate plot of each city/region's location. Optional Slide #32 provides descriptions of the codes in the dataset.<br><br>Teacher emphasizes that it is difficult to see patterns/trends or relationships in raw data. By graphing, the data, we can more easily observe any patterns. Depending on students' familiarity with graphing data, the teacher may need to provide more support in discussing the different types of graphs and which graph might be most appropriate to represent this data and answer the investigative question. Teacher might consider using Excel to show a few different graph types and help students reason through which type of graph might best represent the air pollution data. A line graph would be best, but a bar graph would also work. Groups will also need to decide whether they will make a double or triple line graph (depending on how many years they have data for their city), using three different colors or make separate graphs for each year.<br><br>4.2 Groups make a graph (or graphs) to represent the amount of air pollution per month for their city across all years using the Excel spreadsheet: WA_Air_Pollution_Data. Once groups have finished making their graph(s), they should answer the graph analysis questions as a group.<br><br>4.3 Teacher brings students back together and asks them report out to the entire class about their findings for their city.<br>● Teacher projects Slide #17 and reads aloud the topic and the question: *Why do we need to analyze data from across cities in order to make a claim about whether the time of year affects the amount of air pollution in Washington?*<br>● Teacher solicits ideas from students about why we need to compile data from across cities in order to make a claim about whether the time of year affects the amount of air pollution in Washington. Students should say that since the question is about whether there is a relationship between the time of year and the amount of pollution in Washington, they need to analyze data from multiple cities, not just their assigned city. <u>The more data (air pollution from different cities) they analyze, the more reliable their claim will be.</u> | 4.2 Students analyze and interpret the data represented in their graph by answering the graph analysis questions on the handout.<br><br>4.3 Students discuss their ideas about why we need to compile data from across cities in Washington (rather than just one city) to make a claim about whether the time of year affects the amount of air pollution. |

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| | 4.4 Groups share out the months with the highest air pollution and the months with the lowest air pollution for each year. Teacher tallies these months in the table on Slide #18.<br><br>4.5 Teacher reads aloud questions on Slide #18 and solicits students' responses:<br>• *Does there appear to be a trend in the highest amount of air pollution and the month(s) across cities?*<br>• *Does there appear to be a trend in the lowest amount of air pollution and the month(s) across cities?*<br><br>4.6 Teacher projects slide #19 and allows students time to do Turn and Talk for the question, then calls on a couple of students to share their thinking with the class.<br><br>4.7 Teacher projects Slides #20-22 and presents the information on the slides. After the information has been presented, check for understanding by asking the class: *According to the information you just learned about wildfires in Washington, what is a likely explanation for why the amount of air pollution is highest in August/during the fall?* | 4.4 Groups share out the months with the highest and lowest air pollution for each year. Teacher tallies these months in the table on Slide #18.<br><br>4.5 Students discuss questions with their group, then a few students share out with the class.<br><br>4.6 Students do Turn and Talk for question on Slide #19.<br><br>4.7 Students explain that the wildfire season happens during later summer and early fall and is a likely explanation for the higher levels of pollution observed during August and nearby months. |
| Making a Claim and Supporting it with Data | 5.1 Read overview Part III on the Student Handout as a class. Groups are given a few minutes to write a claim that answers Investigative Question #1 and support their claim with data from the table on Slide #18. Leave Slide #18 projected so that students can reference it and include quantitative details in their evidence statement from the table.<br><br>Depending on students' skill level with writing claims and evidence, sentence frames written on the whiteboard might be helpful:<br>• CLAIM: There _____[is/is not] a relationship between the time of year and the amount of air pollution in Washington.<br>• EVIDENCE: Our evidence comes from data on the amount of air pollution each month, measured in 9 cities in Washington during 2014, 2015, and 2016. Of the 9 cities, _____cities had the highest air pollution in August, followed by _____cities in September and _____cities in July. | 5.1 Groups are given time to write a claim and support it with data. |

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| Generating Basic Statistics to Answer a New Investigative Question | 6.1 Teacher projects Slide #23 and reads aloud the topic and question.<br>• *How do basic statistics help us interpret and gain additional meaning from the data?*<br><br>6.2 Teacher projects Slide #24, reads aloud Investigative Question #2 and gives students a minute to discuss the Turn and Talk questions.<br>• *How does location affect the amount of air pollution in Washington?*<br><br>6.3 Teacher explains that in addition to graphing data, another way that scientists organize and interpret data in order to find meaning is through statistical analysis. Next, groups will find some basic statistics for their city's air pollution and then compare those statistics with another group in order to answer Investigative Question #2: *How does location (city) affect the amount of air pollution?*<br><br>Continue with the Power Point presentation on basic statistics using Slides #25-29. Introduce the concepts of statistics, mean, median, minimum, and maximum.<br><br>6.4 Read overview for Part IV on the Student Handout as a class. Groups complete Student Handout Part IV. First they generate basic statistics for their city.<br><br>Once most groups are finished calculating statistics for their city, teacher projects Slide #30. Each group then pairs up with another group and compares statistics for their city and the other group's city in order to answer Investigative Question #2 and the additional questions on the handout.<br><br>Teacher might consider providing sentence frames on the whiteboard for the claim and evidence statements:<br>• CLAIM: _____[city] has a higher mean (or median) level of air pollution than _____[city].<br>• EVIDENCE: Our evidence is that the mean (or median) air pollution for all three years (or each separate year) _____was _____. The mean (or median) air pollution for _____was _____. | 6.1 Students listen and ask questions.<br><br>6.2 Students Turn and Talk to discuss the questions.<br><br>6.3 Students listen and ask questions.<br><br>6.4. Groups calculate mean, median, min, and max. After the statistics have been generated and compared with another group, the two groups collaborate to write a claim that answers Investigative Question #2 and support it with statistics. |

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| | 6.5. Teacher leads a discussion about which statistics the groups thought were most relevant to support their claim. Groups should have cited the median and/or mean and, possibly, the maximum. Students should come away from the discussion with the understanding that the median is less sensitive to outliers, so if one of the city's data set had some extreme air pollution measures, the group could have used the median. If both cities had a fairly standard set of measurements, the mean is fine to use.<br><br>6.6 After groups are finished writing their claims to answer Investigative Question #2, teacher will ask the entire class to compare and contrast results.<br>● *Which city had the highest maximum? Which city had the lowest minimum?*<br>● *What city had the highest mean? What city had the lowest mean?*<br>● *What city had the highest median? What city had the lowest median?*<br>● For each question, the teacher will challenge students to answer why they think those are the findings. Teacher will ask students what the general trends and patterns are for each metric. | 6.5 Students actively participate in discussion.<br><br>6.6 Students actively participate in discussion, basing their comments on the data. |
| Observing and Asking Questions about the State of Global Air Pollution | 7.1 Read overview for Part V on the Student Handout as a class. Have individual students or groups use computers to explore the State of Global Air map (http://www.stateofglobalair.org/air#PM) and then write their observations and possible investigable questions that they are curious about.<br><br>7.2 If any students or groups finish early: they can explore how air pollution levels have changed in different countries over the last couple of decades by following the link to State of Global Air plot view: http://www.stateofglobalair.org/data/#/air/plot<br>○ Go to the "Choose a country" tab<br>▪ In the drop down menu, pick one of the countries you identified from the map view.<br>▪ Click on that country name.<br>○ The plot should generate a yellow line representing PM2.5 levels between 1990 and 2015.<br>○ To compare the three country PM2.5 in a time series, you can add a country by selecting them in the "+Add countries" drop down menu. | 7.1 Students explore the State of Global Air map, then write observations and investigable questions they are curious about.<br><br>7.2 Students who finish early can explore how air pollution levels have changed in different countries in the last couple of decades |

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| Discussion & Wrap-up | 8.1 Students share with the class interesting observations and investigable questions from their exploration on the State of Global Air webpage. An Exit Ticket could be assigned at this point asking students to summarize what they learned from exploring the State of Global Air webpage.<br><br>8.2 Teacher asks students what we can do with this data and results to improve air quality/pollution in Washington. Teacher asks students to generate ideas in their groups. Students report out and teacher writes ideas on the board. | 8.1 Students share interesting observations and investigable questions they came up with while exploring the State of Global Air webpage.<br><br>8.2 Students will ask each other questions and discuss their ideas. |

**Student Assessment Opportunities**

- Students' thoughtful participation during class discussions, group share-outs, as well as responses on the Student Handout can all be used for assessment purposes.

**Student Handout & Teacher Resources**

Student Handouts:

- **Student Handout:** *Data Science in Global Health* (1/student or group)
- **Excel spreadsheet:** WA_Air_Pollution_Data

Teacher Resources:

- Air Pollution slide deck (elements of slide deck below)
  - Part I: Introduction to Air Pollution (Slides #1-6)
  - Part II: Air Pollution and Human Health (Slides #7-9)
  - Part III: Data Science and Air Pollution in Washington State (Slides #10-12)
  - Part IV: How Air Pollution is Measured (Slides #13-16)
  - Part V: Compiling Data Across Cities in Washington (Slides #17-22)
  - Part VI: Generating Basic Statistics (Slides #23-30)

**Suggested Lesson Extensions**

- For the Introduction, students could be asked to engage in a self-documentation activity around sources of ambient air pollution in their own community and lives. This resource provides an overview of how to engage in this kind of culturally-responsive launch to the lesson.
  - **STEM Teaching Tools Practice Brief #31:** How to launch STEM investigations that build on student and community interests and expertise.
- This lesson could be extended to focus additional time to understanding the health impacts of air pollution on different body systems.
- Students could use the latitude and longitude information provide for each city/region in the dataset to plot the locations using Google Maps.
- Students can also explore how air pollution levels have changed in different countries over the last couple of decades by following the link to State of Global Air plot view: http://www.stateofglobalair.org/data/#/air/plot
  - Go to the "Choose a country" tab
    - In the drop down menu, pick one of the countries you identified from the map view.
    - Click on that country name.
  - The plot should generate a yellow line representing PM2.5 levels between 1990 and 2015.
  - To compare the three country PM2.5 in a time series, you can add a country by selecting them in the "+Add countries" drop down menu.

**Notes on Adaptations and Inclusivity**

- **Scientific & Computational Vocabulary:** Students may need some support in understanding the terminology embedded in this lesson. This may be particularly true for emerging bilingual students and students with lower reading levels. The following list captures some of the scientific, mathematical, and computational terms used in the lesson materials.
    - **Mean:** The mean or average that is used to derive the central tendency of the data in question. It is determined by adding all the data points in a population and then dividing the total by the number of points.
    - **Median**: A simple measure of central tendency. To find the median, we arrange the observations in order from smallest to largest value. If there is an odd number of observations, the median is the middle value. If there is an even number of observations, the median is the average of the two middle values.
    - **Minimum**: The smallest observation (number) in a sample of data.
    - **Maximum**: The largest observation (number) in a sample of data.
    - **Data assessment**: The process of scientifically and statistically evaluating data in order to determine whether they meet the quality required for projects or business processes and are of the right type and quantity to be able to actually support their intended use.
    - **PM2.5:** Refers to atmospheric particulate matter (PM) that have a diameter of less than 2.5 micrometers, which is about 3% the diameter of a human hair.

- **Inclusivity for All Learners:** Consider how the lesson activities may need to be adapted to be accessible for all learners. For example, what accommodations may a student with a visual or mobility impairment need to engage in the computational work? How might you elicit, build connections with, and leverage students' everyday expertise with data practices? How might you group students with diverse expertise and learning needs into teams so that they can support each other?

## TEACHER RESOURCES

**Background Information on Air Pollution in Global Health**

WHO Ambient Air Pollution: Pollutants
https://www.who.int/airpollution/ambient/pollutants/en/

Our World in Data: Air Pollution
Hannah Ritchie and Max Roser, October 2017
https://ourworldindata.org/air-pollution

State of Global Air 2019 Report
IHME, 4/3/19
http://www.healthdata.org/news-release/state-global-air-2019-report

Health Impacts of Air Pollution
European Environment Agency, 4/22/16
https://www.eea.europa.eu/signals/signals-2013/infographics/health-impacts-of-air-pollution/view

Air Pollution, Climate, and Health
Breathe Life, Climate & Clean Air Coalition, WHO
https://www.who.int/sustainable-development/AirPollution_Climate_Health_Factsheet.pdf

The Weight of Numbers: Air Pollution and PM2.5
UnDark Magazine and the Pulitzer Center on Crisis Reporting
https://undark.org/breathtaking/

**Career Links**

The following careers are related to data sciences and global health.

- **Biostatistician:** https://www.careersinpublichealth.net/careers/biostatisticians/
- **Data analyst:** https://careerlink.com/quick/data-science-jobs
- **IHME Post-Bachelor Fellow:** http://www.healthdata.org/about/team/pbf

The career of a Data Analyst is featured on the STEM Global Pathways to Global Health Careers poster and accompanying fact sheets (see the Information Technology section):

- **Poster: Pathways to Global Health Careers:** https://www.wghalliance.org/resource/global-health-career-poster/
- **Fact Sheet: Pathways to Global Health Careers:** https://www.wghalliance.org/resource/global-health-career-fact-sheets/

**Credit:** This activity was originally developed as a high school-level lesson by the Institute for Health Metrics and Evaluation (IHME), a global health organization located in Seattle, WA and adapted for a STEM Global Teacher Workshop in April 2019. Original authors include: Austin Carter, Doctoral Candidate and Researcher, IHME; Joseph Frostad, Doctoral Candidate and Researcher, IHME; Sean Lassiter, Senior Education Program Manager. This middle school-level adaptation was authored by Janneke Petersen for Laughing Crow Curriculum. Lesson plan development, editing, and remote learning adaptations by Dr. Kristen Bergsman of Laughing Crow Curriculum.