Published on *The Embryo Project Encyclopedia* (https://embryo.asu.edu)

"The Environment and Disease: Association or Causation?" (1965), by Austin Bradford Hill [1]

By: Abboud, Carolina J. Keywords: Environment [2]

In 1965, Austin Bradford Hill published the article "The Environment and Disease: Association or Causation?" in the *Proceedings of the Royal Society of Medicine*. In the article, Hill describes nine criteria to determine if an environmental factor, especially a condition or hazard in a work environment, causes an illness. The article arose from an inaugural presidential address Hill gave at the 1965 meeting of the Section of Occupational Medicine of the Royal Society of Medicine in London, England. The criteria he established in the article became known as the Bradford Hill criteria and the medical community refers to them when determining whether an environmental condition causes an illness. The criteria outlined in "The Environment and Disease: Association or Causation?" help identify the causes of many diseases, including cancers of the reproductive system.

In "The Environment and Disease: Association or Causation?" hereafter referred to as "Environment and Disease" Hill lays out the nine criteria that he argues the medical community should consider before assigning a specific environmental cause to a particular illness or disease. Starting in the 1920s, Hill studied diseases and their causes in London, England. In 1924, Hill and his colleague Richard Doll showed that smoking caused lung cancer. Hill's research involved pinpointing the causes of diseases, often environmental as in the case of smoking and lung cancer, and culminated in the Bradford Hill criteria elaborated in "Environment and Disease."

Because Hill originally presented "Environment and Disease" as an address, he speaks in first person and begins the article with an introduction that sets out the goal of the first meeting of the Section of Occupational Medicine. Hill articulates that his goal is to determine how the medical community can detect the relationship between occupational conditions and resulting disease. Within the address, Hill enumerates the nine criteria individuals in the medical community should consider to identify a particular factor as the cause of a certain disease. Hill discusses the first criteria in greatest length and progressively decreases the amount of attention given to the following criteria as the article progresses. After explaining the nine criteria, Hill cautions his readers not to put too much faith in tests of significance, which are statistical methods that indicate how much of a role pure chance played in the results. Researchers studying diseases use those tests to determine the likelihood that a specific cause was responsible for a disease rather than chance. Hill concludes the article with another warning not to take dramatic action to alter a work environment too quickly and without strong evidence.

In the introduction, Hill describes the part of the Royal Society of Medicine called the Section of Occupational Medicine. According to Hill, that section consists of physicians and surgeons that specialize in the relationship between illness and the hazards and conditions of occupations. As president of the section, Hill opens the first meeting by questioning how

physicians and surgeons involved in the field of occupational medicine can determine if occupational hazards or conditions cause the diseases associated with those occupations. Hill describes his motivation for creating formal criteria as a method to answer that question. Before describing his list of criteria, Hill states that proving without a doubt that a factor causes an illness takes time and research beyond simply using his criteria. Hill proposes that his criteria will provide a relatively quick and logical way of determining if the relationship between a factor and a disease is most likely causal and merits intervention or further research.

The first criterion Hill lists is strength, which means the strength of the correlation between a factor and a disease, or how well those two variables are linked. Correlations indicate a connection between two variables, though such a connection does not necessarily indicate a causal relationship. Hill spends the most space discussing strength as a criterion, and he uses several examples to illustrate strong correlations between environments and diseases. First, Hill refers to the relationship between scrotal cancer, a cancer that affects the tissue around the sperm [3]-producing organs in men and chimney sweeps in nineteenth century London, England. Because of the enormous increase of that particular cancer in chimney sweeps, and in no other group of people, the physician Percival Pott deduced a causal relationship between exposure to chimney soot and scrotal cancer. Hill also discusses the link he and his colleague Doll investigated about the correlation between smoking and developing lung cancer, from which they deduced a causal relationship. For his final example, Hill discusses a 1854 cholera epidemic in London, England that physician John Snow traced back to a single contaminated water supply, based on the strength of the correlation between the people who received water from there and the people who got cholera. Hill finishes with a warning that despite the strength criteria, physicians should not overlook cases in which the correlation between factor and disease is not strong, for many factors cause disease in only a portion of the people exposed to them.

The next criterion Hill presents is consistency, which he defines as whether physicians have repeatedly observed the association between a factor and a disease in many people and at many different times and places. As an example, Hill returns to smoking and lung cancer, and he notes that other groups besides Doll and him had observed that smokers developed lung cancer at a higher rate than non-smokers. However, he continues to warn his readers not to be over-reliant on the consistency criterion or any of his criteria. He explains that different investigations into the same topic can yield different results without destroying the chance of a causal relationship. Likewise, the same results from similar investigations do not necessarily indicate a stronger causal relationship. Further Hill describes, in some cases, as with a single group of nickel refiners who developed lung and nasal cancer, no repetition of observation took place and still the medical community correctly established a causal relationship.

Hill then discusses his third criterion of specificity, or how uniquely the environmental factor is associated with the disease. He argues that if particular workers at particular work sites die of the disease, then a strong causal relationship exists. However, as before, Hill cautions his readers not to overemphasize specificity because sometimes a factor seems to cause many diseases when in reality another factor related to the original one causes the disease. He states for example that infected milk causes many different diseases, but the different bacteria that can infect milk cause the diseases and not the milk itself. Hill also tells his readers that a causal relationship can exist even if one or more criterion do not apply. In his example of smoking and lung cancer, specificity is low, but the strength of the causal relationship makes up for that lack. To conclude the specificity criterion, Hill points out that many diseases have

more than one cause. Therefore, he argues, specificity may indicate a causal relationship, but the absence of specificity does not preclude that there could be a causal relationship.

From the fourth criterion onward, Hill discusses each criterion with only a few paragraphs. The fourth criterion is temporality, which he defines as determining whether the factor causes the disease or the disease itself leads to that factor, especially in cases of diseases that take years to develop. Hill urges physicians to question which variable came first, using diet as an example and whether diet causes the disease, or people with the disease choose that diet. He notes that the issue of temporality may not arise often but physicians should keep that criterion in mind, especially when considering diseases associated with industry.

Hill names his fifth criterion biological gradient, on which he also refers to as a dose-response curve. Hill describes that criterion as whether the number of people diagnosed with the disease increases with an increased number of people exposed to the environmental factor, or whether an increased number of people diagnosed does not reflect an increase in the number of people exposed to the factor. If more people are diagnosed with lung cancer when more people smoke, then a linear relationship exists between smoking and the number of people diagnosed with lung cancer. However, if the rate of diagnosis decreases with the number of people exposed to the factor, Hill states that such a relationship weakens the argument for causation but does not necessarily destroy it entirely. In those cases, Hill recommends searching for a more complex relationship between the environmental factor and the disease.

Hill introduces plausibility as his sixth criterion, stating that physicians can more confidently declare a causal relationship if they can understand how the factor biologically caused the disease. Although he lists plausibility as the sixth most important criterion, Hill states that he does not consider it essential. He references the case of chimney soot causing scrotal cancer in the eighteenth century and how physicians at the time did not see how soot caused scrotal cancer, leading many to dismiss the causal relationship. As of 2017, researchers have determined that the soot lodged in the skin of the scrotum and exfoliated cells at a rapid rate, which then caused cells to replicate more quickly, enabling cancer-causing mutations to occur with greater frequency. Hill warns physicians not to fall into premature dismissals simply because no current science supports the link between factor and disease.

To partially counter the tendency to dismiss factors that may be important, Hill presents coherence as his seventh criterion. Hill states that data from a causal investigation should not seriously conflict with present scientific understanding of the disease. In other words, a physician should not claim to have discovered a new causal relationship between a factor and a disease if that relationship contradicts everything currently known about the factor or the disease. He states that the correlation between lung cancer and smoking is coherent with existing scientific evidence.

Next, Hill lists experiment as his eighth criterion. He states that if experimental evidence can show the cause and effect relationship under investigation, the relationship gains a great deal of validity. He recognizes that experiments can only rarely be applied to causal relationships seen in the work environment, and he pays less attention to it compared to other criteria. Hill spends only a paragraph discussing the experiment criterion and the next and final criterion of analogy. In the article, analogy means extending the results of one medical case to another. He describes as an example a sedative called thalidomide, which was banned in 1960 after causing birth defects [4] in fetuses exposed during pregnancy [5]. He argues that by using the

analogy criterion, a physician could deduce that other drugs similar thalidomide would cause similar effects. Hill spends only two sentences on analogy as a criterion before moving on to his conclusions.

After stating all nine criteria, Hill reiterates that the medical community should not use exact rules or criteria to establish causal relationships. Hill's nine criteria provide guidelines for determining the strength of a possible causal relationship and help determine if any other explanation, besides a causal relationship, is probable.

Hill concludes his article with two final warnings. The first one is an acknowledgement of how much science relies on statistical tests of significance and how those do not always indicate if a theory is correct. Hill does not dismiss the technique, but he does say that interpretation of data does not rely on statistics and numbers alone. Even if statistical tests indicate a link between two variables is significant, Hill claims that the link could be too small to be of any practical use. In his next warning, Hill states that the medical community should have strong evidence before suggesting that the public should make a large change in their lives. However, even without much evidence, the medical community should not ignore any knowledge that suggests that such large changes are necessary to better the public's wellbeing.

Later researchers cited Hill's "Environment and Disease" over 6,000 times. Many of those researchers used the Bradford Hill criteria to determine the causal relationship between a factor and a disease, including reproductive cancers.

Sources

1. Bosch, Francesc X., Attila Lorincz, Nubia Muñoz, C. J. L. M. Meijer, and Keerti V. Shah. "The Causal Relation Between Human Papillomavirus and Cervical Cancer." *Journal of Clinical Pathology* 55 (2002): 244?65. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1769629/ [6] (Accessed February 23, 2016).
2. Brown, John R., and Thornton, John L. "Percivall Pott (1714?1788) and Chimney Sweepers' Cancer of the Scrotum." *British Journal of Industrial Medicine* 14 (1957): 68?70. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1037746/ [7] (Accessed February 23, 2016).
3. Doll, Richard, and Austin Bradford Hill. "Mortality in Relation to Smoking: Ten Years' Observations of British Doctors." *British Medical Journal* 1 (1964): 1399?410. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1814697/ [8] (Accessed February 23, 2016).
4. Hill, Austin Bradford. "The Environment and Disease: Association or Causation?." *Proceedings of the Royal Society of Medicine* 58 (1965): 295. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1898525/pdf/procrsmed00196-0010.pdf [9] (Accessed February 23, 2016).
5. Snow, John. *On the Mode of Communication of Cholera*. London: John Churchill, 1855. http://collections.nlm.nih.gov/ext/cholera/PDF/0050707.pdf [10] (Accessed February 24, 2016).

In 1965, Austin Bradford Hill published the article ?The Environment and Disease: Association or Causation?? in the Proceedings of the Royal Society of Medicine. In the article, Hill describes nine criteria to determine if an environmental factor, especially a condition or hazard

in a work environment, causes an illness. The article arose from an inaugural presidential address Hill gave at the 1965 meeting of the Section of Occupational Medicine of the Royal Society of Medicine in London, England. The criteria he established in the article became known as the Bradford Hill criteria and the medical community refers to them when determining whether an environmental condition causes an illness. The criteria outlined in ?The Environment and Disease: Association or Causation?? help identify the causes of many diseases, including cancers of the reproductive system.

Subject

Hill, Austin Bradford, Sir, 1897- [11] Doll, Richard [12] Royal Society of Medicine (Great Britain). Section of Occupational Medicine [13] Causation [14] Pott, Percivall, 1714-1788 [15] London, England [16] Snow, John, 1813-1858 [17] Epidemiology [18] Diseases [19] Carcinoma, Squamous Cell [20]

Topic

Publications [21]

Publisher

Arizona State University. School of Life Sciences. Center for Biology and Society. Embryo Project Encyclopedia.

Rights

Copyright Arizona Board of Regents Licensed as Creative Commons Attribution-NonCommercial-Share Alike 3.0 Unported (CC BY-NC-SA 3.0) http://creativecommons.org/licenses/by-nc-sa/3.0/

Format

Articles [22]

Last Modified

Wednesday, July 4, 2018 - 04:40

DC Date Accessioned

Thursday, March 23, 2017 - 22:26

DC Date Available

Thursday, March 23, 2017 - 22:26

DC Date Created

2017-03-23

DC Date Created Standard

Thursday, March 23, 2017 - 07:00

- Contact Us

© 2018 Arizona Board of Regents

- The Embryo Project at Arizona State University, 1711 South Rural Road, Tempe Arizona 85287, United States

---

Source URL: https://embryo.asu.edu/pages/environment-and-disease-association-or-causation-1965-austin-bradford-hill

Links:
[1] https://embryo.asu.edu/pages/environment-and-disease-association-or-causation-1965-austin-bradford-hill
[2] https://embryo.asu.edu/keywords/environment
[3] https://embryo.asu.edu/search?text=sperm
[4] https://embryo.asu.edu/search?text=birth%20defects
[5] https://embryo.asu.edu/search?text=pregnancy
[6] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1769629/
[7] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1037746/
[8] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1814697/
[9] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1898525/pdf/procrsmed00196-0010.pdf
[10] http://collections.nlm.nih.gov/ext/cholera/PDF/0050707.pdf
[11] https://embryo.asu.edu/library-congress-subject-headings/hill-austin-bradford-sir-1897
[12] https://embryo.asu.edu/library-congress-subject-headings/doll-richard
[13] https://embryo.asu.edu/library-congress-subject-headings/royal-society-medicine-great-britain-section-occupational-medicine
[14] https://embryo.asu.edu/library-congress-subject-headings/causation
[15] https://embryo.asu.edu/library-congress-subject-headings/pott-percivall-1714-1788
[16] https://embryo.asu.edu/library-congress-subject-headings/london-england
[17] https://embryo.asu.edu/library-congress-subject-headings/snow-john-1813-1858
[18] https://embryo.asu.edu/library-congress-subject-headings/epidemiology
[19] https://embryo.asu.edu/library-congress-subject-headings/diseases
[20] https://embryo.asu.edu/medical-subject-headings/carcinoma-squamous-cell
[21] https://embryo.asu.edu/topics/publications
[22] https://embryo.asu.edu/formats/articles