Int. J. Biometeorol. 1980, vol. 24, number 4, pp. 329-339.

Weather Patterns and Asthma Epidemics in New York City and New Orleans, U.S.A.

by

Inge F. Goldstein*

ABSTRACT. — Twenty-five years of data on asthmatic attacks in New Orleans (covering approximately 170,000 asthma attacks) have been analyzed to identify "asthma epidemic" days, defined as days on which an unusually high number of asthmatic individuals had attacks. Similar data covering three years was obtained for New York City. A preliminary examination of detailed meteoroligical data revealed a consistent meteorological pattern preceding and associated with such "asthma epidemic" days which consisted of a cold front preceding an asthma epidemic by one to three days followed by a high pressure system. The significance of these meteorological findings and their relationship to other environmental agents such as natural or man-made atmospheric pollutants that are likely to be associated with asthma attacks will be discussed.

INTRODUCTION

The objective of this study of epidemic asthma, which is still in its pilot stage, is to develop models permitting the prediction in time and space of asthma epidemics. By asthma epidemics we mean time periods and/or geographical locations in which the incidence of asthma episodes greatly exceeds chance expectation. We will use emergency room data on asthma visits in New Orleans and New York City municipal hospitals in order to find reliable and objective procedures for identifying such "asthma epidemics": next, we intend to examine and interpret the long range trends in emergency room visists for asthma in New Orleans and New York City; and finally, we hope to identify those environmental factors associated with the epidemics (environmental factors including not only natural and artificial pollutants but also meteorological variables).

The long range goals of this study are not only to contribute to our understanding of the etiology of asthma, but in a more immediate way to suggest mechanisms for aiding physicians and health services to plan treatment strategies including drug therapies.

Asthma has been identified as "a disease characterized by an increased responsiveness of the trachea and bronchi to various stimuli, and made manifest by difficulty of breathing due to generalized narrowing of the airways. This narrowing is dynamic and changes in degree either spontaneously or because of therapy" (DHEW Publication,

* Environmental Epidemiology Research Unit, Division of Epidemiology,
Columbia University School of Public Health, 600 West 168th Street, New York, New York 10032, U.S.A.

Presented at the Eighth International Congress of Biometeorology, 9-14 September 1979, Shefayim, Israel.

1973). "Bronchial asthma is a disorder of the respiratory tract characterized by periodic attacks of obstructive respiratory dyspnea resulting in wheezing, irritating cough and labored respiration. The disease is variable in severity, frequency of attacks, and duration"(Gordis, 1973). Asthma is a heterogeneous syndrome; it is believed that various disease entities are lumped together under the general term asthma. The occurrance of well-documented examples of asthma "epidemics" — periods of time during which numbers of attacks in susceptible individuals is far in excess of chance expectation, and the existence of unusually high prevalence in certain geographical locations — Tokyo and Yokohama in Japan and New Orleans in the U.S. for example — and among certain occupations — printers, bakers, florists, cotton mill workers — strongly suggest that some environmental agent or factor plays a major role in inducing such attacks.

An estimated 8.6 million Americans suffer from asthma and about 14 million have or have had the condition. It is a frequent cause of disability, being responsible for 5% of all chronic disabilities. The heterogeneous character of the affliction makes it not surprising that epidemiologic studies have encountered many difficulties; even the most basic figures on incidence and prevalence are unreliable. Mortality figures are of limited use due to the low fatality rate. Our dependent variable at the initial stage of this study will include all emergency room visits at our New York and New Orleans study hospitals which were diagnosed as asthma, irrespective of the type of asthma that was diagnosed.

Many investigators have found an increased frequency of attacks during the months of October and November in the Northern hemispheres (Booth et al., 1965; Greenburg and Field, 1965; Greenburg et al., 1965) and during April and May in the Southern hemisphere (Derrik, 1965, 1966; Derrik Thatcher and Trappet, 1960). The reports cited above are based on clinic and emergency room records but similar seasonal increases have been noted by private practitioners.

"Reproductive particles of many seed plants and fungi as well as certain algae, bacterial actinomycetes, and protozoa regularly undergo atmospheric transport. The resulting natural aerosols (air spora) which include significant human allergens vary in occurrance with local land use and regional cycles of plant growth" (Chang, 1972).

New Orleans is notorious for its reported periodic outbreaks of asthma. These outbreaks have mainly been identified by a vast increase in the number of asthma patients attending Charity Hospital, which serves a large population of lower socio-economic status in metropolitan New Orleans. A public grain elevator which was a source of allergens (molds, etc.) accumulating on the surface of the grain and disseminated into the atmosphere during operation of the grain elevator, was suspected to be causally related to the New Orleans asthma outbreaks. Weil et al. (1965) showed that asthmatics involved in the epidemics demonstrated a high incidence of positive skin tests to extracts from grain dusts. However, many individuals in the normal population of New Orleans also showed positive skin tests to the grain dust extracts. Most crucially, the epidemics have occurred during periods in which the grain elevators were not operating. Salvaggio et al. (1969) studied factors in New Orleans that were associated with epidemics days for the months of September and October, 1963-67. They reported that epidemic periods were associated with low wind speed, low relative humidity, cooler temperatures, and clear weather conditions. The late autumn epidemics in the four years studied were associated with rising barometric pressure. Salvaggio also reported that during 1967-68 (Salvaggio, Seabury and Schoenhardt, 1971) summer asthma episodes were associated with high pollen and spore counts, and that a relationship existed between meteorological factors and pollen and spore counts for the two autumn seasons studied. However, in a report to the Environmental Protection Agency, Hasselblad et al. (unpublished) described some pollen sampling for New Orleans for October 1968 and reported no association between pollen counts and meteorological factors.

It is not surprising that one finds conflicting reports about relationships between pollen, molds, and spore and asthma epidemics and about the relationship between meteorological parameters and pollen molds and spores. Solomon and Mathews (1978) describe the variation in occurrence of natural aerosols (which include human allergens) with regional cycles of plant growth and local land use. They also point out the many problems encoutered in trying to assess exposure of populations even to the well known and identified allergens such as ragweed. They note that no single device will optimally recover air spora, thus many aero allergens still defy enumeration. Overall examinations of dusts tend to be more instructive than cultures because of the strong selective bias that all media impose. Spore viability also may be low and is affected by weather as well as by circadian factors. The problems are very similar to those encountered in monitoring air pollutants such as sulphates, particulates, or even sulfur dioxide (Goldstein, 1978; Goldstein and Landovitz, 1975; 1977a; 1977b; Goldstein, Landovitz and Block, 1974; Goldstein, Goldstein and Landovitz, 1977). This suggests that the setting-up of monitoring networks for biological allergens without improvement in their reliability and validity will not necessarily contribute to the design of epidemiological studies of environmental effects on asthma.

Working in NYC with emergency room visits as the index of asthma frequency, Greenburg et al. (1964; 1965; Greenburg and Field, 1965) could find no associations between asthma and daily levels of sulfur dioxide, oxides of nitrogen or smokeshade, although he found increases in frequencies of visits to the emergency room for asthma to be related to decreases in the temperature, specifically with onset of the first and second cold periods in the fall seasons (that is, periods requiring home heating). Pollen counts did not show any association with these asthma epidemics. In fact these asthma epidemics occurred well after the high pollen seasons that are known to be associated with hay fever. However, obviously not all possible molds, pollen, and spores to which asthmatics might be sensitive were monitored. Greenburg suggested that the association of the asthma epidemics with the first two cold spells of the fall seasons might possibly be due to the resuspension of settled dust particles by the first operations of home heating systems that have not operated over the summer.

Work in Brisbane, Australia by Derrick, Thatcher and Trappet (1960) and Derrick (1965; 1966; 1972) led them to conclude that the spring and fall waves of asthma in Brisbane were probably due to airborne allergens, perhaps fungal spores. The strong correlations of the magnitudes of fall and spring waves with temperature and humidity over the previous weeks suggested that biological allergens were involved; the decrease in visits with rain suggested the allergen was air-borne so that rain could wash it from the air.

Several studies demonstrated a high association with concentration of the house dust mite which has a seasonal increase which coincides with the seasonal increase in asthmatic attacks in several locations in the world.

WEATHER AND CLIMATE STUDIES

Weather and climate are also known to affect asthma: some hypotheses attribute a direct causative effect to certain kinds of weather, others regard the influence of weather or climate on the production and dispersal of air-borne irritants and allergens as responsible. The nature of local vegetation, the concentration of house dust mite, the dispersion of spores, pollen and molds, the build-up of atmospheric pollutants, the prevalence of respiratory infection, are all likely to affect the occurrence of asthmatic attacks and are in turn affected by climate and/or weather. Interaction between meteorological and other factors may.also be significant. Asthmatics who have been subjected to different weather conditions, may for example, react differently when exposed to the same pollutant; or the same set of pollutants may, under different weather conditions, yield chemical end-products which affect health in a different fashion.

To summarise we note that both clinical and epidemiological evidence suggest that asthma attacks may be precipitated by exposure to environmental agents both natural — spores, seeds, molds — and man-made pollutants — metallic salts (Pt., Ni., Cr.).

STATISTICAL METHODOLOGY

The recognition that there are temporal and spatial variations in the incidence of asthma attacks has been used both to suggest etiological hypotheses and to test them. However, the identification of time and space clustering of asthma has almost entirely been done by impressionistic criteria rather than by precise and objective methods.

We have developed statistical methods descrrbed elsewhere (Goldstein and Arthur, 1978; Goldstein and Rausch, 1978) for more precise identification of temporal and spatial clusters. An expected number of emergency room visits was obtained by using a 15-day moving mean centered on the day in question. "Unusual days" were defined as those with numbers of visits in the upper tail of an assumed inhomogeneous Poisson distribution. The data were then studied by season of the year, fall being defined as the months from September through November, and so on.

NEW YORK CITY AND NEW ORLEANS ASTHMA STUDY

In New York City (NYC) we found that in the fall seasons the numbers of such unusual days were significantly greater than one would expect to occur by chance alone. Further, the unusual days in other seasons appeared to be distributed at random in time and among the emergency rooms and age categories. In the fall, unusual days appear to occur in clusters of adjacent days, and to occur simultaneously in several emergency rooms. This provides evidence for the "global" rather than "local" character of the time clusters of asthma for NYC. In other words, they appear in more than one geographical area of the city at once. Thus, in a search for environmental agents in NYC that might be responsible for the asthma epidemic days described above, one should look for agents that are unusually high throughout the city rather than agents that are concentrated only in some parts of the city on or just before those days. This fact is important also in the planning of environmental monitoring stations; an extensive monitoring network is not essential for the purpose of identifying the agent or agents responsible for the asthma epidemics.

The data for the study were visits for asthma to emergency rooms at three municipal hospitals in two different inner-city areas which were similar in demographic and socioeconomic characteristics. The data were divided by age of patient into two categories — under 13 years of age and 13 years of age and over — giving a total of 6 figures (two age groups at each of the three hospitals for each day of the study).

Figure 1 shows a plot of daily adult visits for asthma to all three emergency rooms at our three study hospitals combined for the year 1971.

Table 1 shows the frequency of days on which the observed number of visits lie in the upper 1% of the Poisson distribution.

Figures 2 and 3 show the distribution in time and among hospitals for 2 months of "unusual" days for asthma, where "unusual days" are defined as all days on which the number of visitors at the emergency rooms was so large that the probability (according to the Poisson distribution) of having this number or more was equal to or less than 0.05.

Figure 2, which includes one winter and one summer month, shows that the "unusual" days occur randomly at the different hospitals. Figure 3 shows the results for two fall months; not only is there a large number of unusual days but there is some tendency for these days to occur at all, or almost all of the hospitals on the same day or within one or two days of each other. Two such episodes of a marked time-space clustering of unusual days are shown on Fig. 3 by cross hatching and include between them 19 out of the total 30 "unusual" days observed in the two months. It is clear that some environmental factor precipitating asthma attacks was acting over the entire city during these periods.

We are applying the above procedure of time series analyses for the identification of epidemics to the New Orleans data which we are collecting. In this paper, however, we

TABLE 1. Frequency of days whose observed number of patients with asthma attacks at three New York City hospitals lie in the upper 1% of the poisson distribution (1969-1971).

		SEASON[a]								
Hospital	Age (Years)	1969 Fall	69-70 Winter	1970 Spring	1970 Summer	1970 Fall	70-71 Winter	1971 Spring	1971 Summer	1971 Fall
Cumberland	<13	5	0	3	0	1	2	1	1	0
	⩾13	1	0	0	1	1	0	2	0	3
Kings County	<13	—	—	—	—	6	1	1	2	7
	⩾13	4	2	1	1	3	2	0	1	1
Harlem	<13	0	0	1	0	1	0	1	1	3
	⩾13	2	1	1	0	1	3	2	1	1
Total		12	3	6	2	13	8	7	6	15
Mean(b)		2.4	0.6	1.2	0.4	2.2	1.3	1.2	1.0	2.5

a. Seasons consist of 3 months: Fall — September through November, etc.

b. Expected mean is approximately 0.9.

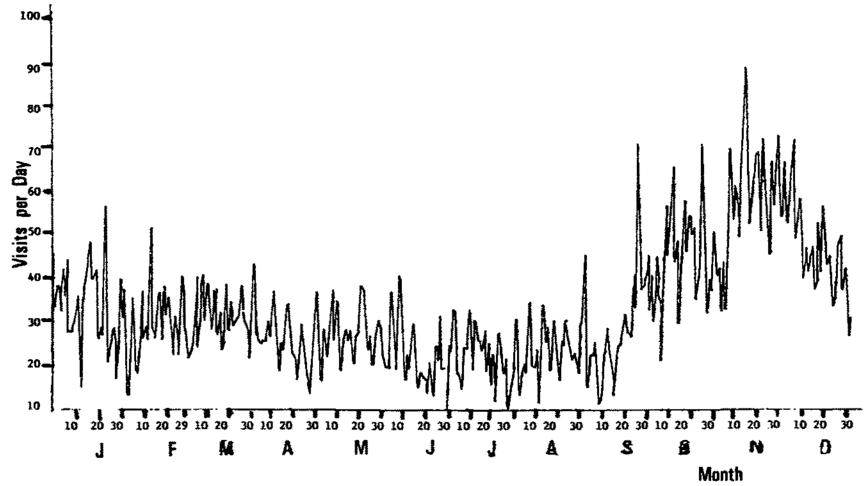

Fig. 1. Daily asthma emergency room visits for three New York City hospitals for 1971.

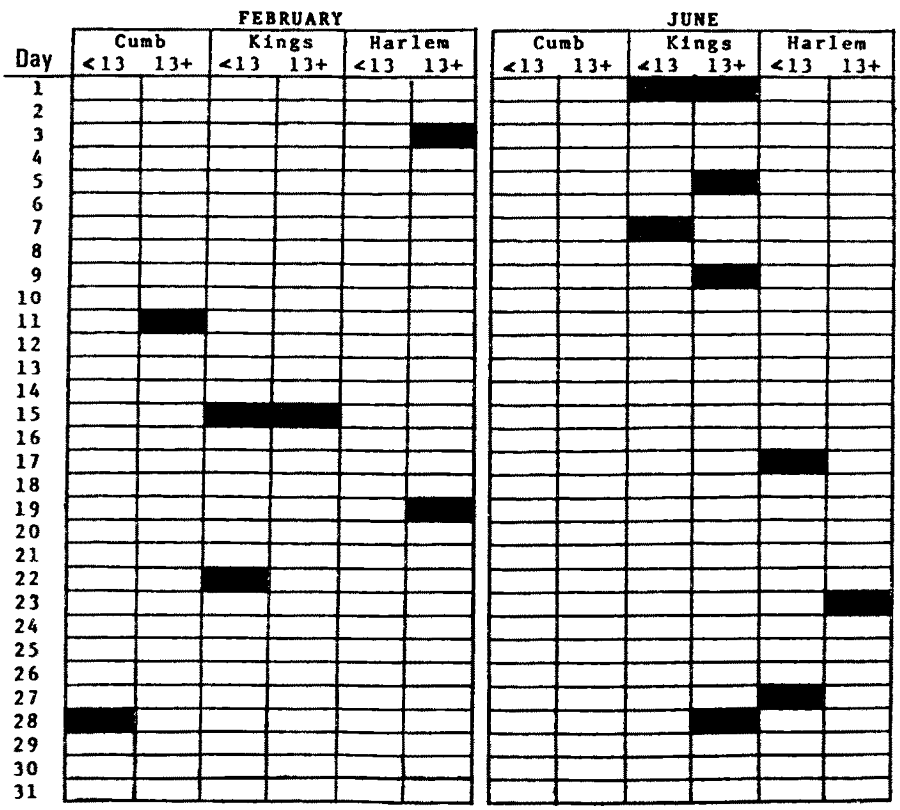

Fig. 2. Non clustering for select months for "unusually high" days to Cumberland, Kings County and Harlem hospitals for asthma (ages <13 and 13 years). (From Goldstein and Rausch, 1978). Unusually high days are defined by $P<0.05$.

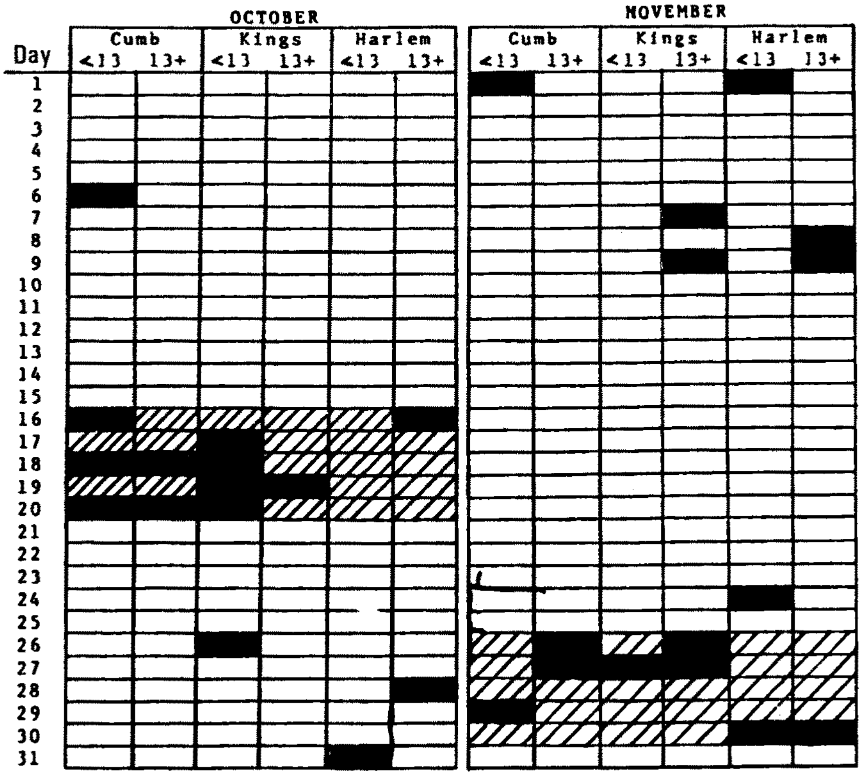

Fig. 3. Clustering for select months for "unusually high" days to Cumberland, Kings County and Harlem hospitals for asthma (ages <13 and 13 years), 1970. (From Goldstein and Rausch, 1978.) Unusually high days are defined by $P<0.05$.

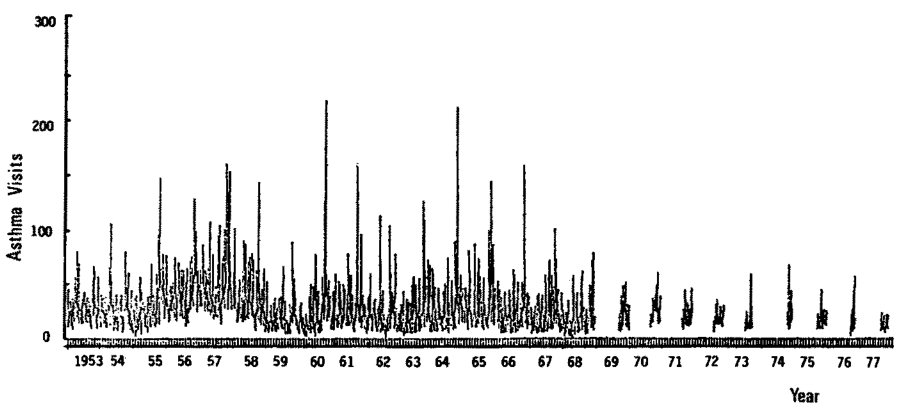

Fig. 4. Daily number of asthma patients to Charity Hospital emergency room (New Orleans, La.) 1953-1977.

will only present some preliminary results obtained from examination of an incomplete set of 25 years of asthma data from Charity Hospital in downtown New Orleans.

Figure 4 represents a plot of daily visits for asthma at Charity Hospital for the years 1953-1977. Individual points are difficult to read, however, this figure is particularly useful for getting an overall picture. Data is in the process of being gathered for the gaps in the years 1969-1977. All fall periods are included in this plot. In the years where there are data for the entire period, we can note the almost invariable occurrence of the high asthma peaks in the fall seasons and the distinct seasonal trends. Table 2 and 3 represent an abbreviated description of synoptic meteorological patterns associated with asthma epidemic days in New Orleans in the years 1954-1968 and New York City respectively.

TABLE 2. Abbreviated Descriptions of Synoptic Meteorological Patterns Associated with Asthma Epidemic Days in New Orleans, Louisiana, 1954-1968.

*1954, 15-16 October** (60,80 mean 31)**
Temperature during preceding 6 days had been mild with frequent rain. Cold front passage on 14th with winds to 15.6 m/s, and colder, drier air from the Great Plains. High pressure centre moved through vicinity of New Orleans and winds became light.
*1955, 26 October** (147 mean 52)**
Cold front passage 24th. New Orleans near center of high pressure during episode.
*1956, 9-11 November** (112, 128, 122 mean 69)**
Cold front passage 8th. High pressure center in New Orleans area on 10th.
*1957, 30 October** (160 mean 61)**
Month was mostly cool and dry as polar air masses moved southward from Canada. Asthma levels were generally high. Peak on 30th came on the second day of very light winds near the center of the high pressure area.
*1958, 21 October** (148 mean 40)**
Weak high pressure ridge over area.
*1959, 26 October** (89 mean 22)**
Cold front passage 23-24th, brought a 4-day dry spell in contrast to frequent rainfall October 4 to 22. Weak high pressure center over Florida on 26th.
*1960, 2 November** (218 mean 47)**
Cold front passage October 30-31 was followed by weak high pressure over area. Relatively dry.
*1961, 18 October** (160 mean 40)**
Cold front passage on the 14th had been followed by a moderate rise in asthma admissions on the 15th and 16th along with cooler temperatures. A sharp peak in asthma on the 18th occurred on the second day of very light winds associated with a high pressure ridge overhead.
*1962, 7-9 October** (67,102, 104 mean 32)**
Warm and humid with afternoon rains. Weak, slow-moving pressure system.
*1963, 8-9 October** (108,126 mean 42)**
No large temperature changes. Weak pressure patterns. High pressure area moved slowly toward New Orleans from the mid-Atlantic states. Rainfall this month was far below normal.
*1964, 20-22 October** (118, 212, 101 mean 51)**
Cold front passage 18-19th. Unseasonably cold. Stationary high pressure center just south of New Orleans on 21st. Light winds.

* The day or days with the largest number of asthma visits for the fall season.
** The numbers in brackets represent the number of visits to Charity Hospital on each episodic day listed, and the mean represents the daily mean number of visits for the month in which the epidemic occurred.

*1965, 26-27 October** (95,144 mean 39)**
Cold front passage 24th. No rain. High pressure area was centered over Oklahoma on 27th.
*1966, 27 October** (159 mean 33)**
Elongated, almost stationary high pressure ridge had been over the New Orleans area since the 25th.
*1966, 3 November** (153 mean 30) **
Cold front passage on 1st. Unseasonably cold the 2nd and 3rd. High pressure was centered over the New Orleans the 3rd with freeaing temperatures in morning and light winds.
*1967, 10 October** (101 mean 25)**
Cold front passage on 8th with 6 hours of rain. Weak high pressure over New Orleans on 10th; temperatures below normal.
*1968, 20-21 November** (71,70 mean 27)**
Cold front passage on night of 17-18. Cold 19-20. High pressure was centered over New Orleans the 20th.

TABLE 3. Abbreviated Descriptions of Synoptic Meteorological Patterns Associated with Asthma Epidemic Days in New York City.

1969, 21-22 September[a] (88,77 mean 40)[b]
High asthma followings the passage of a cold front over New York City on 18 September. On September 21st and 22nd the City was under the center of a high pressure system.
1970, 18-19 October[a] (69,71 mean 52)[b]
A cold front passed over New York City on October 16th followed by another cold front on October 19th. Pressure was generally high from the 18-20th of October.
1970, 26-27 November[a] (74,82 mean 55)[b]
A cold front passed over New York on November 23rd. High asthma morbidity occurred on the 3rd and 4th days, and a high pressure system lingered over the area.
1965, 27-29 November[c]
A cold front passed over New York City on the 24th and 26th. The center of a high pressure system was near New York City on the 27th and 28th.
1964, 13-17 September[c]
Cold fronts passed over New York City on September 11th and 15th, hurricane Dora passed off shore on the 14th and high pressure was in the area on the 16th.
1964, 26 September[c]
A cold front passed during the night of the 23rd and 24th, and high pressure was in the area on the 26th.

[a] Asthma epidemic days selected from New York City emergency room records for Harlem, Cumberland, and Kings County Hospitals combined.

[b] The numbers in brackets present the number of visits to Harlem, Cumberland, and Kings County Hospitals combined on each epidemic day listed, and the mean represents the daily mean number of visits for the month in which the epidemic occurred.

[c] These dates were described as asthma epidemic days in L. Greenburg et al's paper: "Asthma and Temperature Change", Arch. Environ. Hlth., 12: 1966. (The number of of asthmatic attacks on those days is not available — the data collected for that period has since been destroyed.

CONCLUSIONS

A preliminary examination of the meteorologic data shows that almost every asthma epidemic in both New Orleans (defined as the day with the largest number of visitors to Charity Hospital for asthma in New Orleans for the fall period in each of the years 1953-1968) (1953 did not have an asthma epidemic) and New York City, was preceded by the passage of a cold front (by one to three days) followed by a high pressure system. We intend, of course, to investigate how often this particular meteorologic sequence was not accompanied by asthma epidemics. Roughly speaking, cold fronts not followed by high pressure systems were not associated with epidemics. Both cold and warm fronts are associated with an exchange of air: new air, possibly containing asthmatogens, replaces the existing air. Warm fronts, however, are usually followed by rainfall, which tends to cleanse the air of pollutants while cold fronts followed by high pressure systems tend to result in stagnant and rain-free conditions which tend to retain air-borne particles.

These preliminary conclusions need to be investigated in much greater depth. More precise specification of the weather conditions associated with epidemis is needed to distinguish them from those not so associated, together with resolution of the question of whether those conditions are invariably associated with epidemics or not. Either way, additional clues to possible causal agents will be obtained.

In addition weather patterns passing over New York City that are associated with asthma epidemics will be followed to see whether they pass or bypass New Orleans and whether an asthma epidemic accompanied their passage over New Orleans. If the movement of global weather patterns can be used to explain asthma epidemics in New York City and in New Orleans, additional geographical locations will be included in our study to explain time and space occurrence of asthma epidemics.

The purpose of this presentation is to show that some common meteorological patterns are present in almost all the epidemics described. This conclusion is, of course, based on preliminary examination of the data. We intend to examine the data in a much more rigorous way, including making a search for days with similar meteorological patterns to those present on asthma epidemic days then examining the asthma attack pattern on those days. In addition, we will have to include every epidemic day as determined by the statistical techniques described above, rather than just the days with largest numbers of visits in each season.

ACKNOWLEDGEMENT

This work was supported by a contract from the National Oceanographic and Atmospheric Administration and by the Study on Statistics and Environmental Factors in Health under the auspices of SIAM Institute for Mathematics and Society.

Mr. William Hodge, Senior Scientist at the National Oceanic and Atmospheric Administration, National Climatic Center, Asheville, N. C. has supplied us with the weather data and helped to get the study off the ground.

REFERENCES

BOOTH, S., DEGROPT, I., MARKUSH, R. and HORTON, J. (1965): Detection of asthma episodes in seven cities. Arch. Environ. Hlth., 10: 152-155.

CHANG, W. W. Y. (1972): Pollen survey. In: Allergic Diseases — Diagnosis and Management. R. Patterson (ed.), Lippincott, Philadelphia, pp. 649.

DERRIK, E. H. (1965): The seasonal variation of asthma in Brisbane: Its relation to temperature and humidity. Int. J. Biometeor., 9: 239-251.

DERRIK, E. H. (1966): The annual variation of asthma in Brisbane: Its relation to the weather. Int. J. Biometeor., 10: 91-99.

DERRIK, E. H. (1972): Asthma and the Brisbane climate. Aust. N.Z. J. Med., 2: 235-246.

DERRIK, E. H. THATCHER, R. H. and TRAPPET, L. G. (1960): The seasonal distribution of hospital admissions for asthma in Brisbane. Aust. Ann. Med., 9: 180-187.

DHEW PUBLICATION (1973): Respiratory Diseases: Task Force Report on Problems, Research Approaches, Needs. No. 73: 432. Washington, D.S. USA.

GOLDSTEIN, I. (1978): Evaluation of research strategies for investigation of health effects of air pollution. Bull. N.Y. Acad. Med., 54: 1119-1131.

GOLDSTEIN, I. F. and ARTHUR, S. (1978): Asthma Alley; A space clustering study of asthma in Brooklyn, New York City. J. Asthma Res., 15: 81-93.

GOLDSTEIN, I. F. and LANDOVITZ, L. (1975): Sulfur dioxide: harmful pollutant or air quality indicator? J. Air Poll. Con. Ass., 25: 1195.

GOLDSTEIN, I. F. and LANDOVITZ, L. (1977a): Analysis of air pollution patterns in New York City: I: Can one station represent the large metropolitan area? Atmosph. Environ., 2: 47-52.

GOLDSTEIN, I. F. and LANDOVITZ, L. (1977b): Analysis of air pollution patterns in New York City: 11. Can one aerometric station represent the area surrounding it? Atmosph. Environ., 2: 53-57.

GOLDSTEIN, I. F., and RAUSCH., L. (1978): Time series analysis of morbidity data for assessment of acute environmental health effects. Environ. Res., 17: 266-275.

GOLDSTEIN, I. F., LANDOVITS L., and BLOCK, G. (1974): Air pollution patterns of New York City. J. Air Poll. Con. Ass., 24: 148-152.

GOLDSTEIN, I. F. GOLDSTEIN, M., and LANDOVITZ, L. (1977): The relation of air pollution to mortality. J. Occup. Med., 19: 375.

GORDIS, L. (1973): Epidemiology of Chronic Lung Diseases in Children. Johns Hopkins University Press, Baltimore and London, pp. 137.

GREENBURG, L.and FIELD, F. (1965): Air pollution and asthma. J. Asthma Res., 2: 195-198.

GREENBURG, L., FIELD, F., REED, J. I., and ERHARDT, C. L. (1964): Asthma and temperature change. Arch environ. Hlth., 8: 642-647.

GREENBURG, L., ERHARDT., C. L. FIELD, F., and REED, J. I. (1965): Air pollution incidents and morbidity studies. Arch. environ. Hlth., 10: 351-356.

SALVAGGIO, J., SEABURY, J., and SCHOENHARD, E. A. (1971): New Orleans asthma. V. Relationship between charity hospital asthma admission rates, semiquantitative pollen and fungal spores count, and total particulate aerometric sampling data. J. Allergy, 48: 96-114.

SALVAGGIO, J., HASSLEBLAD, V., SEABURG, J., and HEIDERSCHEIT, L. T. (1960): New Orleans Asthma 11, Relationship of climatologic and seasonal factors to outbreaks. J. Allergy, 45: 257-265.

SOLOMON, W. R. and MATHEWS, K. P. (1978): Aerobiology and inhalant allergens. In: Allergy: Principles and Practice. E. Middleton, Jr., C. E. Reed and E. F. Ellis (ed.). Mosby, St. Louis, pp. 899.

WEIL, H., ZISKIND, N. M. DEBES, V., HORTON, R. J. and DICKERSON, R. C. (1965): Recent developments in New Orleans asthma. Arch. environ. Hlth., 10: 148-151.