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LOMA LINDA UNIVERSITY

School of Graduate Studies

A STUDY OF AIR TEMPERATURES WITHIN GROUPETTES

by

Mabel Starkey Pittendrigh

A Thesis in Partial Fulfillment

of the Requirements for the Degree

Master of Science in the Field of Nursing

June 1963

66669

I certify that I have read this thesis and that in my opinion it is adequate, in scope and quality, as a thesis for the degree Master of Science.

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CHAPTER I

INTRODUCTION TO THE STUDY

The therapeutic value of moisturized air in the treatment of respiratory conditions of infants and young children has long been recognized.¹ Early attempts to provide moisturized air for the child centered around a teakettle of boiling water and a blanket enclosed crib. The steam was directed to the inside of the improvised tent through a newspaper funnel. Recognizing the limitations of such equipment, designers and inventors set about overcoming the dangers of fire and scalding inherent in the introduction of live steam into a canopied crib. One of the first improvements consisted of an enclosed chamber of water stationed at floor level and heated by electricity. This design overcame the danger of fire but the steam, now brought to the patient through a long narrow metal tube, was still a source of danger.² Some hospitals met the problem by designing special rooms or cubicles equipped with steam vents. Children in their cribs were moved into the steam room for specified periods of treatment, but of course children in medical isolation were denied entrance. Nursing personnel were presented

¹Waldo E. Nelson, Textbook of Pediatrics (Philadelphia: W. B. Saunders Company, 1959), p. 742.

²Bertha Harmer and Virginia Henderson, Textbook of the Principles and Practice of Nursing (New York: The Macmillan Company, 1957), pp. 706-08.

the problem of supplying "steam therapy" for the children thus denied entrance to the steam room. Soon another problem became evident. Nurses working in the steam rooms found it necessary to wear water-repellant clothing.

When the Croupette was invented and placed on the market by the Air-Shields Corporation it received immediate acceptance as the answer to many of the former problems. Here was a compact portable design small enough to be set up inside a crib wherever need on the pediatric unit, and one which provided either fully saturated air or oxygen as ordered for the individual child. Here, too, was a design which overcame the previous dangers of fire and scalding since saturation of air or oxygen is accomplished by forcing the stream of gas through a nebulizer. In spite of its many advantages, nurses working with the Croupette from day to day began to wonder about a number of factors. Directions which come with the Croupette indicate that it may be operated using a combination of ice and water in the chamber or with tap water alone. Obviously, with ice added to the water in the chamber, the air flowing to the child is cooler than when ice is not added. How many degrees does the addition of ice cool the air? Does the size of the child or the height of his body temperature influence these changes? Does the room temperature influence the temperature of air within the Croupette? Do differences in air temperatures occur within the Croupette when compressed air is used instead of oxygen? This study was made to discover variations in air temperature which occur within the Croupette during treatment of children with

respiratory illness and if possible, to identify some of the factors which influence variations.

I. THE PROBLEM

Statement of the problem. What is the temperature of air and variations which occur during the time a child is receiving treatment in a Croupette? What are some of the factors which influence the temperature and variations?

Need for the study. A perusal of medical and nursing literature reveals that for some respiratory conditions warm air is recommended, while for other conditions cold air (cool mist) is considered more beneficial. Since the Croupette is not equipped with thermometers the nurse has no accurate way of knowing how warm or how cold the air is inside the Croupette. Is it not reasonable to consider that variables such as the size of the child, the child's body temperature, room temperature, oxygen versus compressed air would effect the level of air temperature within the Croupette? Knowing the temperature of air within the Croupette would guide the nurse in providing greater comfort to the patient and thus contribute to his recovery.

Thus, there is need to find out what changes in air temperature occur during treatment of a child in a Croupette (1) when the room temperature is high, (2) when the child varies in weight, (3) when the child has an elevated body temperature, (4) when the Croupette is operated on oxygen, (5) when forced air is used instead of oxygen.

An inquiry addressed to the Air-Shields Corporation asking

if any formal research had been made upon the temperature of air within the Croupette supplied the following information. After the Croupette was designed, "the first units were placed in various hospitals for clinical evaluation as to their effectiveness, simplicity of operation, and patient comfort." Since the reports from the "pioneer" units were good, the Air-Shields Corporation went into production. The company was unable to provide the writer "with any formal outlines regarding the types of research which had been carried out in the development of the Croupette."³ See appendix.

Purpose of the study. The purpose of the study was to find the temperature of air and variations which occur during treatment of a child in a Croupette, and to identify some factors which influence air temperature and variations.

Hypothesis. It was hypothesized that air temperature within the Croupette may not be constant and may vary due to specific identifiable factors.

Assumptions. The following assumptions were accepted as a basis for this study: (1) directions for operation of the Croupette as given by the manufacturer provide the most beneficial results to the patient; (2) that Croupettes were operating properly and were in optimum working condition.

Scope and limitations. The scope and limitations of the study were as follows:

³Correspondence with the Air-Shields Corporation by the researcher.

1. The study was made in one selected hospital.
2. The study was made on fifty children between the ages of two months and three years.
3. All children included in the study suffered respiratory illness.
4. The Croupettes used in the study were manufactured by the Air-Shields Corporation of Hatboro, New Jersey.
5. Croupettes were operated either on oxygen at seven liters or on compressed air at ten pounds pressure.
6. Data were collected while the chamber of each Croupette was filled with both ice and water as directed by the manufacturer.
7. Each test period consisted of two hours and fifteen minutes during which data were collected at the end of the first fifteen minutes, one hour later and again at the end of the second hour.
8. Four factors were selected for study as to their effects upon the temperature of air within Croupettes, namely:
(a) weight of the child, (b) body temperature of the child,
(c) temperature of the room, (d) oxygen versus compressed air.

Definition of terms. Croupette: the word Croupette was coined by the Air-Shields Corporation as a name for their product which was designed by them to provide moist air or oxygen to the child in respiratory distress. A folding metal frame covered with a plastic canopy confines the air or oxygen which has been saturated with water vapor by passage through a fine nebulizer.

II. METHODOLOGY

The method used in this study was experimental. A review of nursing, medical, and other scientific literature in the area was made to give background information to the researcher.

A control study was made to refine the technique.

After obtaining permission for the study from medical and nursing personnel at the White Memorial Hospital, Los Angeles, data were collected on fifty children, all of whom were suffering respiratory illness, and all of whom were receiving Croupette therapy. Two thermometers were suspended inside each Croupette from which three recordings were made at stated intervals over a period of two hours and fifteen minutes. Data recorded for each test period were as follows: (1) the weight of the child, (2) the temperature of the room taken at the beginning and end of each test period, (3) the rectal temperature of each child taken at the beginning and end of each test period, (4) the use of oxygen or pressurized air in operation of the Croupette.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to find variations in air temperature which occur within the Croupette during treatment of children with respiratory infections. Special effort was put forth to find literature dealing with the treatment of respiratory illness in which moisturized air or oxygen was utilized and to determine recommended temperatures for air within the Croupette.

I. THERAPY FOR SPECIFIC RESPIRATORY ILLNESS

Acute infections of the larynx. Nelson in summarizing the treatment of spasmodic laryngeal spasm and other acute conditions of the larynx makes the following statement:

Humidification of the inspired air is beneficial in all laryngeal infections, irrespective of their severity, to lessen the irritation and drying of the secretions. Cold humidification is preferable to steam and is best provided by a tent or specially designed room. In the home a "croup tent" can be improvised by using a steam humidifier.⁴

An explanation is due as to the meaning of cold humidification. It would seem that the author is referring to the method of producing humidification rather than to the temperature of the air. Cold humidification is accomplished by forcing air through a fine nebulizer under

⁴Waldo E. Nelson, Textbook of Pediatrics (Philadelphia: W. B. Saunders Company, 1959), p. 780.

water. The air in passage picks up water vapor to the point of saturation or even supersaturation. In writing of prophylactic treatment for acute spasmodic laryngitis, Nelson recommends that the sleeping room be kept moderately warm (70°F.) and well humidified. The same author states, "Cold air should be avoided during respiratory infections; some children subject to croup cannot sleep in cold, well ventilated rooms without having an attack."⁵

The above facts are well corroborated by similar statements in Kerley's textbook of pediatrics published forty years earlier. He says, "Exposure to cold is a predisposing cause of acute catarrhal laryngitis." Kerley reminds the reader that two conditions must be kept in mind during the treatment of croup:

. . . first, the inflammatory infiltration and dryness of the parts, producing the metallic cough and stridulous breathing; second, the laryngeal spasm, which is purely a nervous manifestation, doubtless due to irritation of the terminal filaments of the recurrent laryngeal nerves.⁶

To combat the dryness of the parts and to assist in allaying the spasm, he recommended the use of steam inhalations. Since the Croupette was not known at that time, vaporization was produced by boiling water. The child received warm air but how warm is not stated.

Birch, in reporting a recent study of two hundred infants and children with laryngeal stridor, found that treatment was most effective when a wide spectrum antibiotic was used and the children

⁵Ibid., p. 778.

⁶Charles Gilmore Kerley, The Practice of Pediatrics, (Philadelphia: W. B. Saunders Company, 1919), p. 288.

provided a fully moisturized air either by a humidifier or by placement in a "wet cubicle" for twentieth-four to forty-eight hours.⁷ No mention is made of air temperatures before, during, or after treatment.

One of the more common acute infections of the larynx is croup. Marlow and Sellow in discussing this condition in their recent textbook on pediatric nursing state that

Cold air may precipitate an attack at any time in susceptible children, particularly if an upper respiratory tract infection is present. Even moving the child from a warm room where he has spent the day to the cooler bedroom for the night may induce an attack of croup. . . . Treatment is directed toward reduction of the spasm of the laryngeal muscles. The child must be placed in an atmosphere of high humidity. . . . The water vapor serves to liquefy secretions, and the warmth, if ordered, tends to reduce the spasm of the muscles and to relieve the inflammation of the mucous membrane of the throat. A drug such as benzoin may be added to the water, but actually it is steam vapor that is therapeutic. The child is put in a croup tent to concentrate the warm moist air about him.⁸

Under the heading "Points in the Use of the Croup Tent" the authors give specific instructions to the nurse in these words:

If it is necessary to remove the child from the tent for sometime, . . . a warm blanket should be thrown around him so that he is not chilled by exposure to air at room temperature. . . . The child must be kept dry. Steam condenses on the clothing and the bed covers. These should be changed when damp. . . . The temperature within the tent should be checked frequently and kept below 90° F. If the temperature goes up much above this, the child's body temperature will also be elevated.⁹

⁷D. A. Birch, "Laryngeal Stridor in Infants and Children," Journal of Laryngology and Otology. 75: 833-40. September 1961.

⁸Dorothy R. Marlow and Gladys Sellow, Textbook of Pediatric Nursing (Philadelphia: W. B. Saunders Company, 1961), p. 438.

⁹Ibid., p. 439.

Throughout the above discussion, reference is made to the traditional type of humidifier in which vaporization is produced by heating water to the boiling point. The same authors further state, "With the Groupette cool mist can be provided. . . . One reason why cool mist is ordered rather than hot steam is that cool air may lower the child's temperature, while the warmth of the steam-heated croup tent may raise it."¹⁰ Cool mist was mentioned without a statement as to the degrees of temperature which should be maintained, although it was stated that the bedroom should be warm (temperature approximately 70° F.). One could therefore conclude that air inside a Groupette providing cool mist would be less than 70° F.

An article by Levesque outlines the nurse's role in the care of the child with croup. She emphasizes the need for constant knowledgeable observation of the child and the possible emergency need for tracheostomy. For treatment she recommends a steam room or cubicle moderately humidified, but makes no mention of the temperature of air to be maintained during therapy.¹¹

Acute rhinitis. Undoubtedly the most common of all respiratory illness is the common cold. According to Lyon and Wallinger,

The treatment consists largely in nursing care, since there is no specific remedy. Rest is indicated; the temperature of the room should be increased by means of mechanical devices or by the evaporation of water on radiators. Exposure to cold air is

¹⁰Ibid., p. 440.

¹¹Lilian A. Levesque, "Nurse's Role in Croup Management," Hospital Topics, 39:66-7. November 1961.

irritating to the mucous membranes, especially in the early stages of a cold.¹²

In their discussion of the common cold, Marlow and Sellow express in different words several of the same concepts as those of Lyon and Wallinger.

The humidity of the room should be kept at 80 to 90 per cent in order to liquefy the secretions in the respiratory tract and reduce the cough. Excellent mechanical devices to increase the humidity of the atmosphere are on the market. If none is available, a long shallow pan of water may be placed on the radiator. But unless the radiator is very hot, evaporation is slow, and the moisture in the room is not sufficiently increased. The temperature of the room should be about 70° F.¹³

Laryngotracheobronchitis. Laryngotracheobronchitis seldom if ever occurs as a primary infection. The condition usually represents an extension downward of the inflammatory processes present in the common cold, pharyngitis, or croup.¹⁴ The condition has been defined by Kelley in these words:

An acute infective inflammation of the larynx, trachea, and bronchi characterized in typical cases by toxemia, edema of the larynx and subglottic region, thick viscid, obstructive, and often crusting nonmembranous exudate in the tracheobronchial tree.¹⁵

The disease may be either viral or bacterial in origin. Among

¹²Robert A. Lyon and Elgie M. Wallinger, Nursing of Children (Philadelphia: W. B. Saunders Company, 1959), p. 312.

¹³Marlow and Sellow, op. cit., p. 301.

¹⁴Nelson, op. cit., p. 785.

¹⁵Vincent C. Kelley, Brenneman-McQuarrie-Kelley Practice of Pediatrics (Hagerstown, Maryland: W. F. Prior Company, Inc., 1960), Vol II. Chapter 45, p. 1.

the more common bacterials are to be found the streptococci, pneumococci, staphylococci and the Hemophilus Influenzae. The most severe and typical cases occur in children under three years of age. These younger children possess little previous built-up immunity and their air passages are small thus becoming more easily occluded. In fulminating cases, respiratory distress may be severe, characterized by indrawing at the suprasternal notch and clavicles, epigastrium and intercostal spaces. Stridor and wheezing develop. Cough may or may not be present. In the latter case the secretions are too viscid to be moved by the incoming or outgoing air producing an absence of the cough reflex.

This curious phenomenon . . . was first discovered in acute laryngotracheitis. . . . Not only is the hectic blast absent but also the more important tussive squeeze. The cilia help, but the tussive squeeze of the entire lobe is of the utmost importance in drainage.¹⁶

Breathing dry air desiccates the mucus into crusts causing further obstruction. In cases where crusting occurs to occlude a larger bronchus, atelectasis follows.

A means of preventing crusting and plug formation is by saturating the air with moisture. Nothing less than saturation will prevent desiccation of the viscid fibrinous secretions. Some years ago there was ill-advised criticism of the croup kettle and croup tent by practitioners who had never seen or at least had never recognized the high viscosity of tracheo-bronchial secretions. Also they did not realize that the air of modern dwellings is desiccated in the cool weather during which the disease under consideration usually occurs. Outdoor atmosphere at 0° F. though saturated with moisture is almost devoid of water because the dew point is inversely as the

¹⁶Chevalier Jackson, "Peroral Pulmonary Drainage, Natural and Therapeutic with Special Reference to the Tussive Squeeze," American Journal of Medical Science. 1933. 186: 849.

temperature. Take this air and heat it to 70° F. and we have a desiccating atmosphere that is almost cauterant in its effects on the tracheobronchial mucosa. . . . Secretions under such circumstances are promptly dehydrated into solids.¹⁷

Involvement of the laryngeal mucosa and subepiglottic area causes severe inspiratory distress for which the only relief may be tracheotomy. "In acute severe epiglottitis tracheotomy is required in 50 per cent or more of cases and should not be delayed when the indications are clear."¹⁸ After tracheotomy has been performed,

The inspired air, which is normally moistened, filtered, and warmed to body temperature during its passage through the nose, now passes directly into the trachea and lungs. It must, therefore, be artificially warmed, moistened and filtered; this is one of the chief duties of the nurse.

In order artificially to moisten, filter, and warm the inhaled air to body temperature, the following methods are used: (1) gauze squares, dampened with warm sterile water or normal saline, are kept over the mouth of the tube. . . . (2) a steam inhalator, with or without a croup tent, that warms and moistens the air gives great comfort to the patient. The temperature of the room is kept at about 80° F. if possible.¹⁹

Nelson's recommended therapy for laryngotracheobronchitis centers around oxygen, humidification, and antibacterial therapy. As previously quoted in the discussion of croup, he recognizes the value of moisturized air in the treatment of all laryngeal infections, irrespective of their severity, to lessen the irritation of mucous

¹⁷Kelley, op. cit., Vol. II., Chapter 45, p. 8.

¹⁸Nelson, op. cit., p. 780.

¹⁹Bertha Harmer and Virginia Henderson, Textbook of the Principles and Practice of Nursing (New York: The Macmillan Company, 1957), p. 1044.

membranes and drying of secretions.²⁰ Treatment of laryngotracheo-bronchitis according to Jeans, Wright, and Blake is similar, including oxygen, humidification, and broad spectrum antibiotics. They advise that the child be placed immediately in an atmosphere saturated with water vapor. They warn that the administration of oxygen may be actually harmful unless fully moisturized.²¹

Writing in 1961, Thomas and Ulpis describe laryngotracheobronchitis as a seasonal hazard. They emphasize the importance of water vapor and the role of the nurse in keeping the temperature of the air within the Croupette at a comfortable level. They say,

Humidification of the inspired air is essential. This may be accomplished with steam, but it is better provided by a Croupette or in a room where high humidity is maintained. The nurse sees that the Croupette is functioning properly at all times. The amount of ice in the ice chamber of the Croupette is adjusted to keep the temperature in the tent at a comfortable level.²²

Bronchiolitis. The condition of bronchiolitis is known under a variety of names: interstitial pneumonia, acute obstructive bronchitis, capillary bronchitis, generalized obstructive emphysema. It is classified by Nelson under the heading of pneumonia rather than bronchitis, because he finds it difficult to conceive of a pure bronchiolitis

²⁰Nelson, op. cit., p. 780.

²¹Philip C. Jeans, F. Howell Wright, and Florence G. Blake, Essentials of Pediatrics (Philadelphia: J. B. Lippincott Company, 1958), p. 390.

²²John M. Thomas and Elza B. Ulpis, "A Seasonal Hazard-Laryngo-Tracheobronchitis," American Journal of Nursing, 61: 52-4. March 1961.

without involvement of the interstitial tissues.²³ The exciting factor in this condition is considered to be chiefly viral, among which are influenza types A, B, C, and the adenovirus group.²⁴ Other recognized causes include pneumococci, streptococci, and the *Hemophilus Influenzae*. Allergy either as a causative or contributing factor is gaining recognition by pediatricians.²⁵

The condition occurs typically in infants and young children, fully one-half of whom are under six months of age. The incidence is highest during the months of winter and early spring and seems to coincide somewhat with the epidemics of upper respiratory infections found in older children and adults.

Acute bronchiolitis in infants is a serious condition. In most cases the onset follows an upper respiratory infection of two to three days' duration, after which a dry persistent cough develops and a variable temperature rises less than three or four degrees above normal. Although the fever is not high, the child is irritable, apprehensive, and gives evidence of increasing dyspnea. The respirations are rapid and shallow with moderate suprasternal and intercostal indrawing on inspiration. Expiration may be accompanied by grunting. X-ray

²³Nelson, op. cit., p. 794.

²⁴R. H. Parrot, "Newly Isolated Viruses in Respiratory Disease," Pediatrics, 20: 1066-69. 1959.

²⁵B. F. Feingold, "The Influence of Acute Infection upon the Course of Allergy in Children," Journal of Pediatrics, 34: 545-48. 1959; Geraldine L. Freeman and Richard H. Todd, "The Role of Allergy in Viral Respiratory Tract Infections," American Journal of Diseases of Children, 104: 330-34. October 1962.

examination of the chest reveals an emphysematous chest with widening of the rib spaces and lowering of the diaphragm. Widely scattered small areas of atelectasis may be found throughout the lung fields. The over-distention of the chest is due to trapping of air in the distal bronchioles through check-valve action of the inflammatory exudate. Air is allowed ingress without egress. Complete plugging of the bronchiole results in atelectasis. With increasing obstruction of the bronchioles, breath sounds diminish and excursions of the chest wall become more and more limited. The infant with acute bronchiolitis requires alert medical and nursing care. Dehydration induced by excessive loss of water through hyperventilation and the inability of the dyspneic child to drink or suck usually requires the administration of intravenous fluids. According to Nelson,

The treatment is symptomatic. All infants with bronchiolitis should be placed in an atmosphere of high humidity, preferably with cold vapor rather than steam. Those with even moderately severe dyspnea should also receive oxygen therapy; one should not wait for the development of cyanosis.²⁶

Treatment of bronchiolitis, according to Silver, Kempe, and Bruyn would "place the child in a warmed atmosphere which is high in oxygen and well saturated with water vapor."²⁷ Jaeger states that the administration of cold humidity reduces the labor of the infant's respiration in bronchiolitis.²⁸ Marlow and Sellew state, "the child requires an

²⁶Nelson, op. cit., p. 795.

²⁷H. K. Silver, C. H. Kempe, and H. B. Bruyn, Handbook of Pediatrics (Los Altos, California: Lange Medical Publications, 1959), p. 235.

²⁸Margaret Ann Jaeger, Child Development and Nursing Care (New York: The Macmillan Company, 1962), p. 229.

atmosphere of high humidity. (Cold vapor is better than hot steam.)²⁹

Four authorities have each stated their opinion as to the best therapy for bronchiolitis. All advocate the use of air or oxygen of high humidity. Three specify cold vapor while Silver, Kempe and Bruyn recommend a warmed atmosphere. These authors write freely of warm and cold, but do not specify degrees of temperature. The Croupette is commonly used in many hospitals to provide the aforementioned cool or cold vapor. Marlow and Sellew in giving specific nursing care for infants with bronchiolitis advocate the use of the Croupette.

A Croupette is extremely useful in the care of these little patients. It provides high humidity and oxygen, if oxygen is used. The Croupette aids the child's breathing through the higher oxygen content and liquefies secretions in the bronchioles, making coughing less distressing to the child. Air under pressure may be used to provide increased humidity if oxygen is not necessary.³⁰

Likewise, Goddard recommends the Croupette for treatment of children with bronchiolitis. He states that the younger the child the greater his need for placement in the Croupette. He makes no mention of air temperature level within the Croupette as a factor in treatment.³¹

Pneumonia. Pneumonitis, an inflammatory involvement of the alveoli with exudation into the air spaces occurs in all age groups but is particularly threatening during infancy and early childhood.

²⁹Marlow and Sellew, op. cit., p. 303.

³⁰Ibid, p. 304.

³¹Roy F. Goddard, "Inhalation Therapy for Children's Hospital Services," Hospital Topics. 39:67-9. July 1961.

Etiology in most cases is due to either bacterial or viral infection, though among infants and small children aspiration pneumonias are not uncommon. Bronchopneumonia is more commonly found in young children because of the young child's inability to localize infection.³² As the child grows older his defense mechanisms function more effectively and the pathology is then limited to a lobe or portion of a lobe (lobar pneumonia).

Nelson questions the value of vaporized water in treating peripheral pulmonary disease.

The use of vaporized water in peripheral pulmonary disease is less certainly effective. (Referring to laryngitis and tracheobronchitis.) The air from the lower part of the trachea to the periphery of the lung is normally saturated with water at body temperature, whereas, air saturated at room temperature (24° C.) is only 50 per cent saturated when raised to body temperature. Thus a saturated atmosphere does not necessarily supply saturated gas to the peripheral air passages. The effect, if any, of water vapor on peripheral pulmonary disease of all age groups needs further critical study. When used, water vapor is best administered as a cool mist.³³

Although the value of vaporized water may be questioned in peripheral pulmonary disease, all authorities so far reviewed have recognized its value in inflammatory pathology of the larynx, trachea, and the bronchi. Since the bronchi as well as the alveol are involved in bronchial pneumonia of children under three years of age, it is common practice to provide them with vaporized water. In fact, they are placed in a Croupette as soon as admitted to the hospital. Inside

³²Eugene L. Slatkowski and Esther L. Voorsanger, "Pneumonia in Children," American Journal of Nursing, 59: 1720-23. December 1959.

³³Nelson, op. cit., p. 742.

the Croupette they receive the cool mist so often advocated.

II. HUMAN RESPONSE TO CHANGE IN AIR TEMPERATURE

Alveolar-capillary air. A recent study by Rubenstein, Pardee, and Eldridge reveals a number of important facts about the temperature changes of air inside the bronchial tree. Human experiments were made to test the thermal homeostasis of the alveolar-capillary structures. It was found (1) that the temperature of ordinary room air (36.7°C.) is brought practically to core body levels while still in the small bronchi, (2) that maximum hyperventilation with room air did not measurably lower the temperature of blood adjacent to the lateral wall of the right atrium, and (3) that even when the air was chilled to 5° C. there was no discernible effect on the temperature of brachial or carotid artery blood. In conclusion, the investigators stated, "The experimental data and mathematical calculations based on physical constants indicate that human alveolar temperature is virtually constant even under the most extreme thermal conditions."³⁴ It should be noted that the above experiment was performed on healthy adults. That the same findings would accrue from children suffering respiratory illness may be questioned. But, if it is true for children as well as for adults that air, apparently regardless of external temperatures, leaves the small bronchi at core body levels, the question naturally rises, why should medical workers be concerned as to the temperature of air used

³⁴Edward Rubenstein, Robert C. Pardee, and Frederic Eldridge, "Alveolar-capillary Temperature," Journal of Applied Physiology, 15: 10-12. January 1960.

in therapy of respiratory disease? Gleaned from the literature already reviewed are two possible reasons: (1) cold air is irritating to the inflamed mucosa of the larynx, trachea, and bronchi, (2) temperatures above 90° F. within the croup tent tend to increase body temperature. Further light on the subject may be obtained from the study by Yaglou and his committee on atmospheric comfort who set about determining thermal standards for industry. The chief aim of the committee was to discover the atmospheric factors which provided the most comfort for the workers. According to Yaglou,

A state of comfort exists when heat regulation is accomplished with a minimum of physiological adjustment or when an individual is entirely unaware of heat or cold. . . . The principal factors affecting thermal comfort are physical (temperature, radiation, humidity, air movement and clothing), and physiological, including the state of health, sex, age, physical activity, and acclimatization. No satisfactory method has been found for combining the four physical environmental conditions. For accurate work, it is, therefore, necessary to define thermal conditions by their constituent factors, whether special integrating devices are used or not.³⁵

When an individual is entirely unaware of heat or cold a state of comfort exists. One of the duties already ascribed to the nurse in this review of literature is the maintenance of a comfortable temperature within the Croupette. Thus providing comfort becomes another reason for concern on the part of medical workers as to the temperature of air within the Croupette.

Adult response to temperature variation. Yaglou's report includes

³⁵Report of the Committee on Atmospheric Comfort. "Thermal Standards in Industry," American Journal of Public Health, Yearbook, Part II, 40: 131-43. May 1950.

the findings of a number of studies in which temperature, humidity, air movement, and amount of clothing worn were varied. He describes two tests made on thirteen soldiers at Fort Knox. In the first test, each soldier was required to carry a twenty pound pack for four hours, walking at a pace of three miles per hour. The temperature was 94° F., and the humidity maintained at 36 to 100 per cent. Some of the soldiers grew sick and vomited before the first hour was completed, but all recovered sufficiently to finish. The second test was performed under the same conditions except the temperature was increased two degrees and the humidity was maintained between 38 and 100 per cent. Even with this small increase in temperature, all of the men showed distress within the first one-half hour and by the end of the first hour most were disabled. Only three or four completed two hours and only one or two were able to complete the four hours. Some collapsed outright. Physical examinations revealed pulse rates of 150 and above, while rectal temperatures rose to 102° F. and above.³⁶ These experiments demonstrate the debilitating effects of high temperature and high humidity upon human beings and their capacity to work.

In what way do the above findings pertain to children suffering respiratory infections? The child in respiratory distress labors hard to breathe. The respiratory rate is increased and many accessory muscles are brought into play. The heart beats faster. Death if it ensues may be due to exhaustion rather than anoxia.³⁷ The need for fully

³⁶Ibid., p. 133-143.

³⁷Jeans, Wright, and Blake, op. cit., p. 390.

saturated air to prevent drying of secretions with resultant occlusion of the bronchioles has been stressed. Hard labor and high humidity would appear to make the temperature level within the Croupette an important factor in the child's response to therapy. Thus far no known studies have been made to learn which temperature is most beneficial to the child.

Response of premature infants to air temperature change. Studies have been made on premature infants to find the optimum temperature for survival. Silverman writes concerning one of his studies as follows:

In an attempt to evaluate thermal influences on survival in the first five days of life we undertook a fourth clinical trial. Two air temperatures were chosen for contrast: 84° F. . . . and 89° F. . . . The relative humidity was 80 to 90 per cent in both sets of incubators. . . . The conditions of the trial were maintained until each infant reached the age of five days.³⁸

One hundred and eighty-two premature infants were included in the study. Eighty-four per cent of the 90 infants who occupied the warm incubators survived the trial period while only 68 per cent of those in the cooler incubators survived. It is to be noted that the difference in the temperatures chosen was only five degrees.

A similar study was made on premature infants by Jolly, Molyneux, and Newell. In this study two hundred and fourteen babies were included. The temperatures chosen for the "hot group" were 96 to 99° F., while the temperature for the "cold group" was set at 85° F. The results for

³⁸William A. Silverman, "The Effect of the Atmospheric Environment on the Premature Infant," Journal of Pediatrics, 58: 581-84. April 1961.

this study are as follows:

The mortality rate of the "cold" babies was 9.5 per cent higher than that of the "hot" babies. . . . The breakdown of the mortality figures into respective weight groups shows an increasing advantage to the "hot" baby as one goes down the weight scale.³⁹

These two studies concerning the survival of premature infants in relation to air temperature have been included in this review of literature to indicate that human response to environmental temperature varies with age and stage of development. That these findings have any meaning so far as the hospitalized infant and young child suffering respiratory illness is concerned is questionable.

III. SUMMARY

A review of medical, nursing, and other scientific materials was made to find literature dealing with the treatment of respiratory illness in children in which Croupette therapy was utilized and to find recommended temperatures for air within the Croupette. The following information was obtained.

1. Moisturized air or oxygen is useful in the treatment of laryngeal, tracheal, and bronchial conditions to lessen irritation of mucous membranes, prevent drying of secretions, and to allay muscle spasm.
2. Cold air is irritating to inflamed mucous membranes of the larynx, trachea, and bronchi.
3. "Cold humidification" is preferable to steaming.

³⁹H. Jolly, P. Molyneux, D. J. Newell, "A Controlled Study of the Effect of Temperature on Premature Babies," Journal of Pediatrics, 60: 889-94. June 1962.

4. Warmed moist air is physiologically beneficial following tracheotomy.
5. Fully humidified air helps to maintain the cough reflex in laryngotracheobronchitis.
6. The value of vaporized water in the treatment of peripheral pulmonary disease needs further study.
7. A state of comfort exists when heat regulation is accomplished with a minimum of physiological adjustment or where an individual is entirely unaware of heat or cold.
8. Individual response to temperature change is dependent upon physiological factors, state of health, sex, age, physical activity, and acclimatization.
9. High temperatures with humidity reduce human capacity for work.
10. The nurse should function to maintain a comfortable air temperature level within the Croupette.
11. The terms warm, cold, cool are used by writers without stating exact degrees of temperature.
12. No recommended temperature for air within the Croupette was found, although room temperature was given as 68 to 70° F.

CHAPTER III

METHOD OF INVESTIGATION AND COLLECTION OF DATA

The purpose of this study was to find the air temperature and the extent of change which occurs inside the Croupette during treatment of a child with respiratory infection, and also, to determine some of the factors which influence change in air temperature. The Croupette is constructed to convey moisturized air or oxygen to a child enclosed under a plastic canopy. Saturation of the gas with water vapor is accomplished by forcing the air or oxygen through a fine nebulizer. Cooling is accomplished by passing the gas through a metal pipe surrounded by ice and water. Since the Croupette is not equipped with thermometers, it was hoped that this study would answer a number of questions. For example, what effect do the following comparable factors have upon the temperature of air inside the Croupette: (1) oxygen versus pressurized air; (2) body weight of twenty pounds or more versus body weight of ten pounds or less; (3) elevated body temperature versus normal body temperature; (4) room temperatures above eighty-one degrees versus seventy-nine degrees or less.

A review of literature revealed the following:

1. That moisturized air or oxygen is generally accepted as valuable therapy for infections of the larynx, trachea, bronchi and bronchioles.
2. That there is a lack of agreement by various authorities as to whether warm or cool air is more beneficial for different respiratory conditions.

3. That authorities in most instances fail to specify in exact degrees what they mean by warm or cool.
4. That the value of moisturized air in the treatment of peripheral pulmonary disease needs further study and research.
5. That most authorities agree that the optimum room temperature is 68 to 70° F.

I. METHOD OF APPROACH

Selection of facilities. The pediatric unit of the White Memorial Hospital, Los Angeles, California, was chosen for the study. Permission was obtained from the medical and nursing staff of the hospital to conduct the study. The unit has a capacity of forty-one with a daily average of approximately thirty patients during the time data were being collected. Data were collected from the first of March through July of 1962.

Selection of patients. All children three years and younger who were admitted to the pediatric unit suffering respiratory illness and who were given Croupette therapy were included in the study except for a small number who were acutely ill and in marked respiratory distress. Regretably, this smaller number were not included because of the necessary intense nursing and medical care being administered which precluded keeping the canopy closed for the required test period of two hours and fifteen minutes. The upper age limit of three years was set for two reasons: (1) respiratory illness is more serious and more common in children three years and younger;⁴⁰ (2) children over three years of age are too large to fit comfortably into the small confines of the

⁴⁰Nelson, op. cit., pp. 743-744.

Croupette. Data were collected on fifty children who met the qualifications as to age, type of illness and therapy.

Selection of method. The method used in this study was experimental. "The experiment is expected to reveal causal relations. In other words, it deals with . . . interaction."⁴¹ Beveridge states:

An experiment usually consists in making an event occur under known conditions where as many extraneous influences as possible are eliminated and close observation is possible so that relationships between phenomena can be revealed.⁴²

In order to assess the data obtained, the parallel group technique was employed. "This technique is considered more accurate than depending solely upon a comparison of averages and variabilities of the groups considered as whole."⁴³ Four parallel groups were selected in order to study some of the factors which possibly could modify or influence the temperature of the air within the Croupette. The four groups were selected as follows:

1. All the children whose Croupettes were operated on oxygen were matched with an equal number of children whose Croupettes were operated on pressurized air.
2. All the children weighing ten pounds or less were matched with an equal number of children weighing twenty or more pounds.
3. All the children with elevated body temperatures were matched with an equal number of children whose body temperatures were normal or slightly below.

⁴¹Carter V. Good and Douglas E. Scates, Methods of Research (New York: Appleton-Century-Crofts, Inc., 1954), p. 697.

⁴²William I. B. Beveridge, The Art of Scientific Investigation (New York: W. W. Norton and Company, 1950), p. 13.

⁴³Scates and Good, op. cit., p. 708.

4. All the children whose Croupettes were operated in room temperatures of 79° F. or below were matched with an equal number of children whose Croupettes were operated in rooms of 81° F. or above.

Control study. A control study was made to refine techniques for collection of data. An unoccupied Croupette was operated on a pump at ten pounds pressure for a period of two hours and twenty minutes. In preparation, the chamber was filled with ice and water as directed by the manufacturer, and two thermometers were suspended inside the Croupette. Since the purpose of the study was to find the temperature of air surrounding the child during treatment, care was taken in placing the thermometers to avoid the area proximal to the ice chamber and the stream of cool air issuing directly from the inlet. Accordingly, one thermometer (known as Thermometer X for the remainder of this study) was hung eight inches from the level of the bed, eight inches from the ice chamber, and six inches to one side of the midline of the Croupette. These measurements were made to approximate the best placement of the thermometers in future when recordings should be made for occupied Croupettes. The second thermometer (known as Thermometer Y for the remainder of this study) was hung approximately eight inches from the level of the bed at the midline of the Croupette and at a point as far distal from the inlet of air as possible. Four consecutive readings were taken at ten minute intervals, then again in forty minutes and a final reading one hour later. A third thermometer was suspended from the top rail at the foot of the crib, outside the Croupette, and readings were taken at the beginning and again at the end of the test period of two hours and twenty minutes in order to

find the temperature of air outside the Croupette (room temperature). At the beginning of the trial period all three thermometers registered 80° F. By the end of the first ten minutes Thermometer X read 73 degrees and Thermometer Y, 72 degrees. During the next ten minutes both thermometers registered 66 degrees and remained at this temperature for the remainder of the test period, even though the room temperature continued stable at 80 degrees. The air temperature inside the Croupette remained fourteen degrees cooler than the room temperature after the Croupette had been in operation 20 minutes.

Verification of thermometers. Ten Fahrenheit alcohol-type thermometers were checked for conformity at varying temperatures. At room temperature when each registered 72 degrees, they were placed in a refrigerator. After eight minutes they each registered 48 degrees. Then they were placed in a basin of water for a period of five minutes. When removed from the water each one read 94 degrees. The thermometers were calibrated with five spaces for each ten degrees; a temperature reading for an uneven number meant finding the half-way distance between two fine lines. Thus an error of a fraction of a degree plus or minus was always possible. But because no grossly detectable difference could be noted in the readings of any one thermometer, it was felt that they were all sufficiently accurate for this study. The thermometers were manufactured by Taylor Instrument Companies, Rochester, New York. Literature from the manufacturer concerning the thermometers stated that they had been "built for accuracy and quality," and that they had been "tested at low and high ranges so as to assure accurate room, summer and winter temperatures."

Description of technique. As previously stated the purpose of the study was to find the variations in air temperature within a Croupette in which a child is receiving treatment for a respiratory condition. All Croupettes were operated on either pressurized air at ten pounds pressure or on oxygen at seven liters. In preparation for each test period, the chamber of each Croupette was filled with cracked ice and water, and three thermometers were suspended as outlined in the control study: Two thermometers X and Y inside the Croupette and one from the top rail at the foot of the child's crib. Rectal temperatures were taken and recorded for each child at the beginning and again at the end of the two hour and fifteen minute interval. The average of the two rectal temperature recordings became BT (body temperature) and appears thus on tables of data. Likewise the room temperature was taken at the beginning and end of each test period and these were averaged to make RT. Air temperatures as registered on thermometers X and Y inside the Croupettes were recorded after the Croupette had been in operation fifteen minutes, again at the end of an hour and again at the end of the second hour. The average of the six recordings appears as AT (air temperature) for the remainder of this study. An average of the six recordings presented a clearer picture of the actual air temperature surrounding the child than any one recording by itself. Temperature differences of X and Y varied from zero to five degrees but readings for either one were not consistent from one Croupette to the other. No discernable pattern emerged except that readings taken fifteen minutes after closure of the canopy were more often a little higher than those taken at the hour intervals.

These recordings taken at the end of the fifteen minute interval were included in the average of AT in order to coincide more closely with actual practice since routine nursing and medical care of small children with respiratory illness requires that the canopy be lifted at rather short intervals. Whenever the canopy is lifted, much of the cooled air is replaced by air at room temperature.

Recording temperatures for X and Y fifteen minutes after closure of the canopy was chosen in reference to findings of the control study. The control study revealed that at some point between the first and second ten minute recordings, the temperature of air inside the Croupette dropped to 66 degrees Fahrenheit and remained so throughout the remaining two hour test period. Variations in the temperatures of X and Y were no doubt influenced by a number of factors, among these may have been; (1) a change of position on the part of the child; (2) inadvertent placement of the thermometers in reference to the ice chamber, exhaled warm air, or the incoming cooled air. Taking the temperature at successive hour intervals, after the initial fifteen-minute period allowed for cooling, was done to discover the changes in air temperature which occur during prolonged therapy.

The weight of each child used in the study was also recorded since body weight was selected as one of the factors to be investigated as to its effect upon air temperature change inside the Croupette. The child's body weight appears as WT on tables of data.

Another factor to be studied as to its effect upon air temperature within the Croupette was the use of pressurized air instead of oxygen. This data was collected for each Croupette in the series.

II. COLLECTION OF DATA

After placement of thermometers as outlined in the control study, the ice chamber was filled with ice and water in accordance with the manufacturer's instructions. Data recorded at the beginning of each test period included:

- (1) the child's weight,
- (2) the child's rectal temperature,
- (3) the room temperature,
- (4) oxygen versus pressurized air.

Readings for thermometers X and Y inside the Croupette were recorded fifteen minutes after closure of the canopy, one hour later and again at the end of the second hour. At the close of the test period the child's rectal temperature was taken again and recorded; the room temperature was also noted and recorded.

III. TREATMENT OF FINDINGS

Data were tabulated and analyzed, conclusions drawn, and recommendations made.

IV. SUMMARY

The purpose of the study was to find the variations in air temperature which occur during treatment of a child in a Croupette and to determine relationships between selected factors which influence change of air temperature within the Croupette. To provide background information to the researcher a review of nursing, medical, and other scientific literature in the area was made. Data were collected on

fifty infants and small children, ages two months to three years, who had been admitted to a selected hospital. All of the children suffered respiratory infections and all were given Croupette therapy. Each Croupette was operated for a test period of two hours and fifteen minutes on either oxygen or pressurized air according to doctor's order. Data collected during each test period included: (1) oxygen versus pressurized air in operation of the Croupette; (2) child's body weight; (3) child's rectal temperature taken at the beginning and again at the end of each test period; (4) room temperature taken at the beginning and again at the end of each test period; (5) air temperature inside the Croupette, read and recorded three times during each test period on two thermometers suspended inside the Croupette. Data obtained were tabulated and analyzed, conclusions drawn and recommendations made.

CHAPTER IV

FINDINGS AND INTERPRETATION OF DATA

This experimental study was done to find the variations in air temperature which occur within a Croupette during treatment of a child with a respiratory infection, and to identify some of the factors which influence changes in air temperature within the Croupette. Data were collected on fifty children, ages two months to three years, and the Croupettes in which they were given therapy. Four factors were studied as their effects upon air temperature within the Croupette: (1) oxygen at seven liters compared to forced air at ten pounds pressure; (2) body weight of ten pounds or less compared to body weight of twenty pounds or more; (3) elevated body temperature compared to normal or below normal body temperature; (4) room temperature of eighty-one degrees or above compared to room temperature of seventy-nine degrees or below.

I. PRESENTATION OF DATA

Clinical diagnosis of patients included in the study. All children included in the study were three years of age or less and all were suffering respiratory infections. The diagnosis given for each child was obtained from his chart. Twenty-three children, ages three months to two years, were diagnosed as having bronchiolitis. Of this number all but three were under one year of age. Seventeen children were diagnosed as having pneumonia for whom the age span extended from two months through three years. Twelve of the seventeen children suffer-

ing pneumonitis were under one year of age. Six children, ages five months through three years, were diagnosed as having croup, only two of whom were under one year of age. Three children had laryngotracheo-bronchitis. Their ages were six and one-half months, seven months, and three years. One three-year-old child included in the study was admitted with a diagnosis of bronchial asthma. Of the fifty children included in the study only fourteen were over one year of age, in other words, 72 per cent were under one year of age. See Table I for distribution of infants and children by age and diagnosis.

Oxygen versus pressurized air. Of the fifty children included in the study sixteen received oxygen therapy by way of the Croupette. A parallel group was selected from the remaining 34 who had received pressurized air instead of oxygen. An effort was also made to match room temperatures in which therapy was administered. Average body weight for the group of children receiving oxygen was 17 pounds 6 ounces; their average body temperature was 100.28 degrees Fahrenheit. For the group receiving pressurized air, the average body weight was 18 pounds 10 ounces; their average body temperature was 100.2 degrees Fahrenheit. Average room temperature for the group receiving oxygen was 80.34 degrees, while for the group on forced air the average room temperature was 80.9 degrees. Average air temperatures inside the Croupettes using oxygen equalled 74.59 degrees, S.D. 1.75; while the air temperatures inside the Croupettes on forced air averaged 74.52, S.D. 1.79. See Table II for details of matched pairs and averages.

There was found to be no significant difference in air temperature

TABLE I

DISTRIBUTION OF CASES BY AGE AND DIAGNOSIS

Age in months	Bronchiolitis	Pneumonia	Croup	Asthma	Bronchitis*
2		2			
3	4	3			
4	1	1			
5	3	1	1		
6	2	1			1
7	2	1			1
8	1	1			
9	2				
10	4	1			
11	1	1			
12					
15		1			
16	1				
18	1	1	1		
19			1		
20		1			
23			1		
24	1	1			
36		1	1	1	1
Totals	23	17	6	1	3
Total of all cases - 50					

* Laryngotracheobronchitis

TABLE II

COMPARISON OF AVERAGE AIR TEMPERATURE VARIATIONS RECORDED WITHIN
CROUPETTES SUPPLIED BY OXYGEN AT SEVEN LITERS VERSUS FORCED
AIR AT TEN POUNDS PRESSURE, OCCUPIED BY CHILDREN
MATCHED FOR WEIGHT AND BODY TEMPERATURE IN
ROOMS OF COMPARABLE TEMPERATURE

OXYGEN AT SEVEN LITERS					FORCED AIR, TEN POUNDS PRESSURE				
Series Number	WT	BT	RT	AT	Series Number	WT	BT	RT	AT
1	6' 9"	98.3	81	72.18	3	6' 10"	99.4	81	72.5
2	22' 2"	99.1	80	76.	21	22' 2½"	98.8	80	77.33
4	25' 6"	99.3	81.5	76.33	49	28'	99.1	82	75.16
10	22'	103.3	80	77.17	31	21' 8"	102.	81	74.5
16	39'	99.8	79	75.	30	37'	99.2	78	76.33
33	13' 1½"	101.6	80	75.2	43	12' 7"	101.5	82	74.33
27	19'	99.9	81	74.5	29	19' 6"	100.6	82	75.16
32	15' 12"	102.1	82	76.14	18	17' 11"	102.4	82	74.33
20	21' 11"	101.9	83	75.66	47	21' 8"	100.7	82	74.66
24	18' 4½"	100.5	80	75.33	28	16'	100.1	81	75.16
45	10'	97.1	78	72.	22	8' 2"	99.3	82	74.
46	16'	102.8	76	74.66	7	29'	102.9	76	75.
11	14' 7"	98.3	77	71.83	9	15'	98.3	82	72.5
37	19'	101.7	83	76.	34	18' 9"	101.4	81	77.66
35	8' 2"	100.3	80	71.5	8	8' 2"	98.5	84	70.66
41	14' 8"	98.8	80	74.	36	15' 8"	99.9	79	73.
Averages					Averages				
17' 6" 100.28 80.34 74.59					18' 10" 100.2 80.9 74.52				
S.D. = 1.75					S.D. = 1.79				

All temperatures are given in degrees Fahrenheit

WT Weight of child

BT Body temperature taken by rectum

RT Room temperature

AT Air temperature inside Croupette

within Croupettes in which pressurized air at ten pounds pressure was used instead of oxygen at seven liters when the following factors were matched: (1) the weight of the child, (2) the body temperature of the child, (3) the temperature of the room. The widest variation in air temperature between any one matched pair was 2.67 degrees. See Series numbers 10 and 31 on Table II. In ten of the sixteen matched pairs, the variation in air temperature between individual matched pairs was one degree or less. For example, see Series numbers 1 and 3, 4 and 49, 11 and 9 on Table II.

Body weight of ten pounds or less versus twenty pounds or more.

Of the fifty infants and children included in the study six weighed ten pounds or less. A parallel group of six children weighing twenty pounds or more were selected from the remaining 44 children. The children were matched for body temperature, and as far as possible, the room temperatures in which Croupette therapy was administered were also matched. The six infants of lesser weight averaged 7 pounds 14 1/2 ounces; the heavier group averaged 23 pounds 5 ounces; a difference of 15 pounds 6 1/2 ounces. Average body temperatures were normal for both groups, 98.78 and 99.2, respectively. The room temperatures averaged 81 degrees for the lesser weight group and 81.75 degrees for the heavier group. Air temperatures inside the Croupettes for infants weighing ten pounds or less averaged 72.14 degrees, S.D. 1.26; whereas for the children weighing twenty pounds or more, the average air temperature was 76.19 degrees, S.D. .72; a difference of 4.05 degrees. By statistical analysis and using a t Table it was found that four degrees indicates

a probability of significance approaching 99 to 99.9 per cent. See Table III for details of matched pairs and above given averages. The greatest difference 6.65 degrees was seen between Series numbers 8 and 21; the smallest difference 3.16 degrees was noted between Series numbers 45 and 49.

The trend would appear from the small number of cases studied, that a direct relationship exists between the size of the child and the temperature of the air within the Croupette. It may be that the radiation of body heat within the small confines of the Croupette elevates the temperature of the air, in which case, the larger the child, other factors being equal, the greater the rise in air temperature. Findings from this study indicate that on the average the infant weighing less than ten pounds is surrounded by air four degrees cooler than that which surrounds children weighing twenty or more pounds.

Normal body temperature versus elevated body temperature. Among the fifty children included in the study were nine whose rectal temperatures were elevated. The mean body temperature for all nine of these children was 102.3° F. A parallel group of nine children with normal rectal temperatures (average 99.3° F.) was selected from the remaining forty-one children included in the study. See Table IV. The children were matched for body weight and each matched pair received Croupette therapy in rooms of comparable temperature. For the group of children with elevated body temperatures, the average air temperature inside their Croupettes was 75.37° F., S.D. .85 degrees whereas for the group with normal body temperatures, the air temperatures averaged 73.62° F.,

TABLE III

COMPARISON OF AVERAGE AIR TEMPERATURE VARIATIONS WITHIN CROUPETTES
 RECORDED FOR INFANTS WEIGHING TEN POUNDS OR LESS WITH THOSE
 WEIGHING TWENTY POUNDS OR MORE. INFANTS WERE MATCHED
 FOR BODY TEMPERATURE IN ROOMS OF
 COMPARABLE TEMPERATURE

UNDER TEN POUNDS					ABOVE TWENTY POUNDS				
Series Number	WT	BT	RT	AT	Series Number	WT	BT	RT	AT
1	6' 9"	98.3	81	72.18	2	22' 2"	99.1	80	76.
3	6' 10"	99.4	81	72.5	4	25' 6"	99.3	82.5	76.33
8	8' 2"	98.5	84	70.68	21	20' 6"	98.8	80	77.33
22	8' 2"	99.3	82	74.	40	20' 4"	99.3	84	75.83
35	8' 2"	100.3	80	71.5	44	23'	99.5	82	76.33
45	10'	97.	78	72.	49	28'	99.1	82	75.16
Averages					Averages				
7' 11 $\frac{1}{2}$ " 98.78 81 72.14					23' 5" 99.2 81.75 76.19				
S.D. = 1.26					S.D. = .72				

All temperatures are given in degrees Fahrenheit

WT Body weight of child

BT Body temperature of child

RT Room temperature

AT Air temperature in Croupette

TABLE IV

AVERAGE AIR TEMPERATURE VARIATIONS WITHIN CROUPETTES RECORDED FOR
 INFANTS WITH NORMAL BODY TEMPERATURE AS COMPARED TO INFANTS
 WITH ELEVATED BODY TEMPERATURES. INFANTS WERE
 MATCHED FOR SIZE IN ROOMS OF LIKE
 TEMPERATURES

NORMAL TEMPERATURE					ELEVATED TEMPERATURE				
Series Number	WT	BT	RT	AT	Series Number	WT	BT	RT	AT
14	17' 12"	99.4	77	71.83	46	16'	102.8	76	74.66
13	16' 10"	99.9	79	72.33	18	17' 11"	102.4	81	74.66
2	22' 2"	99.1	80	76	31	21' 8"	102.	81	74.5
26	18' 2"	99.3	81	74.5	12	18' 2½"	103.1	80	76.
15	15' 7"	99.8	80	72.33	33	13' 1½"	101.6	80	75.2
9	15'	98.3	82	72.5	32	15' 12"	102.1	82	76.14
17	12' 1"	99.7	81	74.33	43	12' 7"	101.5	82	74.33
19	23' 15"	99.3	81	71.17	10	22'	103.3	80	77.17
40	20' 4"	99.3	84	75.83	20	21' 11"	101.9	83	75.66
Averages					Averages				
17' 13" 99.3 80.55 73.62					17' 10" 102.3 80.55 75.37				
S.D. = 1.79					S.D. = .854				

All temperatures recorded in degrees Fahrenheit

WT Body weight of infant

BT Body temperature taken by rectum

RT Room temperature

AT Air temperature inside Croupette

S.D. 1.79 degrees. The difference in air temperature between the two groups was 1.75 degrees. Statistically, this figure is better than the .02 level of probability or a significance of 98 per cent. Thus it appears that the difference in air temperatures between the two groups was not due to chance. The findings from this study indicate that an elevation of less than three degrees of body temperature influences the temperature of air within the Croupette from one to one and one-half degrees. The trend indicates that the higher the body temperature the higher the temperature of air within the Croupette. That this trend was not true in each of the matched pairs may be seen on Table IV. In Series numbers 2 and 31, the air temperature was one and one-half degrees lower for the child with an elevated body temperature of 102° F.; while in Series numbers 19 and 10, the air temperature was five and one-half degrees higher for the child with an elevated temperature of 103.3° F.

Room temperatures of seventy-nine degrees or below versus eighty-one degrees or above. Of the fifty children included in the study only seven received Croupette therapy in rooms of 79° F. or below. A parallel group of seven children was selected from the remaining 43 children who received Croupette therapy in rooms of 81° F. or above. Pairs of children were matched for body temperature and body weight. See Table V. The prevailing room temperatures on the pediatric unit throughout the months during which data were being collected averaged 80.6° F. The lowest room temperature recorded was 76° F.; the highest 86° F. Table V shows that the two groups of children received Croupette therapy in rooms which averaged 77.4 degrees and 83.14 degrees; a difference of 5.74 degrees. Air temperatures inside the Croupettes averaged 73.09 degrees

TABLE V

COMPARISON OF AVERAGE AIR TEMPERATURE VARIATIONS RECORDED WITHIN
CROUPETTES OPERATED IN ROOMS OF TEMPERATURES SEVENTY-NINE
DEGREES OR BELOW VERSUS CROUPETTES OPERATED IN ROOMS
OF EIGHTY-ONE DEGREES OR ABOVE. CHILDREN WERE
MATCHED FOR BODY TEMPERATURE AND WEIGHT

SEVENTY-NINE OR BELOW					EIGHTY-ONE OR ABOVE				
Series Number	WT	BT	RT	AT	Series Number	WT	BT	RT	AT
50	19'	99.9	79	74.	6	18' 3"	100.1	85	78.16
45	10'	97.2	78	72.	42	11' 10"	99.1	82	76.
14	17' 12"	99.4	77	71.83	38	17'	99.3	84	76.33
46	16'	102.8	76	74.66	37	19'	101.7	83	76.
11	14' 7"	98.3	77	71.83	48	14' 8"	99.1	85	78.33
7	29'	102.9	76	75.	5	31' 8"	100.8	82	74.5
13	16' 10"	99.9	79	72.33	26	18' 2"	99.3	81	74.5
Averages					Averages				
18' 2"		100.06	77.4	73.09	19' 1"		99.9	83.14	76.26
		S.D. = 1.46					S.D. = .933		

WT Weight of child
BT Body temperature taken by rectum
RT Room temperature
AT Air temperature taken inside the Croupette

S.D. 1.46 and 76.26 degrees S.D. .93 respectively, a difference of slightly more than three degrees. Statistically, this difference is better than the .01 level with a probability of significance approaching 99 per cent, indicating that a direct relationship may exist between the temperature of the room and the temperature of air within the Croupette. The higher the temperature of air in the room the higher the temperature of air within the Croupette. This finding was verified in eight of the nine matched pairs. On Table V, Series numbers 7 and 5 show that the air temperature was one-half degree lower for Series number 5 who was receiving therapy in a room temperature of 82 degrees, but it should also be noted that the body temperature of Series number 7 was one degree higher than that of Series number 5. The greatest difference in air temperatures occurred between Series numbers 11 and 48. Air temperature in the Croupette of Series number 11 was six and one-half degrees less than in the Croupette of matching Series number 48; room temperatures were 77° F. and 85° F. respectively.

Variations in air temperatures. The highest single reading for either thermometer X or Y was 83 degrees; the lowest 68; a difference of 15 degrees. When the six temperature recordings for each study period of two hours and fifteen minutes were averaged, the highest average temperature of air in any one Croupette was 78.16° F.; the lowest 70.77° F.; a difference of seven and one-half degrees. Thus it can be seen that in certain instances, infants were subjected to temperatures averaging 7 and 1/2 degrees higher than were other infants in this study. See Table VI.

Table VI reveals that the readings for thermometers X and Y varied throughout each study period of two hours and fifteen minutes, the variation in most instances ranging from 0 to 5 degrees.

II. SUMMARY

Data were collected to find the variations in air temperature within Croupettes which occur during treatment of children with respiratory illness, and also, to determine some of the factors which modify or change the temperature of air within the Croupette. Data were collected on fifty children two months to three years of age who were patients on the pediatric unit of a selected hospital. Parallel group technique was used to assess the data. Four factors were chosen for study as to their effect upon air temperature within the Croupette. Findings obtained from an analysis of the data were as follows:

1. Oxygen versus pressurized air. The difference in air temperatures within the Croupettes operated at seven liters and within those operated on pressurized air at ten pounds averaged only .07 degrees, a difference too small to be statistically significant.

2. Body weight of ten pounds or less versus body weight of twenty pounds or more. The air temperatures within the Croupettes of children weighing twenty pounds or more averaged 76.19 degrees S.D. 0.72 while in the Croupettes of children weighing ten pounds or less, the air temperature averaged 72.14 degrees S.D. 1.26 a difference of four degrees. Four degrees is statistically significant indicating that a direct relationship may exist between the weight of the child and the

TABLE VI

AIR TEMPERATURE READINGS WITHIN CROUPETTES FOR THERMOMETERS X AND Y
THE SIX READINGS WERE AVERAGED TO MAKE "AT"

Series Number	15 min.		1 Hr. 15 min.		2 Hr. 15 min.		Average of readings, AT
	X	Y	X	Y	X	Y	
1.	74	75	72	70	70	72	72.18
2.	76	78	74	76	74	78	76.
3.	74	75	72	72	70	72	72.5
4.	76	78	76	78	74	76	76.33
5.	74	76	75	77	72	74	74.5
6.	80	83	76	78	76	76	78.16
7.	76	77	75	76	72	74	75.
8.	72	72	70	72	68	70	70.66
9.	72	72	72	74	72	73	72.5
10.	75	76	76	78	78	80	77.17
11.	73	73	70	72	71	72	71.83
12.	74	72	76	76	75	77	76.
13.	72	74	70	72	72	74	72.33
14.	72	74	70	73	70	72	71.83
15.	70	72	72	74	72	74	72.33
16.	75	76	75	74	74	76	75.
17.	74	75	73	75	74	75	74.33
18.	75	72	76	77	74	74	74.66
19.	70	72	72	70	72	71	71.17
20.	78	78	74	74	74	76	75.66
21.	78	80	78	78	76	74	77.33
22.	76	76	74	72	74	72	74.
23.	76	76	78	76	78	76	76.33
24.	76	80	72	74	74	76	75.33
25.	72	74	72	74	74	74	73.33

TABLE VI (continued)

AIR TEMPERATURE READINGS WITHIN CROUPETTES FOR THERMOMETERS X AND Y
THE SIX READINGS WERE AVERAGED TO MAKE "AT"

Series Number	15 min.		1 Hr. 15 min.		2 Hr. 15 min.		Average of readings, AT
	X	Y	X	Y	X	Y	
26.	74	77	74	76	72	74	74.5
27.	74	76	73	76	72	76	74.5
28.	78	80	72	73	74	74	75.16
29.	74	78	74	75	74	76	75.16
30.	76	78	76	78	74	76	76.33
31.	76	76	74	74	73	74	74.5
32.	76	78	76	77	74	76	76.14
33.	74	75	75	77	74	76	75.2
34.	80	78	76	76	78	78	77.66
35.	73	74	70	72	70	70	71.5
36.	74	74	74	76	70	70	73.
37.	78	78	74	76	74	76	76.
38.	78	80	76	76	74	74	76.33
39.	80	78	75	76	75	76	76.66
40.	78	77	74	75	74	77	75.83
41.	74	75	74	74	73	74	74.
42.	78	78	76	76	74	74	76.
43.	75	76	74	75	72	74	74.33
44.	78	78	75	75	76	76	76.33
45.	76	74	70	72	70	70	72.
46.	78	80	72	74	72	72	74.66
47.	76	74	74	74	74	76	74.66
48.	77	76	80	82	78	77	78.33
49.	74	75	75	77	74	76	75.16
50.	75	74	74	74	72	75	74.

temperature of air within the Croupette.

3. Normal body temperature versus elevated body temperature.

For the group of children with elevated body temperatures, the average air temperature inside their Croupettes was 75.37 degrees, (S.D. 0.85); whereas for the group with normal body temperatures, the air temperatures averaged 73.62 degrees, (S.D. 1.79); a difference of 1.75 degrees. Statistically this difference appears to be significant and may indicate a direct relationship between the body temperature of the child and the temperature of air within the Croupette.

4. Room temperature of seventy-nine degrees or below versus eighty-one degrees or above. Air temperatures within the Croupettes operated in rooms of 79° F. or below averaged 73.09 degrees (S.D. 1.46), while air temperatures within the Croupettes operated in rooms of 81° F. or above averaged 76.26 degrees (S.D. .93); a difference of three degrees. Statistically, three degrees is significant and may indicate a direct relationship between the temperature of the room and the temperature of air within the Croupette.

5. Variations in air temperature. The highest single air temperature reading within a Croupette was 83 degrees; the lowest 68 degrees; a difference of 15 degrees. The greatest difference in average air temperatures between different Croupettes was seven and one-half degrees. Temperatures within individual Croupettes varied throughout the two-hour-and-fifteen-minute study period from 0 to 5 degrees.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

This study was conducted to find the variations which occur in air temperature within Croupettes during treatment of children suffering respiratory infections and to identify some of the factors which influence variations. Data were collected on fifty children, two months to three years of age, all of whom were receiving Croupette therapy and all of whom had been diagnosed as having respiratory infections.

A review of literature revealed that, (1) moisturized air or oxygen has long been recognized as of value in the treatment of respiratory problems among infants and small children; (2) some authorities recommend "warm air" while others recommend "cool mist" as preferable therapy, the exact temperature of which in neither case is specified; (3) recommended room temperatures are often given as 68 to 72° F.

The experimental method was used in conducting the research. In order to assess the data obtained, the parallel group technique was employed. Four parallel groups were selected in order to study some of the factors which possibly could modify or influence the temperature of the air within the Croupette. The four groups were selected as follows:

1. The sixteen children whose Croupettes were operated on oxygen were matched with an equal number of children whose Croupettes were operated on pressurized air. The children in this group were matched for body weight and body temperature and received therapy in rooms of like temperature.

2. The six children weighing ten pounds or less were matched with an equal number of children weighing twenty pounds or more. The infants in this group were matched for body temperature and received therapy in rooms of like temperature.
3. The nine children with elevated body temperatures were matched with an equal number of children whose body temperatures were normal or slightly below normal. The children in this group were matched for body weight and received therapy in rooms of like temperature.
4. The seven children whose Croupettes were operated in room temperatures of 79° F. or below were matched with an equal number of children whose Croupettes were operated in rooms of 81° F. or above. The children in this group were matched for body temperature and body weight.

Oxygen versus pressurized air. The difference in air temperatures within the Croupettes operated on oxygen at seven liters and within those operated on pressurized air at ten pounds pressure averaged only .07 degrees, a difference too small to be statistically significant.

Body weight of ten pounds or less versus body weight of twenty pounds or more. The difference in air temperatures within the Croupettes of children weighing twenty pounds or more averaged 4.05 degrees higher than in the Croupettes of children weighing ten pounds or less. By statistical evaluation of the comparative data and by using a t Table the difference of four degrees of temperature was found to be better than the .01 level of probability with a significance of 99 to 99.9 per cent. The findings from the six matched pairs included in this grouping indicate that the larger the child, other factors being equal, the higher the temperature of air within the Croupette.

Normal body temperature versus elevated body temperature. The difference in air temperatures within the Croupettes of children having elevated body temperatures averaged 1.75° F. higher than in the Croupettes

of children with normal or slightly below normal body temperatures. By statistical evaluation of the comparative data and by using a t Table the difference of 1.75° F. was found to approach the .02 level of probability or a significance of 98 per cent. The findings from the nine matched pairs included in this grouping indicate that a trend exists, when other factors are equal, that the higher the body temperature the higher the temperature of air within the Croupette.

Room temperature of seventy-nine degrees or below versus eighty-one degrees or above. The difference in air temperatures within the Croupettes of children who received therapy in rooms of eighty-one degrees or above averaged 3.17° F. higher than the temperatures recorded within the Croupettes of those children who received therapy in rooms of seventy-nine degrees or below. By statistical evaluation of the comparative data and using a t Table, the difference of slightly more than three degrees was found to approach the .01 level of probability with a significance of 99 per cent. The findings from the seven matched pairs included in this grouping, indicate that the higher the temperature of air in the room the higher the temperature of air within the Croupette.

Maximum air temperature changes within Croupettes. The difference between the highest and lowest temperature recorded in any of the Croupettes was fifteen degrees. The difference between the highest and lowest average air temperatures recorded during a study period of two hours and fifteen minutes was seven and one-half degrees. The difference between the highest and lowest temperatures recorded for any one Croupette was five degrees.

II. CONCLUSIONS

At the beginning of this study it was hypothesized that air temperatures within Croupettes may not be constant and may vary due to specific identifiable factors. The findings suggest that the hypothesis may be accepted and that temperature within the Croupette may not be constant and may be influenced by certain extrinsic factors. Conclusions drawn are not conclusive because they are based upon limited data but the following trends seem to be indicated:

1. Other factors being equal, oxygen at seven liters and forced air at ten pounds may be used interchangeably without altering the temperature of air within the Croupette.
2. Other factors being equal, a direct relationship exists between the weight of the child and the temperature of air within the Croupette.
3. Other factors being equal, a direct relationship exists between the body temperature of the child and the temperature of air within the Croupette.
4. Other factors being equal, a direct relationship exists between the temperature of the room and the temperature of air within the Croupette.

III. RECOMMENDATIONS

Because statistically significant variations in air temperatures within Croupettes were found it does not follow that these findings are significant medically. No known studies have been made to find the temperature of air most beneficial to the infant and small child suffering respiratory infection, although the terms cold, cool, and warm are used not infrequently in describing therapy for these little patients.

The routine placement of a thermometer within the Croupette would enable nurses and other medical workers to make observations which may in time answer the above implied question.

Recommendations for further studies in this area are as follows:

1. That study be made of the effect on temperature of air within the Croupette when body temperature of the child is above 103° F.
2. That study be made using oxygen at variable liters and forced air at variable pressures.
3. That study be made as to the effect upon the temperature of air within the Croupette when the temperature of the room is 70° F.
4. That study be given to the use of the Croupette as a device for reducing elevated body temperatures.
5. Since not all Croupettes are operated using a full chamber of ice and water as was done in this study, a survey type of study should be conducted to find the temperature of air within Croupettes as they are commonly operating on pediatric units.
6. That study be made to determine the oxygen concentration provided in Croupettes when oxygen is used instead of pressurized air.
7. That study be made of the humidity in the Croupette.
8. That study be made to find the temperatures of air most beneficial for children suffering specific respiratory illness.

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EAGLE

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APPENDIX

AIR-SHIELDS, INC.

Hatboro, Pennsylvania Osborne 5-5200

October 10, 1961

Mrs. Mabel Pittendrigh
Teacher Pediatric Nursing
Loma Linda University
School of Nursing
Los Angeles 33, California

Dear Mrs. Pittendrigh:

In reply to your letter of October 3, we are sorry but we will be unable to provide you with any formal outlines regarding the types of research which have been carried out in the development of the CROUPETTE Cool-Vapor and Oxygen Tent.

Prior to the introduction of the CROUPETTE some 12 years ago, we had been asked by our friends in the profession if we could provide some type of apparatus that would provide cool vapor therapy in an oxygen enriched atmosphere for treating various respiratory disorders in pediatric patients. As is the normal procedure in developing any new product for the medical profession, the first units were placed in various hospitals for clinical evaluation as to their effectiveness, simplicity of operation, and patient comfort. The reports of these "pioneer" units were very good and we were assured that the CROUPETTE did fulfill a very definite need and would be accepted.

Since those first units, there have been many improvements which have made the CROUPETTE even easier to use and maintain. The fact that there are now over 17,000 CROUPETTES in daily use throughout the world attests to its effectiveness.

Thank you for your continued interest.

Sincerely yours,

(signed)

John H. Schilder
Sales Department

JHS:jk

LOMA LINDA UNIVERSITY
School of Graduate Studies

A STUDY OF AIR TEMPERATURES WITHIN CROUPETTES

by

Mabel Starkey Pittendrigh

An Abstract of a Thesis
in Partial Fulfillment of the Requirements
for the Degree Master of Science
in the Field of Nursing

June 1963

ABSTRACT

An experimental study was conducted to find the variations in air temperature which occur within Croupettes during treatment of infants and small children with respiratory infections, and to discover some of the factors which influence change of air temperature. Fifty children, two months to three years of age, all of whom suffered respiratory illness and all of whom received Croupette therapy were included in the study. Data were collected over a test period of two hours and fifteen minutes for each child. The parallel group technique was used in analysis of data. Conclusions drawn were not conclusive because they were based upon limited data but the following trends were indicated: (1) other factors being equal, oxygen at seven liters and forced air at ten pounds pressure may be used interchangeably without altering the temperature of air within the Croupette, (2) other factors being equal, a direct relationship exists between the weight of the child and the temperature of air within the Croupette, (3) other factors being equal, a direct relationship exists between the body temperature of the child and the temperature of air within the Croupette, (4) other factors being equal, a direct relationship exists between the temperature of the room in which therapy is administered and the temperature of air within the Croupette. The hypothesis, that air temperatures within Croupettes may not be constant and may vary due to specific identifiable factors may be accepted. Because statistically significant variations

in air temperature within Groupettes were found, it does not necessarily follow that the findings are medically significant. It is recommended that study be given to finding the optimum air temperature for the child suffering specific respiratory illness.