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Hertford Hill, Nr. Warwick, Great Britain.

OBSTRUCTIVE AIRWAYS DISEASE:
IMMEDIATE AND LATE RESULTS OF
TREATMENT IN AN ALPINE CLIMATE

By

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INTRODUCTION

Seventy-three British patients with obstructive airways were treated in Davos at 1,500 metres. The beneficial effects of mountain climate on bronchial asthma and infective bronchitis have been recognised for many years. This communication confirms the previous findings and is the first to record the effects of mountain climate upon respiratory function in such patients and to relate the results to physiological data.

Storm van Leeuwen (1924) considered that freedom from asthma in the Alps was due to an absence of allergens in the air and he described an experiment in which asthma was produced in a Dutch patient at Davos when exposed to dust which had been brought from Holland and to which the patient had previously, in Holland, been shown to be hypersensitive; he thus postulated that whilst a patient in the Alps may be free from asthmatic attacks, the hypersensitivity persists. This opinion was supported by *Van Geuns* (1956)¹ who in a study of 200 patients in Davos found no evidence of altered skin reactions over a period in excess of one year. However, in a later study of bronchial provocation tests *Van Geuns* (1956)² demonstrated decreased bronchial reactions after twelve months in the Alps.

In Spain, *Diaz and others* (1932) associated increased prevalence of asthma with high humidity and *Harsh* (1952)

showed a direct correlation between humidity and house dust sensitivity. *Dingle* (1955) reported high pollen counts during thunder-storms in Ann Arbor, Michigan, and pointed out that although average climatic predictions might be misleading to asthmatic patients, short term predictions of wind conditions and pollen clouds could be extremely useful by indicating precautions to avoid attacks. *Ordman* (1955) found a higher prevalence of respiratory allergic conditions in the coastal areas of South Africa than in inland areas. He concluded that the higher morbidity in the coast was due to a combination of high atmospheric temperature with high relative humidity in a constantly narrow range, day and night throughout the year.

The first clinical report from Davos, *Turban* (1911), related to 143 asthmatic patients of whom 68 per cent immediately became free from attacks, 25 per cent were improved, 7 per cent were unchanged and after returning to the lowlands 44 per cent continued free from attacks. *Burckhardt* (1930) found 30 per cent permanently cured in a one to ten year follow-up of 89 asthmatic children treated in Davos. *Brock* (1942) found improvement in 95 per cent of asthmatic children and *Cohen* (1949) who reported favourable results in 57 children who had been transferred to Davos because they had not improved in Open Air Schools in Birmingham, England. *Wissler and others* (1951) observed 202 asthmatic children; 87 per cent had immediate improvement and in a follow-up of 1 to 6 years 26 per cent remained cured.

DEFINITION AND SELECTION OF PATIENTS

The patients selected for treatment had bronchial asthma or chronic bronchitis, conditions which was defined as follows:

Bronchial asthma: "Episodes of airways obstruction accompanied by dyspnoea. Between episodes most patients had only mild wheezing or slight breathlessness. Some patients also had occasional episodes of bronchial infection". For brevity, patients in this group were termed, asthmatic.

Chronic bronchitis: "Patients with frequent or continuous

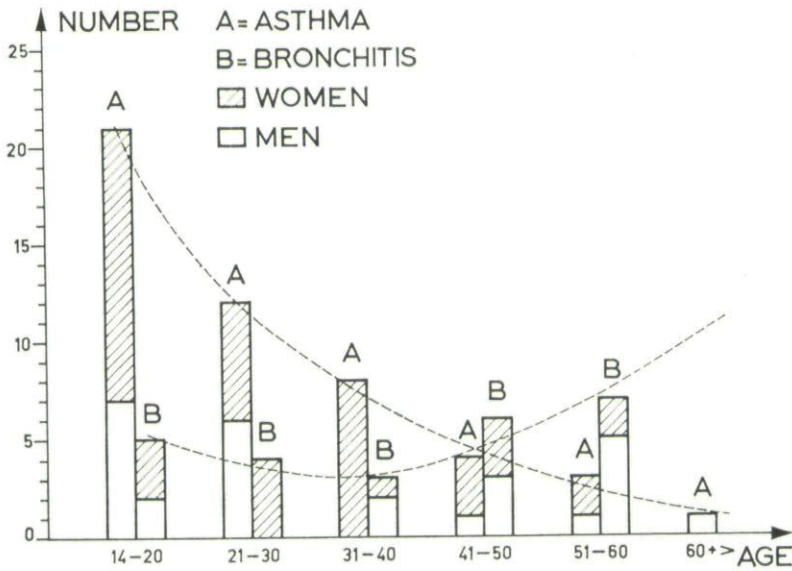


Fig. 1.

The age and sex distribution of asthmatic and bronchitic patients.

bronchorrhoea or bronchial infections usually accompanied by partly reversible airways obstruction." These patients were termed, bronchitic.

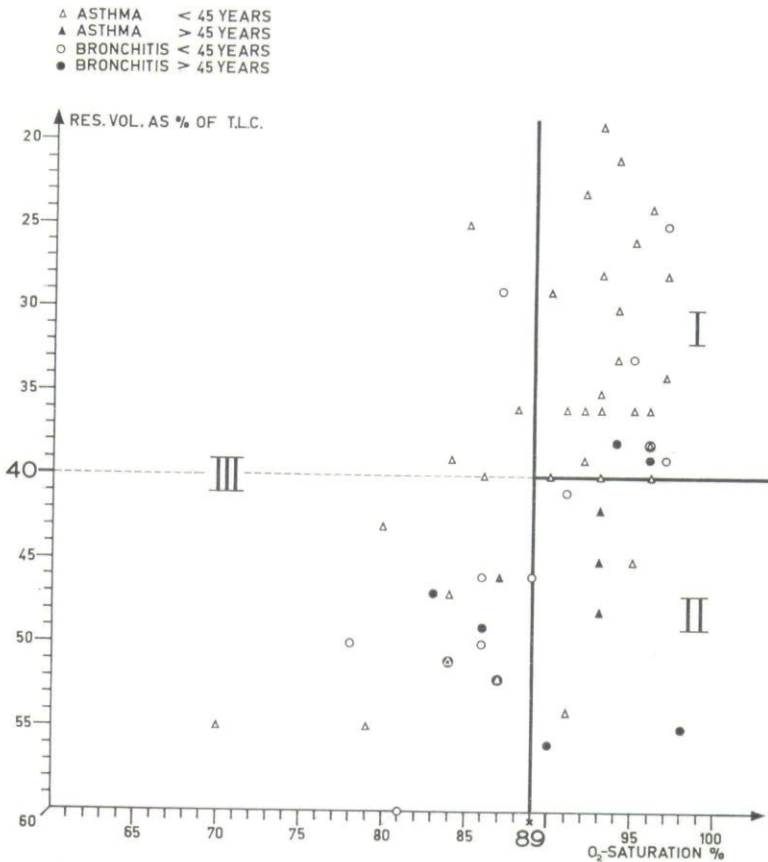
Only patients with considerable and long standing disability were accepted. Several had spent part of their childhood in special residential schools.

More than 100 English patients have now been to Davos but this is a report of the immediate results in the first 73 patients and the late results in the first 32 patients from Warwickshire.

AGE GROUPS

The age and sex distribution of the asthmatic and bronchitic groups is shown in Fig. 1; the majority of the asthmatic patients were under the age of 40 and there were more females than males in this group. In the bronchitic group, there was a wide range but the majority were over the age of 40.

COMPARISON OF THE RES. VOL. % OF T.L.C. AND ARTERIAL OXYGEN SATURATION



15 patients not recorded

Fig. 2.

Comparison of the residual volume as percentage of the total lung capacity and arterial oxygen saturation.

RESPIRATORY FUNCTION STUDIES

Quantitative studies were made for most patients before, during and after treatment in Switzerland and the results given are the best recorded in each of the three phases of manage-

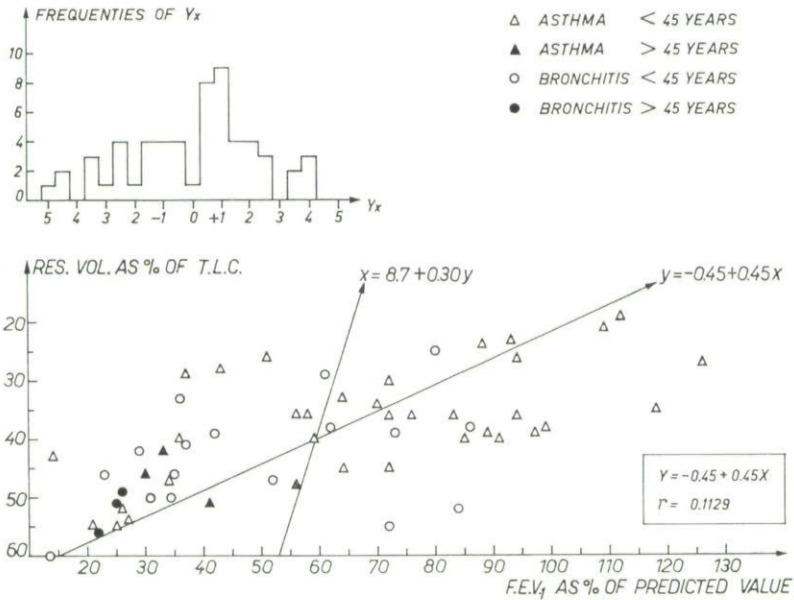


Fig. 3.

Relationship of residual volume as percentage of total lung capacity to the forced expiratory volume 1.0 sec as percentage of predicted value.

ment. Oxygen saturation and residual volume estimation were made on 58 patients in Davos and these are plotted in Fig. 2; the asthmatic patients are indicated by open or closed triangles and the bronchitic patients by open or closed circles. The patients fell roughly into three groups:

- Group 1. Residual volume—less than 40 per cent of T.L.C. (total lung capacity) and oxygen saturation greater than 89 per cent.
- Group 2. Residual volume greater than 40 per cent T.L.C., oxygen saturation greater than 89 per cent.
- Group 3. Oxygen saturation less than 89 per cent.

Patients with the least respiratory disability were in Group 1 which included 58 per cent of the asthmatic patients but only 32 per cent of the bronchitic patients. Over half the bronchitic

patients had an oxygen saturation lower than 89 per cent and one-third had a diffusion defect as judged by further reduction of oxygen saturation following standardized exercise.

Time forced expiratory volumes were estimated in 60 patients before and after inhalation of 1 per cent Isoprenaline. The average of results in the asthmatic group of 40 patients was 65 per cent of predicted normal and in the bronchitic group of 20 patients was 46 per cent of predicted normal. After Isoprenaline these percentages increased to 75 per cent and 52 per cent respectively. These changes were not statistically significant ($P > 0.05$). In Fig. 3 the Forced expiratory Volume one second (FeV 1.0 sec) as a percentage of the predicted normal is plotted against residual volume as a percentage of total lung capacity. The correlation of the FeV_{1.0} with the residual volume estimation was not absolute but it will be noticed that there was a greater tendency to direct correlation in the patients over the age of 45 years.

ALLERGY

Skin tests were made against approximately twenty allergens with Bencard reagents. Wheal formation 10 mm greater than the control we regarded as positive, the results were read after fifteen minutes and observed daily for one week. The results are shown in Table 1; in the asthma group 73 per cent of patients were positive and 27 per cent negative, whereas in the bronchitic group 20 per cent were positive and 80 per cent negative. In each case these findings were statistically significant ($P > 0.05$).

TABLE 1
Distribution of Significant Skin Reactions in Asthmatic and Chronic Bronchitic Patients.

	Total number of patients	Skin tests	
		Positive	Negative
Bronchial asthma	48	35 (73 %)	13 (27 %)
Chronic bronchitis	25	5 (20 %)	20 (80 %)

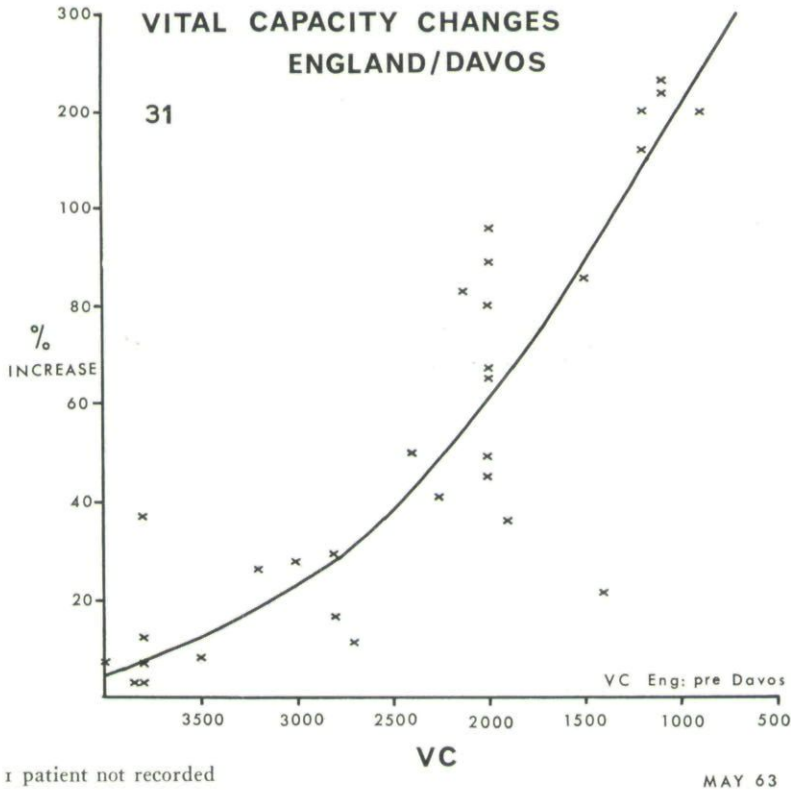


Fig. 4.

Percentage increase of vital capacity after commencement of alpine therapy.

IMMEDIATE RESPONSE TO TREATMENT IN SWITZERLAND

An improvement in vital capacity occurred within days of reaching Davos. This was seen in all cases where measurements were made and in Fig. 4, vital capacity prior to transfer is plotted against the percentage increase in Switzerland. There was a remarkable exponential correlation. No similar changes were found in normal persons.

The general response to treatment in Davos was recorded under four headings; much better, better, unchanged and dead, the definitions of these categories and the results with sub-

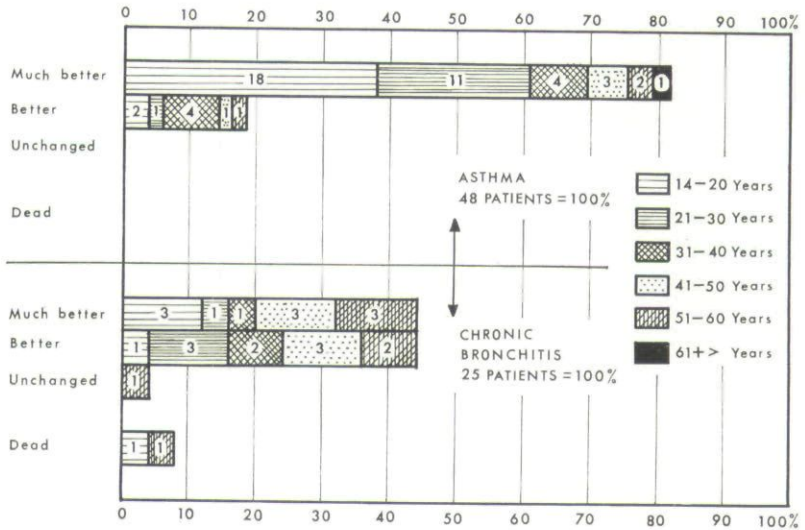


Fig. 5.

Progress of asthma and Bronchitis patients in Switzerland.

Definition of terms:

Much better: Completely cured or substantially improved with only very occasional relapses.

Better: Periodic attacks but free most of the time.

divisions for age are shown in Fig. 5. Without exception the asthmatic patients were improved and 39 of the 48 (83 per cent) were much better.

In young asthmatic patients the response in Davos was uniformly excellent. A few patients had occasional mild wheezing of which some episodes were prolonged. Bacterial isolation from the sputum of these patients yielded *Hemophilus influenzae*, pneumococci, *Neisseria*, *Klebsiella aerogenes* (Friedländer bacillus), *Staphylococci* and *Escherichia coli*, in descending order of frequency.

The results in the bronchitic patients varied somewhat but considering the severity of disease were remarkably satisfactory, and 11 of the 25 (44 per cent) patients were much better. Two patients died, the first was a man aged 60 who following

lobar staphylococcal pneumonia with residual cavitation developed severe persistent bronchospasm which was probably due to fungus infection. The patient was confined to Hospital for one year before transfer to Davos where for four months he steadily improved only to die from coronary artery disease. The second death was in a boy aged 17 whose condition at the time of admission to Davos was desperate, he had severe staphylococcal bronchiectasis, *aspergillus fumigatus* infection and cor pulmonale. His condition fluctuated, his bronchial tree remained infected and after twelve months the prognosis was accepted as hopeless. He returned to England where he died one day later.

LONG TERM FOLLOW-UP OF PATIENTS AFTER RETURN TO ENGLAND

For various reasons it was impossible to follow-up all of the patients and the following results are confined to those from Warwickshire. However we considered that the 32 patients from Warwickshire were in many respects representative of the whole group. The follow-up related to patients treated in Davos between the years 1958 and 1962, and the final assessment was in 1964. In recent years there has been little chemotherapeutic advance but one cannot discount the possible beneficial placebo effect, described by *Harris* (1964), of a prolonged period of hospital treatment, nevertheless it was hoped that this effect would so far as possible have been eliminated by the preliminary period of hospital assesment in England.

GENERAL RESULTS

Follow up assessments were made at yearly intervals after return of the patient to England; the criteria were identical to those used in Davos and the results are shown in Table 2. The proportion of patients who remained much better was approximately one third. There was a difference in the prognosis of asthmatic and bronchitic patients and the results at the end of the first year after return to England, in five age groups, are

shown in Table 3; the numbers were insufficient to justify presentation of the analysis by year of follow-up. The age distribution was uneven and this may account for some of the differences but the asthmatic patients progressed very well and the older bronchitic patients less well. The prognosis of bronchitic patients was not directly related to the vital capacity or to the $FEV_{1.0}$ sec, but it was related to the residual volume.

TABLE 2
Follow-Up Classification of 32 Warwickshire Patients in England after Completion of Alpine Therapy.

Classification of patients	Year of follow-up			
	1	2	3	4
Much better	12	9	6	2
Better	15	11	7	1
Unchanged	5	3	1	—
Dead	—	2	1	—
Total patients	32	25	15	3

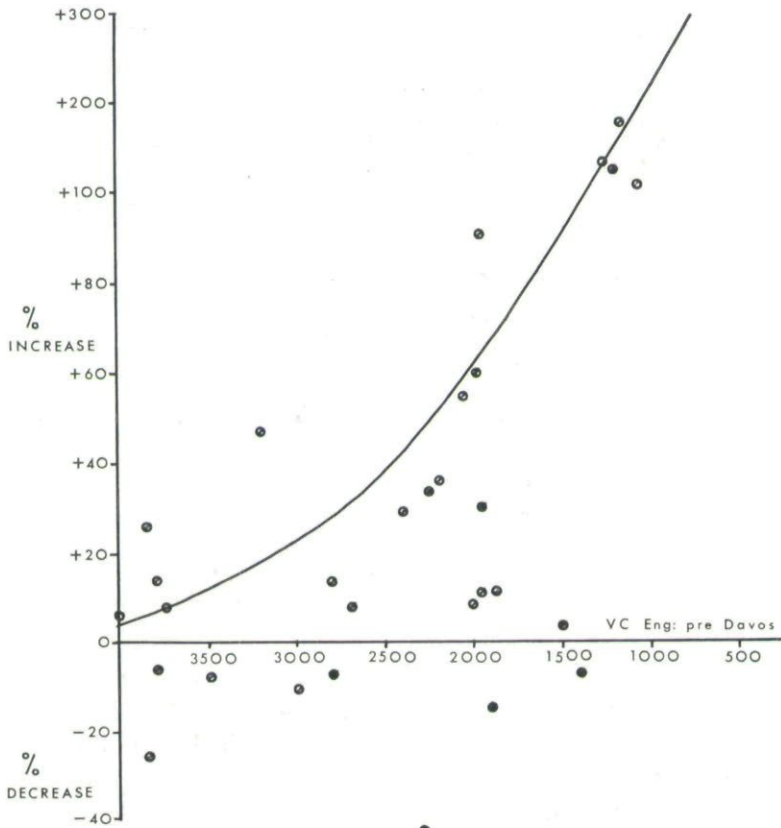
For Definitions see Fig. 5.

TABLE 3
Results in 32 Asthmatic and Bronchitic Warwickshire Patients in Five Age Groups one Year after Completion of Alpine Therapy.

Age group	Asthmatic patients				Bronchitic patients			
	Much better	Better	Un changed	Total	Much better	Better	Un changed	Total
14-20	6	4	—	10	—	1	—	1
21-30	5	2	—	7	—	1	1	2
31-40	1	3	1	5	—	2	—	2
41-50	—	—	—	—	—	1	1	2
51-60	—	—	—	—	—	1	2	3
Totals	12	9	1	22	—	6	4	10

VENTILATION TESTS

The vital capacity changes in Davos, Fig. 4, were maintained in many cases after return to England; nine patients con-



1 patient not recorded

Fig. 6.

Vital capacity assessment before and after treatment in an alpine climate.

tinued more than 40 per cent in excess of the best figure obtained in England before transfer and fourteen were improved by more than 20 per cent. These changes are shown in Fig. 6, in which it will be seen that the distribution of improvement was similar to that in Davos. In eight patients the vital capacity had fallen a little after return to England, four of these patients were bronchitic and four were asthmatic.

In 15 of the 22 asthmatic patients, the $FeV_{1.0}$ as a percentage of the V.C. was greater after return to England than

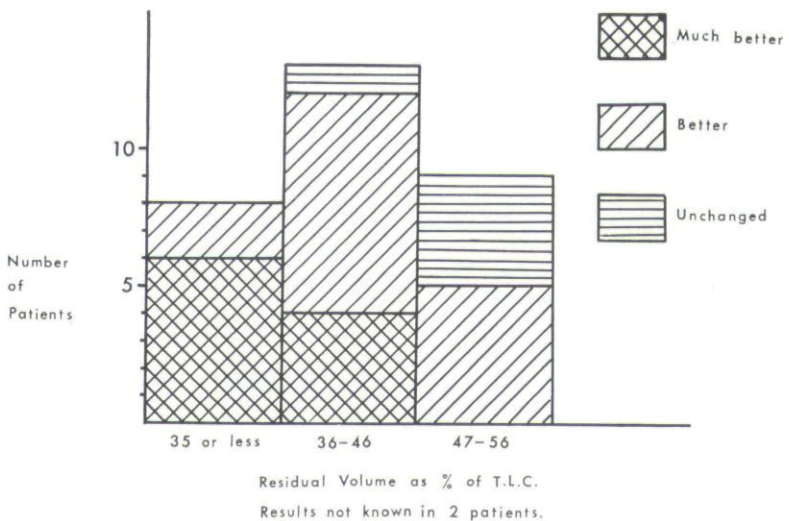


Fig. 7.

Results in 32 asthmatic and bronchitic Warwickshire patients classified by residual volume as a percentage of total lung volume.

in Switzerland and none of the remainder was more than 5 per cent lower than in Switzerland. Neither the absolute vital capacity nor the extent of its improvement in Davos was correlated with the immediate progress and neither was a reliable index of prognosis.

RESIDUAL VOLUME

Estimations of the residual volume related to total lung capacity and classified according to the general progress are shown in Fig. 7. No patient whose residual volume was greater than 47 per cent of the T.L.C. was better and only 4 of the 13 patients in the range 36-46 per cent were much better. Of those below 35 per cent, 6 of the 8 patients were much better. The numbers of patients in this analysis do not satisfy the usual statistical criteria; nevertheless, no patient with a residual volume greater than 47 per cent of the T.L.C. derived substantial improvement from treatment in Davos. In contrast all

patients with a normal residual volume were substantially improved.

LOSS OF WORK

A patient measures the severity of his disability by sickness necessitating loss of remunerative work. The average loss of work by the patients in the year prior to transfer to Davos was 27 weeks and in the four years following return to England was 5, 5, 7 and 1 week respectively, (the number of patients in each year of survey were 32, 25, 15 and 3); this data is shown in Table 4. The improved capacity for work applied to all patients. There were nine who had undertaken no work in the year before treatment in Davos—after return to England, five of these were able to work and their periods of sickness were:— 3, 20, 1, 14 and 25 weeks respectively.

TABLE 4
Average Loss of Work of 32 Asthmatic and Bronchitic Warwickshire Patients before and after Alpine Therapy.

	Pre-alpine	Year of follow up			
		1	2	3	4
Loss of work in weeks per year	27	5	5	7	1
Total number of patients	32	32	25	15	3

GENERAL COMMENTS

a) *Chronic Bronchitis.*

The patients in this group were from a wide age range but the average age was older than for the asthmatic patients. Some had bronchitis complicated by bronchiectasis of considerable severity. The ages were as follows:— 16, 21, 24, 37, 38, 41, 44, 51, 57 and 57.

The three patients over 50 years of age did not do well. In each case the vital capacity increased by approximately 25 per cent during treatment in Davos and their results are included

in Fig. 1, but after return to England the figures fell, there was a general deterioration and two of these patients have died.

b) *Bronchial Asthma.*

Most of the patients returned to England improved and as shown in Table 3 had continued improved after one year; not all were completely free from attacks but only one patient, a neurotic 36-year old housewife was not improved. The asthmatic attacks in some of the patients had at the onset been seasonal but before transfer to Davos had in nearly all cases become perennial.

Thirteen of the patients had significant emotional or adaption difficulties. All of these were largely overcome in Davos. Substantial integrational difficulties were avoided by psychiatric screening before transfer to Davos.

Attention had been given to the occupation of patients in Davos and where possible, postal courses of instruction were initiated in liaison with the appropriate Technical Colleges. The better results were in those patients who undertook rehabilitation with keenness, application and appreciation of the benefits likely to accrue from improved employment. Separation of the patients from their homes rarely led to difficulty and in some cases broke an unsatisfactory emotional link with either a parent or sibling and this facilitated independence and a sense of well-being which was reflected in the patient's progress after return to England.

DISCUSSION

The majority of patients with asthma improved with the passage of time and Fry (1961) in a general practice found in an observation period of five to ten years that only 7 per cent had severe residual disability. Prognosis deteriorated with age of onset; poor results were found in 5 per cent of patients in whom the onset was before the age of 15, but in 18 per cent of patients in whom the attacks had started in adult life.

Williams & Williams (1949) in a follow-up of 64 hospital asthmatic patients reported death in 11 (17 per cent), poor results in 19 (30 per cent) and although twelve (19 per cent) were cured this was ascribed to eight different causes. *McCracken* (1950) investigated 80 hospital asthmatic patients and found similar results; cured 17 (21 per cent) improved 43 (54 per cent) unimproved 12 (15 per cent), dead 8 (10 per cent). *Cardell & Pearson* (1959) drew attention to the frequency of death from asthma in a review of 68 fatal cases from King's College Hospital, London. Forty per cent of their patients died during an asthmatic attack, 37 per cent died of pulmonary infection or its sequelae and of the remainder dying of intercurrent disease 16 per cent had some pulmonary lesion due to infection. Antibiotic treatment has improved the situation but despite the introduction of steroids asthma remains dangerous and in the Registrar General's Report for England and Wales 1962 there were 1352 deaths from asthma. *Bruce Pearson and others* (1961) studied 102 patients on short term steroid therapy and there was a poor response in 33, and of 36 patients on long term therapy there were ten failures. They concluded, that steroid therapy is not always successful, that relapses are common, and that response is usually better in males than females. This interesting differential effect of steroids according to sex is probably reflected in the pattern of deaths from asthma. Before 1956 there were more male than female deaths but consistently since that year there have been more female than male deaths in Great Britain.

Treatment in an Alpine Climate must be assessed against the above background. The Warwickshire patients were drawn from a population of nearly one million, they were the worst cases from various hospitals and therefore almost certainly had more severe disease than those of *Williams & Williams* (1949) and of *McCracken* (1950). In Davos the results were exceptional: almost all patients previously dependent upon steroids or Isoprenaline were able to stop treatment and indeed because of their excellent health they posed problems of occupation related to work, discipline, rehabilitation and physi-

cal exercise. Eighty three per cent of the asthmatic patients and 44 per cent of the bronchitic patients remained improved one year after return to England. These results were impressive and in concordance with previously published results.

Clearly many aspects require further study. The optimum length of stay for asthmatic patients is not proven though the evidence of decreased bronchial reactions to allergen provocation tests by *Van Geuns* (1956) ¹ suggester that it should be in excess of twelve months. For bronchitis the optimum time may be different and it is possible that transfer for the winter months only would be sufficient and indeed this arrangement has been used successfully with two patients with bronchiectasis.

Černelč (1965) has shown that asthmatic children treated by climate therapy do better than treated by hyposensitization. He also demonstrated that the addition of hyposensitization to climate therapy did not significantly improve the results. Nevertheless future research into climate therapy will probably be directed to a more detailed study of the spectrum of allergic hypersensitivity in asthmatic patients. This will necessitate facilities for respiratory function tests, the assessment of skin and bronchial reactions to specific allergens and perhaps serial estimations of histamine effects upon the bronchi in England and in Davos. From patients treated in Davos we have some evidence, to be published later, of reduced bronchial sensitivity to histamine in asthmatic patients but no changes have been found in bronchitic patients. We have had only a limited experience of patients with allergic aspergillosis: in two cases there was a significant reduction of obstructive airways in Davos but no evidence of reduced skin reactions to an extract of the fungus.

The specific factors promoting improved results in Davos are unknown and altitude alone is certainly not a significant factor for *Baker* (1948) found a high prevalence of allergic disease in Mexico City where the altitude is 2100 metres and *Chambers and other* (1962) exposed asthmatic patients for six hours to a simulated altitude of 2500 metres in a pressure chamber and observed no effect upon bronchospasm. However,

climatic features are undoubtedly of importance and meteorological data from Davos and Wirwickshire are appended. There has been no detailed study of the particulate content of the atmosphere of Davos but the following three factors are probably significant:—

- 1) the reduced variety and the reduced potency of certain inhaled allergens;
- 2) the remarkable absence of wind, and this freedom from dust in the air, which is probably of importance in allergic asthma;
- 3) the dryness and low humidity of the air, which probably affects the accumulation if not the production of bronchial secretions.

Psychogenic aspects play a significant part. *Keripke* (1960) has described the effects when adolescent asthmatic patients become dependent upon parents and *Bukantz & Peshkin* (1959) have presented evidence as a result of their experiments in Denver, Colorado, that 18 to 24 months is the optimal time for separation from parents; so called p“arentectomy”. Some of the patients in this series had been to special schools and had been separated from their home environment, however, most of these patients had bronchiectasis and were in the bronchitic group. Several of the asthmatic patients had significant psychogenic disturbances and with only one exception all of these did extremely well in Davos and it is interesting that *Dobbs* (1959) made a similar observation in asthmatic children. There is no doubt that most healthy adults are stimulated by a visit to an Alpine resort. Nevertheless it must also be borne in mind that prolonged domicile in a hospital staffed by foreigners and in a foreign country soon loses its glamour, difficulties may be exaggerated and misunderstandings arise. These difficulties may be especially frequent with individualistic British patients, especially where summary justice from a British Doctor is not immediately available.

The patients were treated in an Alpine Climate for periods

in excess of twelve months. The data recorded above and clinical impressions gathered over a period of seven years lead us to conclude that the results were substantially due to the treatment in an Alpine Climate.

SUMMARY

Seventy-two patients were treated in an Alpine Climate for approximately sixteen months. They had obstructive airways disease due to either bronchial asthma or chronic bronchitis. Eighty three per cent of the asthmatic patients and 44 per cent of the bronchitic patients improved soon after arrival in Davos. Two patients died, one from coronary artery disease and one, whose condition at the time of admission had been desperate, from pulmonary aspergillosis. Following treatment in an Alpine Climate periods of sickness were greatly reduced and capacity for work increased in asthmatic and bronchitic patients. The long-term results were particularly satisfactory in young patients. In patients with persistent bronchial infection and a residual volume greater than 47 per cent of the total lung capacity the improvement was temporary and incomplete. Vital Capacity and $FeV_{1.0}$ sec were unrelated to prognosis. Without exception the vital capacity was increased in Davos and the extent of improvement was related to the initial volume in England.

ACKNOWLEDGEMENT

The treatment of these patients was financed out of various voluntary funds. The project was the result of the persistent stimulus, perseverance and faith of Miss Rene England, County Director of the British Red Cross Society, Warwickshire. The Headquarters Branch of the British Red Cross Society directed the scheme and we thank the successive B.R.C.S. Welfare Officers who worked with the British patients in Davos.

We also thank Mrs. P. Crockert and Mrs. Wolf who coordinated education rehabilitation aspects, Mr. A. D. Van Essel for statistical data and Miss Stella Newton, Mrs. Rhona Williams and Mrs. Mary Annat for secretarial assistance.

REFERENCES

- Baker, J.*: Allergy in Children as Related to Altitude. *Ann. Allerg.* 1, 33, 1948.
- Brock, J.*: Statistische Untersuchungen über das kindliche Bronchialasthma. *Deutsch. Med. Wschr.* 46, 1120, 1942.
- Bruce Pearson, R. S., Bayliss, J. H. & Shellie, H. G.*: The Treatment of Chronic Asthma with Prednisolone and the Newer Steroids. *Brit. Med. J.* 1, 315, 1961.
- Bukantz, S. C. & Peshkin, M. M.*: *Pediat. Clin. N. Amer.* 6, 755, 1959.
- Burckhardt, J. L.*: Dauerresultate klinischer Kuren bei kindlichen Asthma. *Schweiz. Med. Wschr.* 2, 1194, 1932.
- Cardell, B. S. & Bruce Pearson, R. S.*: Death in Asthmatics Thorax. 14, 341, 1959.
- Cernelo, Draga*: Comparisons of Climate and Specific Hyposensitization Treatment in Asthmatic Children. *Acta Allergol.* 20, 105, 1965.
- Chambers, van V., Allansmith, M. R. & Simon, H. J.*: Effect of Simulated Altitude Change on Asthma. *Ann. Allerg.* 20, 666, 1962.
- Cohen, H. M.*: Davos Alpine School. City of Birmingham, School Health Report. 56, 1949.
- Dingle, A. Nelson*: A Meteorological Approach to the Hay Fever Problems. *J. Allergy* 26, 297, 1955.
- Dobbs, R. H.*: English Asthmatic Children in Switzerland. *Bronchial Asthma, a Symposium.* Chest and Heart Association, p. 64, 1959.
- Fry, J.*: Acute Wheezy Chests. *Brit. Med. J.*, 1, 227, 1961.
- Harris, L. H.*: Placebo Effect in Chronic Bronchitis. *Brit. Med. J.* 1, 244, 1964.
- Harsh, G. F.*: The Correlation between Humidity and Housedust Sensitivity. *Rees-Stealy Clinic, Section on Allergy*, p. 118, 1952.
- Jimenez-Diaz, S., Cuenca, B. S. & Puig, J.*: Climatic Asthmas. *J. Allergy* 3, 396, 1932.
- Keripke, S. S.*: Psychologic Aspects of Bronchial Asthma. *Amer. Dis. Child.* 100, 157/935, 1960.
- Leeuwen, W. Storm van*: Bronchial Asthma in Relation to Climate, Section of Therapeutics and Pharmacology. *Roy. Soc. Med. Proc.* 17, 19, 1924.
- McCracken, D.*: Prognosis in Bronchial Asthma. *Brit. Med. J.* 1, 409, 1950.
- Ordman, D.*: Respiratory Allergy in the Coastal Areas of South Africa. The Significance of Climate. *S. Afr. Med. J.* 29, 173, 1955.
- Turban, K. & Spengler, L.*: Resultate der Asthmabehandlung im Hochgebirge. *Ann. Schweiz. balneol. Gesellschaft.* Heft II, 72, 1906.
1. *van Geuns, H. A.*: Asthma and Housedust in the High Mountains. *Int. Arch. Allergy* 8, 290, 1956.
 2. *van Geuns, H. A.*: Provocation Tests and Bronchial Asthma in the High Mountains. *Acta Allergol.* 10, 194, 1956.
- Williams, E. O. & Williams, G. E. O.*: The Natural History of Asthma. *Brit. Med. J.* 2, 897, 1949.
- Wissler, H., van, Konge, E. & Gasser, C.*: Resultate der Hochgebirgskuren beim Asthma bronchiale der Kinder. *Helv. Paediat. Acta.* 6, 235, 1951.

APPENDIX

Barometric pressure in Davos 629 mm Hg. thus normal $P.O_2$ alveolar = 75 mm Hg. and normal O_2 sat. = 93 per cent.

Lode Spirograph D 53, capacity 10 litres. Residual volume estimations were by the closed circuit method with helium. Blood gas analyses during rest and exercise. Oxygen saturation of arterial blood measured with the Haemoreflector of *Zijlstra & Brinkman* (Clinical Oximetry (1951) *W. G. Zijlstra, Van Gorcum & Assan*) $P.CO_2$ measured by the technique of *Rossier* (Physiologie und Pathophysiologie der Atmung, *P. H. Rossier, A. Buhlmann, L. Wiesinger*, Springer, Heidelberg, 1956). The predicted values from the tables of *Miller, Johnson & Woe*: Applied Physiology, March, 1959, Vol. 14, No. 2). The lung volumes are expressed in ml at B.T.P.S., the gas volumes in ml at S.T.P.D.

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