From the Royal Medical Board, Stockholm, Sweden.

THE VIPEHOLM DENTAL CARIES STUDY

Purposes and Organisation

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Dental caries is one of the greatest medico-social problems of today, as it affects such a high percentage of the population and shows a tendency to increase with the standard of living. WESTIN & WOLD (1934) who studied this point in young men called up for military service in Sweden, found only one out of a thousand to be caries free. We have found that of the children seen at the children's clinics of the Public Dental Service during the 1946—1949 period, only about 7 out of every thousand 7-year old children were caries free, the average number of caries free children in school age (7—15 years) being about 3 per thousand.

During the realisation of the project prescribed by the resolution passed by the Swedish Riksdag in 1938 concerning the organisation of the Public Dental Service it was found that the costs would be heavy if all the requirements were to be satisfied by this service.

It is, of course, difficult to estimate how much is spent on dental treatment in Sweden (population 7 mill.). A rough idea of the total amount may be obtained from the figures given in Table 1. The major part of the expenses is due to dental caries.

As a rule treatment is directed against already damaged teeth, the purpose of such therapy being to prevent local spread of caries and to restore the function of the bite. It would, however, be more satisfactory to prevent the development of such lesions.

Such prophylaxis could be performed by the patient himself, either to prevent the arisal of caries or to stop the progression of the disease. On the other hand public measures would probably be successful. A general long-term prophylaxis, in which the individ-

TABLE 1

		Crowns in millions
A. *Direct expenses*		
1) Amount paid by patients to dental surgeons in general practice (2,600 practitioners not employed in the Public Dental Service with a gross annual income of 30.000—40.000 Swedish crowns)		78—104
2) Public Dental Service (1950)		22
3) Odontologic training and research paid by public grants		7
		107—133
B. *Indirect expenses*		
1) Loss of income in connection with dental treatment (about 10 million working hours)	(approx.)	20
2) Expenses caused by sequels,	at least	10
	Total	137—163

ual plays a passive rôle, the public health authorities being responsible for the elaboration and performance of suitable prophylactic measures, should probably be preferred. Towards the end of the nineteen-thirties the investigation of the organisation of the Public Dental Service forced the question of prophylaxis into the foreground. A synopsis of possible prophylactic measures and of the scientific investigations that might substantiate the value of such prophylaxis showed that the results of relevant scientific studies were often contradictory and not convincing.

This was the situation in the beginning — strong need of prophylactic measures against dental caries and no definite scheme for the most promising approach to the elaboration of such measures.

THE PURPOSES

Historical

In 1939 a proposal about the need of research in the field of dental prophylaxis was submitted to the Swedish Riksdag by Mr. Sjödahl and others. The Swedish Government requested the Medical Board "to perform, in cooperation with the Board of the Dental School, a general investigation concerning what measures should be taken to decrease the frequency of the most common dental diseases in Sweden."

An extensive investigation, for which several experts were consulted was started to find out how the request of the government

should best be realised. The president of the committee, responsible for the odontologic methods, was Professor G. Thourén.

The work of this committee gradually resulted in the decision to start at the Vipeholm Hospital, Lund, an investigation of the relationship between diet and dental caries. The report of the committee has been published in *Svensk Tandläkare-Tidskrift* 41: 1, 1948.

Planning of the Investigation

When the investigation was planned it was thought that the study in human beings would yield direct information about the effect of various factors on caries. Experimental and clinical studies hitherto available had not provided a definite answer to such basic questions as to whether dental caries should be regarded as the expression of a disturbance of the general condition of the patient, e. g. a deficiency disease, or whether it was due to local oral factors related to the diet. Scientific investigations had been based mainly on epidemiologic studies, laboratory experiments and animal experiments. The study period of experimental clinical trials available was too short, the series were too small or the control of the experimental conditions was unsatisfactory. Consequently the results of these investigations were contradictory, especially regarding the role played by carbohydrates in dental caries.

It was thought that the Vipeholm Hospital, with its large number of practically permanent patients, would provide an opportunity to perform long-term nutritional studies under well-controlled conditions, studies of value to the clinician and to fundamental research. According to the plan of investigation, each of the separate departments was to represent an experimental or control group. Thanks to the fact that these departments are separated from one another, and, as the patients are under continuous observation of nurses, it was possible to check how the experimental prescriptions were followed by the patients.

The experimental variables should consist of additions to a well balanced diet, the same for the entire hospital. Caries activity was to be assessed on the basis of regular examination of the teeth, which was to be performed by the best methods available and by

specially trained dentists. This should then permit conclusions regarding the relationship between the experimental conditions and dental caries.

The general condition of the patients should also receive careful attention in order to be certain that the experimental variables had no undesired side effect on them.

Before the investigation was started the plan was presented to the Government and to the Riksdag, although it was the Medical Board who planned the studies, and was responsible for the performance of the investigation. The investigation was approved on condition that the general health and the state of the teeth of every patient should be carefully checked at regular intervals.

Preparatory Period Jan. 1945—Jan. 1946

The registration of dental caries was commenced in Febr. 1945 and the rest of the year was used for the selection of patients and for trying various methods of registration.

The Vitamin Study Period Jan. 1946—July 1947

The so-called Vitamin Study was started in Jan. 1946. The purpose of this study was to elucidate the question whether dental caries activity in man is related to any of the most important accessory food stuffs. The results of this study are published elsewhere (*Medicinalstyrelsens odontologiska försöksverksamhet vid Vipeholms sjukhus i Lund*, *Svensk Tandläkare-Tidskrift*, 41: 1, 1948).

In these trials caries activity was fairly low and did not differ with certainty from one experimental group to another, that is dietary surplus of various vitamins or of calcium fluorine or bone meal had no caries-arresting effect under the experimental conditions. These trials should be regarded as preparatory and supplementary to the subsequent carbohydrate trials. For instance, the vitamin trials showed that with an all-round diet, containing sugar in a quantity representing half of the average consumption in Sweden and comprising the usual amount of starch, was accompanied by a low caries activity in the series studied. Caries activity was not affected by the addition of the above-mentioned substances to the food.

Carbohydrate Study Period July 1947—July 1951

The carbohydrate consumption in Sweden has changed considerably since the turn of the century. Formerly potatoes and whole meal bread prepared with fermenting dough represented the main carbohydrate consumption in Sweden. Sugar was regarded as a delicacy. Today we have bread baked with baker's yeast and selected types of flour and the annual consumption of sugar in 1950, for example, was 47.1 kg per person. In 1953 the consumption dropped to 41.2 kg. This places Sweden as second or third nation regarding the consumption of sugar. As far as Sweden is concerned, it is easier to give a list of dishes in which sugar is not used than of those in which it is used.

It was against this background that investigations were started to discover any relationship between the consumption of carbohydrates and dental caries. These investigations are referred to later as *Carbohydrate Study I and II.* Various amounts of substances or foodstuffs containing carbohydrates were added to the food of the different groups in which caries activity was studied.

Experience soon showed that the Vipeholm investigation proper, i. e. the study of the relationship between caries activity and the composition of the diet, should be supplemented with a number of sub-studies of other types, the so-called *supplementary studies.* The purpose of these was

1) to throw further light on the relationship between caries activity and the experimental conditions,

2) to check how the experimental conditions were followed by the patients,

3) to find out any side-effects of the experimental conditions,

4) to throw light on the great differences in caries activity between different individuals under the same experimental conditions.

These supplementary studies proved necessary for the correct interpretation of the observations made in the investigation proper.

As facilities were available at the Station, a number of other *special studies* of relevant interest were also carried out.

The investigations carried out at the Station during the period February 1945—July 1951 are summarised in Table 2.

The results of these studies have been published separately by the research workers concerned.

TABLE 2

Studies carried out during the 1945—1951 period at the Dental Research station of the Royal Medical Board.

I. Clinical experimental studies of the relationship between diet and caries activity (the Vipeholm investigation proper).[1]
   1. Preparatory period (1945).
   2. Vitamin Study Period (1946—1947).
   3. Carbohydrate Study Period I (1947—1949).
   4. Carbohydrate Study Period II (1949—1951).

II. Supplementary studies.

   A. 1. Clinical examinations, in order to get an idea of the general condition of the patients (height, weight, mental and physical condition).[8]

      2. Reliability of the method in the determination of caries activity.[1]

   B. Biochemical studies.
      1. Amount of calcium and phosphorus in the blood and in the saliva.[8]
      2. C-vitamin content of the blood.[8]
      3. Carotene- and vitamin A-content of the blood.[8]
      4. Blood and urinary glucose levels.[8]
      5. The pH and carbon dioxide content of the blood and ketones in the urine.[8]
      6. The pH of the saliva.[8]
      7. Buffering capacity of the saliva.[8]
      8. Viscosity of the saliva.[8]
      9. Excretion of phosphate with the urine.
      10. Daily variation in the sugar content of the saliva.[8]
      11. Elimination of sugar in the saliva following ingestion of different foodstuffs.[8]

   C. Bacteriological studies.
      1. Number of lactobacilli in the oral cavity.[8]
      2. Effect of certain heterocyclic carbon compounds on the

formation of acid in saliva from patients with active caries.[8]

3. Classification of lactobacilli strains isolated from patients with active caries.[8]
4. The effect of the concentration of glucose and sucrose on acid production, growth and viability of lactobacilli and streptococci.[8]

D. Histopathological studies.

1. Histopathology of dental lesions observed.

E. Intra-oral photography.

1. Method of intra-oral photography.[8]

III. Special studies.

1. Investigation of caries activity in Hungarian farm labourers working in Sweden.[8]
2. Investigation of the relationship between the fluorine content of drinking water and the frequency of caries in the receiving area of the Public Dental Service at Tibro.[8]
3. Investigation of the amount of sweets consumed by school children in Lund.[8]
4. Investigation of the frequency of caries in children 12—15 years old.[8]
5. Investigation of iodo-acetic acid as to its caries arresting effect.[8]
6. Investigation of the effect of certain heterocyclic compounds on the frequency of caries in hamsters.
7. Comparative studies of the caries-promoting effect of sucrose and "technical glucose" in the rat.
8. Relationship between the consumption of chocolate and caries activity in the personnel of the Vipeholm Hospital.[1]
9. Relationship between the position of the teeth and dental caries.
10. Investigation of caries activity at the Shool for Deaf-mutes in Lund and the Institution for the Blind in Lund.

11. Investigation of the caries activity in certain undergraduates of the dental school; clinical examinations and chemical studies of the saliva.[1]

[1] Published in this issue.
[2] „ elsewhere in English.
[3] „ „ „ Swedish.
Reprints obtainable from the Dental Research Station, Vipeholm Hospital, Lund, Sweden.

ORGANISATION

Premises

During the period 1945—1948 the premises of the experimental station consisted of three rooms on the staff-floor of one of the wards. These rooms were divided to provide space for the registration of dental caries, record office, at laboratory for making models and an x-ray room. Most of the supplementary studies were carried out mainly at the institutions of the University of Lund, where the co-workers were engaged. However, it soon proved necessary to extend these supplementary studies, which owing to the smallness of the station, had to be carried out at different places. This decentralisation incurred high costs and made organisation and co-operation difficult. At the end of 1948 it was therefore decided that further rooms should be reserved for the station. The floor surface of the station is at present 300 m^2. The station thus extended was ready for use in January 1950.

Investigation of certain problems, especially studies requiring complicated apparatus, are, however, still performed at laboratories belonging to the University of Lund, the State Dental School in Malmö, and Malmö General Hospital.

Personnel

In the beginning the personnel engaged for this investigation consisted of dentists, a physician for the supervision of the experimental conditions and two dental nurses. The studies were

carried out mainly under the direction of the senior physician in charge of Vipeholm Hospital.

With the expansion of the investigation it proved necessary at the end of 1948 to appoint a special director of studies, Dr. B. E. Gustafsson, responsible to the Medical Board.

The personnel of the station is at present the following:

Director of studies
1 secretary

Registration of caries
1 chief dental surgeon
4 dental surgeons
2 dental nurses

Medical examinations
1 physician

Bacteriological studies
1 bacteriologist
1 dental surgeon
1 technical assistant

Biochemical studies
1 biochemist
3 technical assistants

Statistics
1 statistician

Since 1948 the technical assistants have had full-time employment for which they receive a monthly salary, while the other members of the staff receive consultation fees and payment for the actual work done. The costs of the station and the investigation were paid by allowances from public funds and by private donation.

Supervision

The work at the station is carried out under the direction of the Medical Board, where all matters concerning the investigation etc. are treated by the Dental Division.

The work at the station was inspected several times a year by Dr. J. Axel Höjer, Director general of the Medical Board, Dr. A. B. Maunsbach, Chief of the Dental Division of the Medical Board and by Professor G. Thourén, member of the Scientific Council of the Medical Board. The inspection consisted mainly of conferences with the personnel of the station. In addition, joint consultations have continually taken place between the above mentioned and Professor E. Abramson, Professor E. Brunius, Professor G. Westin and others.

In 1948 a committee was appointed for the management of the donations given by the sugar and chocolate industries. This committee was called *Nämnden för teknisk-vetenskaplig forskning rörande karies* and consisted of the following members: Director general Dr. J. A. Höjer (Chairman) and Dr. A. B. Maunsbach, Chief of the Dental Division, as representatives for the Royal Medical Board, Professor G. Thourén and Professor G. Westin as members of the Scientific Council of the Royal Medical Board, Professor G. Blix and Professor N. O. Abdon as representatives for the Swedish chocolate and sweet manufacturers and Dr. B. E. Gustafsson as representative for the Research Station.

Costs of the Investigation

Scientific investigations of this type with part-time employment of several scientists and full time employment of a number of assistants incur large expenses. The Vipeholm investigation is probably the largest of its kind that has ever been performed. In view of the small population of Sweden (about 7 millions), the financial support given must be regarded as generous (Table 3).

In addition, toffee and caramels were supplied free of charge by the Swedish chocolate and sweet manufacturers (the values of these supplies are not included in Table 3).

The costs of the Carbohydrate Study (4 years) are about half a million Swedish crowns. When comparing these costs with costs of other types of investigation usually supported by grants or donations and carried out at scientific institutions supported by public funds, it should be borne in mind that all costs, both overhead and running, had to be covered by grants. For a medium sized University research institution with about 20 employees the running expenses alone will thus amount to some 150,000 Sw. Crowns per year, that is 600,000 in 4 years. To this must also be added grants from different sources for special investigations.

It must be left to future investigation to judge the scientific value of the results obtained at the Vipeholm Dental Research Station. The purpose of the investigation was not to solve all problems concerning the most common dental diseases, nor was it intended to try to elucidate all aspects of the problem of caries, but simply to try to find out what prophylactic measures might be of practical value in this field. If the observations and conclusions made in the present investigation should result in a de-

TABLE 3

Public funds and donations in Sw. Crowns received by the Odontologic Research Station 1944—1951

	Total	Public funds	Donations
Preparatory Period and Vitamin Study Period:			
Public funds 1944—1945		55,000	
A.B. Astra (Sept. 14. 1944)			20,000
Knut and Alice Wallenberg's Foundation (Jan. 26. 1945)			25,000
Public funds 1945—1946		30,000	
„ „ 1946—1947		25,000	
	155,000	110,000	45,000
Carbohydrate Study Period I and II:			
Public funds 1947—1948		53,000	
„ „ 1948—1949		53,000	
„ „ 1949—1950		83,000[1]	
„ „ 1950—1951		53,000	
Knut and Alice Wallenberg's Foundation			
Sept. 27. 1948			50,000
Sept. 2. 1949			50,000
Swedish chocolate and sweet manufacturers and Swedish sugar company:			
1948—1949			75,000[2]
1949—1950			75,000
1950—1951			60,000
	552,000	242,000	310,000
Total:	707,000	352,000	355,000
Amounts used up to July 1. 1951:	596,000	338,000	258,000

[1] 30,000 Sw. Cr. for the examination of Hungarians working in Sweden.
[2] 30,000 Sw. Cr. for the equipment of new laboratories.

crease of caries activity in Sweden by 0.5 per cent for one year only, it would be enough to compensate the costs for the entire investigation.

It is difficult to survey all the work done between the planning of the present investigation and the results hitherto obtained, and yet, the results published before and now represent only the first stage of an investigation that must be continued for many years.

The control of caries require further investigation. This has been realised in most countries, where special research stations for dental diseases have been arranged with public founds. Such institutions have been started in U.S.A., Norway and Australia, for example.

REFERENCES

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