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Report to the Local Government Board upon the available data in regard to the value of boiled milk as a food for infants and young animals. By Janet E. Lane-Claypon, M.D., D.Sc. (Lond.).

February 24th, 1912.

(This report embodies the result of an inquiry undertaken in connection with the Board's Grant for Auxiliary Scientific Investigations.)

Part IV.—Method and Results of working up the Berlin Material.

The material for this research was obtained, as already mentioned (p. 4), from the Infant Consultation of the Naunyn Strasse in Berlin. This consultation is conducted by Dr. Ballin, to whom I am deeply indebted for permission to use his material.

Source of the Material.—Six years ago, infant consultations were started by the municipality of Berlin, under the auspices of a special fund, the Schmidt-Gallisch Stiftung.

Four were first started, and then another, and finally two more, thus making seven in all, in different parts of Berlin.

Each of these consultations is in charge of a medical officer who has made a special study of the diseases and ailments of children. The attendance is so large that assistants have been appointed to assist the medical officer in the discharge of his duties. The consultations are held daily, and at the Naunyn Strasse (where the material here dealt with was obtained) the average daily attendance is about 100 babies.

Each Consultation has its own staff of health visitors attached. These are women who have been thoroughly trained for work among children, and are appointed by the municipality to visit the homes of the babies who are brought up to the consultation. Their duty is to instruct the mothers in the general care and hygiene of the infant in accordance with the directions given by the medical officers at the consultation.

The clientèle of the consultation consists exclusively of the working classes. The fathers of the children who are brought up to the consultation are for the most part

Parents whose income is over 40 marks a week are expected to pay a private doctor, and are only allowed to attend in very special cases.

The attendance at the consultation is entirely voluntary, except in a few cases where the babies are illegitimate, and are boarded out under the Poor Law authorities; here the consultation is used as a means of keeping the baby under medical supervision.

The simpler ailments of children are dealt with at the consultation, but sick children in need of in-patient treatment are referred to the hospital.

Breast-feeding is actively encouraged, and the great majority of the children are breast-fed. Small nursing-bonuses are given to the nursing mothers. (Usually about two marks a week.)

The Milk Supply to the Consultation.—Regulations to ensure the quality and purity of the milk for the babies attending the consultation were drawn up when the consultations were first started, and tenders were invited from dairies who were willing to comply with the regulations. The milk was required to be of a high standard, and was subjected to regular chemical and bacteriological examination by the municipality.

Two years ago, the town of Berlin started its own dairies outside Berlin, and all the municipal institutions are now supplied from these municipal dairies.

In these dairies 200 cows are kept which are tubercle-free, and the farm is conducted upon all the model lines of an up-to-date dairy.

The milk is examined chemically and bacteriologically, and I was informed that the fat content is never less than 3 per cent., and the bacterial count varies from 20,000 to 30,000 per c.c. The milk is thus one of great purity.

After milking, the milk is rapidly filtered, bottled, and cooled to 3–4° C., at which temperature it is kept in the cold chamber. It is sent off as soon as possible by special train to Berlin, where it is delivered in cooled vans to numerous centres (about 80) in various parts of the town, whence it is fetched by the mothers of the infants attending the consultation, who are being artificially fed.

Milk is not given out by the consultation, except in a very few cases in which for some reason a plain milk dilution is not considered suitable.

The milk is paid for in full if possible by the parents of the babies, or in part if the social conditions are poor. Each case is dealt with on its own merits on the report of the health visitor, and in some cases the milk is given free. No child is allowed to have a deficient supply of milk as a result of the poverty of its parents.

Over-feeding is avoided by the amount ordered by the medical officer being written on a separate card, which the mother has to show to the dairy when the milk is fetched. The card is valid only for a certain number of days (usually 7–10 days, according to the discretion of the medical officer of the consultation), being stamped

with the date up to which the milk may be given out by the dairy. After that date the mother must bring the baby up to the consultation in order to have the card stamped for a further period. The food of the infant and the milk of the municipality are thus kept under control.

The milk is ordered to be diluted on much the same lines as are followed in this country. The preparation of the milk in the home is under the care of the health visitor who personally instructs the mother in this important matter. The milk is fetched from the dairy, is cooled, and is directed to be brought to the boil, and to be allowed to froth up twice. It is then at once covered, and placed in a vessel of cold water. In hot weather the water is directed to be changed frequently. Thus every care is taken of the food for the artificially-fed baby.

The Notes taken at the Consultation.—Full and careful notes are taken at the Consultation, and entered on special sheets. The notes show the date of the child's birth, the date of its first attendance at the consultation, the feeding of the infant before its first attendance, the health of the parents, the number of children in the family, the wages and the general social condition of the family, the legitimacy or illegitimacy of the infant, and any other point which may require noting.

During the attendance of the infant the dates of its attendance, the weight at each attendance, the directions as to feeding, and the medical notes as to the child's health are all entered upon these sheets. In addition the remarks of the health visitors as to the general condition of the home, the baby, and the milk are entered after each visit. The visits are made at frequent intervals.

The records are thus very complete, and many thousands of such charts are stored at the consultation in the Naunyn Strasse.

In copying the data required from these consultation sheets, the following points were taken—

(1) The date of the child's birth.
(2) The date of its first attendance at the consultation.
(3) The legitimacy or otherwise of its birth. (Nearly all were legitimate.)
(4) The wages of the father.
(5) The number of children in the family.
(6) The weight at each attendance.
(7) The date of each attendance.
(8) The medical notes.

The last three points were tabulated in columns in the following manner, the day of age of the children being worked out afterwards and carefully checked—

Date.	*Day of Age.*	*Weight.*	*Remarks.*
10th August, 1908.	20	3,300 grammes.	Breast, six times a day.
20th August, 1908.	30	3,500 „	Bronchitis.

and so on.

Selection of Material.—It will be remembered that the object of the investigation was to compare the nutrition, as measured by weight, of infants fed on the breast and on boiled cows' milk. The selection of the material presented several points of difficulty. It was necessary to deal with two main series of infants :—

(1) Healthy babies of the average artisan class, fed upon milk in various forms, in order to have a control consisting of the average baby.

(2) Healthy babies of the same class but fed only upon boiled cows' milk, in order to study the difference, if any, produced upon the average baby of the class by feeding it exclusively upon boiled milk, as compared with the infant of class (1).

In considering the babies of this first class, it appeared that far the larger portion were fed upon the breast, and that all the others were fed upon boiled cows' milk. There were a very few cases of mixed feeding upon the breast and on boiled milk, lasting over a few weeks.

This was of course foreseen, since the material which was to be used was that of an infant consultation where the babies were if possible fed upon the breast, and failing that upon boiled milk.

Hence if the babies attending the consultation had been taken seriatim, regardless of the variety of feeding they were receiving, and had been utilised for preparing control statistics under the first head given above, the results would have been complicated by the presence of a considerable number of babies of the second class, which was required to be a class by itself. It was decided to exclude from the control series all babies who had received less than four months breast feeding, taking into consideration further points described below.

Further, in order to eliminate the effects of temperature it was considered advisable as far as possible to take the babies of both classes from the same years. They were all taken from the years 1907–08, and 1908–09, and about half the cases taken came from each of these years.

The most serious difficulty in the selection of the material arose from the varied age at which the children commenced attendance, the varied length of attendance, and the question of the serious illness or death of the child during its attendance at the consultation or soon after the cessation of its visits. It was finally decided to exclude (*a*) all infants who were over four months of age at the time of their first attendance ; (*b*) all who did not attend over a period of at least four months with regularity ; (*c*) all babies who were suffering from constitutional diseases, or who developed such during their attendance at the consultation ; and (*d*) to exclude all babies who died during their attendance at the consultation, owing to the difficulty of ascertaining how far they had been initially healthy babies.

Figures kindly supplied to me by Dr. Ballin, which are not here reproduced, confirm the conclusion, at which I had independently

arrived, that the exclusion of babies mentioned under (*d*) above did not materially affect the statistics.

Analysis of the Material.—The material has been analysed with the view of showing the age of the babies at their first attendance at the consultation, and also how long they remained under the care of the medical officers of the consultation.

The day of age of the babies has been worked out for each attendance (as already explained) upon the copies of the consultation charts.

A table was then constructed of the day of age of the children at their first attendance and of the age at which they ceased attending the consultation.

It was then apparent that the duration of attendance of the infants which were brought up at the same day of life, was so varied that it would be impossible to construct a table of any reasonable form which would give the length of attendance in weeks, much less days. Further the calculation of the age of an infant in weeks becomes somewhat inaccurate towards the later months of the first year, owing to the difference between the calendar and lunar month. Thus 36 weeks is nearer eight calendar months than nine, and thus "weeks" gives a false impression of the age. A month of 30 days was therefore taken as the unit of attendance in the table given below. Thus the age of life from 180–210 days is taken as from the 6–7 month of age. Any child leaving the consultation between those days of life, comes under the column dealing with the 6–7 month, and so on. Many of the cases attended up to 13 months of age or even rather over but they have not been dealt with over 12 months of age.

The unit of grouping for the first attendances has been taken as one week (seven days), since where only 120 days (four months) the limit of age allowed in this research for the first attendance) were being dealt with, (see p. 31), 30 days is evidently too large a unit. As 120 days is between 17 and 18 weeks, 18 weeks have been entered upon the table, although 120 days was the figure taken in collecting the material.

It seemed of interest to give the actual number of children who attended for the first time upon each day of life, and therefore a special column (column II.) gives the actual numbers of children who were brought up for the first time on each consecutive day of age of the period of seven days under consideration.

The length of time of breast-feeding in both series evidently requires consideration, but it could not be given in the same table, and is therefore given separately below. (See pp. 34, 35.)

In the tables given (Tables I. and II.)—

Column I. gives the age of the babies at the first attendance at the consultation grouped in periods of one week (seven days).

Column II. gives the actual number of children who were brought up for the first time on each of the consecutive

days, of the period of seven days of column I. Thus the number of children who were 25 days old when first brought up would be given by the fourth figure of the fourth period of seven days.

Column III. gives the ages of the children on leaving the consultation which had been first brought up at the age given in column I. grouped in periods of 30 days.

Column IV. gives the total number of children which were brought up for the first time during the period of age given in column I.

Table I.

Showing the age of first attendance and of leaving the Consultation of the Babies of the Control or Breast-fed Series.

I. Age in weeks.	II. No. brought at each day.	III. Age on leaving (in months).							IV. Total in each week.
		4–5.	5–6.	6–7.	7–8.	8–9.	9–10.	10–12.	
1	3. 2. 0. 3. 0. 4. 4.	2	1	1	0	4	0	8	16
2	5. 7. 8. 6. 6. 7. 10.	9	4	5	3	1	3	24	49
3	8, 11, 9, 15, 12, 5, 7.	8	11	5	6	8	9	20	67
4	9. 4. 3. 8. 0. 3. 4.	2	3	7	5	1	2	11	31
5	1. 2. 4. 5 2. 3. 2.	—	1	3	1	2	1	11	19
6	5. 2. 3. 5. 2. 2. 3.	—	6	3	1	3	0	9	22
7	3. 1. 2. 3. 4. 2. 2.	—	4	1	5	1	2	4	17
8	1. 2. 1. 0. 3. 3. 0.	—	3	2	2	1	0	2	10
9	2. 2. 3. 4. 3. 2. 2.	—	3	6	2	2	1	4	18
10	1. 1. 1. 1. 2. 0. 1.	—	—	3	1	1	0	2	7
11	2. 4. 3. 3. 0. 0. 1.	—	—	4	1	1	1	6	13
12	3. 0. 0. 0. 3. 5. 1.	—	—	—	4	1	2	5	12
13	2. 1. 0. 1. 2. 0. 2.	—	—	—	1	0	2	5	8
14	1. 1. 0. 0. 0. 0. 2.	—	—	—	1	0	1	2	4
15–18	——	—	—	—	—	3	1	3	7
		21	36	40	33	29	25	116	300

This table shows that comparatively few of the children attended only the minimum period of 120 days. The actual number of such cases was 28 in all, made up of

11 babies whose first attendance was at an age of from 1–30 days.
9 „ „ „ „ „ 30–60 „
7 „ „ „ „ „ 60–90 „
1 baby „ „ „ „ 90–120 „

Twenty-one of these babies appear in the first column of column III which gives the numbers who attended up to the age of from 120–150 days, and seven babies in the other columns of column III.

TABLE II.

Showing the age of first attendance and of leaving the Consultation of the Babies of the boiled cows' Milk Series.

I. Age in weeks.	II. No. brought at each day.	III. Age on leaving (in months).							IV. Total in each week.
		4–5.	5–6.	6–7.	7–8.	8–9.	9–10.	10–12.	
1	2. 0. 0. 1. 2. 0. 2.	1	0	1	1	0	0	4	7
2	2. 1. 1. 1. 5. 7. 2.	0	1	4	2	0	3	9	19
3	6. 4. 3. 8. 2. 4. 2.	0	1	3	0	1	2	22	29
4	6. 2. 4. 4. 4. 4. 3.	3	3	2	1	3	1	14	27
5	1. 1. 3. 1. 4. 2. 4.	0	0	2	0	1	3	10	16
6	1. 2. 1. 2. 4. 1. 1.	3	0	2	3	0	1	3	12
7	1. 2. 2. 2. 2. 0. 5.	—	—	1	2	0	1	10	14
8	1. 3. 2. 3. 3. 2. 4.	—	—	—	2	0	2	14	18
9	2. 0. 3. 4. 2. 0. 2.	—	—	2	1	2	2	6	13
10	0 3. 2. 1. 1. 0. 2.	—	—	—	1	0	1	7	9
11	0. 3. 1. 1. 1. 0. 2.	—	—	1	2	2	1	2	8
12	0. 3. 1. 0. 0. 1. 1.	—	—	—	2	0	0	4	6
13	1. 2. 4. 0. 1. 1. 1.	—	—	1	1	2	1	5	10
14	1. 1. 1. 1. 1. 1. 0.	—	—	—	—	—	1	5	6
15–18	——	—	—	—	—	3	1	6	10
		7	6	19	18	13	20	121	204

Here still fewer children attended only the minimum number of days, but three attended a few days under the 120.

Including these three, in all nine babies attended the minimum time and these were as follows :—

4 babies whose first attendance was at an age of from 1–30 days.
3 " " " " 30–60 "
2 " " " " 60–90 "

Seven of these children appear in the first column of column III. where the numbers who attended up to the age of from 120–150 days are given.

These tables show that the great majority of children attended well over the minimum period of 120 days, or four months. All the children who attended up to from 8–9 months of age, must evidently have attended over four months.

On this basis adding together the figures in the last three columns of column III. it is seen that in the control or breast-fed series 170 children attended over four months. While in the other series or boiled milk series 154 babies attended over four months. This, however, does not give the full number, since in the other columns of column III. there are many children who had already attended many more than four months at the age of eight months.

Length of Breast-feeding.—In the control or breast-fed series of babies, all had been breast-fed for at least four months; about 10 of these children were having *allaitement mixte* part of this time, but as it is impossible to take every minor point into consideration this was ignored. Moreover this series was taken as a general control, and not as a purely breast-fed series.

Age of Weaning in Control Series.—In this series there were in

all 52 babies who were weaned between the ages of four and six months. The rest were weaned at about nine months of age.

Age of Weaning in the Series of Babies fed upon Boiled Cows' Milk.—In this series, out of 204 babies—

78 had never been breast-fed.
41 had been breast-fed for periods varying from 1–8 days.
15 had been breast-fed for periods varying from 9–14 days.
40 had been breast-fed for periods varying from two weeks to two months.
17 had been breast-fed for periods of over two months, but under four months.
13 had been breast-fed once or twice a day for a few weeks after birth, but otherwise had had only boiled cow's milk.

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Analysis of the Medical Notes upon the Health of the Babies which attended the Consultation.—Before proceeding to the results obtained from the material itself the health of the babies under review must be considered. It has already been stated that the minor ailments although noted upon the charts, have been ignored. But the notes upon the condition of the babies as regards rickets are of interest. These are of course only of use where the child attended up to from 9–10 months of age. There are a few notes as to rickets in the children under this age, but these will be neglected, and only the notes of the older children will be considered. Every baby who is still attending the consultation at the age of 12 months, is examined for rickets, and if no note is entered it means that no evidence of this trouble could be detected. (Dr. Ballin explained to me that this was the usual routine of the consultation.)

The remarks fall into several main headings, including teeth, no teeth, rickets, rickets with teeth, and rickets but stands.

Taking the babies who were still attending at the age of from 10–12 months, it is seen from the analysis of the cases just given that 116 babies of the control or breast-fed series, and 121 babies of the boiled milk series, were still attending at that age.

Only the remarks as to the presence of rickets need be considered, the other cases being taken as healthy. Tabulating the notes the following figures are obtained—

Number of children noted as showing

	In the control series.	In the boiled milk series.
No teeth ...	2	5
Rickets ...	7	15 and 1 ?
Rickets with teeth	16 and 2 ?	11 and 2 ?
Rickets but stands	5	5 ? rickets.
	30 and 2 ?	31 and 8 ?

If failure to cut a tooth by the age of 10 months be taken as a sign of rickets, then out of 116 babies of the first series there were 30 babies who showed definite evidence of rickets, and 2 where it was doubtful.

In the boiled milk series there were 31 out of 121 babies which had definite rickets, and 8 which were doubtful.

Whichever way the figures are taken they are too close to admit of any deductions as to any greater incidence of rickets as a result of feeding upon boiled milk as compared with breast-feeding. Nor are a series of 116 and 121 cases large enough for this purpose. All that can be said is that, as far as the figures of these particular cases go, there is no evidence of any greater frequency of rickets among the babies fed upon boiled cows' milk than in those fed upon the breast. The percentage of Berlin babies which are suffering from rickets is known to be high.

In this connection compare Escherich (p. 26).

Results obtained by working up the Material.—In working up the material which had been obtained from the Berlin consultation the first point was to add the weights of all the babies of each series at the same day of life, and then divide by the number of babies weighed, thus obtaining the average weight of the babies under consideration at the same day of life.

The average weights so obtained showed considerable inequalities, and the number of average weights thus obtained was unwieldy and cumbersome. It was therefore decided to take the unit of age as eight days, and to group together all the weights of the babies from 1–8, 9–16 days of age and so on up to 368 days of age.

The total weights of all the babies which were weighed in each eight-day period of life were divided by the total number of babies weighed. Thus the average weight of all the babies of each series for consecutive periods of eight days of life up to one year of age was obtained, the inequalities of the averages for each day being thus smoothed out and the number of average weights reduced to a convenient number for plotting on a curve.

No serious overlapping of weighings was produced by this method, since the babies were usually brought up at intervals of eight or ten days, so that it was only in exceptional cases that the weight of the same baby was recorded twice in any period of eight days.

Table III. shows the results obtained by thus working up the babies of the control or breast-fed series, and Table IV. the corresponding results for the babies of the boiled cows' milk series.

In these tables

Column I. shows the age in periods of eight days of the babies considered.

Column II. given the number of observations, *i.e.*, the number of babies which were weighed upon each of the consecutive days of each period of eight days; the figures being given in chronological order.

Column III. gives the total number of observations (weighings) in each period of eight days, as given in column I.

Column IV. gives the average weight of the babies of each series for each period of eight days corresponding to the period of column I.

NOTE.—As regards Column II., in collecting the weights of the babies the weights were worked up for each day separately up to 100 days of age, from 100–224 days of age they were worked up in two-day periods, and from 224–368 days the weights were worked up in four-day periods. This is shown in the tables.

The average weights found, and shown in Tables III. and IV. are plotted on Diagram I.

The total number of observations worked up for the cases in Series I. amount to 6,297 and for Series II. to 5,444.

TABLE III.

Showing the average weights of the babies of the control or breast-fed series, grouped in periods of eight days, and the number of observations made.

I. Age in days.	II. No. of observations on each day.	III. Total No.	IV. Average Weight.
			Grammes.
1–8	3. 2. 0. 4. 0. 4. 6. 5.	24	3,185
9–16	10 10 9. 11. 11. 12. 12. 22.	97	3,317
17–24	16. 21. 23. 19. 19. 20. 13. 13.	144	3,507
25–32	20. 24. 16. 19. 20. 19. 31. 18.	167	3,746
33–40	16. 19. 19. 27. 23. 25. 18. 15.	162	3,939
41–48	29. 18. 27. 19. 19. 24. 29. 27.	192	4,119
49–56	18. 19. 33. 25. 19. 18. 26. 17.	175	4,291
57–64	29. 29. 31. 24. 30. 29. 25. 27.	224	4,443
65–72	23. 20. 35. 27. 27. 25. 27. 35.	219	4,638
73–80	26. 24. 28. 19. 32. 34. 31. 21.	215	4,737
81–88	34. 40. 27. 29. 31. 25. 26. 26.	238	4,937
89–96	35. 22. 41. 32. 27. 30. 23. 22.	232	5,079
97–104	26. 27. 25. 33. 61. 52.	224	5,191
105–112	54. 58. 45. 60.	217	5,380
113–120	54. 54. 58. 50.	216	5,666
121–128	60. 57. 61. 53.	231	5,659
129–136	52. 61. 59. 55.	227	5,757
137–144	60. 48. 56. 56.	220	5,929
145–152	47. 50. 51. 43.	191	6,033
153–160	47. 56. 45. 43.	191	6,237
161–168	50. 50. 45. 39.	184	6,274
169–176	47. 47. 48. 40.	182	6,312
177–184	41. 41. 46. 43.	171	6,434
185–192	41. 32. 27. 47.	147	6,458
193–200	32. 28. 41. 27.	128	6,664
201–208	32. 37. 29. 35.	133	6,709
209–216	31. 31. 30. 28.	120	6,734
217–224	32. 37. 35. 32.	136	6,798
225–232	54. 56.	110	6,778
233–240	55. 54.	109	6,886
241–248	58. 42.	100	6,891
249–256	42. 47.	89	7,118
257–264	38. 40.	78	7,276
265–272	46. 40.	86	7,217
273–280	43. 38.	81	7,388
281–288	36. 41.	77	7,281
289–296	28. 35.	63	7,608
297–304	34. 38.	72	7,567
305–312	36. 32.	68	7,801
313–320	22. 36.	58	7,555
321–328	32. 26.	58	7,753
329–336	37. 20.	57	7,704
337–344	26. 22.	48	7,752
345–352	21. 22.	43	8,034
353–360	22. 15	37	8,077
361–368	19. 15.	34	8,274

TABLE IV.

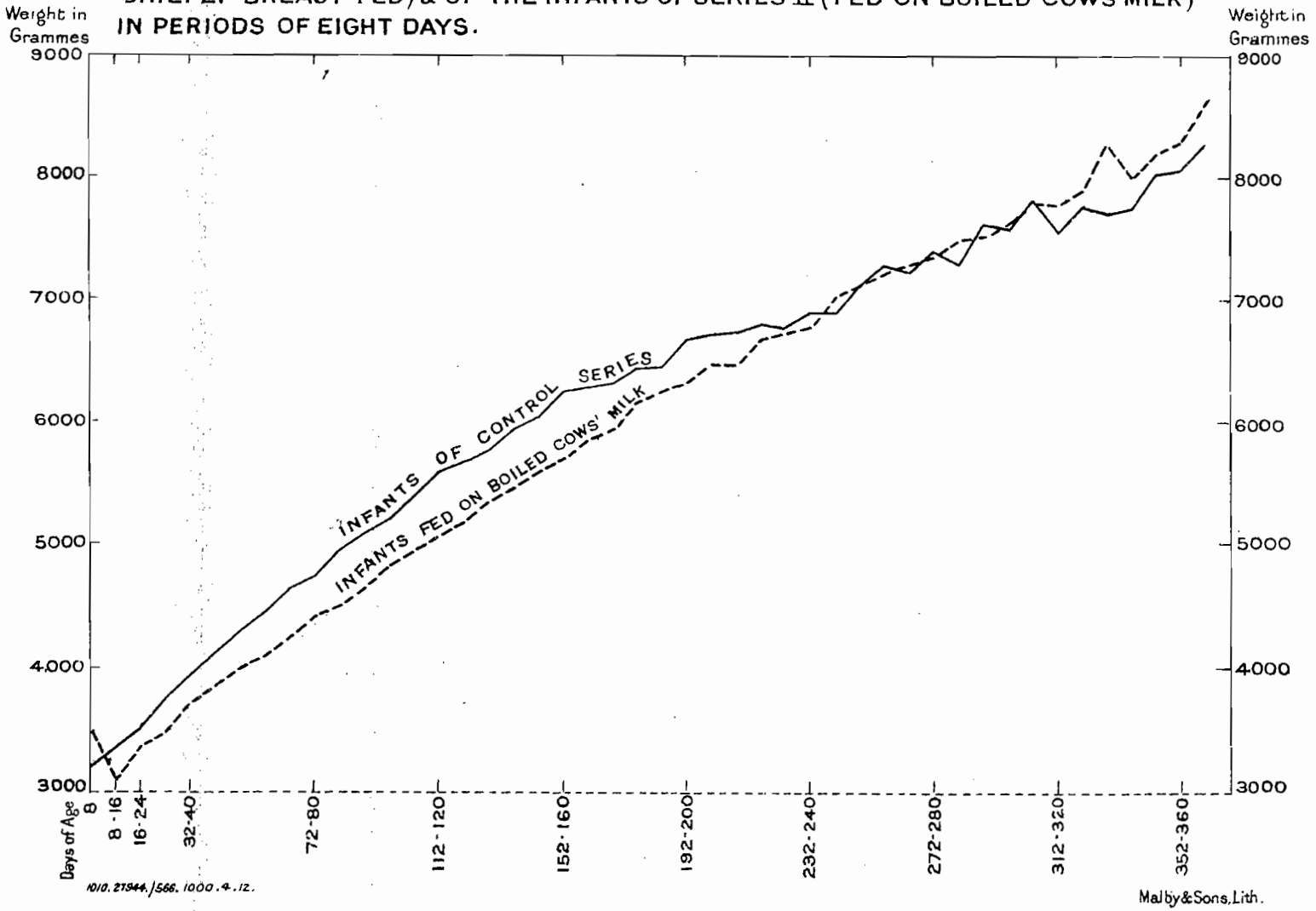
showing the average weights of the babies of the boiled cows' milk series, grouped in periods of eight days, and the number of observations made.

I. Age in days.	II. No. of observations on each day.	III. Total No.	IV. Average weights.
			Grammes.
1–8	2. 0. 0. 1. 2. 0. 3. 2.	10	3515
9–16	2. 3. 2. 6. 7. 5. 9. 6.	40	3090
17–24	7. 11. 6. 15. 11. 13. 4. 9.	76	3358
25–32	15. 17. 15. 14. 14. 13. 11. 14.	113	3472
33–40	15. 14. 15. 14. 17. 17. 15. 18.	125	3708
41–48	12. 13. 21. 13. 17. 15. 23. 17.	131	3848
49–56	15. 23. 16. 16. 17. 21. 17. 18.	143	3991
57–64	23. 14. 26. 21. 18. 12. 19. 19.	152	4082
65–72	21. 20. 21. 20. 15. 23. 15. 20.	155	4240
73–80	22. 20. 24 20. 20. 22. 22. 9.	159	4407
81–88	25. 16. 26. 31. 20 24. 26. 28.	196	4486
89–96	18. 13. 34. 16. 26. 21. 32. 25.	185	4628
97–104	15. 22. 30. 10. 55. 30.	162	4814
105–112	47. 49. 39. 38.	173	4935
113–120	46. 46. 44. 42.	178	5052
121–128	41. 53. 40. 45.	179	5171
129–136	46. 38. 46. 41.	171	5326
137–144	41. 45. 43. 35.	164	5436
145–152	40. 40. 41. 41.	162	5569
153–160	47. 40. 37. 36.	160	5669
161–168	36. 45. 40. 27.	148	5831
169–176	45. 41. 39. 39.	164	5915
177–184	29. 38. 41. 36.	144	6146
185–192	33. 33. 37. 37.	140	6242
193–200	36. 37. 34. 31.	138	6319
201–208	67. 62.	129	6475
209–216	77. 53.	130	6467
217–224	68. 65.	133	6677
225–232	66. 67.	133	6721
233–240	52. 59.	111	6770
241–248	62. 52.	114	7010
249–256	53. 70,	123	7112
257–264	37. 57.	94	7204
265–272	53. 41.	94	7274
273–280	39. 41.	95	7347
281–288	48. 43.	91	7481
289–296	37. 48.	85	7512
297–304	40. 39.	79	7610
305–312	42. 42.	84	7788
313–320	28. 34.	62	7765
321–328	40. 27.	67	7887
329–336	36 28.	64	8281
337–344	28. 31.	59	7985
345–352	20. 23.	43	8194
353–360	27. 21.	48	8281
361–368	25. 13.	38	8613

Analysis of the curves of Diagram I.—Diagram I. shows at once that a considerable divergence between the two curves starts in the early days of life, and continues well-marked up to about the 208th day, after which it disappears fairly rapidly. The question

DIAGRAM 1.

SHOWING THE AVERAGE WEIGHTS OF THE INFANTS OF SERIES I (CONTROL SERIES, CHIEFLY BREAST-FED) & OF THE INFANTS OF SERIES II (FED ON BOILED COWS' MILK) IN PERIODS OF EIGHT DAYS.



1010. 27944./566. 1000.4.12.

Malby & Sons, Lith.

suggested by these curves is,—Is the difference between the average weight of breast-fed and of babies of the same age fed upon boiled cows' milk due to the method of feeding?

Diagram I. would seem to have answered this question affirmatively. Before, however, stating this definitely to be the case, it is advisable to consider whether some other factor may not be concerned, to which this difference can be attributed.

Such a factor might be the error due to the so-called "Error of Sampling." If this error is significant, then the curves may have a different interpretation to the apparently obvious one, and it therefore becomes essential to examine the importance of this factor, before proceeding to draw deductions from the curves as they stand in Diagram I.

*Analysis of the Data by Statistical Methods.**—In dealing with the error of sampling the important point will evidently be to ascertain how much the mean value obtained from the observations as shown on the curves is likely to differ from the mean of all babies in the same class, that is to say what is the probable error of the mean.

Suppose M_1 and M_2 are the means of the two sets of observations, then the accuracy of each must evidently depend upon

(*a*) The number of observations upon which it is based, and

(*b*) The divergence of these observations from their mean value.

In statistical work the expression $\cdot 67449 \frac{s}{\sqrt{N}}$ is taken to represent the probable error, where $s =$ the square-root of the average of the squares of the distances of the observations from the mean, and is known as the "Standard Deviation," and where $N =$ the number of observations. (Cp. Yule. Introduction to the Theory of Statistics. Chaps. VII. and XVII.)

The measures of reliability or the "probable errors" for the two means will be $\cdot 67449 \frac{s_1}{\sqrt{N_1}}$ and $\cdot 67449 \frac{s_2}{\sqrt{N_2}}$ respectively. These expressions may be called E_1 and E_2.

Experience has shown that unless the difference between M_1 and M_2 is at least two or three times as great as $\sqrt{E_1^2 + E_2^2}$ then it is not safe to assert that the difference found is really significant; it might be due to an error of sampling.

This method is only strictly speaking applicable when the variables, *i.e.*, the observations are "normally" distributed (vide Yule, op. cit. Chap X.) but it may fairly be used as a sufficiently accurate test for material such as the present.

This test of the error of sampling has been applied over three periods of eight days, in each of the series. The three periods selected were the three consecutive periods included from the 137th to the 160th day after birth. These periods were selected as being those where there were a large number of observations in both series, and where the numbers of each series were most nearly equal.

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* For instruction in the statistical methods employed and for supervision of the results obtained I am deeply indebted to Dr. Major Greenwood, Junr., of the Lister Institute, and have much pleasure in thanking him for his most valuable help.

The unit of grouping taken was 200 grammes, and the results obtained are given in the accompanying table.

Days of age.	Mean weight (in grammes).		Difference $M_1 \sim M_2$ (in grammes).	Probable error.		Value of $\sqrt{E_1^2+E_2^2}$.	Ratio of $\frac{M_1 \sim M_2}{\sqrt{E_1^2+E_2^2}}$
	Series I.	Series II.		Series I.	Series II.		
137–144	5,929	5,436	495	44·98	44·59	63·6	7·8
145–152	6,033	5,569	455	43·84	41·20	60·1	7·6
153–160	6,237	5,669	548	48·25	44·00	65·1	8 4

The mean of these observations bears therefore such a ratio to the value of $\sqrt{E_1^2+E_2^2}$ as to show clearly that the difference between the mean values of the two series can hardly be due to an error of sampling.

It appears that there is a difference between the values obtained for the series of babies fed upon the breast and for those fed upon boiled cows' milk, and that this difference can hardly be attributed to errors of sampling. It does not, however, necessarily follow that the difference of food has been the causative factor, and it becomes necessary to ask whether there can be any other factor at work which is producing the difference found.

The question of the health of the children need not be taken into consideration since the children were all, as far as it was possible to judge from the careful medical notes, in a good state of health.

The social class of the children seemed a possible factor, and in spite of the fact that the parents of the children all belonged approximately to the same social class, it was considered advisable to investigate the possible significance of any difference which existed between the social conditions of the homes.

Nothing very striking in this direction could be expected at the outset, since in no case was the family in circumstances of more than moderate comfort, such persons not being encouraged to attend the consultation, and only being received in quite exceptional cases. On the other hand no infant was allowed to suffer from any deficiency of food, since in cases of poverty the milk for the infant is supplied free by the town. Hence the question of possible relative starvation does not come in at all.

In order to arrive at the significance, if any, of the social conditions upon the observed difference in the weight of the two series of babies, it was necessary to investigate the relation between the weight of the infant, the wages of the father, and the method of feeding.

For this purpose the weights of the babies of both series at the age of 137–144 days of life were taken. Illegitimate infants and those of families who were living upon the wages of the mother, were omitted, as not being entirely comparable. 345 observations were available for this purpose.

The correlations between the three variables taken in pairs were found to be—

*(1) For artificial feeding and wages, ·16.

*(2) For artificial feeding and weight of child, — ·28.

†(3) For weight of child and wages of father, — ·02.

The correlation between weight of the child and the method of feeding was determined, the wages of the father being kept constant, (coefficient of partial correlation, *vide* Yule, *op. cit.*, pp. 225–249) and the figure obtained was — ·29 ± ·03, and the correlation between wages of parents and weight of the infant, keeping the feeding constant, is — ·026 ± ·036.

It would appear therefore that the weight of the child is more closely associated with the nature of the food than with the social class, as indicated by the wages of the father.

It must, however, again be emphasised that we are here dealing with a class of persons who are by no means a random sample of the population, but are almost a selected social class. A table of the wages of the parents as found to be distributed in making out the correlation of the feeding in relation to the wages is given below (see Table VI) ; it might appear at first sight that this table shows a considerable range of distribution since the wages show a variation of from 10–42 marks a week. A further examination will show that the great majority of the fathers were earning from 20–30 marks a week, that is to say, they were earning the average artisan wage, and the cases taken belong as a whole to a definite class of the population ; it would be hardly possible to confine the cases to a smaller range of wages than 20–30 marks a week. The cases falling below this figure are rendered more equal than appears from the table by the fact that no baby is allowed to have a deficient food-supply, since if it is artificially-fed the milk is supplied free if the family cannot afford to pay for it, and the nursing mothers receive a nursing bonus, and if necessary may receive a further subsidy.

The question of environment may have some influence in this connection since presumably a family earning 15 marks a week will not live in such sanitary rooms as one earning 30 marks, but this is again partly mitigated by the regular visits of the health visitor, who endeavours to procure fresh air and cleanliness for the child.

Hence these figures, although of interest, cannot be used for more general deductions as to the relation of the weight, wages, and method of feeding of the infant population as a whole. It is fairly certain that, inasmuch as few of the more prosperous artisans attend the consultation the correlation between weight of infant and wages is less than would have been found in the general population. Even, however, assuming that the infants attending the consultation belonged to much more widely distributed social strata, it is unlikely that the correlation would be raised to any value approaching that

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* Determined by the method of Pearson ([53]) (in Biometrika VII., 1909, p. 96).

† Determined by the ordinary product-moment method. (Cp. Yule ([68]), *op. cit.*, Chap. IX.)

The −ve sign indicates that body-weight decreases as the proportion of artificially-fed babies increases.

found for the correlation between the method of feeding and the body-weight. Moreover this last correlation would probably be higher in the general population.

The distribution of the weight in relation to the food of the infants under consideration is given in Table V and shows that the maximum of the weight-frequency occurs at a lower level of weight in the boiled cows' milk series than in the breast milk series. Table VI gives the distribution of the feeding in relation to wages.

In both Tables V and VI there are only 345 observations in a total number of 504 children owing almost entirely to the fact that a number of the children did not happen to come up for weighing at the age of life which was taken, namely, from 137–144th day of life. Only a very few children were omitted because of illegitimacy or because the mother was the wage-earner of the family.

Table V.

Showing the distribution of the Observations on the Weight of Infants in relation to their Food at the 137–144*th day of life.*

Weight of Infants in grammes.	Number of Infants having such a weight		
	In breast milk series.	In boiled milk series.	Total.
3000–3200	1·0	·5	1·5
3200–3400	1·0	·5	1 5
3400–3600	0	0	0
3600–3800	4·0	2·5	6·5
3800–4000	3·0	3·5	6·5
4000–4200	6·0	3·5	9·5
4200–4400	3·0	6·0	9·0
4400–4600	2·0	4·0	6·0
4600–4800	6·5	8·5	15·0
4800–5000	8·0	9·5	17·5
5000–5200	10·0	11·0	21·0
5200–5400	10·0	10 5	20·5
5400–5600	13 5	10·5	24·0
5600–5800	14·0	17·5	31·5
5800–6000	16·5	16·0	32·5
6000–6200	19 0	15·5	34·5
6200–6400	20·5	4·5	25·0
6400–6600	11·0	7·0	18·0
6600–6800	18·0	3·0	21·0
6800–7000	10·0	4·0	14 0
7000–7200	13·5	·5	14·0
7200–7400	6·5	·5	7·0
7400–7600	—	·5	·5
7600–7800	3·0	·5	3·5
7800–8000	2·5	—	2·5
8000–8200	·5	—	·5
8200–8400	1·5	—	1·5
8400–8600	·5	—	·5
	205·0	140·0	345·0

TABLE VI.

Showing the distribution of the Observations on the Feeding of the Infants in relation to the Wages.

Weekly Wages of Father in Marks.	Number of Fathers earning such weekly wage		
	In breast milk series.	In boiled milk series.	Total.
10	1·0	·5	1·5
11	4·0	2·5	6·5
12	0·0	0·0	0·0
13	·5	·5	1·0
14	·5	·5	1·0
15	3·0	0·0	3·0
16	·5	·5	1·0
17	2·0	1·0	3·0
18	2·5	2·5	5·0
19	7·0	2·0	9·0
20	22·5	13·0	35·5
21	20·5	7·0	27·0
22	31·0	15·5	46·5
23	28·0	12·5	40·5
24	17·0	14·0	31·0
25	20·5	19·5	40·0
26	8·0	5·0	13·0
27	11·0	12·0	23·0
28	9·5	9·5	19·0
29	1·5	5·0	6·5
30	10·0	13·0	23·0
31	2·0	0·0	2·0
32	·5	0·0	·5
33	·5	1·0	1·5
34	—	—	0·0
35	—	2·0	2·0
40	1·0	1·0	2·0
42	1·0	—	1·0
	205·0	140·0	345·0

The following inferences may be drawn as to the divergence of the two curves in Diagram I up to the 208th day :—

(1) There is a significant difference between the average weight of infants fed upon the breast and upon boiled cows' milk, in favour of the former ; and

(2) An important factor in this result is the method of feeding.

The curves of Diagram I may be divided into three parts, namely :—

(1) The first part where the curves cross and then diverge ; the curve of the boiled milk series, which starts above the curve of the breast-fed series, falling rapidly below this latter curve.

(2) The second part of the curves where the two curves run approximately parallel from about the 24th to the 200th day of life, and

(3) The last part of the curves where the divergence is obliterated, the subsequent tendency being for the curve of the boiled cows' milk series to show a value a little above that of the breast-fed series.

From the preceding statistical analysis it appears that the divergence of the *middle part* of the curve is to be attributed essentially to the difference in the method of feeding of the two series.

The first and third parts of the curves remain for consideration and will now be dealt with, the first part being taken first.

Further Analysis of the First Part of the Curves of Diagram I.—At no part of the curves is the tendency to diverge so markedly shown as in the first part of the curves, during a period extending over the first three of the eight-day periods of life. The average weight of the breast-fed babies shows a rise from the first, while that of the babies fed upon boiled cows' milk falls throughout the two first eight-day periods, and shows no rise above the first eight-day period until the 33–40th days of life.

It is a matter of common knowledge that every baby loses weight during the first few days of life, and a drop in the average weight of the breast-fed babies in the second eight-day period was almost to be expected. This possible fall in the curve is concealed to some extent by the grouping of the weights into periods of eight days, the first period including the period of fall in weight. In many of these cases the observations would commence at a time when the loss of weight after birth had already taken place, and the child was again beginning to increase in weight. The absence of fall in the curve of the breast-fed babies can therefore be explained.

When a comparison is made between the two curves, it appears that while one curve rises the other falls, and evidently there is either some fundamental factor or factors at work producing this difference, or some source of error has crept into one or both of the curves.

It was considered desirable first to eliminate any possible source of error. The same source of error as was sought for in the middle part of the curves may evidently be at work in this part of the curves, namely, the error of sampling, and this was therefore investigated.

Statistical Examination of the Average Weights obtained in the first four periods of Eight Days.

The same method and notation as were used in dealing with the middle part of the curves was applied, viz. :—

N=Number of observations.

s = Standard deviation.

E=Probable error, and is represented by the expression

$$.67449 \frac{s}{\sqrt{N}}$$

M_1 and M_2 are the means of the two series, their difference being "D."

By this method the following values were obtained and are tabulated below :—

—	Days of Age.	Mean (in grammes).	Standard Deviation.	Probable Error.	$\sqrt{E_1^2+E_2^2}$	$\frac{D}{\sqrt{E_1^2+E_2^2}}$
Series I ...	1–8	3,185	622	85·8		
		D=330			122·0	2·7
Series II ...	1–8	3,515	410	87·4		
Series I ...	9–16	3,312	544	37·3		
		D=222			60·5	3·7
Series II ...	9–16	3,090	452	48·3		
Series I ...	17–24	3,512	632	35·4		
		D=145			49·5	2·92
Series II ...	17–24	3,367	460	35·7		
Series I ...	25–32	3,745	652	34·1		
		D=272			47·5	5·7
Series II ...	25–32	3,473	522	33·1		

The average weight of the babies fed upon boiled cows' milk is higher for the first eight-day period than that of the breast-fed babies. The former value is based upon 10 observations, and the latter upon 24 ; it becomes a question whether any importance can be attributed to this difference in average weight or whether it may not be due to an error introduced by the extremely small number of observations available for the boiled cows' milk series.

Ten observations are not sufficient for the formula given in the above table of results to be justifiably employed, since the reliability of the method is exaggerated when the number of observations is very small.

The method introduced by " Student " ([61]) is applicable for small number of observations. It is based upon the probability of the occurrence of the mean value obtained by the ordinary method among the average population.

Taking $3185 \pm 85{\cdot}8$ (the " probable error " of 3185 is 85·8) grammes as the mean weight of babies in the average population it appears that the chance of 10 observations from such a population having a mean of 3515 grammes with a standard deviation of 410 is 1 in 50. Suppose, however, that the mean weight of the average baby in the population were 3357 grammes, it is then found that the probability that a population with a mean weight of the babies of this age of 3357 grammes (3185 + twice the probable error, *i.e.*, 172) should give in 10 observations a mean of 3515 is 1 in 7. It may be remarked that so far as the evidence goes, there is about 1 chance in 10 that the mean weight of the controls is not less than 3359.

It seems therefore that the difference between the weights of the two series for the first eight-day period, might be considered as due to an error of sampling brought about by the extremely small number of observations available for the series of babies fed upon boiled cows' milk. It may be taken that the babies of both series whose weights were observed during this period of life can be considered as average samples of the population, the influence of

other factors, if present, which would tend to cause a divergence of the two series, being inappreciable compared with that caused by the error of sampling.

The figures of the later periods, are based upon sufficiently large number of observations for the ordinary method to be reliable.

The tabulated results show that the ratio of the difference of the means to the measure of the sum or difference of the probable errors ($\sqrt{E_1^2 + E_2^2}$) is in all cases greater than 2, and hence the difference in weight of the two series, may fairly be attributed to some factor other than the error of sampling.

A source of error might arise in respect of the distribution of the variables.

In applying the usual method, it is assumed that these are "normally" distributed; inspection of the distribution of the individual weights suggests that this condition is not accurately fulfilled, and the process is not then strictly reliable ([34]).

The figures, however, approximate sufficiently to the normal type for it to be unlikely that an appreciable error is introduced in basing the results obtained upon the application of this formula.

Some factor other than the error of sampling must therefore be sought for.

The possible influence of the social conditions has already been dealt with fully in a previous section of this report (see pp. 41, 42) in connection with the middle part of the curves, and it has been shown that in this part of the population, which is to a great extent a selected population, this is a negligible factor. It need not therefore be raised again.

The main factor for consideration will evidently be that of the feeding and it seems not unreasonable to suppose that the loss in weight which occurs in all children is on the average more prolonged in babies fed upon boiled cows' milk, than in babies fed upon the breast.

Birk ([5]), in some experiments carried out upon the metabolism of infants in the first days of life, found that the breast-fed babies he investigated had regained their birth-weight in 4 or 5 days after birth. And it appears probable from the data given above in Table III. that the average breast-fed baby regains its birth-weight at any rate within a period of eight days, since there is a marked rise in average weight during the second eight-day period.

Birk found that although an infant may show absolute loss of weight during the first few days of life, yet it is retaining nitrogen, and in the cases studied by him, at the time the child regained its birth-weight, namely at the fifth day, there was a positive nitrogen balance of 951·3 milligrammes.

This, however, only occurred with breast-fed babies who were given colostrum.

A child fed upon the milk of a wet-nurse who was in a later stage of lactation, and had no longer any colostrum, showed a negative nitrogen balance. It may well be that the colostrum is of great importance in the metabolism of infants during the first days of life. Colostrum is very rich in nitrogen, and according to Pröscher ([57]) the nitrogen content of the milk has an important relationship to the rate of growth of the young animal of many species. Griffith and Gittings ([35]) found that the loss of weight after birth could be prevented, by giving the child to a wet-nurse during the first day or two, but that after a few weeks no difference could be detected between the infant whose loss of weight had been prevented, and one whose loss of weight had been allowed to occur.

The physiological loss of weight which occurs after birth appears to be greatly accentuated in the case of children fed upon boiled cows' milk, and it seems possible that the absence of colostrum is an important factor in its causation, in addition to the disadvantage arising from the use of the milk of another species.

No data appear to be available in regard to babies fed upon the colostrum of cows, either boiled or raw; nor any upon infants fed upon raw cows' milk either in comparison with breast feeding or with boiled cows' milk.

There are a fair number of data in regard to the causation of the loss of weight in breast-fed babies, but this is scarcely within the scope of the present report.

The difference between the curves of the two series is in all probability very intimately connected with, if not entirely due to the method of feeding, and points to the great importance of breast-feeding for infants, especially in the early days of life: this is also in entire accord with the clinical experience and has been forcibly voiced by Czerny ([20]) and many others.

Analysis of the latter parts of the curves.—The difference between the average weights of the two series begins to decrease at about the 180th day of life, and then disappears fairly rapidly, until at about the 230th day it is no longer present. From this age onward no difference between the two curves can be detected, except possibly in favour of the boiled milk series towards the end of the first year.

If Tables III. and IV. be referred to it will be seen that the number of observations is becoming smaller, and that therefore the reliability is somewhat lessened; the numbers are however still sufficiently large for further statistical investigation to be unnecessary.

A considerable number of the healthy babies of the breast-fed series, which had been weaned at about the age of nine months, ceased attending before the end of the first year, and there is almost certainly a tendency for the less robust breast-fed babies to predominate, in this series. The babies fed upon boiled cows' milk tend on the whole to be brought up to the consultation to a somewhat later age, partly no doubt because the mother having got accustomed to getting the milk through the consultation, and knowing it to be reliable, prefers to continue getting the milk in this

manner, and partly also because, if she is poor, she gets the milk at a reduced rate.

It was stated (on p. 35) that of the 300 babies of the breast-fed series, 52 were weaned between the ages of four and six months, so that a not inappreciable number of the babies of Series I. were actually receiving the same food as the babies of the other series, during the period from the 180th day onwards.

It is not improbable also, that many of the mothers who were still feeding their infants during the period of from 6–9 months, were not giving such a free supply of milk for the infant as at an earlier period of the baby's life. It might well be that the infant was receiving sufficient milk for the needs of the organism, but not as much as was required for an optimum rate of growth, and might not be obtaining as rich a food-supply as the babies of the boiled cows' milk series, who were receiving a carefully regulated quantity of food material.

It appears from the work of Schlossmann ([59]), Budin ([12]), and Finkelstein ([30]) that many wet-nurses are capable of giving large quantities of milk over prolonged periods, amounting in some cases to 10–13 months. This is, however, not universal. There is the additional consideration that the wet-nurses are presumably in much more favorable circumstances in the regular life and food of an institution, than the mothers of the average artisan family.

In Schlossmann's cases it was found that the quantity of milk given by a woman who was considered an excellent wet-nurse, and was under very favorable circumstances increased up to about the 60–70th day of lactation, and then maintained a fairly constant and high level, up to about the 200–210th day of lactation, after which it became irregular in quantity and tended to decrease. He observed the same also in a second case.

Budin and Finkelstein's cases show a longer period of full lactation in most of the wet-nurses.

Bunge ([14]) states that the period of lactation in women is gradually becoming shorter. Without entering into this much discussed question, it may be mentioned that the age of weaning is now considerably younger than it was some time ago, before the introduction of artificial feeding. (Cp. Introduction to this report p. 2.) It may be that the optimum length of breast-feeding in the human species is the same as it always was, but that children were formerly kept upon the breast for a period exceeding the physiological period, and a high degree of under-feeding may have been the result ; the extremely high rate of mortality among young children in the middle ages and later, may have had some connection with an unduly prolonged lactation.

In this connection Silbergleit ([60]) has recently shown that among the population of Berlin as a whole, the percentage of breast-fed infants has decreased during the ten years from 1895 to 1905, and

that the percentage of bottle-fed infants has increased disproportionately for the later months of infancy. In other cases the duration of breast-feeding is becoming shorter among the population of Berlin as a whole.

It does not seem necessary to seek any further for reasons as to the causes of the disappearance of the difference between the average weights of the two series.

Under the conditions such as obtained in the consultation from whose records the observations dealt with in this report have been compiled, it seems that after the age of six to eight months no appreciable difference in weight between the breast-fed babies and babies fed upon boiled cow's milk can be detected.

It is impossible to say how far this would hold for the population at large, since as soon as the babies come under observation in the matter of weight, they likewise come under medical care and attention ; there can however be very little doubt, that this favorable result is due in a great measure to the medical care and knowledge which is available for the babies attending the Consultation.

If the average weights of the babies of both series are compared with the corresponding figures given by Camerer ([17]), it appears briefly that, neglecting the weight at birth, the rate of growth of Berlin babies given in this report is rather less than that given by Camerer. As a whole, the initial weights are higher and the final weight at the end of the first year, lower.

Compared with the figures of Finkelstein (Waisensäuglinge, p. 9) who has compared his figures with those of Camerer, it seems that the figures given in this report are intermediate in value between the average values obtained by Camerer and Finkelstein. Owing to the differences between the quantity and quality of the material used in the different sets of observations it would not be profitable to carry the comparison any further.

The percentage rate of growth of babies of both series.—It seemed desirable to study the rate of growth of the babies of the two series dealt with in this report.

This was done in the following ways :—

(1) By estimating the percentage increase per kilo. of body-weight during each period of eight days, each series being taken separately.

(2) The rate at which growth took place as measured by the time required by the babies of each series for the doubling of the initial average weight, the values of the first eight-day period being omitted on account of the small number of observations available in the series of babies fed upon boiled cows' milk.

(3) By estimating the percentage deficit of the average weight of babies fed upon boiled cows' milk as compared with the weights of the breast-fed babies. The weights of the breast-fed babies being taken as 100.

The results of the first method are given in Table VII. and are plotted in Diagram II. Both series show an extreme irregularity in the rate at which the weight increases, but after the first two estimations it would be difficult to point out any marked difference between the values of the two series.

TABLE VII.

Showing percentage rate of increase for each period of eight days, of the babies of both series, up to the age of eight months.

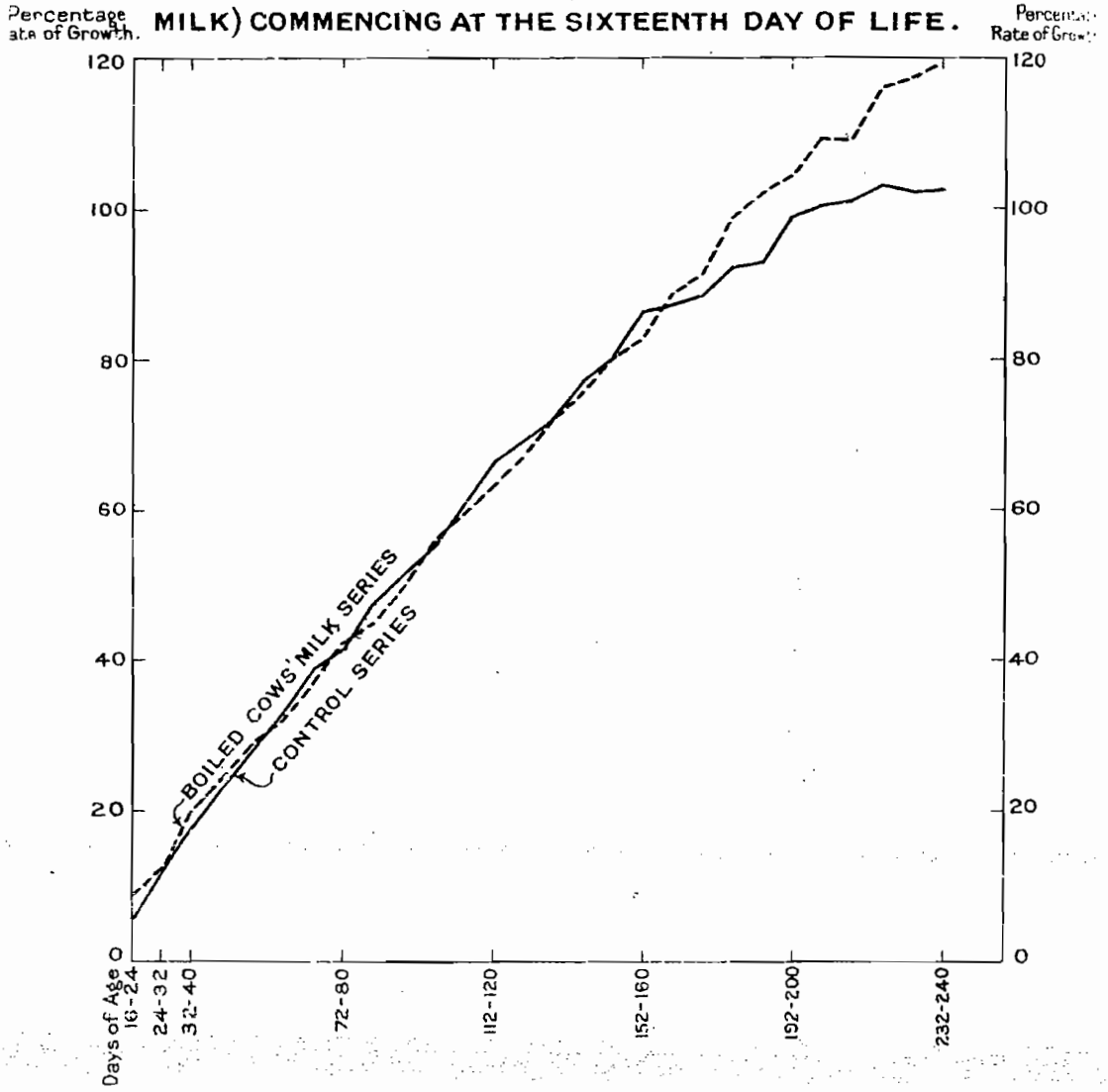
Age in days.	Breast-fed Series.			Boiled Cows' Milk Series.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
1–8	3185	—	—	3515	—	—
9–16	3348	163	5·1	3090	—425	—12·0
17–24	3507	159	4·7	3358	268	8·7
25–32	3746	239	6·8	3472	114	3·4
33–40	3939	193	5·1	3708	236	6·8
41–48	4119	180	4·6	3848	140	3·8
49–56	4291	172	4·2	3991	143	4·1
57–64	4443	152	3·5	4082	91	2·9
65–72	4638	195	4·4	4240	158	3·9
73–80	4737	99	2·1	4407	167	3·9
81–88	4937	200	4·2	4486	79	1·8
89–96	5079	142	4·9	4628	142	3·2
97–104	5191	112	2·2	4814	186	4·0
105–112	5380	189	3·6	4935	121	2·5
113–120	5566	183	3·6	5052	117	2·8
121–128	5659	93	1·7	5171	119	2·4
129–136	5757	98	1·7	5326	155	3·0
137–144	5929	172	3·0	5436	110	2·0
145 152	6033	104	1·8	5569	133	2·4
153–160	6237	204	3·4	5669	100	1·8
161–168	6274	37	·6	5831	162	2·9
169-176	6312	38	·6	5915	84	1·4
177–184	6434	122	1·9	6146	231	3·9
185–192	6458	24	·4	6242	96	1·6
193–200	6664	206	3·2	6319	77	1·2
201–208	6709	45	·7	6475	156	2·5
209–216	6734	25	·4	6467	— 8	— ·1
217–224	6798	64	1·0	6677	210	3·2
225–232	6778	— 20	— ·3	6721	44	·7
232–240	6886	108	1·6	6770	49	·7

After this age the increase becomes very variable.

The results of the second method are shown in Table VIII. and are plotted on Diagram III., which shows that as regards rate of growth there is little to choose between the two series. The babies fed upon boiled cow's milk doubled their weight at the 185–192nd

DIAGRAM III.

SHOWING THE PERCENTAGE RATE OF GROWTH OF THE INFANTS OF BOTH SERIES (CONTROL & BOILED COWS' MILK) COMMENCING AT THE SIXTEENTH DAY OF LIFE.



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day, or a fortnight earlier than the breast-fed babies, but they started with an initially lower weight, since the first value was omitted, on account of the small number of observations.

Table VIII.

Showing the percentage rate of Growth of the Babies of both series starting from the second eight-day Period of Life. Control series being the Breast-fed Babies and the other series being Babies which were fed upon Boiled Cows' Milk.

Age in days.	Control Series.			Boiled Milk Series.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
8–16	3348	—	—	3090	—	—
17–24	3507	159	4·7	3358	268	8·6
25–32	3746	398	11·8	3472	382	12·3
33–40	3939	591	17·6	3708	618	20 0
41–48	4119	771	23·0	3848	758	24·5
49–56	4291	943	28·1	3991	901	29·1
57–64	4443	1095	32·7	4082	992	32·1
65–72	4638	1290	38·5	4240	1150	37·2
73–80	4737	1389	41·4	4407	1317	42·6
81–88	4937	1589	47·4	4486	1396	45·1
89–96	5079	1731	51·7	4628	1538	49 7
97–104	5191	1843	55·0	4814	1724	55·7
105–112	5380	2032	60·6	4935	1845	59·7
113–120	5566	2218	66·2	5052	1962	63·4
121–128	5659	2311	69·0	5171	2081	67·3
129–136	5757	2409	71·9	5326	2236	72·3
137–144	5929	2581	77·0	5436	2346	75·9
145–152	6033	2685	80·1	5569	2479	80·2
153–160	6237	2889	86·2	5669	2579	83·4
161–168	6274	2926	87·3	5831	2741	88·7
169–176	6312	2964	88·5	5915	2825	91·4
177–184	6434	3086	92·1	6146	3056	98·8
185–192	6458	3110	92·8	6242	3152	102·0
193–200	6664	3316	99·0	6319	3229	104·4
201–208	6709	3361	100·3	6475	3385	109·5
209–216	6734	3386	101·1	6467	3377	109·2
217–224	6798	3450	103·0	6677	3587	116·0
225–232	6778	3430	102·4	6721	3631	117·5
233–240	6886	3538	102·6	6770	3680	119·0

The third method, giving the percentage deficit of the average weights of the babies fed upon boiled cows' milk as compared with the breast-fed babies, shows that at no period of life does the deficit exceed 10 per cent., and that during the greater part of the period under observation the deficit is much less (see Table IX.).

It is probable that this favourable result is largely due to the fact that these babies were attending the consultation, and were therefore under favorable conditions. It is a more favorable result than the majority of the results that have been obtained in the feeding

experiments upon animals who received the milk of a foreign species. The results of clinical experience and the evidence given in Parts II. and III. of this report, render it doubtful whether this result could be surpassed by feeding babies upon raw cows' milk.

Table IX.

Showing the percentage relationship between the average weights of the babies of the two series.

Series I. consisting of breast-fed babies, and Series II. consisting of babies fed upon boiled cows' milk.

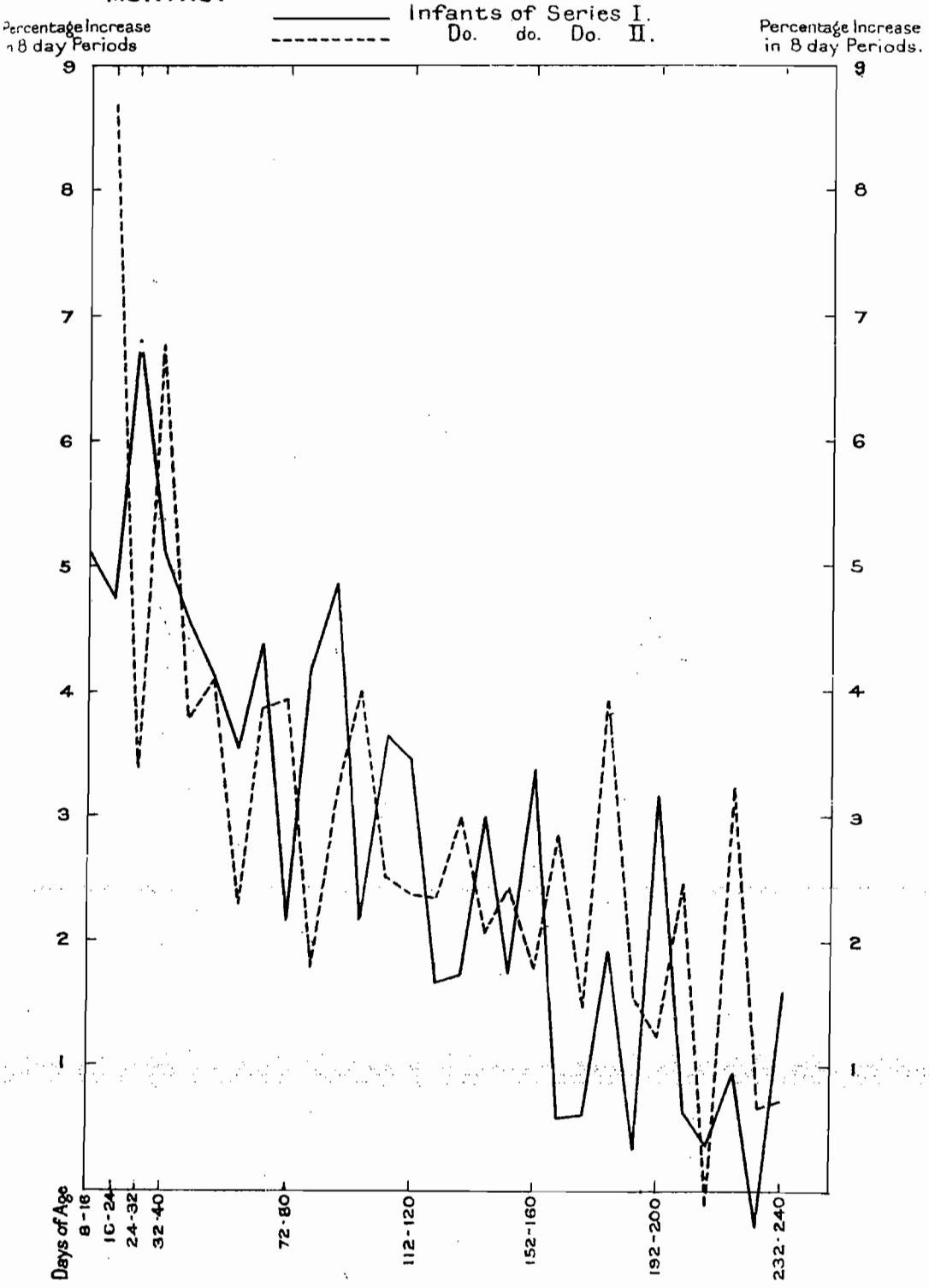
Age in days.	Average weight in grammes.		Difference (in grammes).	Percentage value of Series II to Series I.
	Series I.	Series II.		
1–8	3,185	3,515	—330	110·3
9–16	3,348	3,090	258	92·2
17–24	3,507	3,358	149	95·7
25–32	3,746	3,472	274	92·6
33–40	3,939	3,708	231	94·1
41–48	4,119	3,848	271	93·4
49–56	4,291	3,991	300	93 0
57–64	4,443	4,082	361	91·8
65–72	4,638	4,240	408	91·4
73–80	4,737	4,407	330	93·0
81–88	4,937	4,486	451	90·8
89–96	5,079	4,628	451	91·1
97–104	5,191	4,814	377	92·7
105–112	5,380	4,935	445	91·7
113–120	5,566	5,052	514	90·7
121–128	5,659	5,171	488	91·3
129–136	5,757	5,326	431	92·5
137–144	5,929	5,436	493	91·6
145–152	6,033	5,569	464	92·3
153–160	6,237	5,569	568	90·8
161–168	6,274	5,831	443	92·9
169–176	6,312	5,915	397	93·7
177–184	6,434	6,146	288	95·5
185–192	6,458	6,242	216	96·6
193–200	6,664	6,319	345	94·8
201–208	6,709	6,475	234	96·5
209–216	6,734	6,467	267	96·0
217–224	6,798	6,677	121	98·2
225–232	6,778	6,721	57	99·1
233–240	6,886	6,770	116	98·3
241–248	6,891	7,010	—119	101·7
249–256	7,118	7,112	6	99·9
257–264	7,276	7,204	72	99·0
265–272	7,217	7,274	—57	100·7

Note.—After this age the percentages are very variable.

Further analysis of a portion of the material.—It seemed desirable to investigate the average weights of the babies whose weight-charts and notes had been copied for the purposes of this report, in order to get two series, one consisting of babies exclusively breast-fed, and the other consisting solely of babies who had never been breast-fed, but who had been fed from birth upon boiled cows' milk only.

DIAGRAM II.

SHOWING PERCENTAGE RATE OF INCREASE FOR EACH PERIOD OF EIGHT DAYS ON THE INFANTS OF BOTH SERIES (CONTROL & BOILED COWS MILK) UP TO THE AGE OF EIGHT MONTHS.



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The charts were re-sorted, and it was found that among the babies of the breast-fed series, there were 130 whose records were available from about a fortnight after birth up to at least the 200th day of life, and who during this period had received only breast milk.

Among the 204 babies who had been fed upon boiled cows' milk there were 78 who had attended the consultation during the same period of life and who had received only boiled cows' milk. In addition there were 41 babies who had similar attendance records, and who had been fed for periods of not more than eight days upon the breast before receiving boiled cows' milk, as their sole food.

In order to ascertain whether these 41 babies could reasonably be included in one series with the babies who had never been breast-fed, the average weights for the 78 babies who had never been breast-fed and the average weights for those 41 babies who had received the breast for these few days, were worked out separately. No appreciable difference in the average weights was found, so the two sets of babies were added together, and worked up as a series of 119 babies who had been fed exclusively upon boiled milk. The figures for the 78 and 41 babies respectively are given in Table X.

TABLE X.

Showing the average weights and the number of estimations of 78 babies who were never breast-fed, and of 41 babies who were breast-fed for eight days or less.

Age in days.	78 babies never breast-fed.		41 babies breast-fed 1–8 days.	
	Average weight.	Estimations.	Average weight.	Estimations.
1–8	3,350	3	4,325	2 (same baby)
9–16	3,020	17	3,200	9
17–24	3,350	39	3,261	20
25–32	3,485	56	3,245	26
33–40	3,686	55	3,225	35
41–48	3,770	59	3,668	35
49–56	3,888	57	3,906	36
57–64	3,995	68	3,781	34
65–72	4,095	66	4,198	33
73–80	4,254	67	4,348	32
81–88	4,424	86	4,342	40
89–96	4,555	81	4,543	29
97–104	4,769	72	4,787	39
105–112	4,810	65	4,757	38
113–120	4,985	66	4,820	41
121–128	5,073	63	5,020	41
129–136	5,314	68	5,234	33
137–144	5,393	58	5,132	41
145–152	5,483	56	5,526	41
153–160	5,551	58	5,573	31
161–168	5,427	60	5,748	34
169–176	5,816	63	5,803	34
177–184	6,025	49	5,959	33
185–192	5,861	64	5,941	26
193–200	6,295	50	6,335	31

The figures obtained by estimating the average weights of the 130 exclusively breast-fed babies and of the babies fed exclusively upon boiled cows' milk, show the same main characteristics as the curves of the two original series of babies the results of which series were plotted in Diagram I. The divergence is somewhat more accentuated, but the tendency for the two curves to approach one another after about the 200th day, begins to appear after about the 160th day.

The number of observations for the first eight-day period are too small in the case of the babies fed upon boiled cows' milk to merit any special consideration. The average weights are given on Table XI. and the results are plotted in Diagram IV.

TABLE XI.

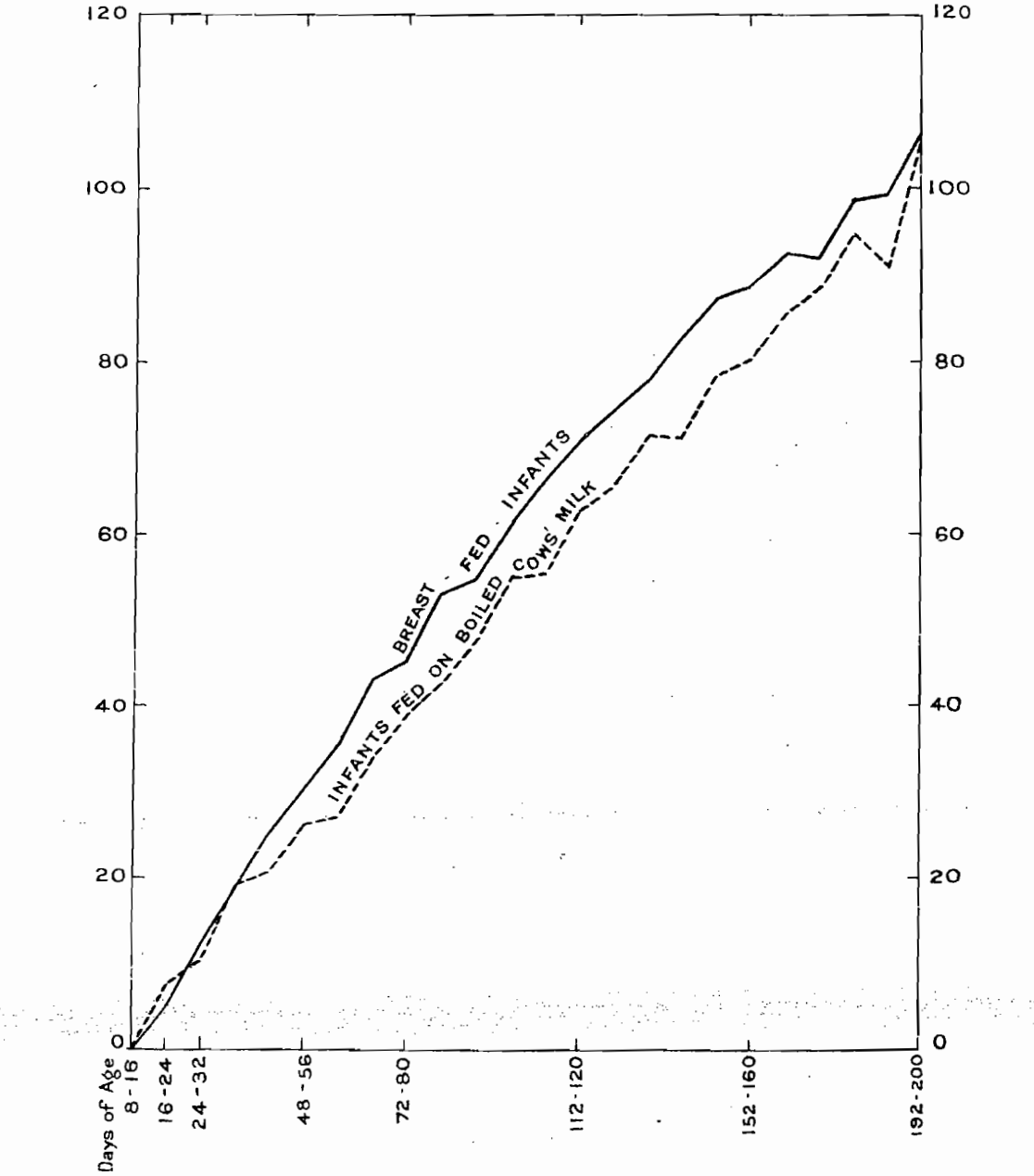
Showing the average weight of 130 *Babies exclusively breast-fed up to* 200 *days of age, and of* 119 *Babies of whom* 78 *had never been breast-fed, and of* 41 *who were breast-fed for less than eight days.*

Age in days.	Breast-fed babies.		Babies fed on boiled milk.	
	Average weight (in grammes).	No. of observations.	Average weight (in grammes).	No. of observations.
1–8	3,019	13	3,740	5
9–16	3,325	42	3,083	26
17–24	3,499	71	3,320	59
25–32	3,738	91	3,409	82
33–40	3,955	87	3,682	90
41–48	4,171	103	3,732	94
49–56	4,327	85	3,895	93
57–64	4,506	107	3,923	102
65–72	4,760	103	4,129	99
73–80	4,836	99	4,284	99
81–88	5,102	102	4,398	126
89–96	5,153	98	4,552	110
97–104	5,360	91	4,775	111
105–112	5,530	95	4,791	103
113–120	5,688	98	5,016	105
121–128	5,808	95	5,052	104
129–136	5,020	82	5,288	101
137–144	6,085	97	5,285	99
145–152	6,229	84	5,501	97
153–160	6,272	81	5,559	89
161–168	6,294	67	5,716	94
169–176	6,381	84	5,811	97
177–184	6,597	71	5,999	82
185–192	6,620	67	5,884	90
193–200	6,856	64	6,310	81

The *percentage rate of growth* of the babies of these two series was calculated up to the day at which they doubled their weight, starting from the second eight-day period. Both the breast-fed babies and the babies fed upon boiled cows' milk doubled their weight at the 193–200th day of life. The rate of growth as shown

DIAGRAM V.

SHOWING THE PERCENTAGE RATE OF GROWTH OF 130 INFANTS EXCLUSIVELY BREAST-FED & OF 119 INFANTS EXCLUSIVELY FED ON BOILED MILK, STARTING FROM THE 16TH DAY OF LIFE UP TO THE AGE AT WHICH THE WEIGHT WAS DOUBLED.



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in the series of breast-fed babies, than in the series of babies fed upon boiled cows' milk. The figures are given in Table XII. and are plotted in Diagram V.

TABLE XII.

Showing the percentage rate of growth of the 119 *babies who had never been breast-fed, and of the* 130 *babies who were exclusively breast-fed, starting from the average weight at the end of the sixteenth day of age, and continuing up to the time at which they doubled their weights.*

Age in days.	Breast-fed Babies.			Babies never breast-fed.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
9–16	3,325	—	—	3,083	—	—
17–24	3,499	174	5·23	3,320	237	7·68
25–32	3,738	413	12·42	3,409	326	10·57
33–40	3,955	630	18·94	3,682	599	19·42
41–48	4,171	846	25·44	3,732	649	21·05
49–56	4,327	1,002	30·13	3,895	812	26·33
57–64	4,506	1,181	35·51	3,923	840	27·24
65–72	4,760	1,435	43·15	4,129	1,046	33·92
73–80	4,836	1,511	45·44	4,284	1,201	38·95
81–88	5,102	1,777	53·44	4,398	1,315	42·65
89–96	5,153	1,828	54·97	4,552	1,469	47·64
97–104	5,360	2,035	61·20	4,775	1,692	54·88
105–112	5,530	2,205	66·31	4,791	1,708	55·40
113–120	5,688	2,363	71·06	5,016	1,933	62·69
121–128	5,808	2,483	74·67	5,052	1,969	63·86
129–136	5,920	2,595	78·04	5,288	2,205	71·52
137–144	6,085	2,760	83·00	5,285	2,202	71·42
145–152	6 229	2,904	87·33	5,501	2,418	78·45
153–160	6 272	2,947	88·63	5,559	2,476	80·31
161–168	6,394	3,069	92·30	5,716	2,633	85·40
169–176	6,381	3,056	91·90	5,811	2,728	88·48
177–184	6,597	3,272	98·40	5,999	2,916	94·58
185–192	6,620	3,295	99·09	5,884	2,801	90·85
193–200	6,856	3,531	106·19	6,310	3,227	104·67

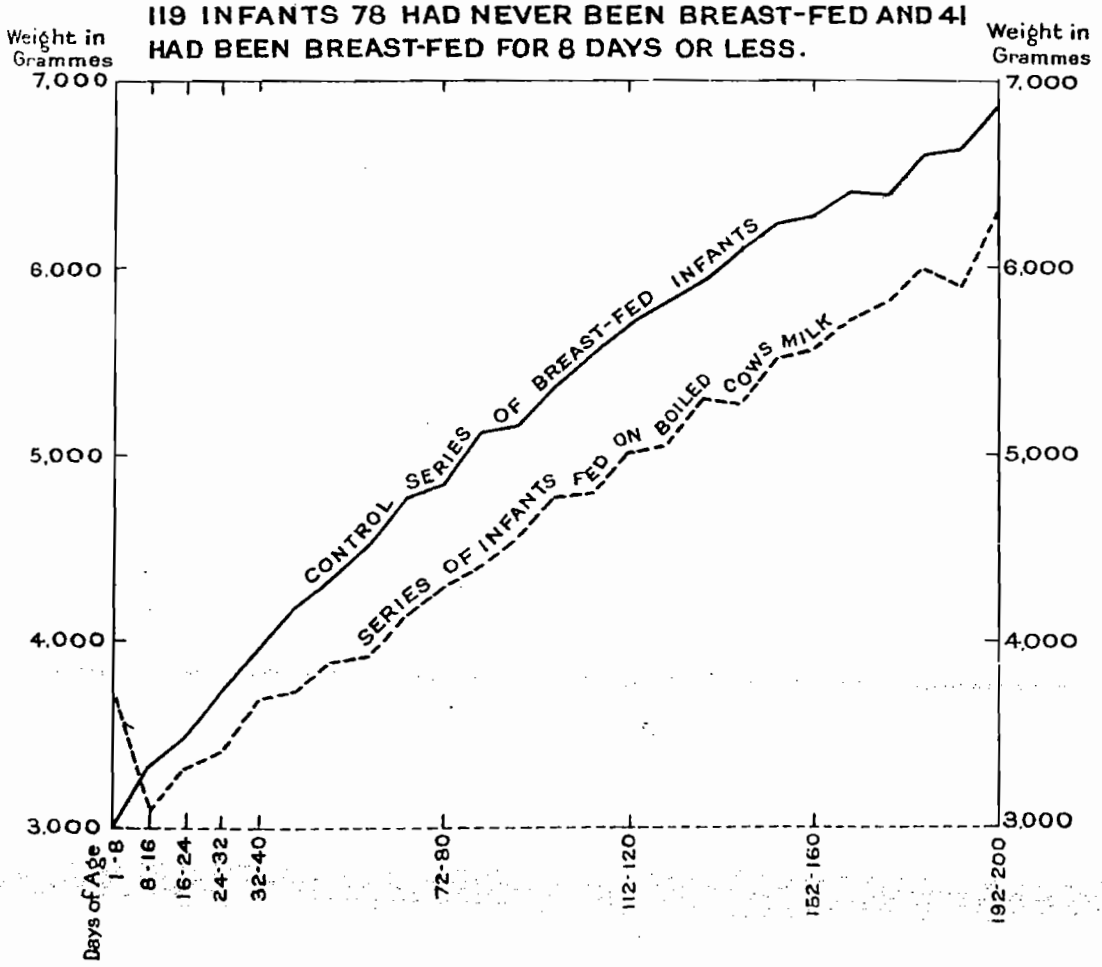
Summary of Results obtained in Part IV.—The Berlin figures dealt with in this part of the report show that, given circumstances similar to those of the Consultation from whence the figures are taken—

(1) Infants fed upon the breast show a higher average weight than infants fed upon boiled cow's milk, up to about the 180–220th day of life. After this age the difference in average weight disappears.

(2) This difference must be attributed to the method of feeding, and not to differences in the social condition of the infants.

DIAGRAM IV.

SHOWING THE AVERAGE WEIGHT OF 130 INFANTS EXCLU-SIVELY BREAST-FED & OF 119 INFANTS EXCLUSIVELY FED UPON BOILED MILK UP TO 200 DAYS OF AGE. OF THE 119 INFANTS 78 HAD NEVER BEEN BREAST-FED AND 41 HAD BEEN BREAST-FED FOR 8 DAYS OR LESS.



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(3) The difference in average weight is most marked in the first 16 days of life; this difference must be attributed to the different method of feeding, and not to any possible "error of sampling."

(4) After the first 16 days the average increase in body-weight is almost identical in both series of babies.

(5) The deficit of average weight of the babies fed upon boiled cows' milk below those fed upon the breast, does not reach 10 per cent. at any period.

Part V.—Summary and Conclusions.

The balance of evidence both experimental and clinical points in the main to the same conclusions. Both lines of research show—

(1) That there is apparently no serious loss of nutritive value produced by feeding an animal upon boiled milk derived from an animal of the same species. At the same time it must be pointed out that the published evidence on this point is scanty.

(2) That, when an animal is fed upon the milk of another species, the milk from which has been found to be suitable for this purpose, such small differences as have been found in the nutritive values of raw and boiled milk have been in favour of boiled milk.

(3) That the milk of the same species has a considerably higher nutritive value for that species than the milk of any other species so far investigated.

The evidence dealt with throughout this report emphasises very forcibly the importance of breast-feeding for the young of all species and shows the special importance of breast-feeding during the early weeks of life.

Where artificial feeding has been employed in animal experiments, boiled milk of a foreign species has given more satisfactory results than similar milk raw. The Berlin figures dealing with infants fed on boiled cows' milk, give extremely favourable results, and in view of the evidence collected in this report could scarcely be expected to be surpassed had raw cows' milk been used.

It may be again pointed out that the Berlin babies who are artificially-fed in connection with the consultation receive milk of a known excellent quality. The excellence of the results obtained in Berlin are almost certainly largely due to the care and supervision exercised at and through the consultation.

The foundations of the information given in this report were obtained by me, when working at the Lister Institute as Jenner Research Scholar, during which period I was also sent abroad to study the methods used in the countries of the Continent in the prevention of infantile mortality, especially in connection with the feeding of infants.

The Berlin material was obtained specially for this report to the Local Government Board.

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