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Report on Influenza amongst the employees of two firms of chemical manufacturers, Messrs. the United Alkali Company of Widnes, and Messrs. the Castner Kellner Company of Runcorn, together with—for control purposes—certain figures relating to the incidence of the disease amongst Ironworkers.

By

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Method of Investigation.

By the courtesy of the firms mentioned and the "Widnes Forge Company" the works were visited and the various chemical processes inquired into.

Lists of the names and addresses of employees engaged in the manufacture of chemicals were obtained and the homes visited. At every house the information set out below was sought and recorded:—

- (1) Names of occupants with age, sex, and occupation of each.
- (2) Number of rooms in house.
- (3) Dates and nature of attack or attacks of influenza.
- (4) Order in which the occupants were attacked.
- (5) The period elapsing between the time the first member became ill, and second cases.
- (6) Complications.
- (7) Whether patient or patients were medically attended.
- (8) Result.

Widnes with a population of 31,541 is a town whose main industries are the manufacture of chemicals, soap, and iron ware. Runcorn's population of 18,000 is engaged largely in similar trades and in tanning. The aggregate number of persons of whom particulars were obtained was 3,417, approximately 7 per cent of the entire population. The 3,417 persons were made up of 944 employees at one or other of the three works plus their wives and families.

Character of Work in which the Population investigated is engaged.

The chemical workers are divided into process workers and non-process workers. Non-process workers are unskilled labourers who wait upon the process workers. They work in an atmosphere where there are chemical fumes, but they are not constantly employed in the same atmosphere—one day they may be on the chlorine plant, next on the vitriol or some other plant where there are fumes.

The process workers are divisible into—

- (a) Those engaged in an atmosphere where chlorine is constantly present.
- (b) Those engaged in the manufacture of vitriol (sulphuric acid).

The chlorine process workers include—

- (1) Those employed in the salt cake department.
- (2) " " " " bleach department.
- (3) " " " " organic department.

In all these departments the workers are employed in an atmosphere where chlorine is always present.

In the "salt cake" process (for practical purposes this includes the "bleach" also) common salt is placed in cone-shaped iron pots into which sulphuric acid is then run.

The hydrochloric acid evolved ($\text{NaCl} + \text{H}_2\text{SO}_4 = \text{NaHSO}_4 + \text{HCl}$) passes direct to the Deacon's decomposers for conversion to chlorine which is passed into condensers—any excess of HCl being absorbed in water. Finally the chlorine is passed over slaked lime to form bleaching powder.

The residue from the furnaces is sulphate of soda or *salt cake*. The gases found are—

HCl and traces of SO_3 in the salt cake department.

HCl and Cl—on the decomposers.

Chlorine—in bleach department.

Organic Process.

Chlorine is generated by the electrolysis of brine and led in pipes to the organic plant where it is passed through benzine to form monochlor benzine. The monochlor benzine is nitrated by nitric acid to form di-nitrochlor benzine which is then converted into di-nitro-phenol by displacement of the chlorine with OH.

The gases that may be found in the neighbourhood of the organic plant are chlorine, monochlor, and benzine vapours, nitric acid, hydrochloric acid. Traces of various nitrous compounds—mono-nitro-chlor-benzine, vapour of acetic acid from monochlor acetic acid.

The workers on vitriol plants may be exposed to any or all of the following gases— SO_2 , SO_3 , NO_2 , HNO_3 , N_2O_2 , N_2O_3 —traces only of the last four are found. The manufacture is carried out in open sheds where natural ventilation only is employed.

In the bleach department some workers use dry masks of several layers of unimpregnated flannel, but this is optional and it is conceded that a man may wear a mask and still be "gassed."

The work done at the Widnes Forge Company's premises is essentially free from anything in the nature of chemical fumes. It consists in the manufacture of castings, &c.

Influenza Incidence on Population investigated.

In the summer outbreak there were 423 attacks = 12.3 per cent.

„ autumn „ „ 288 „ = 8.4 „

„ winter „ „ 369 „ = 10.7

The 1,080 attacks affected 1,036 persons out of a total of 3,417, *i.e.*, approximately 1/3 suffered in one or other wave.

Age and Sex Incidence.—The population of 3,417 comprised 1,737 males and 1,680 females. Of the former 510 or 29.4 per cent., and of the latter 526 or 31.3 per cent suffered. The incidence on certain age groups was :—

TABLE A.

Age Group.	Males.			Females.		
	Total Males.	No. of Cases.	Per-centage.	Total Females.	No. of Cases.	Per-centage.
0-1 - -	25	3	12.0	23	1	4.3
1-5 - -	142	31	21.8	150	26	17.3
5-15 - -	407	105	25.8	396	90	22.7
15-25 - -	247	77	31.2	348	98	28.2
25-35 - -	225	87	38.7	235	103	43.8
35-45 - -	297	108	36.4	222	100	45.0
45-55 - -	224	61	27.2	168	73	43.4
55 and over	170	38	22.3	138	35	25.4
Total -	1,737	510	29.4	1,680	526	31.3

The incidence in each wave on the total population investigated was :—

Age Group.	Summer.	Autumn.	Winter.
	Per cent.	Per cent.	Per cent.
0-1 - - - - -	2·0	—	6·2
1-5 - - - - -	4·4	3·7	11·3
5-15 - - - - -	11·5	5·9	6·9
15-25 - - - - -	15·4	10·2	5·3
25-35 - - - - -	17·4	10·4	14·8
35-45 - - - - -	15·2	11·5	16·4
45-55 - - - - -	13·2	9·6	12·7
55 and over - - - - -	4·2	7·1	13·6

Incidence on certain Age Groups of Process Workers in the Chemical Industry.—Process workers are invariably males.

Those engaged constantly in an atmosphere in which chlorine is always present:—

TABLE B.

Age Group.	No. of Workers.	No. of Cases.	Percentage Incidence.
15-25 - - - - -	21	7	33·3
25-35 - - - - -	84	34	40·5
35-45 - - - - -	131	50	38·2
45-55 - - - - -	87	19	21·8
55 and over - - - - -	62	12	19·3
Total - - - - -	385	122	31·7

Those engaged constantly on vitriol plant:—

TABLE C.

15-25 - - - - -	7	3	42·8
25-35 - - - - -	35	14	40·0
35-45 - - - - -	41	15	36·6
45-55 - - - - -	33	12	36·4
55 and over - - - - -	12	3	25·0
Total - - - - -	128	47	36·7

Inasmuch as Table B. relates to three times as many persons as does C, the smaller per cent incidence in favour of the former is more apparent than real, and it will be of advantage to combine the two Tables as

illustrating the age incidence on process workers generally. This is done in Table D:--

TABLE D

Age Group.	No. of Workers.	No. of Cases.	Percentage Incidence.
15-25 - - - - -	28	10	35·7
25-35 - - - - -	119	48	40·3
35-45 - - - - -	172	65	37·8
45-55 - - - - -	120	31	25·8
55 and over - - - - -	74	15	20·3
Total - - - - -	513	169	32·9

These 169 persons had in all 176 attacks.

Incidence on certain Age Groups of Non-Process Workers.—That is to say, on persons intermittently exposed for varying periods, sometimes to chlorine, sometimes to gases from vitriol plants and at others not exposed at all. Non-process workers may be females.

TABLE E.

15-25 - - - - -	113	41	36·3
25-35 - - - - -	40	17	42·5
35-45 - - - - -	25	3	12·0
45-55 - - - - -	32	12	37·5
55 and over - - - - -	20	4	20·0
Total - - - - -	230	77	33·5

Tables B, C, D, and E therefore set out the incidence of influenza on two classes of chemical workers, one constantly exposed to certain gases and the other exposed intermittently.

Table F, which forms a control, shows the incidence of influenza on the employees of the Widnes Forge Company, who live in the same neighbourhood as the chemical workers of the United Alkali Company and who therefore may be assumed ordinarily to be exposed to the same atmosphere outside working hours.

TABLE F.

15-25 - - - - -	30	15	50·0
25-35 - - - - -	43	19	44·2
35-45 - - - - -	61	25	41·0
45-55 - - - - -	36	11	30·5
55 and over - - - - -	31	9	29·0
Total - - - - -	201	79	39·3

The 79 persons had 85 attacks.

Summarised these figures show that the incidence of influenza on process workers was 32·9 per cent, as compared with 33·5 on non-process workers, 39·3 per cent on iron workers living under precisely similar conditions, and 30·3 per cent on *all males of same age* in the population investigated.

The incidence in each wave on these several classes of persons was :—
On Process workers.

TABLE G.

Age Group.	Summer.	Autumn.	Winter.
	Per Cent.	Per Cent.	Per Cent.
15—25 - - - - -	21·0	10·7	3·5
25—35 - - - - -	21·8	9·2	10·9
35—45 - - - - -	15·6	10·4	12·7
45—55 - - - - -	10·0	9·1	8·3
55 and over - - - - -	4·0	5·7	10·8

On Non-Process workers.

TABLE H.

	Per Cent.	Per Cent.	Per Cent.
15—25 - - - - -	21·7	10·3	3·25
25—35 - - - - -	15·3	8·0	21·8
35—45 - - - - -	4·0	Nil.	8·0
45 and over - - - - -	7·8	5·8	17·6

On Ironworkers.

TABLE J.

	Per Cent.	Per Cent.	Per Cent.
15—25 - - - - -	30·0	13·3	10·0
25—35 - - - - -	13·9	13·9	18·6
35—45 - - - - -	18·0	13·1	14·7
45—55 - - - - -	16·6	5·5	11·1
55 and over - - - - -	Nil.	16·1	12·9

*Incidence on certain age groups among females engaged in home duties—
including nursing.*

TABLE K.

Age Group.	No. of Workers.	No. of Cases.	Percentage Incidence.
15—25 - - - - -	117	28	23·9
25—35 - - - - -	194	87	44·8
35—45 - - - - -	214	95	44·4
45—55 - - - - -	164	71	43·3
55 and over - - - - -	133	35	26·3
Total - - - - -	822	316	38·4

The average incidence therefore was 38·4 per cent. The corresponding figure for all females of like ages in the total population investigated, is 33·1 per cent.

Immunity.—There were 423 attacks in the summer wave, 288 in the autumn and 369 in the winter. 43 persons had two attacks; 14 in the summer and autumn, 21 in the summer and winter, and 8 in the autumn and winter waves. For the whole community of 3,417 persons investigated the table below summarises the result of our enquiries.

3,417			
Summer	- - - 2,994 escaped.	423 attacked.	
Autumn	- 2,720 escaped.	274 (9·1 per cent.) attacked.	14 (3·3 per cent.) attacked.
Winter	2,380 escaped.	340 (12·5 per cent.) attacked.	8 (2·9 per cent.) attacked.
		21 (4·9 per cent.) attacked.	

Further analysis failed to disclose any difference in this respect between the various classes of workers.

Mortality :—

Of the 1,080 attacks, 16 or 1·5 per cent proved fatal.

Of the 423 summer cases, 2 died = 0·47 per cent.

Of the 288 autumn cases, 2 died = 0·69 per cent.

Of the 369 winter cases, 12 died = 3·3 per cent.

Of the 169 cases occurring amongst 513 process workers (chlorine and vitriol) none died.

Of the 230 non-process workers, 36 were attacked in summer, 16 in autumn and 24 in winter. There were no deaths in the first two waves, but three occurred in the last; this gives a case mortality of 12·5 per cent.

Of the 201 iron-workers, 32 suffered in the first, 25 in the second and 28 in the third wave. There were no deaths.

The case mortality of the investigated population set out in age groups was :—

Age groups.	Attacks.	Deaths.	Case Mortality.
0-5	61	6	9·9 per cent.
5-15	197	1	0·5 " "
15-25	185	—	—
25-35	196	1	0·5 per cent.
35-45	224	1	0·4 " "
45-55	140	1	0·7 " "
55 and over	77	6	7·8 " "

Nine males and seven females died. The age periods most heavily affected were 0-5 and 55 and over. There were five deaths of children under three years and four of adults over 60 years.

All the deaths occurred in first attacks, and all but three were attributed to pulmonary complications.

Complications.—It is stated that a large proportion of the chemical works' employees suffered from chronic bronchitis; it is a popular belief that "bad chests" from the "gas" were common. For this reason enquiry was more particularly directed to pneumonia and pleurisy, rather than to bronchitis, as complications. It was found that of the total cases, 58 or 5·3 per cent had pneumonia of one kind or another and 3 or 0·27 per cent.

had pleurisy. The occurrence of these complications in the several waves was:—

	Pneumonia.	Pleurisy.
In the summer - - - - -	1 • 18 per cent.	—
In the autumn - - - - -	5 • 2 „ „	0 • 69 per cent.
In the winter.	10 • 29 „ „	0 • 27 „ „

The pneumonia incidence on age groups was:—

Age group.	Influenza cases.	Pneumonia as a complication.
0-5 - - -	61	13 or 21•3 per cent.
5-15 - - -	195	7 or 3•6 „ „
15-25 - - -	175	9 or 5•1 „ „
25-35 - - -	190	8 or 4•2 „ „
35-45 - - -	208	7 or 3•4 „ „
45-55 - - -	134	4 or 3•0 „ „
55 and over - - -	74	10 or 13•5 „ „

Pneumonia as a complication amongst process workers in chlorine was absent in the summer wave (50 cases¹), while in the autumn (40 cases) it occurred in 5 per cent and in the winter (37 cases) in 2 • 7 per cent.

Among vitriol workers pneumonia as a complication did not occur until the winter outbreak when there was one case, 5•8 per cent., in a man of 61 years. There were 32 influenza cases in the summer and autumn and 17 in the winter.

Non-process workers suffered less severely—

In the summer, of 36 influenza cases, 1 or 2•8 per cent developed pneumonia.

In the autumn, of 16 influenza cases, 2 or 12•5 per cent developed pneumonia.

In the winter, of 24 influenza cases, 2 or 8 • 3 per cent, developed pneumonia.

These figures differ little from those presented by the control cases (ironworkers) among whom there were—

In the summer, 32 influenza cases with no pneumonia.

In the autumn, 25 influenza cases with 3 or 12 per cent, pneumonia.

In the winter, 28 influenza cases with 2 or 7 • 1 per cent, pneumonia.

Incidence of Influenza on Households.

In all 653 houses in the two towns were visited, and of these 410 or 62 • 8 per cent were invaded between June 1918- April 1919. Of 366 houses each containing a process worker in chlorine, 219 or 59•8 per cent were invaded, and in 20 per cent, of these the chlorine worker himself was the first to suffer. Similarly of 167 houses of process workers on vitriol plants, 114 or 68•3 per cent, were affected. Here again in 20 per cent, of instances the first influenza case was the vitriol worker himself. Of 167 control houses (ironworkers) 114 or 68•3 per cent, were invaded, and in 25 per cent, it was the ironworker himself who introduced the disease. Inasmuch as the average number of persons per house was 5•2, the natural chance of any one individual in any house introducing the disease was approximately 20 per cent.

Influence of Overcrowding.—Contrary to expectation we could discover no evidence to show that the incidence on overcrowded houses was greater than that on houses which were not overcrowded.

Incubation Period.—Direct evidence bearing on this point is somewhat scanty owing to the number of factors introduced. Where, however, such was available the period varied from 12-48 hours. Second crops of cases in the same house commonly followed 48 hours after the first.

Influence of Nursing as a factor in the spread.—No appreciable difference was noted between the figures relating to women employed in house duties, including nursing and those engaged in chemical works as non-process workers.

Comments.—In this investigation we were unable to find any artificial means of transference of possibly infected particles from one worker to another in the actual processes carried on.

Owing to the nature of the processes chemical plants cover a comparatively large area of ground. The work is carried on in open sheds and in any one department the workers are few and scattered. There is little intercommunication between the different departments.

All the works have canteens, but our information is that they were little used by the male workers, and when they were used it was customary for the men to use as drinking vessels the utensils in which they brought their food.

In connection with the organic plant of one of the works there is a common washing-up place for eating and drinking utensils, but there is no evidence to show that the incidence on the users was either greater or less than on their fellows who had not access to like facilities. The few female workers are provided with dining rooms. Their eating vessels are washed up, &c. all together, but here again evidence of the influence or otherwise of this factor in the spread of influenza is lacking.

We owe our thanks to Messrs. The United Alkali Company, Messrs. The Castner Kellner Company, and to Messrs. The Widnes Forge Company for their courtesy in supplying information concerning their staffs. We are also indebted to Dr. H. E. Annett, Medical Officer of Health, Runcorn Urban District, and Dr. Albert Jones, D.S.O., M.C., Medical Officer of Health, Widnes Borough, for valuable assistance in prosecuting the inquiry.