

## THE INFLUENCE OF SOCIAL FACTORS ON THE INCIDENCE OF EXTRAPULMONARY TUBERCULOUS INFECTION

### AN INVESTIGATION OF THE ENVIRONMENT OF TUBERCULOUS PATIENTS IN LANARKSHIRE, SCOTLAND

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The influence of social conditions on illness in childhood in London Boroughs has been discussed by Wright & Wright (1942). They analysed the statistical data of the morbidity and mortality of diphtheria, measles, whooping cough and tuberculosis, and, by comparing them with data for social conditions in the same area, determined the correlation between illness and social factors. They noted the effect of substandard housing and of the partial deprivation of many of the amenities of life—food, heat and clothing—owing to deficient economic resources and pointed out that these were important factors in the distribution of tuberculosis in young children.

From 1937 till the end of 1942 I isolated and typed strains of tubercle bacilli from 311 patients, residing in the county of Lanark, who were suffering from extrapulmonary tuberculosis. At the same time I collected data that would enable me to make an assessment of social conditions in order to discover whether any enlightenment on the subject of infection might be gathered from a knowledge of the patient's environment and in order to scrutinize factors that might be of importance in influencing the proportional frequency of the infecting type of the tubercle bacillus.

To this end I collected particulars relating to:

- (a) the number of apartments in the home, including kitchen,
- (b) the average weekly income,
- (c) any history of tuberculosis in the family or immediate contacts of the patient,
- (d) the milk supply.

I then proceeded to analyse each case and to attempt to correlate the clinical condition with the social environment. For this purpose it was necessary to define standards of housing and of income. Any home having two or more members of the household for each apartment I considered sub-

standard, and any family trying to live on 10s. or less per head per week I took as the basis for low economic resources.

#### RESULTS OF INVESTIGATION

##### *The influence of substandard housing on extrapulmonary tuberculosis*

A survey of the home conditions of the 311 persons included in this series of extrapulmonary tuberculous infections disclosed that 72.3% resided in overcrowded houses; 72.8% of patients infected with the human and 71.1% of those infected with the bovine type of the tubercle bacillus gave a history of overcrowding in the home.

Table 1. *Incidence of substandard housing in  
extrapulmonary tuberculosis*

	Type of the tubercle bacillus	Substandard housing	Total cases investigated
Entire county	Human	72.8% (166)	228
	Bovine	71.1% (59)	83
		72.3% (225)	311
Industrial area	Human	74.9% (146)	195
	Bovine	77.6% (52)	67
		75.6% (198)	262
Rural area	Human	60.6% (20)	33
	Bovine	43.7% (7)	16
		55.1% (27)	49

Substandard accommodation was encountered more frequently in the industrial than in the rural area (see p. 241). Of the 262 patients from the industrial area 75.6% came from overcrowded

homes and of the 49 from the rural area 55.1% came from overcrowded homes.

In the industrial area overcrowding was present in the homes of 74.9% of patients from whom human and of 77.6% of patients from whom bovine strains of the tubercle bacillus were isolated. In the rural area overcrowding occurred in the homes of 60.6% of patients from whom human and 43.7% of patients from whom bovine strains of the tubercle bacillus were isolated.

Table 2. *Incidence of substandard housing in tuberculous meningitis*

	Type of the tubercle bacillus	Substandard housing	Total cases investigated
Entire county	Human	71.2% (84)	118
	Bovine	72.3% (34)	47
			71.5% (118) 165
Industrial area	Human	73.1% (79)	108
	Bovine	79.5% (31)	39
			74.8% (110) 147
Rural area	Human	50.0% (5)	10
	Bovine	37.5% (3)	8
			44.4% (8) 18

Consideration of the incidence of substandard housing in tuberculous meningitis showed this condition to be present in 71.5% of the 165 cases investigated; 71.2% of 118 persons with human and 72.3% of 47 with bovine strains of the tubercle bacillus came from overcrowded houses.

Overcrowding occurred in the homes of 74.8% of 147 patients from the industrial area and in 44.4% of 18 from the rural area.

In the industrial area the frequency of overcrowding was 73.1% of 108 patients from whom the human and 79.5% of 39 patients from whom the bovine type of the tubercle bacillus was recovered. In the rural area overcrowding was present in the homes of 50% of 10 patients from whom the human and 37.5% of 8 patients from whom the bovine type of the tubercle bacillus was isolated.

Persons with cervical adenitis had substandard home conditions in 73.6% of the 72 investigated, namely, 76% of 50 from whom human and 68.2% of 22 from whom bovine strains of the tubercle bacillus were isolated.

The incidence in the industrial area was 80.8% in 52 cases and in the rural area 55% in 20 cases.

In the industrial area a history of overcrowding at home was obtained from 82.4% of 34 patients with infections due to the human and from 77.8% of 18 patients with infections due to the bovine type of the tubercle bacillus. In the rural area 62.5% of

16 persons from whom the human and 25% of 4 persons from whom the bovine type of the tubercle bacillus was recovered gave histories of overcrowding at home.

Table 3. *Incidence of substandard housing in tuberculous cervical adenitis*

	Type of the tubercle bacillus	Substandard housing	Total cases investigated
Entire county	Human	76.0% (38)	50
	Bovine	68.2% (15)	22
			73.6% (53) 72
Industrial area	Human	82.4% (28)	34
	Bovine	77.8% (14)	18
			80.8% (42) 52
Rural area	Human	62.5% (10)	16
	Bovine	25.0% (1)	4
			55.0% (11) 20

In bone and joint infections 73% of the 74 persons affected came from overcrowded dwellings, namely, 73.3% of 60 patients infected with the human and 71.4% of 14 patients infected with the bovine type of the tubercle bacillus.

Table 4. *Incidence of substandard housing in bone and joint tuberculosis*

	Type of the tubercle bacillus	Substandard housing	Total cases investigated
Entire county	Human	73.3% (44)	60
	Bovine	71.4% (10)	14
			73.0% (54) 74
Industrial area	Human	73.6% (39)	53
	Bovine	70.0% (7)	10
			73.0% (46) 63
Rural area	Human	71.4% (5)	7
	Bovine	75.0% (3)	4
			72.7% (8) 11

There were 73% of 63 patients in the industrial area and 72.7% of 11 patients in the rural area whose homes were overcrowded.

In the industrial area the frequency of overcrowding was 73.6% in 53 cases with human and 70% in 10 cases with bovine strains of the tubercle bacillus; in the rural area 71.4% in 7 cases with human and 75% of 4 cases with bovine strains of the tubercle bacillus.

This analysis showed that substandard housing was a frequent associated condition in tuberculous

infections, and that it was more frequent in industrial than in rural areas. In each type of infection considered over 70 % of patients from the industrial area lived in overcrowded dwellings; from the rural area 44.4 % of patients with tuberculous meningitis, 55 % of those with cervical adenitis and 72.7 % of those with bone and joint disease came from overcrowded homes. These figures pointed to overcrowding as a substantial factor in the morbidity of tuberculosis.

A more critical survey of housing conditions gave further enlightening information. There were 25 patients of 1 year of age and under from the industrial area and all came from overcrowded homes. Of these there were 20 with tuberculous meningitis, 15 due to human and 5 due to bovine strains of the tubercle bacillus, 4 with cervical adenitis, 2 due to human and 2 due to bovine strains

of the tubercle bacillus, and 1 with bone and joint disease due to the human type of the tubercle bacillus. Twelve of the 18 patients with human and 4 of the 7 patients with bovine strains of the tubercle bacillus came from single-apartment houses.

A single-apartment house consists of one room in which there is usually a range for cooking and a bed recess. There may be a sink with running water, but sometimes water has to be drawn from an outside tap and a common water-closet or privy is shared by several houses. Such houses are fairly common in Scotland even in cities.

In the industrial area, of the patients suffering from tuberculous meningitis due to the human type of the tubercle bacillus 17.2 % of those from satisfactory and 50.4 % of those from overcrowded homes were under 10 years of age. The children from

Table 5. *Housing of children of 1 year and under suffering from extrapulmonary tuberculosis*

	Type of the tubercle bacillus	Apartments in home (including kitchen)				
		1	2	3	4	5
Tuberculous meningitis	Human	10	2	1	—	2
	Bovine	3	—	1	1	—
Cervical adenitis	Human	1	—	1	—	—
	Bovine	1	—	—	1	—
Bone and joint tuberculosis	Human	1	—	—	—	—
	Bovine	—	—	—	—	—

No case of extrapulmonary tuberculosis occurred among persons of 1 year or under living in homes with satisfactory accommodation.

Table 6. *Tuberculous meningitis. Age and sex incidence in relation to housing. Industrial area*

	Age (years)					Total
	Under 5	-10	-15	-20	Over 20	
Satisfactory accommodation						
Human type of the tubercle bacillus:						
Male	2	3	2	9	2	18
Female	—	—	—	3	8	11
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	2	3	2	12	10	29
Bovine type of the tubercle bacillus:						
Male	1	2	—	—	—	3
Female	1	—	—	2	2	5
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	2	2	—	2	2	8
Substandard accommodation						
Human type of the tubercle bacillus:						
Male	13	7	4	11	1	36
Female	12	8	4	12	7	43
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	25	15	8	23	8	79
Bovine type of the tubercle bacillus:						
Male	5	4	2	1	5	17
Female	6	3	2	2	1	14
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	11	7	4	3	6	31
						16.2

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the satisfactorily housed group were all males, but those from overcrowded houses showed an equal incidence in males and females.

Infections due to the bovine type of the tubercle bacillus showed no significant variation in relation to housing conditions.

In the rural area the figures were too small for analysis.

In the industrial area cervical adenitis due to the

human type of the tubercle bacillus occurred before 10 years of age in 16.7% of the patients from satisfactory and in 60.7% of the patients from overcrowded dwellings.

The patient from the satisfactorily housed group was a male and those from the overcrowded houses showed an approximately equal incidence in males and females.

Infections due to the bovine type of the tubercle

Table 7. *Tuberculous cervical adenitis. Age and sex incidence in relation to housing*

		Industrial area					
		Age (years)					
		Under 5	-10	-15	-20	Over 20	Total
		Satisfactory accommodation					
Human type of the tubercle bacillus:							
Male		—	1	—	—	1	2
Female		—	—	1	2	1	4
		—	1	1	2	2	6
Bovine type of the tubercle bacillus:							
Male		—	—	2	—	—	2
Female		—	1	—	—	1	2
		—	1	2	—	1	4
		Substandard accommodation					
Human type of the tubercle bacillus:							
Male		6	2	1	2	1	12
Female		3	6	1	2	4	16
		9	8	2	4	5	28
Bovine type of the tubercle bacillus:							
Male		2	1	2	—	1	6
Female		1	3	1	—	3	8
		3	4	3	—	4	14
		Rural area					
		Age (years)					
		Under 5	-10	-15	-20	Over 20	Total
		Satisfactory accommodation					
Human type of the tubercle bacillus:							
Male		—	—	3	—	1	4
Female		—	—	—	—	2	2
		—	—	3	—	3	6
Bovine type of the tubercle bacillus:							
Male		—	1	—	—	—	1
Female		—	1	—	1	—	2
		—	2	—	1	—	3
		Substandard accommodation					
Human type of the tubercle bacillus:							
Male		3	3	—	—	—	6
Female		—	3	—	1	—	4
		3	6	—	1	—	10
Bovine type of the tubercle bacillus:							
Male		—	1	—	—	—	1
Female		—	—	—	—	—	—
		—	1	—	—	—	1

bacillus in patients from satisfactory homes were too few for comment, only 1 female of a total of 4 patients was under 10 years of age, but 50% of 14 persons from overcrowded homes were under 10 years of age, and the incidence was approximately equal in males and females.

In the rural area there was no patient infected with the human type of the tubercle bacillus from a satisfactory home but 90% of 10 from overcrowded houses were under 10 years of age.

In infections due to bovine strains of the tubercle bacillus numbers were too few for analysis.

In the industrial area human strains of the tubercle bacillus isolated from patients under 10 years of age with bone and joint disease were obtained from 14.3% of the 14 persons from satisfactory and from 28.2% of 39 persons from substandard houses.

There were too few cases in the rural area for analysis.

*The relation of low weekly incomes to extrapulmonary tuberculosis*

A general survey of the economic resources of the 311 patients with extrapulmonary tuberculosis showed that 117 (44.7%) of the industrial group and 10 (20.4%) of the rural group came from homes where the family income was not greater than 10s. per head per week.

A more detailed examination showed that, with the exception of tuberculous meningitis, low-income levels were relatively more prevalent in persons infected with bovine than in those with human strains of the tubercle bacillus.

In the industrial area, among patients with low economic resources, 48.3% (42) of those infected with human strains and 66.7% (20) of those infected with bovine strains of the tubercle bacillus were under 10 years of age.

In the rural area, of persons whose family income

Table 8. *Bone and joint tuberculosis. Age and sex incidence in relation to housing. Industrial area*

	Age (years)					Total
	Under 5	-10	-15	-20	Over 20	
Satisfactory accommodation						
Human type of the tubercle bacillus:						
Male	1	—	—	4	4	9
Female	—	1	—	2	2	5
	1	1	—	6	6	14
Bovine type of the tubercle bacillus:						
Male	2	—	—	—	—	2
Female	—	—	—	—	1	1
	2	—	—	—	1	3
Substandard accommodation						
Human type of the tubercle bacillus:						
Male	3	3	1	11	9	27
Female	4	1	—	2	5	12
	7	4	1	13	14	39
Bovine type of the tubercle bacillus:						
Male	1	2	—	1	2	6
Female	—	—	—	—	1	1
	1	2	—	1	3	7

*Conclusion.* From this evidence overcrowding seemed to be an important factor in influencing the incidence of tuberculous infection, particularly in children, and to be more important in infection with the human type of the tubercle bacillus than in infection with the bovine type.

A noteworthy feature of the analysis was the equality of infection in the sexes under 10 years of age in substandard dwellings and the preponderance of infections among males in satisfactory dwellings.

was below the poverty line, 80% (4) of those with infections due to the human type and 60% (3) of those with infections due to the bovine type of the tubercle bacillus were under 10 years of age.

In the industrial area 53% of the patients with a history of low economic resources were children under 10 years of age; in the rural area 70% of the patients with a history of low economic resources were under 10 years of age.

Of patients under 10 years of age in this survey

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50.8 % in the industrial area and 29.2 % in the rural area belonged to families with low weekly incomes.

Financial impoverishment existed for the most part in homes that were overcrowded for, in the industrial area, there were only 17 out of a total of 117 persons in this series who had satisfactory accommodation at home, and only 1 of 10 in the rural area.

*Conclusion.* To arrive at any definite conclusion from an examination of income is difficult, for some women are better housekeepers than others and the spending power of money varies from district to district. Furthermore, it is easier to feed a large family than a small one on a relatively more meagre income. The figure I took as my basis for establishing a poverty level was 10s. or less per head per

week, and, although this may provide sufficient for a family of seventeen persons, it cannot possibly be sufficient to meet the essential needs of a family of three.

Subsidies are now granted to patients once a diagnosis of tuberculosis is established, but the damage has been done before the grant is even considered so that, although relief may be an admirable attempt to safeguard further potential sufferers in the same household, it does little to prevent the ravages of poverty in families with undiagnosed cases of tuberculosis.

It cannot be denied that the deprivation of many of the amenities of life must have added to the risks incurred by overcrowding, particularly in children. The high percentage in persons affected by the

Table 9. *Age in relation to low economic resources*

	Type of the tubercle bacillus	Industrial area		Rural area	
		Under 10 years	Over 10 years	Under 10 years	Over 10 years
Tuberculous meningitis	Human	26	20	2	—
	Bovine	8	5	2	—
		34	25	4	—
Cervical adenitis	Human	8	8	2	—
	Bovine	8	3	—	1
		16	11	2	1
Bone and joint tuberculosis	Human	8	17	—	1
	Bovine	4	2	1	1
		12	19	1	2

Table 10. *Incidence of low economic resources in extrapulmonary tuberculosis*

	Type of the tubercle bacillus	Patients with low economic resources	Total cases investigated
<i>Industrial area</i>			
Some form of extrapulmonary tuberculosis	Human	44.6 % (87)	195
	Bovine	44.8 % (30)	67
		44.7 % (117)	262
Tuberculous meningitis	Human	42.6 % (46)	108
	Bovine	33.3 % (13)	39
		40.1 % (59)	147
Cervical adenitis	Human	47.1 % (16)	34
	Bovine	61.1 % (11)	18
		51.9 % (27)	52
Bone and joint tuberculosis	Human	47.2 % (25)	53
	Bovine	60.0 % (6)	10
		49.2 % (31)	63
<i>Rural area</i>			
Some form of extrapulmonary tuberculosis	Human	15.2 % (5)	33
	Bovine	31.3 % (5)	16
		20.4 % (10)	49

bovine type of the tubercle bacillus seemed to indicate that low economic resources must have a further influence on susceptibility to infection with the tubercle bacillus, and it can only be suggested that greater liability to infection comes from a lack of some protection conferred on those more favourably situated financially.

The lower figures for the rural area are interesting, for low economic resources are not so important in country districts where food deficiencies are more easily overcome, as most country dwellers have gardens or easy access to cheap vegetable food and fruit.

There can be no doubt that in impoverished households with tuberculous adults the danger of massive infection with the human type of the tubercle bacillus must be aggravated by lowered resistance due to the partial deprivation of many of the amenities of life, but as a generalization it can be said that low economic resources were a factor worthy of note in extrapulmonary tuberculosis, particularly in children, and more especially in infection with the bovine type of the tubercle bacillus.

*Domestic or personal history in tuberculous infections*

A history of contact with other tuberculous persons in the home or of previous manifestation of tuberculous disease in the patient was obtained

from 108 of the 311 subjects considered in this investigation of extrapulmonary tuberculosis.

In the industrial area, patients infected with the human type of the tubercle bacillus coming from homes where other members of the household had suffered from pulmonary tuberculosis and had, therefore, a probable source of infection with the human type of the tubercle bacillus numbered 29 of 108 cases of tuberculous meningitis, 14 of 34 cases of cervical adenitis and 13 of 53 cases of bone and joint disease.

This gave a total of 56 persons out of 195 in whom the probable source of infection was an adult with pulmonary tuberculosis in the household.

In the rural area the total was 9 out of 33 cases infected with the human type of the tubercle bacillus and was made up of 2 of 10 cases of tuberculous meningitis, 3 of 16 of cervical adenitis and 4 of 7 of bone and joint disease.

In the industrial area pulmonary tuberculosis was in the family history of 2 of the 67 persons infected with bovine strains of the tubercle bacillus and these were 2 of the 39 cases of tuberculous meningitis recorded. In the rural area 2 of 8 cases of tuberculous meningitis due to the bovine type of the tubercle bacillus had relations suffering from pulmonary tuberculosis.

A history of contact with a case of non-pulmonary tuberculosis in the home was present in 8 patients in the industrial area and in 1 in the rural area. All

Table 11. *Distribution of history of tuberculosis*

	Tuberculous meningitis		Cervical adenitis		Bone and joint tuberculosis	
	Type of the tubercle bacillus		Type of the tubercle bacillus		Type of the tubercle bacillus	
	Human	Bovine	Human	Bovine	Human	Bovine
<i>Industrial area</i>						
Contact pul.	29	2	14	—	13	—
Patient pul.	8	—	3	1	7	1
Contact non-pul.	—	4	—	2	—	2
Patient non-pul.	—	3	—	—	5	—
	37	9	17	3	25	3
Total cases	108	39	34	18	53	10
<i>Rural area</i>						
Contact pul.	2	2	3	—	4	—
Patient pul.	—	—	—	—	1	—
Contact non-pul.	—	—	—	—	—	1
Patient non-pul.	—	—	1	—	—	—
	2	2	4	—	5	1
Total cases	10	8	16	4	7	4

Contact pul. = contact with a case of pulmonary tuberculosis.

Patient pul. = patient suffering from pulmonary tuberculosis.

Contact non-pul. = contact with a case of non-pulmonary tuberculosis.

Patient non-pul. = patient suffering from non-pulmonary tuberculosis of a form other than those mentioned.

these persons were suffering from infections due to the bovine type of the tubercle bacillus and were, in the industrial area, 4 with tuberculous meningitis, 2 with cervical adenitis and 2 with bone and joint disease; the case in the rural area was a patient with bone and joint disease whose sister suffered from abdominal tuberculosis.

A further group of patients had tuberculous lesions other than those for which they were included in this investigation.

In the groups due to human strains of the tubercle bacillus 8 patients with tuberculous meningitis, 3 with cervical adenitis and 7 with bone and joint infection were proved cases of pulmonary tuberculosis, and 5 other patients with bone and joint disease suffered from extrapulmonary lesions other than the one for which they came under review. These persons were from the industrial area. In the rural area a patient with bone and joint disease, from whom the human type of the tubercle bacillus was isolated, had pulmonary tuberculosis as well, and a patient with cervical adenitis, due to the human type of the tubercle bacillus, suffered also from a tuberculous infection of the spine.

In the rural area no case suffering from meningitis, cervical adenitis or bone and joint infection due to the bovine type of the tubercle bacillus had other manifestations of tuberculosis, but 5 personal histories were obtained from patients in the industrial area; 3 cases of tuberculous meningitis suffered from other extrapulmonary lesions, a patient with cervical adenitis and a patient with bone and joint disease had also pulmonary tuberculosis.

It is interesting that 2 patients with infections due to the bovine type of the tubercle bacillus came from farms. A dairymaid died of tuberculous meningitis, and a dairy farmer's son age 6 years was under treatment for cervical adenitis.

*Conclusion.* These findings go far to explain the high incidence in Lanarkshire of infections with the human type of the tubercle bacillus in cervical adenitis, for 50% of the cases in the industrial area had a family or personal history of pulmonary tuberculosis.

In the rural area 71.4% of persons suffering from bone and joint infections due to human strains of the tubercle bacillus had given a history of pulmonary tuberculosis in the household.

No patient with cervical adenitis or with bone and joint disease due to the bovine type of the tubercle bacillus gave a history of contact in the household with any person suffering from pulmonary tuberculosis.

One patient in the industrial area suffering from tuberculosis of the spine due to the bovine type of the tubercle bacillus had also a pulmonary infection.

It was evident that a history of pulmonary

tuberculosis either in a contact or in the patient was not only an important factor in the incidence of extrapulmonary tuberculosis due to the human type of the tubercle bacillus but it was also a factor influencing the proportional frequency of the type of the infecting tubercle bacillus.

*The milk supply of patients infected with the bovine type of the tubercle bacillus*

There were in the industrial area 67 persons from whom bovine strains of the tubercle bacillus were recovered. Fifty-one were supplied with raw undesignated milk from retailers of milk and 16 obtained milk from dealer 'X'. Part of the supply of dealer 'X' was raw, undesignated milk and part was pasteurized. The pasteurized portion was sold as 'Pasteurized' milk in some districts and as undesignated milk in others.

In the industrial area 16 (84.2%) out of 19 patients under 5 years of age took raw milk and 3 took dealer 'X' pasteurized milk. Of the 17 patients between 5 and 10 years of age, 11 (64.7%) consumed raw milk and the remaining 6 (35.3%) took dealer 'X' pasteurized milk. From this it will be seen that over half of the patients were under 10 years of age and that 75% of these persons consumed raw undesignated milk. The patients who consumed pasteurized milk obtained supplies from shops that retailed in the most part bulk milk from two plants that were found inefficient, but this point will be discussed later.

In the rural area milk consumed by 15 (93.7%) of the 16 persons from whom the bovine type of the tubercle bacillus was isolated was raw and not designated; one patient with tuberculous meningitis took milk that was pasteurized from dealer 'X'. This patient, a female of 4 years, had an aunt with pulmonary tuberculosis, but, unfortunately, the organism from the phthisical case was not obtained for typing.

In Scotland milk, if available, is consumed in considerable quantity as a beverage, with porridge and almost invariably with the sweet course at meals. The risk of massive infection from milk is greater in rural than in urban areas, for supplies usually come from one farm and are not mixed before distribution.

In older persons it is doubtful whether an inquiry into milk supply is of much value, for patients may consume any kind of milk outside the home, and the fact that one particular supply is taken by a household means nothing unless a patient is confined to the house. Nevertheless, 24 out of the 31 persons above 10 years of age (77.4%) were supplied with raw milk and the others with dealer 'X' milk.

The more detailed analysis for the respective diseases in this inquiry gave even more significant results than those of a general survey.

Table 12. *Milk supply of patients with extrapulmonary tuberculosis due to the bovine type of the tubercle bacillus. Industrial area*

Disease	Milk supply	Age (years)						
		Under 5	-10	-15	-20	-25	-30	-40
Tuberculous meningitis	Dealer 'X'	2	5	2	1	1	—	—
	Raw	12	4	2	4	4	—	2
Cervical adenitis	Dealer 'X'	—	1	—	—	—	—	1
	Raw	3	5	4	1	2	1	—
Bone and joint tuberculosis	Dealer 'X'	1	—	—	—	2	—	—
	Raw	1	2	—	1	3	—	—

Raw milk was supplied to 71·8 % of the 39 persons with tuberculous meningitis, to 88·9 % of 18 with cervical adenitis, and to 70 % of 10 with bone and joint disease. The remainder were supplied by dealer 'X'.

*Conclusion.* It was apparent that milk was a probable source of infection in patients harbouring the bovine type of the tubercle bacillus, for, although no attempt was made to correlate milks proved to contain tubercle bacilli with patients from whom the bovine type of the tubercle bacillus was isolated, it was known that such milks must have been ingested by many of the persons affected.

During the period of this investigation I found tubercle bacilli in bulk milk from two of three pasteurization plants in the industrial area, plants from which the majority of consumers of dealer 'X' pasteurized milk were supplied. In each case inspection and examination of the plant showed it to be obsolete and ineffective in action and, as a result, replacement by new and efficient apparatus followed.

With one exception, all the burghs and most of the industrial area of the landward county of Lanark derived pasteurized milk from these two sources. It is significant that the only case of tuberculosis due to the bovine type of the tubercle bacillus in consumers of pasteurized milk in the area supplied from the third plant was a female of 20 years of age who suffered from tuberculous meningitis as a terminal manifestation in miliary tuberculosis.

Dealer 'X' retailed pasteurized milk and also untreated undesignated milk, so that, apart from the probability of infection from the inadequately pasteurized milks, the possibility of infection from raw milk supplied by this dealer cannot be overlooked.

Dairy farming is the principal occupation in the rural area of the county of Lanark, and there were 1255 herds registered to produce milk for sale. Fourteen herds were licensed to produce 'Certified' milk, 246 'Tuberculin-tested' milk and 265 'Standard' milk. The remaining herds were registered to produce undesignated milk. Many herds in the 'Standard' category had failed to pass

the tuberculin test on application for the higher grade of licence.

It is of passing interest to know that during the period of this inquiry I examined samples of bulk milk produced in the county of Lanark and found the results recorded in Table 13.

Table 13. *Biological examination of bulk milk for the presence of tubercle bacilli*

	No. of milks investigated	Samples found to contain virulent tubercle bacilli
1937	705	7·0% (49)
1938	638	6·4% (41)
1939	648	10·7% (69)
1940	210	5·7% (12)
1941	964	4·0% (39)
1942	496	5·7% (28)

The figures for milk examination are those of milks sampled in the landward area of the county and did not include any taken in the large burghs or any 'Certified', 'Tuberculin-tested' or 'Pasteurized' milks. Until the introduction of the designation 'Standard' the milks examined were 'Grade A' or undesignated.

From 1939 almost all samples examined were 'Standard' milks, and the percentage of positive findings was lower than the actual incidence, as examinations of many of the negative samples were repeated on account of their failure to pass the bacteriological standard of cleanliness and examinations of 'positive' samples were repeated after the removal of tuberculous animals from the herd.

Apart from the milks examined from the landward area, samples from retailers in other districts of the county gave 'positive' results and, as many were mixed milks, the incidence of infecting milks was undoubtedly higher than the incidence found among bulk milks collected at individual farms.

The circumstantial evidence for infection from milk in cases of extrapulmonary tuberculosis due to the bovine type of the tubercle bacillus was very strong but not proved conclusively by these findings.

## DISCUSSION

Lanarkshire is the most highly industrialized county in Scotland. The estimated population in 1939 was 506,196 persons and the total area 536,075 acres. Of the total population 443,772 persons resided within the purview of the industrial area of 135,187 acres and 62,424 persons occupied the rural districts that extend to 400,888 acres.

In the *Annual Report of the Sanitary Inspector for the Landward Area of the County of Lanark (1939)* attention was drawn to the general position of overcrowding and, although a slight improvement was noted in rural areas, the situation in the industrial area was considered 'deplorable'. Despite attempts to alleviate conditions there still remained on the register at the end of 1939, 18,756 overcrowded dwelling houses, containing 22,554 families with a total of 96,969 persons. This showed that 32.1% of the entire landward community lived under conditions of overcrowding. Primitive sanitation had aggravated the burden of lack of suitable accommodation in many districts.

In an attempt to discover factors that could influence the proportional frequency of the type of tubercle bacillus and could give a higher incidence of infections with the human type of the tubercle bacillus in extrapulmonary tuberculosis, an examination of social environment as a likely source of information regarding a variation in soil was followed along avenues that might lead to some enlightenment.

Many interesting facts emerged from an analysis of housing conditions and economic resources.

Taking as a basis for substandard housing the accommodation of two or more persons for each apartment, including the kitchen as an apartment, it was found that 225 of the total of 311 cases of extrapulmonary tuberculosis investigated came from overcrowded dwellings.

The frequency of overcrowding was higher in the homes of patients in the industrial area than it was in the rural area.

In a general analysis of cases in the industrial area it was found that 75.9% of patients came from substandard homes, and, in a more detailed analysis, it was still found that over 73% of patients with each disease, tuberculous meningitis (74.8%), cervical adenitis (80.0%) and bone and joint disease (73%), came from substandard homes. An analysis of the type of infecting strain of the tubercle bacillus in each group showed little difference in relation to overcrowding.

In rural areas the general incidence of substandard housing among patients was 55.1%, but this figure was influenced by the majority of persons suffering from bone and joint disease being inadequately housed; 72.7% of such persons lived in over-

crowded dwellings, and there was no appreciable difference between infections due to the human and bovine types of the tubercle bacillus. In patients with tuberculous meningitis and cervical adenitis overcrowding was much more prevalent in those with infections with the human type than in those with infections with the bovine type of the tubercle bacillus.

Examination of age incidence in extrapulmonary tuberculosis in relation to substandard housing showed that all the 25 patients of 1 year of age and under in the industrial area came from homes where overcrowding prevailed and that 16 of them came from single-apartment houses.

That the risk of infection in childhood was much greater in substandard homes than in satisfactory homes was shown by an analysis of infections caused by the human type of the tubercle bacillus before 10 years of age had been reached.

In the industrial area tuberculous meningitis due to the human type of the tubercle bacillus occurred in 50.4% of patients coming from overcrowded homes before the tenth year of life had been completed, but in only 17.2% of the patients from satisfactory homes.

The sex incidence also showed a remarkable difference, for the smaller percentage from good homes were all males and the larger percentage from overcrowded dwellings showed an equal liability to infection in the sexes.

Infections due to the bovine type of the tubercle bacillus showed no significant variation in relation to housing conditions.

Patients with cervical adenitis due to the human type of the tubercle bacillus showed the same difference in occurrence; 60.7% of the patients from substandard homes and 16.7% of those from satisfactory homes were under 10 years of age, and again the change from a preponderance of infected males in satisfactory homes to equality of infection in males and females in overcrowded dwellings was noted.

Infections due to the bovine type of the tubercle bacillus also showed a higher relative proportion among children under 10 years of age in substandard houses, but the difference was not so great as in infections due to the human type of the tubercle bacillus. Infection was equal for the sexes in overcrowded homes.

In bone and joint disease, 28.2% of the patients infected with human strains of the tubercle bacillus residing in overcrowded dwellings, and 14.3% of those living in satisfactory homes were under 10 years of age. The sexes were equally affected in both groups.

Infections due to the bovine type of the tubercle bacillus showed no difference in relation to housing.

In the rural areas numbers were too small for

analysis, but it is noteworthy that although there was no case of cervical adenitis due to the human strain of the tubercle bacillus in persons under 10 years of age living in satisfactory homes, 90% of the patients with cervical adenitis due to the human type of the tubercle bacillus from substandard houses were under 10 years of age.

This analysis revealed several important facts.

Overcrowding was a factor in the lives of the majority of patients from the industrial area and, from the evidence, it was an important factor in influencing the incidence of infection with the tubercle bacillus, particularly in children.

It swayed the balance of the sex incidence so that infection in females became as frequent as in males. This feature was entirely in infections with the human type of the tubercle bacillus, for bovine figures showed nothing significant in relation to housing conditions.

In the rural area, where substandard housing was not so common, figures were too small for an age analysis to be made, but it was a feature that, generally, overcrowding was more prevalent in infection with the human type of the tubercle bacillus than it was in infection with the bovine type.

Examination of the financial resources of patients suffering from extrapulmonary tuberculosis showed that economic hardship was more prevalent in industrial districts, for while 44.7% of the 262 persons residing in the industrial area had weekly family incomes of 10s. or less per head, only 20.4% of the 49 living in the rural area were so poor.

A more critical analysis showed that, in the industrial area, over half of the patients (55.4%) who came from homes where the family income was below the poverty line were children under 10 years of age, and these children comprised 52.1% of children under 10 years of age with extrapulmonary tuberculous lesions.

The incidence was relatively higher among those with infections due to bovine than it was among those with lesions due to human strains of the tubercle bacillus.

A particular survey of rural patients was of little value on account of the small number of cases considered, but it was significant that 70% of patients with low economic resources were under 10 years of age.

The majority of patients coming from families with low incomes lived in overcrowded houses, but the high percentage of children under 10 years of age with infections due to the bovine type of the tubercle bacillus seemed to indicate that some factor apart from overcrowding had an influence on susceptibility to infection with the tubercle bacillus, possibly through the deprivation of some necessary protection that was acquired by those more adequately supplied with the amenities of life.

It can at least be said that, although it was difficult to assess any exact influence of low economic resources in addition to the unquestionable danger of proximity of contacts in overcrowded dwellings in infections with the human type of the tubercle bacillus in children, there was evidence to point to the added influence of poverty in the susceptibility of children to infection with the bovine type.

A history of contact with previously recognized cases of tuberculosis in the home, or of earlier manifestations of tuberculous disease in the patient, was obtained from 108 of the 311 persons examined.

More detailed investigation revealed evidence that contributed a possible explanation of the high incidence of infection with the human type of the tubercle bacillus in cervical adenitis and in bone and joint disease.

Pulmonary tuberculosis in immediate home contacts was found in 58 persons in the industrial area and in 11 persons in the rural area. A further 20 persons in the industrial area and 1 rural patient with bone and joint tuberculosis had pulmonary as well as extrapulmonary lesions.

It was shown that of patients from whom the human type of the tubercle bacillus was isolated 50% of those with cervical adenitis, who came from the industrial area, had a family or personal history of pulmonary tuberculosis and that, in the rural area, in 71.4% of persons suffering from bone and joint disease there was a history of pulmonary tuberculosis in the household.

These figures show that the possibility of droplet infection with the human type of the tubercle bacillus was a frequent hazard in a known high percentage of persons suffering from those two diseases and was a probable cause of the preponderance of infections due to human strains of the tubercle bacillus in the series of cases investigated.

The presence of other members suffering from non-pulmonary tuberculosis occurred in the household of only 8 patients, from all of whom the bovine strain of the tubercle bacillus was isolated and was an interesting feature of this analysis, for, although the probability of case to case infection might be doubtful, the possibility of a common source of infection could not be dismissed.

The possibility of milk supply as a reason for the regional difference in the proportional frequency of human and bovine types of the tubercle bacillus has long been stressed by many workers, and Macgregor & Green (1937) suggested that, in further investigations, this subject should be recorded.

To establish the exact time of the primary infection with the tubercle bacillus is impossible and, for that reason, no attempt was made in this inquiry to correlate examinations of milk supplies for the presence of tubercle bacilli with infections in patients due to bovine strains of the tubercle bacillus.

The kind of milk normally consumed by the patient in his own home was ascertained, and it was astonishing to find such overwhelmingly convincing evidence of the probability of milk being the source of infection in patients from whom bovine strains of the tubercle bacillus were isolated, for every patient in this series consumed either raw, undesignated milk or milk supplied by dealer 'X' which, though sold as undesignated in most places, was very often pasteurized.

The importance of the milk supply in extrapulmonary tuberculosis was shown by the fact that over half of the patients with infections due to the bovine type of the tubercle bacillus were under 10 years of age and that 75% of those persons consumed raw milk; the remainder took dealer 'X' milk that was either raw or pasteurized, and it was known that pasteurization was not always effective, for random samples from two plants were found to contain tubercle bacilli on delivery to the consumer.

In a particular analysis of the several manifestations of extrapulmonary tuberculosis occurring among patients in the industrial area, even more significant pointers to milk as the source of infection in human tuberculosis due to the bovine type of the tubercle bacillus were forthcoming, for raw milk was supplied to 71.8% of the 39 persons with tuberculous meningitis, to 88.9% of those with cervical adenitis and to 70% of those with bone and joint disease. All the others consumed dealer 'X' milk.

From these findings it was possible to conclude that all the social factors considered were important in determining the incidence of tuberculosis in children and the type of the infecting strain of the tubercle bacillus. Substandard housing and history of contact with open cases of pulmonary tuberculosis were more important in infections with the human strains; income and milk supply in infections with bovine strains of the tubercle bacillus.

#### SUMMARY

An investigation into the probable influence of environmental factors on the incidence of extrapulmonary tuberculous infections and into the possible explanation of their effect on regional differences in the proportional frequency of the type of infecting strain of the tubercle bacillus has been described.

The importance of substandard housing and of family history in infection with the human type of the tubercle bacillus, particularly in children, has been noted.

Circumstantial evidence of both low economic resources and milk supply influencing infection with the bovine type of the tubercle bacillus pointed to these factors being important in childhood.

I wish to acknowledge the co-operation I received from the Medical Officers of Health for the several Local Authorities within the county of Lanark.

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