

# Acute appendicitis and bathrooms in three samples of British children

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## Abstract

The occurrence of appendicectomy in three national samples of British children was analysed in relation to household amenities, crowding in the home, and social class. The risk of having the operation depended on the amenities present in the home, in particular whether or not there was a bathroom. This risk was independent of social class.

The findings support a relation between acute appendicitis and Western hygiene, which would explain the geographical distribution of the disease and its changing incidence over time. In the developing world, where children grow up in conditions of poor hygiene, there may be outbreaks of appendicitis when housing improves.

## Introduction

The "hygiene hypothesis" suggests that the rise in appendicitis in Britain during the first half of this century and the continuous fall thereafter were caused by improvements in hygiene.<sup>1</sup> Increasing provision of household amenities such as baths and piped hot water and reduction in domestic overcrowding were important parts of these improvements. The occurrence of appendicectomy has been recorded in three national samples of British children, born in 1946, 1958, and 1970 respectively. We report on the risk of having the operation in relation to household amenities, crowding, and social class in each sample.

## Population and methods

The 1946 cohort was taken from 13 687 infants, who represented 82% of all infants born alive in Britain during one week in March 1946.<sup>2</sup> Twins and illegitimate children were not followed up. Of the remaining 12 472, all who were the children of non-manual and agricultural workers were followed up together with one in four children of manual workers, giving a sample of 5362. Information recorded at the age of 2 included whether the house had a bathroom, a hot water system, and exclusive use of a kitchen and the number of people in the household. Social class was based on the occupation of the father of the survey child in 1957 or, if this was not known, 1946. The sample was stratified into four social groups according to parental occupation, education, and class of origin. During periodic visits up to the age of 15 the occurrence of an appendicectomy was reported and verified from hospital records.

The 1958 cohort was based on all births in Britain during one week in March 1958. A total of 98.5% of these births were included in the British perinatal mortality survey and the survivors followed up at the ages of 7, 11,

and 16 years.<sup>3,4</sup> Information about household amenities was first recorded at age 7. Social class of the head of the household was recorded at the time of birth. Household composition was recorded at birth and at ages 7 and 11. This analysis is based on 5153 children whose address at age 7 was the same as at birth. In 3515 of these children it was known whether or not they had had an appendicectomy before the age of 17.

The 1970 cohort was based on all births during one week in April 1970; 97.5% were included in the British births survey and the survivors followed up at the ages of 5 and 10 years.<sup>5,6</sup> Our analysis is based on 4768 children whose address at age 5 was the same as at birth and who were followed up to the age of 10. Observations made at that time included father's occupation, household amenities, and household composition.

We examined the associations of appendicectomy with social class and the variables implicated by the hygiene hypothesis—that is, household amenities and crowding. The strength of each association was expressed in terms of relative risks and 95% confidence intervals.<sup>7</sup>

## Results

Two hundred and eleven of the 5362 children in the 1946 cohort had an appendicectomy before the age of 15. The prevalence of appendicectomy declined with social group, with a significant fall in relative risk from 1.4 in the first group to 0.7 in the fourth (fig 1). Table I shows the relation with

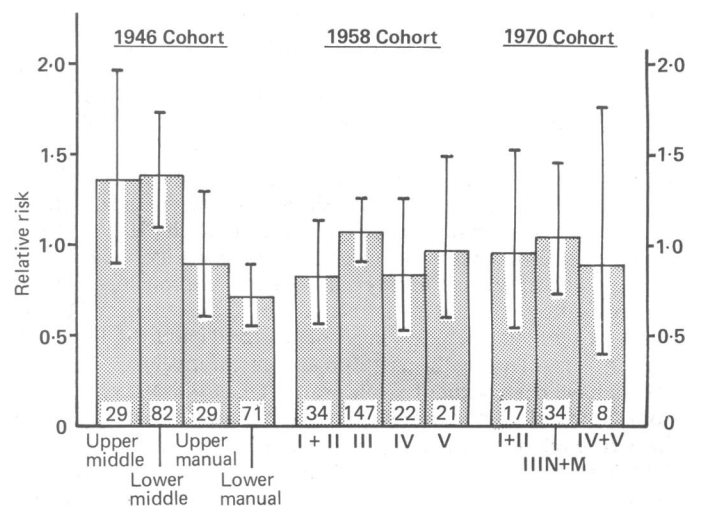


FIG 1—Relative risk of appendicectomy according to social group or class in three cohorts of children. Bars are 95% confidence intervals. Numbers of cases shown (information not available in a few cases).

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household amenities. A household without a bathroom was associated with a reduced relative risk of appendicitis (0.7; fig 2). Lack of a hot water system and shared use of a kitchen had risks of 0.9. There was a progressive fall in risk from possession of all three amenities to lack of all three. After adjustment for social group a household without a bathroom had a risk of 0.8 (95% confidence interval 0.6 to 1.2). Figure 3 shows that relative risks in the four categories of numbers of people per room did not differ significantly from unity.

Two hundred and thirty of the 3515 children in the 1958 cohort had an appendicectomy before the age of 17. Figure 1 shows that there was no trend with social class at birth; neither was there a trend with social class at age 7. Table II lists the amenities in the home. Homes without exclusive use of a bathroom (fig 2), hot water system, and indoor lavatory were all associated with an increased risk of appendicectomy, but only for an indoor lavatory was this significant at the 5% level. Homes lacking one amenity tended to

lack others. Of the 40 homes without exclusive use of a bathroom, 38 did not have exclusive use of an indoor lavatory.

There was no association between appendicectomy and the average numbers of people per room in the home recorded at birth or age 7 (fig 3). Nor was there an association between the total number of people in the home, number of people aged under 21, or numbers of rooms in the home recorded at age 11. There was, however, a relative risk of 1.4 (95% confidence interval 1.0 to 2.0) associated with attendance at a nursery school.

TABLE I—Appendicectomy and household amenities in 1946 cohort

Amenity	Appendicectomy*	Relative risk	95% Confidence interval
Bathroom	136	1.0	
No bathroom	59	0.7	0.5 to 0.9
Hot water system	116	1.0	
No hot water system	81	0.9	0.7 to 1.2
Kitchen, exclusive use	170	1.0	
Kitchen, shared	23	0.9	0.6 to 1.4
All amenities	99	1.0	
Without one amenity	37	0.9	0.6 to 1.4
Without two amenities	50	0.8	0.5 to 1.1
Without three amenities	5	0.5	0.2 to 1.2

\*Totals vary slightly because information not available in a few cases.

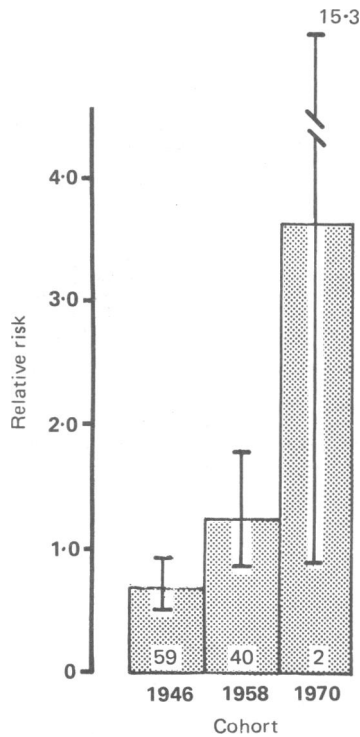


FIG 2—Relative risk of appendicectomy in households without bathroom in three cohorts of children. Bars are 95% confidence intervals. Numbers of cases shown (information not available in a few cases).

TABLE II—Appendicectomy and household amenities in 1958 cohort

Amenity	Appendicectomy*	Relative risk	95% Confidence interval
Bathroom:			
Exclusive use	190	1.0	
None or shared	40	1.3	0.9 to 1.8
Hot water system:			
Exclusive use	204	1.0	
None or shared	26	1.2	0.8 to 1.9
Indoor lavatory:			
Exclusive use	168	1.0	
None or shared	60	1.5	1.1 to 2.0

\*Totals vary slightly because information not available in a few cases.

Sixty eight of the 4768 children in the 1970 cohort had an appendicectomy before the age of 11. Figure 1 shows that there was no trend by social class at age 10. The numbers of children living in households without amenities were small. The relative risk associated with lack of a bathroom was 3.6 (fig 2), but this was based on only two cases and was not significant at the 5% level.

There was a small increase in risk associated with each additional person in the household. This association was stronger for additional children aged under 16 in the household (fig 3). There was an increase in risk of 1.6 for each person additional to the index child (95% confidence interval 1.2 to 2.0).

Comparison of the prevalence of appendicectomy in the three cohorts had to be limited to ages up to 11 years. Values were 2.8% for the 1946 cohort, 2.0% for the 1958 cohort, and 1.4% for the 1970 cohort.

Discussion

We have analysed the prevalence of appendicectomy in relation to household amenities, crowding, and social class in three national samples of children in Britain. In the oldest sample, born in 1946, the risk of having an appendicectomy was higher in children of higher social class (fig 1), as occurred throughout the first part of this century.<sup>8</sup> The risk was also higher in children who at 2 years of age were living in households with amenities, in particular a bathroom (fig 2). This higher risk associated with having a bathroom was not abolished by allowing for social class. It was not secondary to a relation with reduced crowding (fig 3). It could be argued that

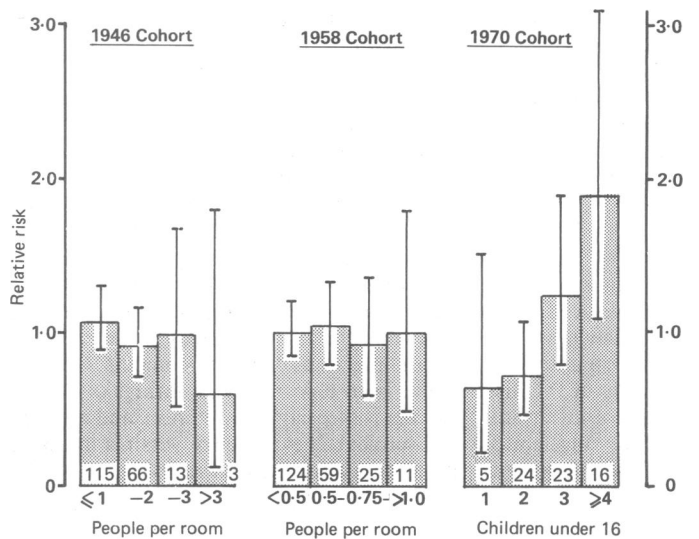


FIG 3—Relative risk of appendicectomy according to crowding in households in three cohorts of children. Bars are 95% confidence intervals. Numbers of cases shown (information not available in a few cases).

higher rates of appendicectomy in wealthier social groups were the result of more demand for or better access to medical care, with higher rates of removal of normal appendices. In Ireland, however, where rates of appendicitis are high and health care is funded privately as well as by the state, the proportion of removed appendices which are pathologically normal is similar to that in Britain.<sup>9</sup> It seems unlikely that appendicectomy rates have been greatly influenced by unnecessary emergency surgery performed on children from wealthier families, certainly since the inception of the National Health Service in Britain.

In the 1958 sample there was no trend in risk of appendicectomy with social class (fig 1) but lack of amenities was associated with an increased risk (fig 2), the strongest association being with lack of an indoor lavatory. There was no association with indices of domestic crowding (fig 3), but attendance at nursery school was associated with increased risk. In the 1970 sample there was similarly no trend with social class (fig 1) but lack of a bathroom was associated with an increased risk (fig 2), though few of the children lived in houses without amenities. In the 1970 sample there was also an increased

risk associated with crowding, indicated by greater numbers of children in the household when the index child was 10 years old (fig 3).

After an abrupt and steep rise during the first decades of this century the incidence of appendicitis has fallen during the past 30 years.<sup>1</sup> It is unclear when this fall began. Mortality declined from the 1930s onwards but incidence rates, estimated from hospital discharges and general practice consultations, are available only from the 1950s. They show a continuous decline which was reflected in the successive fall in prevalence of appendicectomy in the three cohorts. The 1946 sample of children were born at around the peak period of incidence, whereas when the two later samples were born rates were declining.

Our findings support the hygiene hypothesis. This suggests that as hygiene improved young children began to escape infection and thereby became more vulnerable to appendicitis when exposed to infections in later childhood and early adult life. The higher risk of appendicitis associated with households with a bathroom in the 1946 sample supports this. Further supportive evidence comes from recent studies in Anglesey and Hong Kong. Operating theatre records maintained in Anglesey over the past 50 years show a sharp rise in rates of appendicitis after the introduction of a piped water supply and the increase in domestic hot water systems and fixed baths which followed.<sup>10</sup> The remarkable improvements in housing, water supplies, and sanitation in Hong Kong since the second world war have been associated with a steep rise in appendicitis.<sup>11</sup> A case-control comparison showed that patients with appendicitis had had more household amenities and less crowding in early childhood.

The hygiene hypothesis suggests that with continued improvements in hygiene exposure to infections during childhood and early adult life falls and rates of appendicitis fall with it. The higher risk of appendicitis in households in the 1958 and 1970 samples which lacked amenities or were overcrowded supports this. After 1946 there was a steep and continuing increase in the numbers of households in Britain which had amenities. A relation between rates of appendicitis and conditions associated with worse hygiene is also supported by the correlation between rates during 1979-82 in 90 areas of Britain and Ireland and the percentage of households lacking fixed baths and hot water systems (accompanying paper). The association with crowding in the 1970 sample and with attendance at nursery school in the 1958 sample may indicate that both respiratory and enteric infections cause appendicitis. Clusters of cases of the disease have been reported after outbreaks of both kinds of infection.<sup>12</sup> *Yersinia* is of particular interest, and a recent survey in Ireland showed serological evidence of *Yersinia* infection in 31% of cases with histologically proved disease.<sup>13</sup>

We conclude that our findings in three samples of British children support the hypothesis that appendicitis is primarily caused by Western housing rather than by Western diet, as has been suggested previously. This would explain the international distribution of the disease, which is predominantly one of industrialised countries, and the rise in incidence which has accompanied Westernisation of non-industrialised communities—for example, in Africa,<sup>14</sup> Hong Kong, and among the Canadian Indians and Eskimos.<sup>15</sup> It explains the rarity of the disease in urban blacks in South Africa despite their adoption of aspects of Western lifestyle, including low consumption of fibre.<sup>16</sup> It predicts that communities in which children still grow up in conditions of Third World hygiene will experience outbreaks of appendicitis when housing improves. The magnitude and duration of these outbreaks will depend on the speed with which the change from Third World to Western hygiene is effected.

We acknowledge the NCDS user support group for work on the seven, 11, and 16 year follow up of the 1958 cohort.

## References

- 1 Barker DJP. Acute appendicitis and dietary fibre: an alternative hypothesis. *Br Med J* 1985;290:1125-7.
- 2 Wadsworth M. Follow-up of the first national birth cohort: findings from the Medical Research Council national survey of health and development. *Paediatric and Perinatal Epidemiology* 1987;1:95-116.
- 3 Davie R, Butler NR, Goldstein H. *From birth to seven: a report of the national child development study*. London: Longman, 1972.
- 4 Fogelman K, Wedge P. The national child development study (1958 British cohort). In: Mednick SA, Baert AE, Bachman BP, eds. *Prospective longitudinal research: an empirical basis for primary prevention of psychosocial disorders*. London: Oxford University Press, 1981:30-43.
- 5 Butler NR, Golding J. *From birth to five: a study of the health and behaviour of Britain's five year olds*. Oxford: Pergamon Press, 1986.
- 6 Butler NR, Golding J, Haslum M, Stewart-Brown S. Recent findings of the 1970 child health and education study: preliminary communication. *J R Soc Med* 1982;75:781-4.
- 7 Breslow NE, Day NE. Statistical methods in cancer research. *IARC Sci Publ* 1980;No 32.
- 8 Spencer AM. Aetiology of acute appendicitis. *Br Med J* 1938;ii:227-30.
- 9 Attwood SEA, Cafferkey MT, West AB. High appendicectomy rates in Ireland: why? *J Epidemiol Community Health* 1987;41:72-3.
- 10 Barker DJP, Morris JA, Simmonds S, Oliver RHP. Appendicitis epidemic following introduction of piped water to Anglesey. *J Epidemiol Community Health* (in press).
- 11 Donnan SPB. Appendicitis in Hong Kong. In: *The aetiology of acute appendicitis*. Southampton: MRC Environmental Epidemiology Unit, 1986:16-9. (Scientific Report No 7.)
- 12 Palmer SR. The role of *Yersinia* in mesenteric lymphadenitis and appendicitis. In: *The aetiology of acute appendicitis*. Southampton: MRC Environmental Epidemiology Unit, 1986:30-3. (Scientific Report No 7.)
- 13 Attwood SEA, Cafferkey MT, West AB, et al. *Yersinia* infection and acute abdominal pain. *Lancet* 1987;ii:529-33.
- 14 Burkitt DP. The aetiology of appendicitis. *Br J Surg* 1971;58:695-9.
- 15 Schaefer O. Aetiology of appendicitis. *Br Med J* 1979;ii:1215.
- 16 Segal I, Walker ARP. Low fat intake with falling fiber intake commensurate with rarity of noninfective bowel diseases in blacks in Soweto, Johannesburg, South Africa. *Nutr Cancer* 1986;8:185-91.

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## ONE HUNDRED YEARS AGO

A MEETING was recently held at Margate under the auspices of the Burial Reform Association, to which Dr. Rowe addressed some very timely remarks upon the desirability of an alteration in the present system of burial. Dr. Rowe once more pointed out that the decomposition of the body after death is, when viewed from the chemical standpoint, always a combustion, and he admitted the logical consequence—namely, that the most perfect, rapid, and elegant form of combustion was cremation. The “earth-to-earth” system advocated by Mr. Seymour Haden, where the body is placed in a coffin of stout millboard, which rapidly decays, and permits the products of animal decomposition to pass directly into the surrounding earth, is undoubtedly a distinct advance upon the system still prevalent of burying in leaden or stout wooden coffins of many casings, which have the effect of retarding disintegration, and lead consequently to a storing up of huge

aggregations of human remains in every stage of decay. Such a system is not consonant with reason, and the Bishop of London has declared it to be “inconsistent with the principles of the Christian faith;” it cannot therefore be defended upon any other ground than an unreasoning acquiescence in a comparatively modern and most unhygienic custom. The Burial Reform Association, of which the Rev. F. Lawrence, Westow Vicarage, York, is the Honorary Secretary, advocates early interment, and the use of perishable coffins to permit rapid disintegration after burial in the earth. As to the first, there can be no room for difference of opinion; and as to the second, those who are unwilling to carry the matter to its logical conclusion may fairly be asked to resort to this system, to which the term “Eremacausis” has been applied.

(*British Medical Journal* 1888;ii:311)