Epidemiol. Infect. (2001), **126**, 211–217. Printed in the United Kingdom

Risk factors for meningococcal disease in university halls of residence

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(*Accepted 3 November 2000*)

SUMMARY

A retrospective ecological study was undertaken to identify social and environmental factors associated with increased incidence of meningococcal disease in university halls of residence. A standardized questionnaire was sent to UK universities and colleges of higher education outside London, for distribution to halls containing at least 50 students. Incidence rate ratios of invasive meningococcal disease were obtained for a range of social and environmental variables. Multi-variable Poisson regression analysis identified 3 factors as having a strong association: a high proportion of first year undergraduate residents ($P = 0{\cdot}0008$), decreasing smokiness of the hall bar ($P < 0{\cdot}0001$), and opening of hall bar before 1990 ($P = 0{\cdot}0001$). The inverse relationship between disease incidence and smokiness of bars was an unexpected finding, and may be due to confounding factors. Universities should continue to promote awareness of meningococcal disease, encourage vaccination of first year students against serogroup C disease, and where appropriate, take measures to reduce overcrowding.

INTRODUCTION

Outbreaks of meningococcal disease in UK university students in recent years have drawn attention to the risk in this group [1]. The largest reported outbreaks have been in Cardiff and Southampton, involving a total of 13 cases in students, of whom 5 died [2–4]. A UK survey of meningococcal disease in young adults aged 18–21 years during the 4-year period 1994–7 found that the incidence was higher in university students than in other young people of the same age [5]. This excess incidence was noted particularly in universities with a relatively high proportion of catered accommodation. In some universities certain halls of residence contributed a disproportionate number of cases. Seven out of a total of 12 clusters (3 or more cases in one university during a single term) occurred in a particular hall of residence [6]. University clusters, especially those associated with halls of residence, are believed to be due to close social contact among susceptible individuals [7]. However, it is not clear why particular halls of residence should have a greater risk of cases or clusters of disease than others.

A pilot study of social and environmental factors in halls of residence found an association between

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https://doi.org/10.1017/S0950268801005301 Published online by Cambridge University Press

Table 1. *Halls of residence and meningococcal disease*: *single variable analysis*

Variable	Number of halls	Number of cases	Incidence per 100000	95% CI	*P* value
Year hall constructed					
Before 1970	230	58	22·1	17·1–28·5	
1970–89	105	13	10·7	6·2–18·4	
1990 or after	122	14	11·0	6·5–18·5	0·007
Distance from main campus					
< 1 mile	331	44	12·9	9·6–17·3	
1–3 miles	148	44	22·0	16·4–29·5	0·01
Hall has more than 500 residents					
No	428	59	16·8	13·0–21·6	
Yes	63	30	14·7	10·3–21·0	0·5
Percentage of male residents					
< 40%	49	6	16·1	7·2–35·9	
40–60%	293	57	16·6	12·8–21·5	
> 60%	61	2	3·4	1·0–13·8	0·02
Type of accommodation					
Single room on corridor	275	37	13·5	9·8–18·6	
Self contained flats	140	22	13·6	8·9–20·6	
Other	43	4	6·0	2·3–16·0	0·2
Type of hall					
Single block	167	10	9·5	5·1–17·6	
Single block with satellite	44	13	30·5	17·7–52·5	
Multiple blocks	225	58	17·7	13·7–22·9	
Other	19	0	0·0		0·001
Percentage of first year students					
< 50%	78	6	5·9	2·7–13·2	
50–75%	110	26	20·0	13·6–29·4	
> 75%	271	52	17·7	13·5–23·3	0·006
Self catering					
Some residents	267	58	19·7	15·2–25·5	
All residents	221	31	11·9	8·4–16·9	0·02
Single bedrooms					
Some	179	21	10·1	6·6–15·5	
All	308	67	19·4	15·3–24·7	0·006
Catered residents per kitchen					
Number of catered residents	278	43	14·1	10·5–19·1	
< 14	76	10	11·0	5·9–20·4	
14 or more	98	30	28·7	20·1–41·0	0·005
Self catering residents per kitchen					
Number of self catering residents	211	42	20·2	14·9–27·4	
< 7	131	25	15·6	10·5–23·1	
7 or more	135	20	12·8	8·3–19·9	0·2
Smoking allowed in bedrooms					
No	49	27	37·6	25·8–54·8	
Yes	442	62	12·8	10·0–16·4	< 0·0001
Smoking allowed in kitchen					
No	279	35	15·3	11·0–21·3	
Yes	212	54	16·5	12·6–21·5	0·7
Smoking allowed in dining room					
No dining room	221	31	11·9	8·4–16·9	
No	234	57	21·1	16·3–27·4	
Yes	36	1	3·8	0·5–27·3	0·005
Smoking allowed in common room					
No room	102	19	17·2	11·0–27·0	
No	178	45	19·5	14·6–26·1	
Yes	211	25	11·6	7·9–17·2	0·1
Hall has a bar					

https://doi.org/10.1017/S0950268801005301 Published online by Cambridge University Press

No	352	33	10·4	7·4–14·7	
Yes	139	56	23·6	18·1–30·6	0·0001
Variables related to the hall bar					
Smoking allowed in bar					
No bar	352	33	10·4	7·4–14·5	
No	22	10	27·4	14·8–51·0	
Yes	116	46	23·4	17·5–31·3	0·7*
Year bar opened					
No bar	352	33	10·4	7·4–14·6	
Before 1970	56	26	31·5	21·5–46·3	
1970–89	53	14	27·3	16·2–46·1	
1990 or after	27	4	8·1	3·1–21·7	0·02*
Bar volume					
No bar	352	33	10·4	7·4–14·6	
$< = 425$ m^3	50	23	34·4	22·8–51·7	
> 425 m^3	41	18	22·9	14·4–36·4	0·2*
Bar ventilation					
No bar	352	33	10·4	7·4–14·6	
Air conditioning	15	7	20·5	9·8–42·9	
Windows	70	23	23·4	15·6–35·3	
Recycled/Fans	52	26	26·6	18·1–39·0	0·8*
Bar staffing					
No bar	352	33	10·4	7·4–14·6	
Residents	48	19	26·2	16·7–41·1	
Paid bar staff	54	10	10·9	5·9–20·3	
Both	31	18	31·5	19·9–50·0	
Other	2	0	0·0	–	0·02*
How noisy is bar?					
No bar	352	33	10·4	7·4–14·6	
Normal conversation	21	4	10·8	4·0–28·7	
Need to speak up	69	22	18·0	11·9–27·4	
Need to shout	23	8	24·5	12·3–49·0	
Difficult to converse	5	0	0·0	–	0·2*
How smoky is bar?					
No bar	352	33	10·4	7·4–14·6	
Not at all	7	11	68·5	37·9–123·7	
Slightly	29	20	44·2	28·5–68·6	
Moderately	58	9	11·0	5·7–21·2	
Very	24	3	6·1	2·0–18·8	$< 0·0001$*
Annual turnover per resident					
No bar	352	33	10·4	7·4–14·6	
$< =$ £200	38	15	20·5	12·4–34·1	
$>$ £200	43	7	11·4	5·4–24·0	0·2*
Bar capacity					
No bar	352	33	10·4	7·4–14·6	
< 150	44	10	19·6	10·5–36·4	
$> = 150$	63	26	20·1	13·7–29·5	0·9*

* Allowing for the bar effect.

incidence of meningococcal disease and halls of residence with bars. As the numbers were too small to be confident of this or other associations, this ecological study was extended to include universities and colleges of higher education involved in the previous UK incidence survey.

METHODS

We collected data on social and environmental characteristics of halls of residence. These data were linked with information previously collected as part of the UK incidence survey [5].

https://doi.org/10.1017/S0950268801005301 Published online by Cambridge University Press

Definitions

Hall of residence. Single or multiple buildings designated by the university as a hall of residence for undergraduate students. Halls with fewer than 50 residents or with a majority of postgraduate students were excluded.

Case. Confirmed or probable case of meningococcal disease [8] in a student who was resident in a study hall. Cases were included if the onset occurred while the student was in residence or within the first 7 days after leaving residence.

Period of study. The 4 academic years 1994/5–1997/8.

Study population. Halls of residence of those higher education institutions in the United Kingdom in health authorities and boards that had provided data for the UK incidence survey. Universities and colleges in London were excluded because of difficulties in obtaining disease incidence data for London institutions [5].

Data collection

A standard letter and questionnaire were distributed to Vice Chancellors of universities and Principals of other colleges of higher education through the Committee of Vice Chancellors and Principals, and the Standing Committee of Principals. They were asked to arrange for completion of a separate questionnaire for each of their halls of residence that was eligible for inclusion in the study. Data were collected on 31 social and environmental variables including number and age of buildings, distance from main campus and students union, details of residents (numbers, study year, gender), catering arrangements, numbers of bedrooms and kitchens, smoking policy, and various variables relating to hall bars (age, capacity, size, ventilation, noise, smokiness, staffing, financial turnover). Numbers of cases of meningococcal disease by hall of residence had been ascertained previously [5].

Analysis

A Poisson regression analysis was used to study the association between the incidence of meningococcal disease and the social and environmental factors of interest. The number of cases of disease in a hall was modelled as the dependent variable and the social and environmental factors were the explanatory variables. The natural logarithm of the total number of person-years at risk was fitted as an offset. This model provided estimates of incidence rate ratios, together with 95% confidence intervals (CI), for each variable.

Each explanatory variable was first investigated individually for association with invasive meningococcal disease. Those showing an association with a P value of 0·1 or less were included in a regression model. The significance of each variable included in the regression was assessed using the likelihood ratio test. Those with little evidence of effect were excluded from the model. All variables excluded by the single variable analysis were then tested against the final model to ensure they did not contribute toward the prediction. The final model was tested for all two-way interactions between the explanatory variables.

RESULTS

Of the 100 universities and colleges for which incidence data were available, 90 (90%) responded. Questionnaires were completed for 501 halls of residence. Ten halls were excluded because of lack of data on numbers of residents. In the remaining 491 halls, which together contributed 556236 resident years, there were 89 cases of invasive meningococcal disease during the 4-year period of study. The overall incidence rate in these halls was 16·0 per 100000 resident years at risk (95% CI 13·0–19·7).

The factors most strongly associated with the incidence of invasive disease (incidence rate ratio greater than 2 compared with baseline category) were: construction of hall before 1970, more than one accommodation block, 60% or less male residents, majority of students first year undergraduates, 14 or more residents per kitchen for non self-catering students, no smoking allowed in bedrooms or dining room, and halls with bars (Table 1). Among those halls with bars, the risk ratio was greater than 2 in halls with less smoky bars, older bars (opened before 1990), bars staffed by residents, and bars with a high background noise level (Table 1).

After excluding variables with little or no evidence of effect in the initial regression model, 3 factors were identified in the final model as having a strong association with the incidence of invasive meningo-

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Table 2. *Halls of residence and meningococcal disease*: *Poisson regression model*

Explanatory variable	Number of halls	Estimated incidence rate ratio	95% CI	*P* value
Percentage of first years				
< 50%	78	Reference		
50–75%	110	2·95	0·84–10·23	
> 75%	271	5·43	1·67–17·68	0·0008
Year bar opened				
No bar	352	Reference		
Before 1970	56	13·90	6·56–29·45	
1970–89	53	14·23	4·55–44·51	
1990 or after	27	1·32	0·28–6·28	0·0001
How smoky is the bar?				
No bar	352			
Not at all	7	Reference		
Slightly	29	0·58	0·26–1·31	
Moderately	58	0·14	0·05–0·38	
Very	24	0·06	0·01–0·29	< 0·0001

Table 3. *Halls of residence and meningococcal disease*: *other significant variables*

Factor	Estimated incidence rate ratio	95% CI	*P* value
Residents per kitchen for catered students			
No catered residents	Reference		
< 14	0·64	0·28–1·47	
14 or more	1·71	0·89–3·29	0·05
Single bedrooms			
Some	Reference		
All	1·78	1·05–3·04	0·03

coccal disease: proportion of first year undergraduate residents, smokiness of the hall bar, and date the bar was opened (Table 2).

Complete data on these three variables were available for a total of 419 halls. Sixty-nine cases occurred in these halls during the study period, giving an incidence of 15·3 per 100000 resident years at risk. This is close to the overall rate of 16 per 100000, suggesting that halls excluded from the model because of missing data did not differ significantly with respect to the incidence of invasive meningococcal disease from those included in the model.

A higher proportion of first year undergraduate residents was associated with an increased incidence of invasive meningococcal disease. In halls with more than 75% first year residents the incidence rate ratio was about 5 times the rate in halls with less than 50%. Halls with a bar that first opened before 1990 had 14 times the incidence of cases compared with the rate in halls without a bar. In the 27 halls with bars that had opened since 1990 there was no significant difference in incidence compared with the rate in halls without bars. A strong inverse association was found between the smokiness of the hall bar and the incidence of cases. Halls with bars that were not at all smoky had rates about 17 (95% CI: 3·4–100) times higher than bars that were very smoky. No evidence was found of interaction between these variables.

After allowing for the three strongly associated variables, halls with an average of 14 or more students sharing each kitchen for non self-catering residents, and halls with no shared bedrooms demonstrated a weaker but significant association with the incidence of cases (Table 3).

https://doi.org/10.1017/S0950268801005301 Published online by Cambridge University Press

DISCUSSION

Several social and environmental factors were associated with a higher incidence of meningococcal disease in student halls. While some can be explained by the known epidemiology of meningococcal infection, others are more difficult to interpret. A major difficulty in interpretation of ecological studies is that statistical associations between variables based on characteristics of study populations cannot necessarily be extrapolated to the individual level.

The increased incidence of cases in halls with a higher proportion of first year undergraduates is consistent with a greater overall susceptibility to invasive meningococcal disease in this group. Age-specific incidence in young adults peaks at around the age of 18 years [9]. First year students would thus be expected to have a higher incidence than older age groups. Furthermore, exposure to previously unencountered pathogenic strains of meningococci is likely to be higher among new students. Halls with a lower proportion of first years would be expected to have a more stable population, and thus lower levels of population mixing.

The higher incidence observed in halls with bars and with more residents per kitchen may be due to greater levels of social mixing, with susceptible individuals more likely to come into close contact with carriers of pathogenic strains. Overcrowding is a well established risk factor for meningococcal disease [10, 11]. Similarly the lower incidence in halls with bars that opened in the last 10 years could be attributable to reduced levels of crowding and improved ventilation, although no association between disease incidence and bar ventilation was found in this study. This finding has not been adequately explained, but has potential implications for bar design.

The inverse relationship with smokiness of the bar was the strongest of the 3 predictors in the final model. This was an unexpected finding. Smoking is associated with meningococcal carriage [12, 13] and close contact with smokers is associated with an increased risk of disease [8, 14, 15]. A campus outbreak in the United States of America was associated with attendance at a smoky bar [16]. The information collected about smokiness was highly subjective but the dose response relationship was strong. Confounding due to variables not measured in the study is likely. For example, it is possible that the more smoky bars were avoided by non-smoking students or were less crowded. It did not prove possible to assess overcrowding and proximity of face-to-face contact in this survey.

The noise level within the bar was not a significant independent risk factor. However, risk was found to increase with increasing noise to the level where it was necessary to shout (adjusted incidence rate ratio 3·96 compared with bars where normal conversation was possible), and then to fall. This association may relate to the likelihood of droplet transmission, such that risk increases with rising speech volume and diminishing face-to-face distance until speech becomes impossible or 'mouth to ear' only.

Research into individual risk factors in teenagers will assist in the interpretation of the findings from our study. A case control study is currently in progress in England (J. Tully, personal communication). In the meantime universities and colleges of higher education could, where appropriate, take measures to reduce overcrowding in halls of residence. The recently introduced vaccination of first-year students against serogroup C disease should be supported. Awareness of meningococcal disease among university students and staff must be maintained, since the vaccination programme will not protect against the more common serogroup B strains.

ACKNOWLEDGEMENTS

We are most grateful to those at the universities and colleges who completed the questionnaires, and for the support of the Committee of Vice Chancellors and Principals and the Standing Committee of Principals in conducting this survey.

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