The seroepidemiology of varicella zoster virus among pregnant Bangladeshi and white British women in the London Borough of Tower Hamlets, UK

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SUMMARY

We investigated the comparative seroepidemiology of varicella zoster virus (VZV) in pregnant women of two ethnic groups, white British and Bangladeshi, living in an inner city area of London, United Kingdom. Women aged 16–45 years were recruited from antenatal clinics of the Royal London Hospital in the Borough of Tower Hamlets. Complete data were obtained from 275 white British and 765 Bangladeshi women. VZV antibody prevalence was 93·1% (95% CI 89·4–95·8) and 86·0% (95% CI 83·3–88·4) respectively. Women who were born in Bangladesh and lived there at least until the age of 15 years had the lowest odds of being immune (OR 0·37, 95% CI 0·22–0·63). This implies they will have an increased risk of varicella during pregnancy. Women arriving in the United Kingdom in adulthood should be screened routinely during pregnancy and vaccination offered postpartum if they are susceptible.

INTRODUCTION

In the United Kingdom, like other temperate countries, varicella is predominantly a childhood disease and consequently more than 90% of women are immune by childbearing age [1]. In many tropical and subtropical countries, however, the average age of varicella infection appears to be higher [2–5]. When looking at the likelihood of chickenpox occurring in pregnancy, the estimated risk in the UK population is 1/2000 deliveries [6]. Although most cases are mild, complications include spontaneous abortion, premature labour, varicella pneumonitis, premature delivery and congenital varicella syndrome (CVS) [7–9]. The risk of CVS is about 0·4% in the first 12 weeks of pregnancy which increases to 2% between weeks 13–20 [7]. A study in Dublin, Ireland showed that up to 20% of pregnant women from Asia, Africa and Eastern Europe were susceptible to varicella zoster virus (VZV) [10].

In Bangladesh, the seroprevalence of VZV was just 78% in individuals aged 16–25 years and only reached 85% in the 31–35 years age group [11]. In a preliminary investigation (J. Breuer, unpublished data) in East London, where there is a high proportion of Bangladeshi and other immigrants, it was shown that VZV seroprevalence in pregnant women

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was lower for the South Asians than white British women. This implied an increased risk of varicella during pregnancy for immigrant women. The main aim of this study was to examine the VZV status in pregnant women who lived in the same area of East London and to test the hypothesis that difference in seroprevalence is due to country of birth and particularly where childhood is spent, rather than racial origin or ethnicity *per se*. This might provide clues as to whether the higher risk in tropical and sub-tropical countries is due to local environmental factors or to cultural differences which remain after migration. A secondary aim was to identify other risk factors related to chickenpox which could explain the difference in seroprevalence.

METHOD

Study population

The study sample was a subset of the antenatal population of the London Borough of Tower Hamlets whose care is managed by maternity services at the Royal London Hospital. The London Borough of Tower Hamlets has a population in excess of 161064 (Census 1991). The major ethnic groups are white British (63%) and Bangladeshi (22%). Black Africans and black Caribbeans make up 3·5% and 2·5% respectively. White British and Bangladeshi women were recruited during two separate studies. The first was carried out over a period of 6 months from October 2001 to March 2002 at routine antenatal clinics held in community health centres by midwives in the Tower Hamlets Primary Care Trust (PCT). Busy clinics were selected at random, and all women attending were interviewed. The second study was carried out over a 6-month period from September 2003 to February 2004 in the Obstetric Ultrasound department of the Royal London Hospital. The same sampling selection method was applied as in the first study. Since clinics were very busy and patient lists were produced on the same day, women were interviewed according to the next available woman on the patient list.

Patients were invited to participate by explaining to them the purpose of the study and providing them with a letter of invitation. The first author of this study is bilingual in English and Bengali, and was thus able to provide full verbal and written language support. The questionnaire was administered by the author, after verbal and written consent was given.

Women were recruited to the study irrespective of their age and gestation stage. Ethnicity was defined as Bangladeshi if the subject or her parents were born in Bangladesh, and, similarly, as white British if the subject was white and either her or her parents were born in the United Kingdom. This corresponds with the classification of ethnic groups used by the Office of National Statistics for the Census 1991. In this study, ethnicity was assigned by the researcher. Women of other ethnic groups were excluded. Ethical permission for the study was obtained from the East London and City Health Authority (ELCHA) and from PHLS Ethics Committee.

To ensure a representative ethnic sample in the first study, women were recruited from 17 clinics in different areas of Tower Hamlets. Representation was increased in the second study by recruiting in the ultrasound clinic, which is attended by all women booked to deliver at St Bartholomews and the London Hospitals. For both studies interview procedures were modified to maximize the recruitment of women. Thus, wherever possible the midwife introduced the interviewer and asked the woman whether she wished to participate. The response rates among women of both ethnic groups and the relationship between agreeing to participate and the mode of study introduction were noted. The numbers of women booked into each ultrasound clinic precluded recruitment of all those attending. To assess recruitment bias due to refusal, the age and ethnic characteristics of women recruited and not recruited were compared.

Serology

Subjects were asked for permission to access a sample of their serum, which had been taken previously, or would be taken for the management of their pregnancy during their first midwife visit. Sera were stored at -20 °C until they were tested. Serum samples were tested by Behring VZV IgG ELISA (Dade Behring, Marburg, Germany) in the first study and by Diamedix VZV IgG ELISA (Diamedix Corp., Miami, FL, USA) in the second, as the latter was better suited for processing larger batches. The manufacturers quote specificity and sensitivity as 100% and 99·3% for Behring and 96% and 98% for Diamedix.

Questionnaire and data collection

To test the main hypothesis, the following information was sought from subjects: date of birth,

ethnicity, country of birth, whether subjects had lived outside the United Kingdom for ⩾1 year before the age of 15 years, and if so, which country lived in and year of entry into the United Kimgdom. Since varicella is most common in children aged about 1–10 years in the United Kingdom [12, 13], exposure to children aged 1–10 years was used as a surrogate for exposure to varicella following the example of Thomas *et al.* [12]. The questionnaire also asked for information on the patient's history of chicken-pox, and various risk factors such as patient's pre-school attendance (i.e. aged <5 years) of day-care or nursery, number of siblings, birth order, preschool attendance of any siblings, siblings' history of chickenpox whilst living in the same household, number of own children, and other children aged <10 years living in same household, history of chickenpox in the children, own children attending preschool, previous/current employment, birth order of expected child and any previous/current profession involving school or preschool children. If a subject's job in-volved working with children, details were obtained to establish if they had 'significant' contact with children, based on the definition of a 'significant' exposure to VZV in the Immunization Handbook (HMSO, 1996). Contact in the same room (house or classroom) for a significant period (⩾15 min) and face-to-face contact (e.g. while having a conver-sation) were considered significant. The questionnaire was piloted in the first 10 recruits to assess its suitability to the target population. The data gener-ated by the questionnaire and results of the ELISAs were entered into Epi-Info version 6 (CDC, Atlanta, GA, USA).

Sample size

Sample size calculations were based on the lower ex-pected seroprevalence group, i.e. Bangladeshi women (J. Breuer, unpublished data). For the initial study in 2002, the sample size was calculated assuming 80% VZV seroprevalence among Bangladeshis and 90% seroprevalence among white British women; at 5% significance and a power of 80%, with an ad-ditional 20% for multivariable analysis, this gave a required sample size of 250 in each ethnic group. Second sample size calculations using seroprevalence estimates obtained from the 2002 study (95% and 90% amongst UK- and Bangladesh-born women respectively), but the same level of significance and power gave a required sample size of 700

Bangladesh-born and 350 UK-born women (with a ratio of two unexposed to one exposed).

Standardizing test results

As different serological assays were used to test samples collected in 2002 and 2004, the datasets could not be directly merged unless the results were stan-dardized. This was done by re-estimating the positive/ negative cut-off using mixture modelling. This method is described in detail by Gay [14]. Initially, the quantitative assay results (OD) were transformed to the $\log_{10}$ scale and censored results (reported as 0) were assigned to half the detection limit of the assay (there were nine such results for 2002 and two for 2004) [15, 16]. Data were assumed to follow two nor-mal distributions, one for negative and one for posi-tive results. Using mixture modelling, the estimates were calculated by maximum-likelihood methods.

In brief, let n_i be the frequency in one of $i = 1, 2, …,$ 57 serum categories and λ_i be the expected count of that category. Then the maximum-likelihood esti-mates can be calculated by minimizing the deviance D, i.e. the difference between the likelihood of the fitted model (L_C) and the likelihood of the full model, i.e. when $n_i = \lambda_i$ (L_F). The deviance for this model is given by [16]

$$D = -2[\log \hat{L}_C - \log \hat{L}_F] = -2 \sum_{i=1}^{57} n_i \log \frac{\lambda_i}{n_i}.$$

The optimal cut-off point was then estimated to minimize the discrepancy between the specificity and sensitivity on the panel based on the model estimates [14]. Microsoft Excel 2000 was used for the mixture modelling.

Data manipulation and statistical analysis

After the cut-offs of the two tests were estimated, the results were re-classified according to these instead of the manufacturers' cut-offs. The datasets were then merged as there was no indication of potential selection bias. The initial analysis was carried out on the whole eligible population but subsequent analyses were subject to three further exclusion criteria: (1) white British who lived abroad for >1 year; (2) UK-born Bangladeshis who lived abroad for >1 year; and (3) those born in Bangladesh who lived there for <1 year.

A variable combining ethnicity, country of birth and country of childhood was defined as the main

exposure of interest. This variable had four levels (white UK-born, UK-born Bangladeshi, Bangladesh-born immigrated to the United Kingdom as a child, i.e. aged $\leqslant 15$ years or as an adult, i.e. aged >15 years).

Single variable analysis was carried out using a logistic regression model with VZV IgG status positive or negative as the outcome with an association criterion at the 10% level. To show any potential difference between different levels of the exposure variable a multivariable model was fitted adjusting only for age and ethnicity using a stricter association criterion of $P<0.05$. One variable at a time was added into the model and tested for evidence of association trying to determine if any other variables influenced the exposure variable. Once a variable was found to be significant, it was included in the model in a stepwise fashion until no other variables than the ones already in the model showed significant association. Factors highly collinear with immune status (siblings' varicella history and household exposure to varicella) were not included in the analysis. 'Lived abroad for a year or more' and 'years lived abroad' were collinear to ethnicity and were thus not included. Finally, single and multivariable analyses were carried out only for the Bangladesh-born women. STATA version 8.2 was used for the statistical analysis (StataCorp, College Station, TX, USA).

RESULTS

In total, 502 women were invited to participate in the first study (2002), of whom 467 (93%) agreed to participate. Of these 151 were white British, 272 Bangladeshi and 44 of other ethnicity). Response rates for this study were 96% and 92% amongst Bangladeshi and white British women respectively, response rates were generally higher if a midwife was present to introduce the interviewer to the subject (96%) than if the subject was approached directly (89%). Serum samples were available for 439 (94%). In the second study, 976 women in the obstetric ultrasound clinic and maternal assessment unit were invited to participate, i.e. about 20% of women attending the clinic that day. Of these 898 women, 151 white British, 563 Bangladeshi and 184 of other ethnicity took part and 78 refused. The response rate for Bangladeshi women was 92% and for white British women 95.6%, with an overall response rate of 92%. Serum samples were available for 813 (90.4%) of the women in the second study. Forty-six and 164 women

interviewed during the 2002 and 2004 studies respectively were either from another country or ethnicity than the ones of interest and so were excluded.

Mixture modelling

There were 439 samples from 2002 and 813 samples from 2004 available for mixture modelling. The 2-normal distribution fitted the data well for both datasets = [deviance = 26.6 (D.F. = 434) and 44.2 (D.F. = 808) for 2002 and 2004 respectively]. The observed and fitted models are shown in Figure 1. The estimated optimal cut-off point was 1.68 on the $\log_{10}$ scale, i.e. 48.2 mIU/ml for the 2002 dataset (Behring VZV IgG ELISA), and 1.18 on the $\log_{10}$ scale, i.e. 15.2 EU/ml for 2004 (Diamedix VZV IgG ELISA). The mixture model-estimated sensitivity and specificity were for each 100.0% for 2002, and 100% and 99.8% respectively for 2004.

Population characteristics

Complete questionnaire data and IgG results were available for 275 white British and 765 Bangladeshi women (Table 1). The mean age of white British women was 28 ± 6.4 years, with about 47% of women expecting their first child, the average number of siblings was two, and 87% attended preschool or day care before age 5 years (or their sibling attended). The mean age of Bangladeshi women born in the United Kingdom was 24 ± 4.5 years and for Bangladesh-born women it was 26 ± 5 years; 50% and 33% respectively were expecting their first child, 95% and 34% attended nursery or had a sibling that attended nursery in their childhood. There was high correlation between Bangladesh-born women and living abroad for >1 year: 95% answered 'yes' compared to 11% UK-born Bangladeshi and 3% white British women. Bangladeshi women who lived abroad for $\geqslant 1$ year resided in Bangladesh. By contrast most white British women who lived abroad for $\geqslant 1$ year lived in Europe, North America or Australia. There was high correlation for the questions relating to them or a sibling attending nursery and 'previous/current employment' with being white British or UK-born Bangladeshi.

Risk factors for VZV infection

Immunity was strongly associated with being born in the United Kingdom ($P<0.001$) and with ethnicity ($P=0.001$), and these factors are highly correlated. In
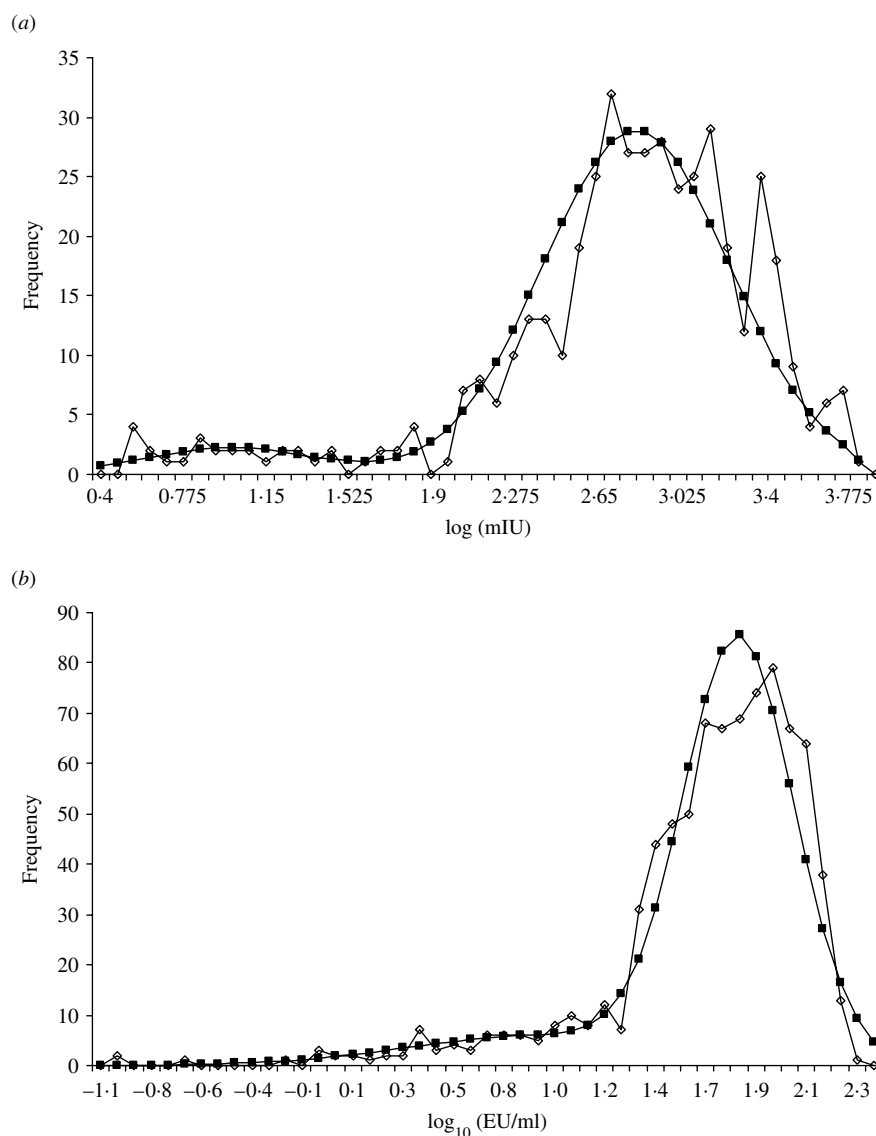
Fig. 1. Observed (–◇–) and fitted (–■–) distributions of VZV IgG ELISA results. (*a*) 2002 data: Behring ELISA (antibody titres, mIU/ml). (*b*) 2004 data: Diamedix ELISA (ELISA units, or EU/ml).

1040 subjects, 93·1% white British women were sero-positive, compared to 95·2% UK-born Bangladeshi women and 84·6% Bangladesh-born women. Sero-prevalence at every age group was lower in women born in Bangladesh (Fig. 2).

To analyse the main variable of interest ('country of birth and childhood') 51 subjects were excluded because they were born in the United Kingdom but lived abroad for >1 year, or were Bangladesh-born but lived there for <1 year, leaving a subset of 989 individuals.

Single variable analysis on all the women combined showed that several factors were significant at the 10% level (Table 2). Being born and raised in

Bangladesh, living there for more than a year, and years lived abroad, were associated with lower immunity. Age, siblings with varicella history, subject/sibling attending nursery, having a child who attended nursery, household exposure to varicella (as an adult), previous/current employment, health of children at work were associated with increased immunity.

The logistic regression model showed that Bangladesh-born women who entered the United Kingdom aged >15 years were significantly less likely to be immune to varicella during pregnancy (OR 0·37, 95% CI 0·22–0·63) than the white UK-born women. For Bangladesh-born women arriving in the United Kingdom as children (≤15 years) (OR 0·60,

Table 1. *Characteristics of the study population*

| Variable (obs) | Level | White British (n = 275) | Bangladeshi | |
			UK-born (n = 105)	Bangladesh-born (n = 660)
Age (yr)	Continuous	Mean 28	Mean 24	Mean 26
(1037)		s.d. 6·4	s.d. 4·5	s.d. 5·0
Lived abroad >1 yr	No	262 (97·0%)	85 (89·5%)	32 (4·9%)
(1025)	Yes	8 (3·0%)	10 (10·5%)	627 (95·1%)
Age when immigrated (yr)	≤15	2 (33·3%)	5 (83·3%)	258 (41·4%)
(635)	>15	4 (66·6%)	1 (16·7%)	365 (58·6%)
No. of siblings	Continuous	Mean 2	Mean 5	Mean 5
(1034)		s.d. 1·7	s.d. 2·0	s.d. 2·2
Sibling	No	18 (6·6%)	0 (0·0%)	4 (0·6%)
(1034)	Yes	256 (93·4%)	103 (100·0%)	652 (99·4%)
Siblings' varicella history	No	17 (8·4%)	8 (8·4%)	110 (20·0%)
(848)	Yes	185 (91·6%)	87 (91·6%)	440 (80·0%)
You or your sibling attended nursery	No	33 (12·6%)	5 (4·9%)	428 (66·5%)
(1009)	Yes	229 (87·4%)	97 (95·1%)	216 (33·5%)
Previous child	No	128 (46·7%)	51 (49·5%)	216 (33·0%)
(1033)	Yes	146 (53·3%)	52 (50·5%)	439 (67·0%)
No. of previous children	Continuous	Mean 1	Mean 1	Mean 1
(1033)		s.d. 1·2	s.d. 1·4	s.d. 1·5
Your child attended nursery	No	32 (22·5%)	24 (38·7%)	151 (31·9%)
(678)	Yes	110 (77·5%)	38 (61·3%)	322 (68·1%)
Other household children	No	202 (73·7%)	55 (53·9%)	314 (47·9%)
(1032)	Yes	72 (26·3%)	47 (46·1%)	341 (52·1%)
Household exposure to varicella	No	213 (77·7%)	83 (80·6%)	466 (71·2%)
(1033)	Yes	61 (22·3%)	20 (19·4%)	189 (28·9%)
Previous/current employment	No	23 (8·6%)	22 (22·0%)	373 (57·7%)
(1016)	Yes	245 (91·4%)	78 (78·0%)	274 (42·4%)
Work involving children	No	207 (84·2%)	55 (69·6%)	183 (66·8%)
(600)	Yes	39 (15·9%)	24 (30·4%)	91 (33·2%)
Health of children at work	Sick	1 (2·6%)	0 (0·0%)	1 (1·1%)
(150)	Healthy	35 (92·1%)	23 (95·8%)	80 (91·9%)
	Both	2 (5·3%)	1 (4·2%)	7 (8·0%)
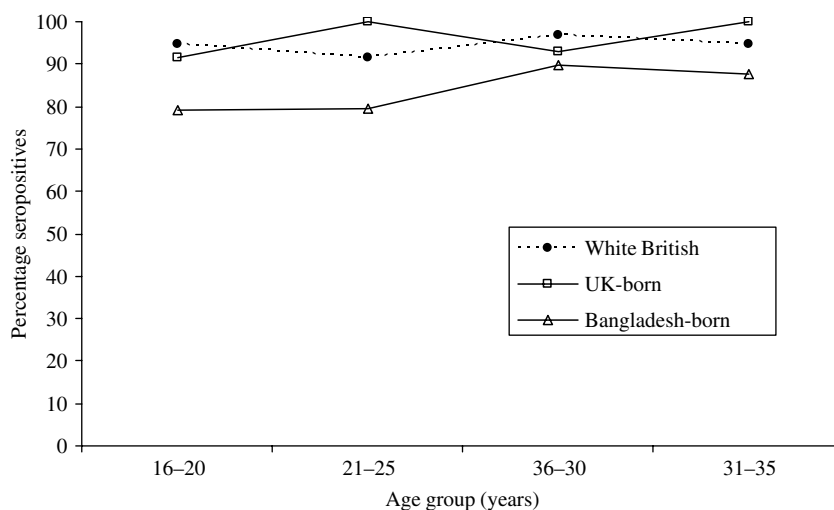
Fig. 2. Percentage of pregnant women immune to VZV by ethnicity and country of birth, stratified by age.

Table 2. *Single variable analysis of risk factors of VZV infection in the study population* (n = 989)

Variable (obs)	Level	IgG negative	IgG positive	%	OR (95 % CI)	P value
Country of birth	UK	21	340	94·2		
(989)	Bangladesh	99	529	84·2	0·33 (0·20–0·54)	<0·001
Ethnicity	White British	17	249	93·6		
(988)	Bangladeshi	103	619	85·7	0·41 (0·24–0·70)	0·001
Grouped ethnicity and	White British	17	249	93·6		
country of birth	Bangladeshi – UK-born	4	90	95·7	1·54 (0·50–4·69)	
(988)	Bangladeshi – arriving ⩽15 yr	30	227	88·3	0·52 (0·28–0·96)	
	Bangladeshi – arriving >15 yr	69	302	81·4	0·30 (0·17–0·52)	<0·001
Age (yr)	Continuous	Mean 26	Mean 27			
(987)		s.d. 5·3	s.d. 5·5		1·04 (1·00–1·07)	0·053
Lived abroad >1 yr	No	19	329	94·5		
(975)	Yes	99	528	84·2	0·31 (0·18–0·51)	<0·001
Years abroad	Continuous	Mean 17·0	Mean 15·5			
(622)		s.d. 6·1	s.d. 7·5		0·97 (0·94–1·00)	0·062
No. of siblings	Continuous	Mean 5	Mean 4·3			
(984)		s.d. 2·4	s.d. 2·4		0·94 (0·87–1·02)	0·128
Sibling	No	2	19	90·5		
(984)	Yes	118	845	87·7	0·75 (0·17–3·28)	0·518*
Siblings' varicella history	No	35	95	73·1		
(806)	Yes	65	611	90·4	3·46 (2·18–5·51)	<0·001
You or your sibling	No	76	382	83·4		
attended nursery	Yes	40	462	92·0	2·30 (1·53–3·45)	<0·001
(960)						
Previous child	No	49	322	86·8		
(983)	Yes	71	541	88·4	1·16 (0·79–1·71)	0·458
No. of previous children	Continuous	Mean 1	Mean 1			
(983)		s.d. 1·5	s.d. 1·4		1·00 (0·88–1·14)	0·993
Your child attended	No	33	162	83·1		
nursery	Yes	47	402	89·5	1·74 (1·08–2·82)	0·026
(644)						
Other household children	No	60	483	89·0		
(982)	Yes	60	379	86·3	0·78 (0·54–1·15)	0·214
Household exposure to	No	101	622	86·0		
varicella	Yes	19	241	92·7	2·06 (1·23–3·44)	0·003
(983)						
Previous/current	No	75	330	81·5		
employment	Yes	45	518	92·0	2·62 (1·76–3·88)	<0·001
(968)						
Work involving children	No	29	389	93·1		
(564)	Yes	16	130	89·0	0·61 (0·32–1·15)	0·135
Health of children at work	Sick	0	2	100·0		
(142)	Healthy	10	120	92·3		
	Both	3	7	70·0		0·085*

* Fisher's exact test.

95 % CI 0·33–1·10) and UK-born Bangladeshi women (OR 2·09, 95 % CI 0·68, 6·37) the difference was not significant. One variable at a time was added to the model including age and ethnicity. Only one variable was found to be significant following multivariable analysis. This was 'previous/current employment' (OR 1·84, 95 % CI 1·13–3·02).

Single variable analysis on Bangladesh-born women only (Table 3) showed that, arriving in the United Kingdom aged >15 years was associated with

Table 3. *Single variable analysis of risk factors in 660 Bangladeshi women born in Bangladesh*

| Variable (obs) | Level | VZV status | | % | OR (95% CI) | *P* value |
		IgG negative	IgG positive			
Age (yr)	Continuous	Mean: 25	Mean: 27			
(659)		s.d. 4·5	s.d. 5·0		1·08 (1·03–1·13)	0·001
Years abroad	Continuous	Mean: 17·0	Mean: 15·5			
(623)		s.d. 6·1	s.d. 7·5		0·97 (0·94–1·00)	0·058
Age when immigrated	⩽15	30	228	88·4		
(623)	>15	67	298	81·6	0·59 (0·37–0·93)	0·021
No. of siblings	Continuous	Mean: 5	Mean: 5			
(656)		s.d. 2·3	s.d. 2·2		1·05 (0·95–1·15)	0·366
Sibling	No	1	3	75·0		
(656)	Yes	101	551	84·5	1·82 (0·19–17·66)	0·492*
Siblings' varicella history	No	34	76	69·1		
(550)	Yes	52	388	88·2	3·46 (2·03–5·49)	<0·001
You or you sibling attended nursery	No	75	353	82·5		
(644)	Yes	25	191	88·4	1·62 (1·00–2·64)	0·045
Previous child	No	41	175	81·0		
(655)	Yes	61	378	86·1	1·45 (0·94–2·24)	0·096
No. of previous children	Continuous	Mean: 1	Mean: 1			
(655)		s.d. 1·4	s.d. 1·5		1·12 (0·96–1·31)	0·128
Your child attended nursery	No	32	119	78·8		
(473)	Yes	39	283	87·9	1·95 (1·17–3·26)	0·012
Other household children	No	49	265	84·4		
(655)	Yes	53	288	84·5	1·00 (0·69–1·53)	0·982
Household exposure to varicella	No	86	380	81·5		
(655)	Yes	16	173	91·5	2·45 (1·39–4·30)	0·001
Previous/current employment	No	74	299	80·2		
(647)	Yes	28	246	89·8	2·17 (1·36–3·47)	0·001
Work involving children	No	18	165	90·2		
(274)	Yes	11	80	87·9	0·79 (0·36–1·76)	0·572
Health of children at work	Sick	0	1			
(88)	Healthy	6	74	92·5		
	Both	2	5	71·4		0·203*

* Fisher's exact test.

increased susceptibility. Age, a history of varicella in siblings, subject/sibling attending nursery, own child attended nursery, household exposure to varicella as an adult, and previous/current employment were significantly associated with immunity to chickenpox. No independent risk factor was found in multivariate analysis.

DISCUSSION

A biological difference determining VZV susceptibility between ethnic groups has been proposed previously [17, 18]. This study has shown decisively that country of birth and country in which childhood is spent, rather than ethnicity on its own determine VZV immunity in adult women. We therefore conclude that environment and exposure alone determine late-onset chickenpox in adults from the tropics. Social factors are liable to dominate the patterns of transmission in all countries. For example, in UK-born children the average age at infection for VZV has fallen in recent years because a greater proportion of children attend nursery [19].

This is the first study to investigate differences in VZV seroprevalence in the United Kingdom in women of different ethnic origin and their risk factors for VZV susceptibility. Being born in Bangladesh was strongly associated with susceptibility. Furthermore, when taking into account the age of immigration from Bangladesh to the United Kingdom, women living there into adulthood had the lowest odds of being immune (OR 0·37, 95% CI 0·22–0·63). Almost 19% of Bangladeshi women (who were born and lived in Bangladesh until after age 15 years) were susceptible

to VZV compared to 6% of white British women. There was no significant difference between white UK-born women, Bangladeshi UK-born and women who moved to the United Kingdom in their childhood (i.e. aged ≤15 years) in multivariable analysis.

Residents in tropical countries such as India, Sri Lanka, South East Asia and the Caribbean have a higher mean age of infection as well as much lower seroprevalence in adults and adolescents compared to those of temperate countries [5, 20–22]. The mean age of infection was 23 years in a study in rural India [23], and 38·3 years in the Caribbean [2] compared to 6 years in Germany [24]. Environmental factors such as interference by other childhood viruses prevalent in tropical, usually less developed countries [23] and high temperatures are thought to interfere with virus transmission [2, 22, 25, 26]. Generally, VZV transmission is less efficient than some other viruses, e.g. measles, which has a secondary attack rate of 71% compared to 61% for VZV [27].

Single variable analysis showed several risk factors, including age, associated with seronegativity in Bangladesh-born women living in the United Kingdom. They were less likely to be immune if they were younger and if they arrived as adults after the age of 15 years; susceptibility was higher if their siblings had not had chickenpox when they were children. They were less likely to be immune if they had not been exposed, in adulthood, to chickenpox in their own home or to other households' children; and if their children had not attended nursery. This suggests that children within the family are an important source of infection for these adult women, a situation reminiscent of rubella and parvovirus B19 in parous women [28]. On the other hand, UK-born women were predominantly immune and the risk factors considered did not show any association with immunity. Risk factors could not be assessed in UK-born Bangladeshi women due to insufficient sample size; only 8/105 of these women were aged >30 years, accounting for the apparent drop in seroprevalence in this age group.

Socio-economic status can be a confounder when comparing ethnic groups [29, 30]. In our study population, UK-born women had significant differences with Bangladesh-born women, particularly in two indicators of socio-economic status. Nursery attendance in early childhood and having employment were associated with being born in the United Kingdom. Employment was significantly associated with

immunity both in single and multivariable analysis, suggesting that social and behavioural differences, some of which we could not measure, play a role in the observed increased susceptibility among Bangladesh-born women.

The subjects in this study were recruited on two occasions 2 years apart and their sera tested with two different although reliable assays. However, this is not a limitation since mixture modelling was used to re-estimate the positive/negative cut-off values for this study which gave standardized results. This enabled us to overcome the problems of this study, but the manufacturers' cut-off criteria should be used for diagnosis.

Susceptibility to VZV was almost three times higher in pregnant women born in Bangladesh placing them at greater risk of infection in pregnancy compared to UK-born women. The findings here probably extend to the diverse immigrant population from other tropical, sub-tropical, Afro-Caribbean and Eastern European countries with lower VZV antibody prevalence. Potentially harmful outbreaks of chickenpox have been reported in similar immigrant communities [3, 4, 31, 32]. Adult varicella is a severe disease with mortality over 4000 times greater than that in children [33]. Should infection occur during pregnancy, the potential consequences for the unborn child include severe neonatal varicella and CVS. Given these risks, it is essential and probably cost-effective to offer VZV screening and postpartum vaccination of susceptibles to immigrant women [34].

DECLARATION OF INTEREST

None.

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