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The association between impetigo, insect bites and air temperature: a retrospective 5-year study (1999–2003) using morbidity data collected from a sentinel general practice network database

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Background. Impetigo is one of the commonest childhood skin infections. Insect bites are commonly implicated in the development of impetigo. There are, however, very few data available to describe the seasonal incidences and association between the two conditions.

Objectives. To describe the seasonal incidence of impetigo in England and Wales and to investigate the reported association with insect bites.

Methods. Clinical diagnoses of impetigo and insect bites were recorded from a sentinel GP network over the years 1999–2003.

Results. The highest mean weekly rates of impetigo were in children aged 0–4 years (84 per 100 000) and in those aged 5–14 years (54 per 100 000). In contrast, the incidence of insect bite only varied between 3 and 5 per 100 000 for males and between 5 and 9 per 100 000 for females. The relative risk (RR) for females consulting over males with impetigo was similar in children [RR 0.99 (95% CI 0.96–1.02)] and adults [RR 1.20 (1.16–1.25)]; the RR of insect bite was similar in children [RR 1.21 (1.09–1.34)] but almost twice as likely in adults [RR 2.13 (2.02–2.25)]. Insect bite peaked almost coincidentally with temperature whereas there was a lag of one-to-two 4-week periods between impetigo and temperature.

Conclusion. There is suggestion of some degree of association between impetigo and insect bites. The improved management of patients consulting with insect bites and better use of antiseptic treatments might provide the basis for reducing the incidence of impetigo in the community.

Keywords. Bacterial, epidemiology, impetigo, insect bites, skin infections.

Introduction

Impetigo

Impetigo is caused by direct inoculation of group A streptococci or *Staphylococcus aureus* into superficial cutaneous abrasions and is frequently associated with insect bites, eczema or burns.[1,2] Impetigo comprises approximately a quarter of all episodes of skin infection, this proportion is higher in children where ~56% of all skin infections are diagnosed as impetigo: the equivalent proportions are 16% in adults and 6% in the elderly.[3] In the fourth national morbidity survey in England and Wales, during the years 1991–1992, 2.8% of children aged 0–4 years and 1.6% aged 5–15 years consulted their GP with impetigo.[4] A similar study performed in The Netherlands during the late 1980's estimated that 2.2% of all children under 14 years consulted their GP each year with impetigo.[5]

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Impetigo is highly contagious and spreads from person to person primarily by direct contact with infected lesions, but also indirectly via fomites.[6] Impetigo is generally sporadic but clusters of cases may occur in families or other groups; outbreaks in nurseries and adult communities have been reported.[6–9] Symptoms are characterized by the presence of discrete fragile vesicles surrounded by an erythematous border that becomes pustular and ruptures to discharge a thin seropurulent fluid that dries to form a thick yellow crust. These lesions are commonly located on the face, especially around the nose and mouth, but they can occur on any part of the body at the site of bites or abrasions.[1,10]

Insect bites

The response to insect bites depends on the amount and intensity of previous exposure to biting by similar insects.[11] People sensitized to one insect species may not respond to another species.[12] However, following repeated exposure most people progress from non-reactive (immunological naiveté), through a delayed hypersensitivity (the typical maculopapular 'mosquito bite' reaction), immediate hypersensitivity (weal and flare) followed by delayed reaction, immediate on its own, and finally to tolerant, a process demonstrated experimentally by Larrivee *et al.* (1964).[13] Most people in the UK are so little exposed to biting insects that they never proceed beyond the delayed maculopapular reaction to any type of insect, with the possible exception of pet owners who become tolerant of flea bites.[14]

Biting arthropods are not currently considered a health risk or a statutory nuisance in the UK. A high proportion of species that feed on blood are not anthropophilic, with birds and large mammals constituting the normal hosts.[15] Nevertheless over 350 species of blood feeding arthropods are found in Britain.[16] They are primarily active during warmer months and are rarely encountered before late February (week 9) or after mid-November (week 46). Outside these periods, bites are likely to be due to overwintering mosquitoes, or occasionally *Culicoides* midges that linger in late autumn or emerge from pupation in early spring.[15]

A specific association of impetigo of the scalp with head louse infestation has been made in some communities.[2,17] Bed bug bites can also stimulate intense reactions to the insect saliva, causing extensive itching with a subsequent risk of infection. Extensive bed bug and flea bites were once common in children, leading to a diagnostic description of 'papular urticaria' in which the lesions often developed impetigo as a result of skin abrasion.[14,17] Even in modern times, the activity of these two species would contribute to the baseline incidence of both insect bite and impetigo throughout the year.

Objectives

The objectives of this study were 2-fold: (i) Insect bites have been implicated as a causative factor in the development of impetigo in a large number of dermatology textbooks;[1,2,14,17] there are, however, very limited data that quantify this relationship. Our primary aim was to investigate this further and assess whether any relationship existed between the incidences of insect bite and impetigo. (ii) In the summer of 2003 the UK experienced some of the highest temperatures on record.[18,19] During this period, the Royal College of General Practitioners Weekly Returns Service (RCGP WRS) noted an unusually high incidence of impetigo. The peak weekly incidence occurred in the week commencing 11 August (33 episodes per 100 000 population) during a period of particularly high temperatures.[18] Therefore, the second aim of the study was to determine the effect of air temperature on levels of impetigo recorded in the community.

Methods

Morbidity data

The RCGP WRS is an information system based on a national network of sentinel general practices throughout England and Wales and is best known for the routine surveillance of respiratory illnesses.[20] Data are recorded by the GPs and stored as Read codes, which are mapped to the International Classification of Diseases (version 9; ICD9) for analytical purposes. Gender-specific episode incidence rates (per 100 000 population) were calculated in 4-weekly periods using the number of new cases recorded in the sentinel network (numerator) and the total network patient population (denominator) in each 4-weekly period (data were aggregated into 4-weekly periods to reduce the variation in signal noise detected on a weekly basis). Incidence rates were calculated for impetigo (ICD9 684) and insect bite (ICD9 910–917 [0.4 and 0.5 only] and E906.4; Table 1) in six age bands (0–4, 5–14, 15–24, 25–44, 45–64 and ⩾65 years) over the years 1999–2003. Rates of insect bite were used as a marker for the timing of insect activity throughout the year. Data regarding the species of biting insect were not available.

Temperature

Central England Temperature (CET) is a weighted mean temperature for England and Wales derived from measurements at four dispersed meteorological stations.[21] Daily values for maximum and minimum CET (1999–2003) were accessed from the Meteorological Office through the British Atmospheric Data Centre (badc.nerc.ac.uk). Daily temperatures were averaged into 4-weekly periods to enable direct comparison with clinical incidence data.

TABLE 1 *ICD9 Chapters and disease codes used for impetigo and insect bites in this study with nearest equivalent matching ICD10 codes*

ICD9 code	Condition	ICD9 chapter	ICD10 Code[a]
684	Impetigo	XII. Diseases of the skin and subcutaneous tissue	L01
910	Superficial injury of face, neck and scalp except eye[b]	XVII. Injury and poisoning	S00, S10
911	Superficial injury of trunk[b]	XVII. Injury and poisoning	S30
912	Superficial injury of shoulder and upper arm[b]	XVII. Injury and poisoning	S40
913	Superficial injury of elbow, forearm and wrist[b]	XVII. Injury and poisoning	S50, S60
914	Superficial injury of hand(s) except finger(s) alone[b]	XVII. Injury and poisoning	S60
915	Superficial injury of finger(s)[b]	XVII. Injury and poisoning	S60
916	Superficial injury of hip, thigh, leg and ankle[b]	XVII. Injury and poisoning	S70, S80, S90
917	Superficial injury of foot and toe(s)[b]	XVII. Injury and poisoning	S90
E906.4	Bite of nonvenomous arthropod	External cause (E Code)	N/A[c]

[a] Nearest equivalent matching ICD10 codes; there is some degree of overlap between the codes of ICD9 and ICD10.
[b]The following fourth digit subdivisions are for use with ICD9 categories 910–917: [0.4] insect bite, nonvenomous, without mention of infection; [0.5] Insect bite, nonvenomous, infected.
[c]Not available—no equivalent ICD10 code was available.

TABLE 2 *Mean weekly episode incidence of impetigo per 100 000 population by gender and age*

Gender	M&F	Male						Female					
Age (years)	All	0–4	5–14	15–24	25–44	45–64	65+	0–4	5–14	15–24	25–44	45–64	65+
1999	20.1	87.7	60.4	22.3	8.1	4.2	3.7	80.4	59.3	26.7	10.5	5.2	3.4
2000	20.4	77.9	61.2	21.8	9.0	4.4	4.7	91.4	59.3	28.8	10.3	5.3	4.1
2001	18.9	87.7	55.5	21.5	7.4	4.4	3.1	86.6	53.2	26.2	10.3	3.6	3.6
2002	17.4	84.4	50.6	18.5	6.7	3.6	3.3	83.2	47.8	21.8	9.7	4.7	3.3
2003	16.9	78.4	48.2	16.4	7.0	3.1	3.0	83.2	48.9	22.6	9.7	4.9	3.5
5–year average	18.7	83.2	55.2	20.1	7.6	3.9	3.6	85.0	53.7	25.2	10.1	4.7	3.6

Analysis

The series of mean weekly incidences of impetigo and of insect bite per 4-weekly period were plotted to show the seasonal variations and secular trends. The impact of age and gender on the incidence of impetigo and insect bite were explored by calculating relative risks with 95% confidence intervals. The relationship between the incidence of each morbid condition and temperature was first examined by plotting each 4-weekly time series and then by plotting incidence against temperature.

Results

Incidence of impetigo and insect bite

The mean weekly incidence rate of impetigo (all-age) averaged over the study period was 18.7 per 100 000 (Table 2). Incidence was highest in children under 5 years (83.2 and 85.0 per 100 000 for males and females, respectively) followed by that for children 5–14 years (55.2 and 53.7 per 100 000 for males and females, respectively); the incidence then decreased rapidly over the age range 15–44 years, and was a minimum for the elderly (≥65 years). Male and female incidence rates reported in children were virtually the same but the incidence for females in each adult age group (excepting the elderly) slightly exceeded the male. Table 3 shows, for children and adults, the relative risk (RR) of females consulting over males with impetigo. Clearly there were no gender differences as regards children; however, for adults, all the annual RRs exceeded unity and females significantly consulted more often than males. The approximate pooled estimate of RR indicated that females were 20% more likely to consult with impetigo.

The mean weekly incidence of insect bite (all-age) averaged over the study period was 5.4 per 100 000, less than a third of that for impetigo (Table 4). There was also much less variation between the age-specific rates. In males, incidence was higher in children than in adults (4.9 and 3.2 per 100 000 for 0–14 and ≥15 years, respectively) but the converse was true for females (6.0 and 7.0 per 100 000 for 0–14 and ≥15 years, respectively): incidence rates in female adults (≥15 years) were on average more than twice those in males (7.0 and 3.2 per 100 000, respectively). Table 5 shows, for children and adults, the RR of females consulting

over males with insect bites. For years 2000 and 2003 the RR of female children consulting significantly exceeded unity. The pooled estimate for all years indicates that female children were 20% more likely to consult than male children. For adults, and for all years excepting 2000, RRs exceeded 2 and, from the pooled estimate, females were twice as likely to consult as males.

Seasonal variations and secular trends

The all-person incidence of impetigo and insect bite peaked during the 4-week periods 8–10 (mid-July to end of September) each year (Figure 1). Examination of weekly incidence data disclosed an average lag of 4.6 weeks between insect bite and impetigo i.e. the time between the maximal peaks of insect bite and impetigo incidence. Analysis of 4-weekly data showed a lag of one 4-week period in the years 2000, 2001 and 2003; in 1999 and 2002 there was a lag of two 4-week periods. Figure 1 also shows the trend lines for the two conditions. The incidence of impetigo declined over the 5 years, the average rate of decline being 3.2% per annum. The declining trend for insect bite incidence was less, the average rate of decline being 2.1% per annum.

Morbidity in relation to temperature

Impetigo is a disease that predominantly affects children.[3–5] Therefore, we analysed 4-weekly rates of impetigo in children <15 years and insect bite (all ages) together with mean maximum and minimum temperatures in each 4-week period (Figure 2). Following the seasonal peaks of maximum temperature, impetigo incidence peaked approximately two four-week periods later in years 1999–2001, and one 4-week period later in the years 2002 and 2003. After the seasonal peak of minimum temperature, there was a lag of two 4-week periods for every year except 2003 (one 4-week lag). In contrast, insect bite incidence peaked at the same time as the peaks of maximum and minimum temperature (i.e. there was no lag).

TABLE 3 *Annual relative risk (RR) with 95% confidence intervals (95% CI) of females consulting with impetigo over males*

Year	Children <15 years		Adults ⩾15 years	
	RR	95% CI	RR	95% CI
1999	0.96	0.90–1.02	1.16	1.06–1.26
2000	1.04	0.98–1.11	1.15	1.06–1.25
2001	0.97	0.91–1.04	1.16	1.07–1.27
2002	0.96	0.90–1.03	1.24	1.13–1.36
2003	1.04	0.97–1.11	1.35	1.23–1.48
All years	0.99	0.96–1.02	1.20	1.16–1.25

Discussion

Incidence of impetigo and insect bite

Our results demonstrate that the highest incidence rates of impetigo were seen in children, confirming data from previous studies.[4,5,7–9,22] The temporal incidences of impetigo and insect bite lagged by ~5 weeks suggesting some association. In hot weather children wear less clothing, and therefore have more skin-to-skin contact thus facilitating transmission. Loffeld *et al*. (2005) recently demonstrated the seasonality of paediatric impetigo in the UK, showing that over an 8-year period (1996–2003) the number of paediatric impetigo outpatient visits peaked in September and mean temperatures peaked in August.[23] Although this study used secondary health care data it still confirms our findings, that a 5-week period (approximately one calendar month) exists between the peak of air temperature, and the subsequent peak of impetigo incidence. We cannot think of an alternative logical hypothesis whereby high temperatures could directly cause impetigo and we therefore conclude that insect bites contribute as a causative factor.

During winter periods, the baseline incidence of insect bite was low in comparison with that of impetigo (Figure 1). If insect bite is associated with impetigo, during winter there must be other factors contributing to impetigo incidence. Social mixing with other children in nurseries or schools, often involving direct contact

TABLE 4 *Mean weekly episode incidence of insect bite per 100 000 population by gender and age*

Gender	M&F	Male						Female					
Age (years)	All	0–4	5–14	15–24	25–44	45–64	65+	0–4	5–14	15–24	25–44	45–64	65+
1999	6.1	7.7	6.8	3.0	4.0	3.9	3.2	7.8	7.9	7.1	8.2	9.2	5.7
2000	5.5	3.9	5.9	3.2	3.8	4.5	2.2	7.3	6.7	6.8	7.0	8.7	4.2
2001	5.3	4.1	4.5	2.9	3.8	3.7	3.1	3.8	6.1	6.9	7.8	8.5	4.6
2002	4.9	3.2	5.0	1.9	3.1	3.4	2.3	5.2	5.2	6.4	6.7	8.2	5.3
2003	5.1	4.6	3.7	2.4	3.5	3.3	2.4	5.5	4.9	7.1	7.7	8.2	5.4
5-year average	5.4	4.7	5.2	2.7	3.7	3.7	2.6	5.9	6.2	6.9	7.5	8.6	5.1

encourages the spread of infection more so than in adults and is a more logical explanation at least during winter. There was a suggestion of reducing trend for impetigo; this may be due to improved standards of hygiene and reducing family size, which reduces the potential for transmission or that there may be a shifting tendency for patients with impetigo to visit hospital accident and emergency departments rather than their GP.[23]

This study has shown higher incidence of insect bite in adult females compared with males [RR 2.13 (95% CI 2.02–2.25)], but similar incidence in children [RR 1.21 (95% CI 1.09–1.34)]. National morbidity studies have always reported a bias of females consultation rates compared with those of males.[4] Prevalence data derived from a subset of practices reporting in the same sentinel network used in this study demonstrate this: the age-standardized prevalence of the ICD9 major disease group 'Skin and Subcutaneous Infections' (ICD9 680–686) is 392 and 463 per 10 000 for males and females, respectively.[3] However, this detection bias is still not sufficient to explain the large gender difference that was observed with insect bites, where rates in females were on average twice those of males (Table 3), and from the pooled RRs females were estimated to be twice as likely to consult than males (Table 5). We feel that there may be several possible explanations: children wear clothing of a similar fashion independent of gender; adult females have larger areas of skin exposed than male adults, especially on the arms and legs providing a greater opportunity to be bitten;[24] mosquitoes are attracted by fragrances from perfumes, soaps and lotions, which are predominantly used by females.[25] Although there are few scientific data to support these social and behavioural patterns, we still think that they are important factors.

TABLE 5 *Annual relative risk (RR) with 95% confidence intervals (95% CI) of females consulting with insect bite over males*

Year	Children <15 years		Adults ⩾15 years	
	RR	95% CI	RR	95% CI
1999	1.11	0.91–1.35	2.14	1.90–2.40
2000	1.31	1.06–1.62	1.87	1.67–2.10
2001	1.23	0.97–1.56	2.05	1.83–2.30
2002	1.16	0.91–1.49	2.36	2.08–2.69
2003	1.28	1.00–1.65	2.33	2.07–2.63
All years	1.21	1.09–1.34	2.13	2.02–2.25

Relationship to temperature

The high incidence of both conditions during the summer months was related to maximum and minimum air temperature.[23] The incidence of impetigo is higher in some tropical countries suggesting that certain meteorological conditions can affect incidence; however this may simply relate to increased insect activity in these regions.[26–28] Our study focused on temperature and did not consider other meteorological factors such as rainfall and humidity, which may be equally important.[26,27,29] The incidence of insect bite peaked almost identically with maximum temperature whereas that of impetigo peaked after a lag of one-to-two 4-week periods. These findings also implicate insect bites as a likely

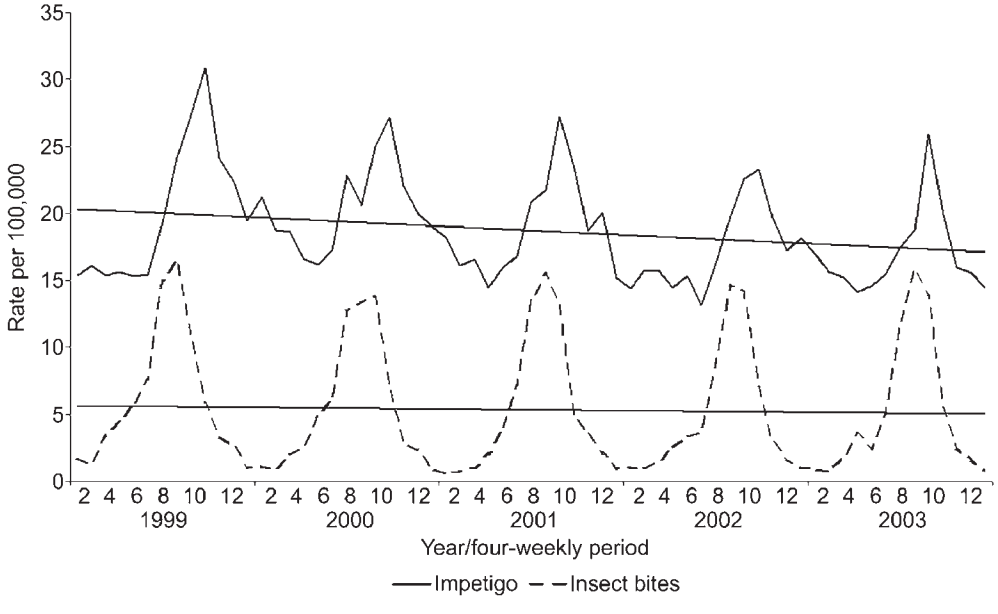

FIGURE 1 *Mean weekly incidence of impetigo and insect bite in 4-week periods (gender combined and all-age); linear trends are superimposed on each series*

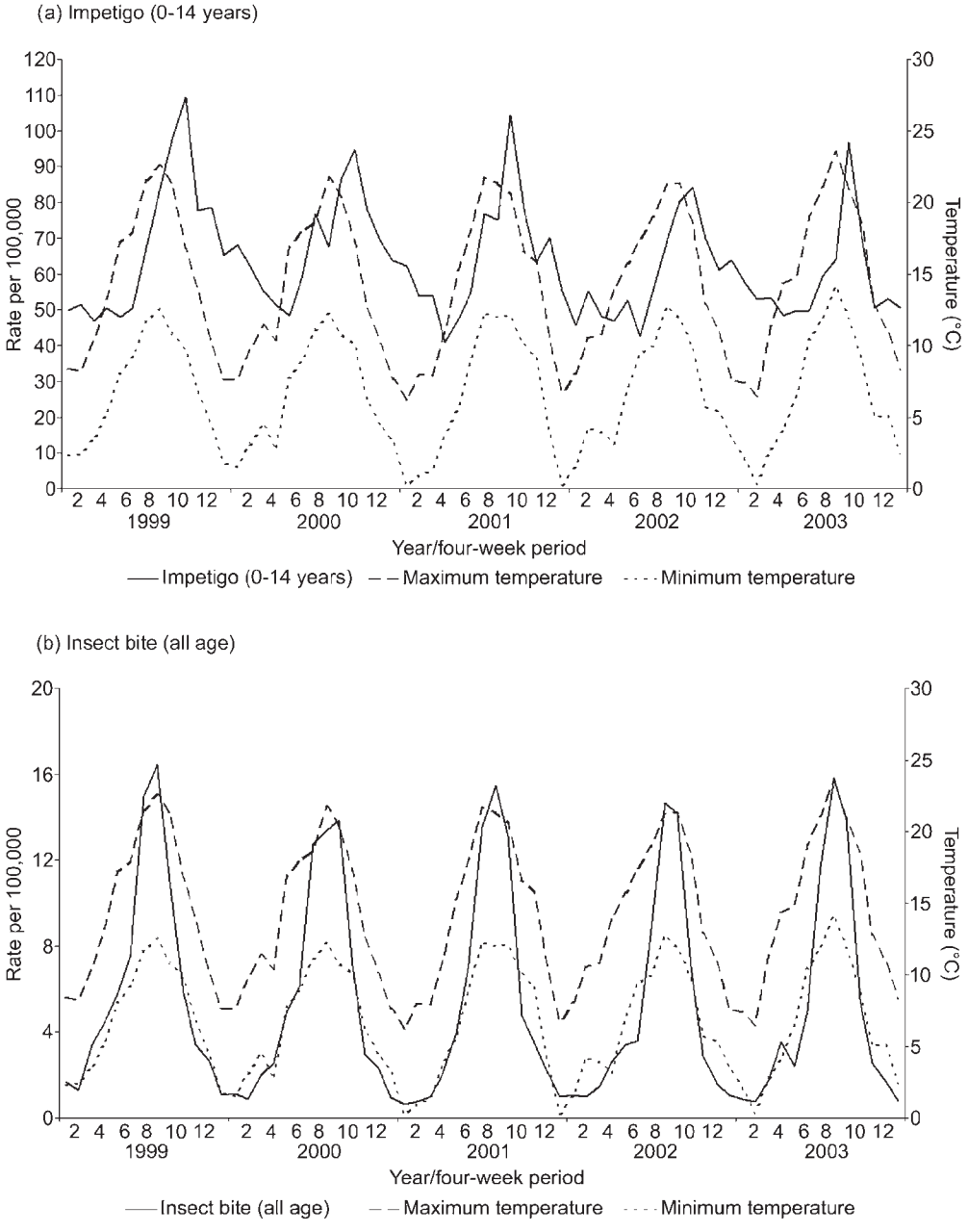

FIGURE 2 *Mean weekly incidence of a) impetigo in (0-14 years) and b) insect bite (all age) in 4-week periods contrasted with maximum and minimum temperature*

source of impetigo infections. Our data demonstrate a stronger relationship between insect bite and temperature. This may relate to the activity of insects, or to social behaviour patterns during periods of high temperature i.e. people spend more time outside during the daytime and evenings and sleep with windows open.

Implications for primary heath care

If insect bites are a cause of impetigo, a lag of ~5 weeks needs to be explained. We think that this period represents the optimal time that it takes for an insect bite to become infected, and reach a level of infection that merits the patient consulting their GP. We also feel that there could be a period of patient 'self-treatment' before consultation, which may also contribute. Impetigo implies the introduction into broken skin of a pathogenic organism. We cannot tell if this occurs at the time of the bite or whether this is due to secondary infection, although insects have been shown to transmit staphylococcal infections.[29] Further study of causality would involve following a cohort of people who have been bitten by insects and monitoring the progress of the bite to identify whether there was subsequent development of impetigo. The potential to minimize the role of insect bite causing impetigo merits further investigation; advice on hygiene is

obvious but the use of antiseptic treatments may be investigated more scientifically.

Concluding remarks

This paper describes current incidence rates of impetigo and insect bite in a large nationally representative consulting population. It informs on the incidence of these two conditions, which affect many people, and for which there are very few reliable sources of data. This study concludes that there is an association between the episode incidence rates of impetigo and insect bite and with air temperature. Although insect bites are only one of several known factors influencing the incidence of impetigo, improved management of insect bites through the use of antiseptic treatments might contribute to reducing the impact of this condition.

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