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Incidence of and risk factors for skin ailments among farmers working with wastewater-fed agriculture in Hanoi, Vietnam

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Summary The use of wastewater in agriculture and aquaculture is widespread in many developing countries, but limited information is available about the health hazards associated with this practice. To study the occurrence of skin ailments in relation to wastewater use in agriculture and aquaculture, an open cohort of 636 adults aged 15—70 years living in a wastewater-irrigated area in Hanoi, Vietnam, was followed by weekly visits for 12 months. A nested case—control study with 108 case/control pairs was conducted to investigate possible risk factors for skin ailments. The incidence rate of skin ailments was 32.5 episodes per 100 person-years at risk. Independent determinants of skin ailments included wastewater contact in the past 7 days (odds ratio (OR = 2.74, 95% confidence interval (CI) 1.29—5.82), female gender (OR = 2.48, 95% CI 1.06—5.76), fish farming-related jobs (OR = 3.47, 95% CI 1.27—9.50) and lack of protective measures (OR = 2.24, 95% CI 1.21—4.12). It is likely that effective promotion of personal protective measures and improved hygiene practices amongst wastewater users will mitigate the risk of dermatological problems and will thus be of benefit to public health in communities that rely on the use of wastewater for agricultural and aquacultural productions.

1. Introduction

Like many developing countries, the use of wastewater in agriculture and aquaculture in Vietnam is a traditional practice of economic importance. Beside the benefits for agricultural and aquacultural productions and the livelihoods of farmers (Siebe and Cifuentes, 1995; Trang et al., 2006a; van der Hoek et al., 2002), wastewater use also poses a hazard to human health. Several studies have assessed the health risks associated with wastewater use, especially the risk of parasitic infections and diarrhoea (Blumenthal and Peasey, 2002; WHO, 2006). Other important health problems

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often mentioned by wastewater farmers are skin problems. However, information about such risks is largely anecdotal and previous studies (Devaux et al., 2001; Feenstra et al., 2000) were often not specifically designed to assess risks for skin problems associated with wastewater use or the nature of these diseases and causative agents in wastewater. Preliminary findings from a recent survey focusing on skin problems among wastewater users in Phnom Penh, Cambodia (van der Hoek et al., 2005), showed that wastewater farmers had a much higher prevalence of skin problems than non-wastewater farmers. As wastewater use is likely to increase in the future owing to a worldwide shortage of groundwater together with a competition between the demands for safe water and increasing use of water for irrigation in agriculture, there is a need for research into the possible link between health problems and exposure to wastewater.

This article reports the findings of a population-based nested case—control study in a Vietnamese community using wastewater in agriculture and for fish production in order to determine the occurrence of occupational skin ailments among wastewater users and to assess the possible determinants for this health problem.

2. Materials and methods

2.1. Study area

The study was conducted in Yen So commune (population 10 500), a periurban area southeast of Hanoi city that is known for its intensive use of wastewater as a water and nutrient source in agricultural and aquacultural productions. Untreated household and industrial wastewater from urban Hanoi is diverted to ponds and fields through pumping stations along a large wastewater canal (Kim Nguu River) and through a system of distributing canals. The commune is divided by a dyke, which protects the city of Hanoi from flooding, allowing only the western part of the commune to be irrigated with wastewater (Figure 1). The eastern part relies on water from the Red River (natural water) for irrigation because wastewater cannot be pumped across the dyke. Monitoring data on the water quality of both water sources (National Environment Agency, unpublished data) showed that the irrigation water from Kim Nguu River had higher pollution levels than that of the Red River, with a high level of pollution with organic matters (Table 1). The quality of wastewater did not meet the Vietnamese national standards for wastewater to be used for agricultural and aquacultural production purposes, with most water quality parameters exceeding the specified limit values, whilst the

Table 1 Water quality of Kim Nguu River and Red River in Hanoi, Vietnam (as measured at the sampling point near Yen So commune in August 2002)[a]

Parameter	Kim Nguu River	Red River
pH	7.5	7.8
Dissolved oxygen (mg/l)	0.5	5.3
Biological oxygen demand (mg/l)	92.4	6.8
Chemical oxygen demand (mg/l)	117.0	9.6
Ammonium (mg/l)	24.8	0.1
Chloride (mg/l)	71	21.3
Total coliforms (MPN/100 ml)	4.3×10^5	6×10^2

MPN: most probable number.
[a] Values are monthly mean values.

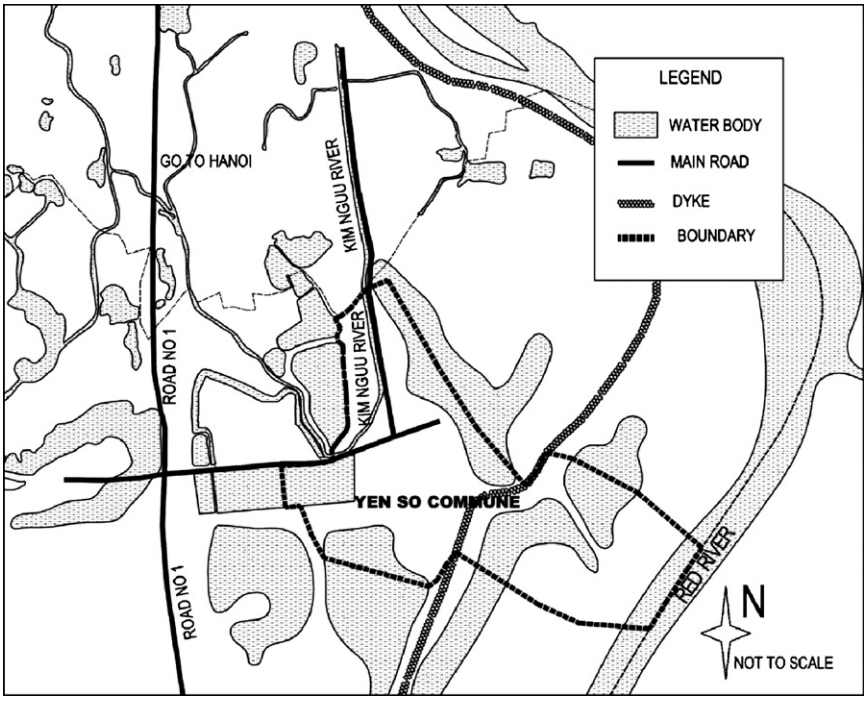

Figure 1 Study area in Hanoi, indicated by the boundary line.

quality of the Red River water was satisfactory for domestic use (Directorate for Standards and Quality, 2005).

Agricultural land on both sides of the dyke is leased to farming households on a quota basis. Consequently, most farmers in Yen So commune are engaged in both wastewater and Red River irrigated farming systems. Approximately 80% of the communal labour force is farmers mainly engaged in fish farming, rice culture and vegetable cultivation, with fish farming being a seasonal activity whilst rice and vegetables are grown throughout the year. However, during agricultural leisure outside the farming seasons, many farmers are also engaged in non-farming types of work.

2.2. Study population and data collection

To collect household background information and to invite the families to participate in a cohort study, 400 households were randomly sampled in a baseline study initiated in October 2002 (Trang et al., 2006a). Information was collected on possession of certain properties, sources of water supply, sanitation and domestic animals for all households. Individual information such as gender, age and education was obtained from all household members. As the study aimed to assess occupational health risk, in particular skin problems, of wastewater use in agriculture and aquaculture, only adults residing in the surveyed households were invited to participate in a 1-year morbidity surveillance programme from 15 November 2002 to 14 November 2003. The selection criteria for inclusion into the cohort were those aged 15—70 years who were involved in some areas of agricultural work (i.e. either fish farming, rice culture, or aquatic or terrestrial vegetable cultivation), regardless of whether they had contact with wastewater or not. Both sexes were included. The follow-up cohort initially included 620 adults. It was an open cohort where people could join or withdraw from the study at any time during the study period. Following their enrolment, subjects were followed up until the end of the study through weekly visits by trained local fieldworkers. During the visits, information on the status of any skin ailments (i.e. any skin problems or skin disorders), length of the illness and residence status of the follow-up subjects was obtained. The information was recorded on a morbidity monitoring sheet for each subject. The study recruited a total of 636 adults who were followed for 218 628 person-days (days under observation).

2.3. Nested case—control study

A case—control study was nested in the prospective morbidity surveillance of the enumerated cohort. Owing to logistical reasons, data collection for the case—control study started at the beginning of March 2003 until the end of the follow-up programme. The incidence density sampling of cases and controls (Greenland and Thomas, 1982) was applied with cases identified by the morbidity surveillance and one control sampled per case at the time of case ascertainment. A case of skin ailment was defined as a subject having a self-perceived skin problem in the last 7 days prior to the day of weekly visits. Signs and symptoms included chronic itchiness or any skin irritation accompanied by itching, rash, scaling, red papules or fungal infection. Cases were verified by the fieldworkers' inspections.

For every detected case of skin ailments, a control was randomly selected from the cohort. Adults who did not have skin ailments over the same period, staying in the commune in the last 7 days, but not living in the same household as the cases were eligible as controls. A case could later become a control if the subject stayed free of skin ailments in the preceding 4 weeks. Similarly, a control could be selected as a case if he developed skin ailments within the specified period, and a subject without the illness from the cohort would be randomly sampled as a control for the newly emerged case.

A corresponding case—control questionnaire interview was conducted with every identified case of skin ailments and controls. Data were collected on the characteristics of the ailments and the history of exposure in the past week of disease onset (for cases), or history of exposure in the past week of the day of interview (for controls). Exposure information included the status of contact with wastewater and wastewater-related activities (i.e. activities involving the use of or contact with wastewater), personal hygiene practices after the contact, use of personal protective measures and other possible risk factors such as contact with diseased persons, contact with animals and sharing certain objects with cases.

2.4. Data analysis

Data were entered into a Microsoft Access database and analysed with STATA 8 (Stata Corp., College Station, TX, USA). Incidence rates of skin ailments were calculated for the cohort over the follow-up period. The person-time at risk was calculated as the observed days at risk between episodes, excluding the symptom-free days following an episode. By definition, an episode of skin ailment was a sequence of days with symptoms of any skin problem, separated by at least 7 symptom-free days from the previous episode. Poisson regression was employed to estimate the rate ratio (RR) from incidence data.

An unmatched case—control analysis was performed for the data from the nested case—control study. Initial bivariate analyses providing odds ratios (OR) were carried out for all explanatory variables to assess the effect of exposure to wastewater and other potential risk factors on skin ailments. These analyses were adjusted for gender and age using an indicator variable for age groups 15—29, 30—44 and $\geq$45 years. A level of significance of 0.05 presented by 95% confidence intervals (CIs) was selected for including variables in a multivariate model. Different logistic regression models were run for the major categories of exposure variables (Model A for general exposure applied to all cases and controls, Model B for people who had contact with wastewater, and Models C and D for hygiene practices among people who washed their body or hands/feet after having wastewater contact). To allow for cluster data derived from repeated observations on the same subjects, i.e. those who were selected as a case or control more than once, the generalised estimating equations method (Liang and Zeger, 1986) was applied in all analyses. The backward stepwise approach was applied for the multivariate regression analyses to reduce the models, as presented later.

Table 2 Socioeconomic characteristics of the study households ($N = 400$) in Yen So commune, Hanoi, Vietnam, 2002—2003

Characteristic	Proportion of households (%)
Main sources of household income	
Vegetable farming	76.3
Rice cultivation	73.0
Subsidiary crops	31.3
Husbandry	25.3
Animal practices	66.5
Houses of permanent and good construction	79.0
Water supply from wells	
Drilled tube wells	78.8
Dug wells	25.8
Hygienic (septic tank) latrines	48.5
Composted human excreta for land application	34.5
Fresh human excreta for land and fishpond application	9.0

2.5. Ethical aspects

People participated in the study after verbal informed consent and were free to join or withdraw from the follow-up at any time during the study period. Ethical clearance for the study was provided by the Medical Ethics Committee of the National Institute of Hygiene and Epidemiology in Hanoi, Vietnam.

3. Results

3.1. Incidence of skin ailments

During the 1 year of the follow-up study, 636 adults (median age 39 years; 65.6% female; 73.9% involved in agricultural work) were enrolled from the 400 households representing a total of 1723 household members (51.7% female; age range 0—91 years). Table 2 summarises the socioeconomic characteristics of these households. Skin ailments were reported by 141 subjects (22.2%), with a total of 192 episodes reported during 216 054 days at risk. This yields an incidence of 32.5 episodes per 100 person-years at risk.

Apart from a high number of cases (38 cases) registered shortly after the start of the study in November 2002 and an increase in June 2003 (32 cases), there was no marked variation in the incidence of skin ailments by calendar month (Figure 2). The incidence rates differed between age groups and gender (Figure 3). The highest incidence (48 episodes per 100 person-years) was observed in the oldest females, compared with 16 episodes per 100 person-years in the youngest (RR = 3.0, 95% CI 1.70—5.28). For the male cohort, a slightly higher, but insignificant ($P > 0.05$), incidence was seen in the group aged 15—29 years compared with the older groups. The incidence in women was higher than men (RR = 2.02, 95% CI 1.46—2.49, adjusting for age).

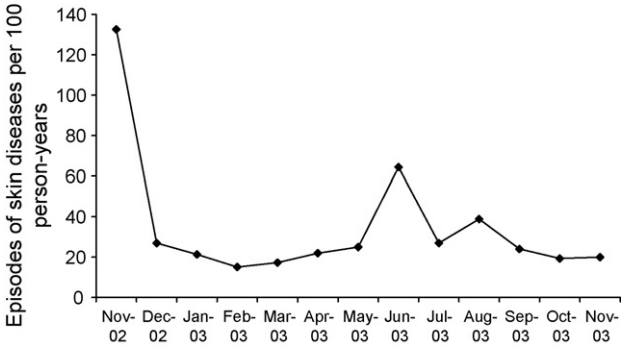

Figure 2 Monthly incidence of skin ailments in 636 adults reported during 216 054 days at risk in Yen So commune, Hanoi, Vietnam, 2002—2003.

3.2. Characteristics of skin ailments

Of the people with skin ailments reported during the surveillance period, 43 people experienced more than one episode. The median duration was 7 days (range 1—64 days). The major self-reported symptom was itching (67.2% of the skin episodes), which was often accompanied by skin chaps, debris, light ulcer or red papules. Self-perceived skin allergy was reported by 45 persons and was believed to be an allergic response after contact with external agents such as water, foods, pesticide and pollens. In particular, 29/45 subjects with skin allergy (of which 24 subjects were included in the nested case—control study) reported that their conditions occurred during the rice harvest season when they were in contact with rice pollens.

The case—control study of skin ailments provided an insight into the symptoms and localisation of dermatological problems. Of the 108 cases of skin ailments included in the nested case—control study, 98 cases (90.7%) had itchy symptoms, either mild or severe. Other symptoms included rash (42.6%), red papules (34.3%), skin chaps and debris (32.4%) and unhealed wounds (16.7%). The skin symptoms were found on several parts of the patients' bodies such as the extremities, back, head or face, but mostly occurred on

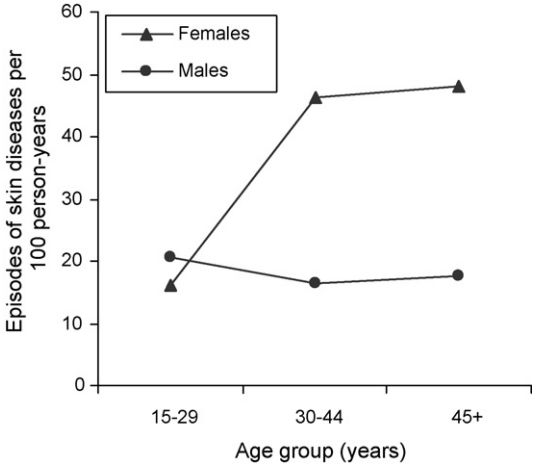

Figure 3 Age group and gender-specific incidence of skin ailments in 636 adults reported during 216 054 days at risk in Yen So commune, Hanoi, Vietnam, 2002—2003.

the hands (37.1% of the cases) and feet (27.8%), especially the skin areas between the fingers and toes. Twenty-one of the 32 cases with skin conditions appearing on the body (29.6% of the cases) were associated with skin allergy or bacterial infections (boil).

3.3. Risk factors for skin ailments

The case—control study for skin ailments recruited 108 cases and 108 controls. Twelve subjects were selected twice as a case and one subject three times, whilst one subject was selected twice as a control.

3.3.1. General risk factors for skin ailments—Model A

Table 3 summarises the results from the bivariate (age- and gender-adjusted) and multivariate (reduced model) analysis. Contact with wastewater was a strong risk factor for skin ailments. Jobs related to fish culture such as fish harvest and fish selling were found to be significantly associated with skin problems. There was no difference in skin ailments between people engaged in fish harvest and fish selling ($P > 0.05$). Similar to the incidence results, gender remained a significant risk factor, with female gender being strongly associated with the risk of skin ailments.

The absence of personal protective measures when people worked in the fields or fishponds increased the risk of skin ailments. Specific investigations into the different types of protective measures used by farmers revealed that this risk could be reduced by wearing long stockings only (OR = 0.22, 95% CI 0.07—0.68), boots (OR = 0.69, 95% CI 0.40—1.21) and gloves (OR = 0.28, 95% CI 0.13—0.62). However, when fitted into the multivariate model, these factors were eliminated during the stepwise analysis. The main reasons stated by the farmers for not protecting their extremities were discomfort or dislike of the measures, as claimed by 85 subjects (39.4%).

Several exposure variables, including contact with people having skin diseases, sharing personal objects with patients and contact with domestic animals, were not associated with an increased risk of skin ailments (data not shown). Other potential confounders, such as educational levels and socioeconomic status (reflected in the possession of household items such as motorbikes, refrigerators, drilled wells and hygienic septic latrines), which were obtained in the baseline study (Trang et al., 2006a), were not associated with skin ailments (data not shown).

3.3.2. Risk factors for skin ailments among people who had contact with wastewater—Model B

Bivariate and multivariate analyses were performed for the subjects who had contact with wastewater in the past week of the onset of skin ailments (95 cases) and the day of interview (74 controls). The results are presented in Table 4. The use of wastewater for a purpose other than irrigating gardens or fields was associated with an increased risk of skin ailments. Other specific agricultural activities involving contact with wastewater such as crop harvest (including rice or vegetables), weeding, transplanting and pesticide spraying were not associated with skin ailments. Fish harvest from wastewater-fed ponds was associated with the risk of skin ailments at the bivariate analysis stage, but was dropped out of the reduced model. Wastewater from the main canal (Kim Nguu River) as the major wastewater source was a strong risk factor for skin ailments.

Information on the length of daily contact with wastewater was obtained for each day within the past week prior to the onset of the skin problem or the day of control interview (Days 0—6). Longer time of wastewater contact (>2 h per day) from Day 2 to Day 6 was significantly associated with the risk of skin ailments, adjusted for age and gender (data not shown). A categorical variable of the total contact hours with wastewater was generated from the reported lengths for Day 2 to Day 5. Data for Day 0 and Day 1 were omitted from this sum of contact hours because of short exposure durations, as were the data for Day 6 because a considerable number of subjects could not remember how long they were exposed to wastewater. In comparison with people having <4 h contact with wastewater during the 4-day period, the effects of total time in contact with wastewater were much greater in people with contact lengths of 4—7 h, 8—11 h and ≥12 h (ORs = 1.33, 4.74 and 6.37, respectively). These effects were independent of age and gender. When controlled for other variables in the multivariate model performed for the subjects exposed to wastewater

Table 3 Risk factors for skin ailments among farmers in Yen So commune, Hanoi, Vietnam, 2002—2003 (Model A including 108 cases and 108 controls)

Variable	Case *n* (%)	Control *n* (%)	OR[a]	95% CI	OR[b]	95% CI
Contact with wastewater	95 (88.0)	74 (68.5)	3.20	1.56—6.56	2.74	1.29—5.82
Fish farming-related jobs (fish harvest or fish selling)	26 (24.1)	14 (13.0)	5.01	1.92—13.06	3.47	1.27—9.50
Not using any protective measures	66 (61.1)	43 (39.8)	2.49	1.40—4.42	2.24	1.21—4.12
Female gender (adjusted for age)	81 (75.0)	75 (69.4)	1.06	0.57—2.00	2.48	1.06—5.76
Age groups[c] (adjusted for gender)						
30—44 years	60 (55.6)	47 (43.5)	2.56	1.10—5.95	3.44	1.32—9.00
≥45 years	37 (34.3)	38 (35.2)	1.98	0.82—4.76	2.64	0.98—7.12

OR: odds ratio.
[a] Age- and gender-adjusted ORs from initial bivariate analysis (pertained to the first three variables).
[b] ORs from the reduced logistic regression model with the generalised estimating equations method.
[c] Referent group was the subjects aged 15—29 years.

Table 4 Risk factors for skin ailments among people who had contact with wastewater, Yen So commune, Hanoi, Vietnam, 2002—2003 (Model B including 95 cases and 74 controls)

Variable	Case *n* (%)	Control *n* (%)	OR[a]	95% CI	OR[b]	95% CI
Using wastewater exclusively for other purpose than irrigation	72 (75.8)	41 (55.4)	2.99	1.51—5.92	2.20	1.03—4.69
Main canal as the major source of wastewater	74 (77.9)	41 (55.4)	2.88	1.46—5.66	3.45	1.55—7.69
Not washing body after contact with wastewater	38 (40.0)	12 (16.2)	3.34	1.60—6.98	3.26	1.42—7.47
Not washing hands/feet after contact with wastewater	16 (16.8)	3 (4.1)	4.38	1.29—14.85	4.06	1.12—14.69
Total hours of contact with wastewater[c]						
4—7 h	18 (18.9)	27 (36.5)	1.33	0.47—3.73	0.71	0.24—2.12
8—11 h	25 (26.3)	12 (16.2)	4.74	1.58—14.23	3.46	1.06—11.29
≥12 h	45 (47.4)	17 (23.0)	6.37	2.20—18.40	3.14	1.03—9.59

OR: odds ratio.
[a] Age- and gender-adjusted ORs from initial bivariate analysis.
[b] Age- and gender-adjusted ORs from the reduced logistic regression model with the generalised estimating equations method.
[c] Referent group was the subjects with length of wastewater contact <4 h during the 4-day period (from Day 2 to Day 5).

(Model B), the association between the number of hours with wastewater contact and the risk of skin ailments remained significant, especially in the people having >8 h of contact during the 4-day period (Table 4). Results from the reduced Model B also showed that personal hygiene practices had strong impacts on the risk of skin ailments. People who did not wash their body, hands or feet after contact with wastewater were at increased risk for skin ailments.

3.3.3. Risk factors for skin ailments among people with hygiene practices after wastewater exposure—Models C and D

In a subset of individuals who washed their body after wastewater exposure (Model C including 57 cases and 62 controls), frequent body washing (OR = 0.46, 95% CI 0.21—1.0) and use of soap for body washing (typically at home) (OR = 0.46, 95% CI 0.19—1.11; $P = 0.08$) tended to protect against skin ailments. However, when fitted in the multivariate model (Model C), these variables were no longer significant.

In another subset of individuals who cleaned their hands and feet with water after wastewater exposure (Model D including 79 cases and 71 controls), reduced risks of skin ailments were significantly associated with frequent washing (OR = 0.31, 95% CI 0.13—0.73) and using clean water from drilled tube wells (OR = 0.12, 95% CI 0.04—0.38). The use of water from shallow-dug wells also reduced the risk of skin ailments, but the difference was only significant at $P < 0.1$ (OR = 0.25, 95% CI 0.06—1.07; $P = 0.061$). Washing with water from local ponds that are usually fed with diluted wastewater or rain water tended to increase the risk of skin ailments, however it was not significant at the stage of univariate analysis (crude OR = 1.75, 95% CI 0.95—3.55).

To separate the exposure to rice pollen as a possible cause of skin ailments from the effects of other risk factors, in particular the impact of wastewater, the multivariate models were also fitted after the exclusion of 24 cases with allergic reactions. The results remained essentially the same, with all variables of the reduced models being significant at $P < 0.05$ (Model A) and at $P < 0.1$ (Models B and D) (data not shown).

4. Discussion

Anecdotal reports indicate that irritations and ailments of the skin are common health problems described by wastewater farmers in different countries. The present study is to our knowledge the first prospective study assessing the incidence of skin ailments and the associated risks factors in a cohort of farmers working in wastewater-fed agriculture and aquaculture. The nested case—control study is a commonly used approach in occupational epidemiology (Rothman and Greenland, 1998) for its efficiency in the collection of additional exposure data than what is readily available from baseline records of the cohort, especially when the exposure was transient, whilst taking the merits of a cohort study such as well defined study base, case findings and incidence estimates. Through this nested case—control design with density sampling, we found that people who were exposed to wastewater had a higher risk of skin problems than those who were not exposed. This was similar to the findings in Phnom Penh (van der Hoek et al., 2005) where wastewater farmers had a higher prevalence of skin diseases than non-wastewater farmers (22% vs. 1%). In contrast, in a community-based study in a periurban settlement of a small town in Pakistan, Feenstra et al. (2000) reported a lower prevalence of skin problems in the farmers exposed to wastewater (3.0% vs. 5.8%), although the difference was not significant (OR = 0.51, 95% CI 0.20—1.32) and the prevalence of skin diseases was rather low in both groups. Since the wastewater used for irrigation in the small rural town in Pakistan was exclusively domestic (Feenstra et al., 2000) and therefore most likely polluted mainly with faecal matters, it could be speculated that the health impact of wastewater of both domestic and industrial origins in Hanoi may be greater. The wastewater in Hanoi contained, in

addition to microbial contamination, a mixture of hazardous agents such as toxic chemicals. Such chemicals may be more likely to irritate the skin of the exposed people and cause more problems to the local farmers compared with wastewater with no or little industrial contamination.

Irritant contact dermatitis, which is a skin disorder appearing following the direct action of irritants on the skin at the place of contact, is commonly found among people involved in 'wet work' (Alberti et al., 1999; Held et al., 2002; Jungbauer et al., 2004). The term 'wet work' refers to occupations that require long-day exposure to water and the agents contained in water. Water can be an external irritant to the skin (Tsai and Maibach, 1999) and prolonged water exposure may cause clinical signs such as scaling, redness, vesicles, pustules and erosion (Alberti et al., 1999). Most of these signs were found in the skin cases recruited in the present case–control study, with nearly 90% reporting a history of contact with wastewater in the previous week of skin ailment onset. In our study, wastewater contact came from a wide range of agricultural activities that required different levels of body exposure, with feet and hands being the most exposed body parts. It has been shown that exposure of hands to water was associated with irritant contact dermatitis (Held et al., 2002). In addition, wastewater, especially raw and preliminary-treated wastewater, harbours many pathogens and toxic chemicals that can cause different health problems, including gastrointestinal and respiratory diseases, as well as ear, eye and skin ailments (Devaux et al., 2001; Feachem et al., 1983; Scarlett-Kranz et al., 1987; Siebe and Cifuentes, 1995). It was impossible to differentiate between skin problems caused by chemicals and pathogens and we did not know to what extent the skin reactions or damage were a result of a combined action of these agents. However, pathogens and chemicals in the wastewater could accelerate the occurrence of new skin problems or worsen existing damage, as shown by the current finding of repeated episodes of skin ailments in 43/141 subjects.

It is noteworthy that 24 cases recruited in the nested case–control study reported erythema and itching appearing in different body parts after spraying pesticides or harvesting rice. A number of follow-up subjects who were excluded from the risk factor analysis also reported similar symptoms during the rice harvest season, which might be caused by exposure to airborne agents such as pollens. Although mainly the feet of farmers were exposed to wastewater during rice harvest, and this exposure might precipitate allergic reactions, it is likely that it might be of less importance compared with exposure to airborne particles (e.g. pollens or aerosols) as the causes of allergic contact dermatitis (Sherertz, 1999). When the subjects with symptoms compatible with allergic contact dermatitis were excluded, wastewater exposure still remained a strong risk factor. Nevertheless, further studies should be undertaken if the relative importance of airborne particle exposure versus wastewater exposure is to be elucidated as causes of allergic contact dermatitis or other skin ailments.

Our results show that the use of protective footwear and gloves could reduce risks for skin problems among farmers engaged in wastewater activities. Other studies have suggested that such measures and improved personal hygiene could reduce risks for wastewater-related diseases, in particular parasitic infections (Ensink et al., 2005; Feenstra et al., 2000; Trang et al., 2006b, van der Hoek et al., 2005). One of the reasons that farmers did not want to use rubber boots was that available models were stiff and impractical for fieldwork. However, following the completion of our study new types of thin, flexible and inexpensive rubber boots and gloves are increasingly used by farmers in the study area. This development is likely to reduce their skin problems. Additional studies are yet needed to assess, for example, to what extent the use of textile stockings and long/sleeved gloves can lower skin problems. The present study also suggests that washing of body parts exposed to wastewater could significantly reduce skin ailments. The exposure information on hygiene behaviour as well as other exposure variables was collected during interviews, and direct observations would have supported the conclusions. Nevertheless, the study stressed the importance of hygiene practices, and thus the cleaning of hands and feet following wastewater exposure should be promoted to farmers. It should be noted that cleaning extremities with water from wells, but not with pond water, lowered the risk of skin problems, which may be explained by a generally higher level of pollution of pond water that was fed with wastewater.

Among the various types of work involved in wastewater contact, fish harvest and fish selling were independent risk factors for skin ailments. The nature of these jobs could itself explain their heavier exposure to wastewater than other occupational categories. Fish harvest involves prolonged wastewater exposure of most of the body during the dragging of fish nets, whilst fish selling requires long-term hand or arm contact with water to keep the fish alive and to process the fish. Saw et al. (2001) also found an increased risk of dermatitis among villagers who fished in the river that received the village sewage.

The significantly higher risk of skin ailments for females, especially those of middle age, was likely due to the fact that female farmers were more highly exposed to wastewater than their male counterparts. Females in the commune are more attached to the daily fieldwork (e.g. weeding, manure application, pesticide spraying or watering), whereas men mainly provide significant inputs to heavier work during time of land preparation, transplanting or harvest of fish and rice. Consequently, females had a higher frequency of exposure to wastewater than males, hence having a higher risk of wastewater-related diseases, including parasitic infections (Trang et al., 2006a). Another reason for the higher risk in females could be the larger number of female participants in the follow-up cohort and their greater willingness to report skin problems or to participate in the case–control interviews. This may also influence the higher incidence rate of skin ailments in females.

Owing to a limited number of longitudinal studies on the incidence of skin diseases, it is difficult to compare the rates of skin ailments in the present study with other studies. Available studies that have assessed the associations between wastewater exposure in agricultural practices and skin diseases (among other health risks) have been cross-sectional studies (Devaux et al., 2001; Feenstra et al., 2000). The majority of studies reported risks for diarrhoea and parasitic infections in communities working with wastewater (Blumenthal et al., 2001; Bouhoum and Schwartzbrod, 1998; Cifuentes et al., 2000; Fattal et al., 1986; Feenstra et al., 2000; Shuval et al., 1989). The

extensive reviews by Shuval et al. (1986) and Blumenthal and Peasey (2002) on the existing studies that addressed the different health effects of wastewater use in agriculture, or even the new guidelines of the WHO (2006) for wastewater use in agriculture, did not mention skin diseases as the consequence of exposure to wastewater. The most reported health effects of wastewater use in agriculture have so far been gastrointestinal diseases and infections of consumers from wastewater irrigation of crops eaten uncooked, or agricultural workers and their families from direct contact with wastewater, and populations living near field sprinklers irrigated with wastewater. In other studies that assessed skin diseases, skin problems have typically been studied as a health risk for sewage treatment plant workers (Scarlett-Kranz et al., 1987; Thorn and Kerekes, 2001) or recreational swimmers in low-quality water (Fleisher et al., 1996), or as dermatological problems in population studies (Figueroa et al., 1998; Gibbs, 1996; Saw et al., 2001) and in occupational health surveys (Jungbauer et al., 2004). Additionally, different from the community-based studies (Figueroa et al., 1998; Gibbs, 1996) in which socioeconomic characteristics (such as housing conditions and density) were commonly found as risk factors for skin diseases, our study did not detect any association between skin ailments and the effects of socioeconomic status.

The present study has some limitations. The 1-year surveillance programme was made up of weekly visits with repetitive interviews on the occurrence of skin ailments. Some participants in the cohort found such weekly visits a 'nuisance'. In addition, no benefits or compensations were provided to the study subjects. Thus, some subjects were not co-operative and refused to report their morbidity status, especially as the study went on. As a result, there were higher numbers of reports during the first few months than the final months of the follow-up. This might be due to a reporting bias because of the initial enthusiasm to participate as well as unacquaintance with the study definitions at the beginning of the programme. Nevertheless, the case—control study only recruited cases emerged from March 2003 when the monthly reporting was rather stable. Therefore, the risk factor analysis was not really impacted by the reporting bias occurring at the beginning of the study.

Our study also relied on recall interviews and, together with underreporting problems, this may have underestimated the true morbidity in the community. Furthermore, the recruitment of cases was based on self-perceived symptoms combined with verification by fieldworkers. A subsequent standard physical examination by a dermatologist could have improved the precision of the study and allowed a determination of risk factors for specific diagnoses.

5. Conclusion

Through a case—control study nested in a morbidity surveillance programme, we showed that contact with wastewater (e.g. in fish culture), lack of personal protective measures, female gender and inadequate personal hygiene were independently associated with the risk of skin ailments in farmers. While proper treatment of wastewater in Vietnam is yet to be attained, farmers should be encouraged to use personal protective measures while working in wastewater-irrigated fields and ponds. At the same time, improved hygiene behaviours should be promoted in communities engaged in wastewater-fed agriculture and aquaculture, thus benefiting general public health. Further studies are warranted to understand the nature of wastewater-related skin diseases and their possible risk factors.

Conflicts of interest statement
The authors have no conflicts of interest concerning the work reported in this paper.

Authors' contributions

All authors planned the study and designed the protocol; DTT and PDC conducted the field study and supervised the morbidity surveillance programme as well as the management of collected data; DTT, AD and KM carried out the analysis and interpretation of the data; DTT prepared the first draft of the manuscript; all authors revised the manuscript critically. All authors read and approved the final version of the manuscript. DTT is the guarantor of the paper.

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