ORIGINAL ARTICLE

Effluents from a pulp and paper mill: a skin and health survey of children living in upstream and downstream villages

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Objectives: A health survey of three villages (upstream village Rantau Baru and two downstream villages, Sering and Pelalawan) in the vicinity of a pulp and paper mill along the Kampar river in the province of Riau, Indonesia was conducted to find whether exposure to the effluents from the mill was related to skin conditions and ill health.

Methods: A cross sectional survey was carried out of children living in the three villages.

Results: Common skin conditions such as dermatitis, fungal infections, insect bites, and malaria were found. No significantly increased risk of dermatitis or any illness in general was found with increasing levels of exposure to river water for downstream villages when compared with the upstream village. However, there was an increased risk of diarrhoea in Sering especially with drinking water directly from the river (prevalence rate ratio (PRR) 4.9, 95% confidence interval (95% CI) 0.4 to 63.9). An increased risk was also found within the upstream village Rantau Baru (PRR 2.3, 95% CI 0.9 to 5.8) and downstream village Sering (PRR 1.4, 95% CI 0.4 to 5.2) when children who drank water directly from the river were compared with those who never did. Analysis of the river water also showed physical and chemical variables within the acceptable range except for faecal coliforms (6 MPN/100 ml) found in the sample taken from Sering.

Conclusions: The effluent from the mill is unlikely to be causing skin conditions and ill health. Diarrhoea may be due to faecal coliform contamination of the water because all raw sewerage is deposited in the river. Community health outreach programmes are being implemented based on these findings.

Industrialisation of developing countries has raised issues of environmental damage. There are many examples of this in both developed and developing nations.¹ However, efforts from international and local government bodies has led to greater control over industrialisation in an effort to reduce this.^{1,2} Despite this, changes do occur regardless of the care taken.

An example is the building of a pulp and paper mill adjacent to the sites of forestation used to produce paper. From a global perspective, this is one of the major industries with mills located in more than 100 countries in every region of the world.³ Construction of this particular pulp and paper mill began in 1993. Commercial production of pulp started in January 1995 and paper production in April 1998. The mill is located on the Kampar river in the province of Riau, Indonesia. This province is situated on the island of Sumatra in south east Asia.

There are about 3 million inhabitants living in an area of 94 561 square km. The main source of income and occupation of its inhabitants comes from agriculture (food and commercial crops, and livestock), forestry, and mining.⁴

This mill uses the elementary chlorine free bleaching process with chlorine dioxide and oxygen in the production of pulp thus producing only small amounts of polychlorinated phenolic compounds. The pulp production is integrated with a paper machine producing wood free uncoated paper. Mean effluent discharge for the whole production of pulp and paper was 35 m³/tonne for July 1999. The combined effluent from the pulp and paper production is first treated in a primary clarification stage whereupon it is led through an equalisation pond. After primary clarification the effluent is biologically treated in an activated sludge treatment plant (residence time of about 24 hours) and after that the effluent is collected in a

second clarifier. After treatment, the combined effluent is transported along a 5 km open channel and discharged into the Kampar river. This activated sludge treatment plant thus degrades the effluent further before discharge.

After the construction of the pulp and paper mill, the inhabitants of two downstream villages, Sering and Pelalawan thought that the effluent from the mill was polluting the river water thus causing skin problems and ill health. An aquatic environmental impact evaluation by an international environmental research group was performed in August and September 1999 to evaluate this claim.⁵ This included a survey of effluent discharge from the mill, river water, and fish biota. All samples were frozen and subsequently analysed at the Institute of Environmental Chemistry at the University of Abo Akademi, Finland.

Findings showed that the absorbable organic halogen in the final treated effluent was 0.11 kg/tonne pulp, low from an international perspective.⁶ The international toxic equivalent expressing the overall toxicity potential of the analysis of chlorinated dioxins and furans was 0.72 pg/l. According to the analysing laboratory, Finnish National Health Institute, the level of analytical accuracy is $\pm 100\%$ at international toxic equivalent levels of < 1 pg/l, indicating that the concentrations of toxic chlorinated dioxins were at the limit of detection. Chlorophenolic substances were found in the untreated effluent but at very low concentrations, this includes 3.1 $\mu\text{g/l}$ 4,5 dichloroguaiacol and traces of 2,4,6 triphenylphenol in the sample collected after the primary clarifier to only

Abbreviations: PCB, polychlorinated biphenyls; PRR, prevalence rate ratios

0.07 µg/l of 2,4,6 tri-pentachlorophenol in the final treated effluent. Of these, 2,4,6 tri-pentachlorophenol is also formed naturally in humic environments,⁷ and 2,4,6 tri-pentachlorophenol occurs ubiquitously as a contaminant where wood is burnt. Total concentrations of potentially toxic resin acids, fatty acids, and phytosterols were all very low.

The data on quality of river water did not show any differences between upstream and the downstream point closest to the effluent discharge. Chlorinated phenols were not occurring above the level of detection in river water. Consistent with these findings, no chlorinated phenols exceeding the detection limit were found in fish bile samples. The researchers thus concluded that overall the risk for humans being in contact with the Kampar river water may be considered practically negligible or non-existent.

Possible health problems derived from the contact or consumption of river water if concentrations of chlorinated dioxins were high include skin conditions such as chloracne and porphyria cutanea tarda⁸⁻¹⁰; as well as more non-specific dermatitis.¹¹ These have been documented in people exposed to high concentrations of these substances. Apart from dermatological conditions, a review of cross sectional studies conducted upon workers exposed to varying degrees of polychlorinated biphenyls (PCB) did not find other consistent clinical outcomes.¹¹

As the concerns of the villagers needed to be investigated, a health survey was conducted. The primary aim of this study was to assess the villagers primarily for any skin conditions and whether these are associated with the effluent produced by the mill. A secondary aim was to assess the general health of villagers. This article presents the findings for the children living in the villages. Resampling and testing of river water was also simultaneously conducted.

MATERIAL AND METHODS

Population studied and sampling procedure

A cross sectional study was conducted in three villages (Sering, Pelalawan, and Rantau Bahru) along the Kampar River. The closest downstream villages are Sering and Pelalawan villages located a distance of 7.7 km and 24.8 km away from the mill whereas Rantau Baru, chosen as a control village, is 45 km upstream from the mill.

A one stage cluster (of people in a house) sampling per village was performed. Each sampling frame consisted of all the houses in each of the villages (Sering 203, Pelalawan 223, and Rantau Baru 149). One hundred houses from each of the villages were sampled. Houses were subsequently mapped and numbered then randomly chosen from a list of random numbers generated for each village. The sampling fractions were 1/2.03, 1/2.23 and 1/1.49 for Sering, Pelalawan, and R B respectively. The methods of the survey relating to children (aged 12 years or below) residing within these villages are presented here.

Questionnaire

Field trips made by trained public health personnel (DK, CSE, WML, HCY, JL, and SSM) included discussions with villagers as well as the local health team about possible health issues and practices. Information was also obtained about pre-existing health facilities and services and the general socioeconomic status and living conditions of the villagers. Two questionnaires were designed, one for the household and the other for each individual child living in the household. To reduce bias, the questionnaires were designed as for a general health survey without specific reference to the river or illness associated with exposure to the river water.

Questionnaires were translated into Indonesian. They were again checked with the local health team to ensure correct translation and clarity. They were also checked to ensure that they were socioculturally correct and appropriate. The

questionnaires were administered by personnel from the local healthcare team and were answered by the primary person caring for children less than 12 years of age after verbal consent was obtained.

Household questionnaire

A questionnaire for each household was designed to determine the number of occupants, duration of habitation in the village, number of members who can read, household income, and household possessions such as radio, television, and motorised boat. Access and use of basic amenities such as electricity, rubbish bin, and water from a sanitary source such as a well was asked about. Similarly, questions were asked about use of toilet facilities including unsanitary (using the river) and sanitary (public and individual); as well as source of drinking water (river, well, pond, or rain water). This included whether water was either always boiled or seldom boiled before drinking.

Personal questionnaire for children

Questions derived from a previous health survey conducted on an indigenous population in Malaysia¹² were adapted and modified with the knowledge acquired from the field trips. Questions were asked about immunisation, recent ill health (any skin conditions, diarrhoea, cough or cold, fever, and passing worms in the past 2 weeks), allergies, and medical history. Questionnaires were asked about usual hygiene measures such as brushing teeth, washing hands before eating, wearing slippers outside the house, and not drinking water taken directly from the river and categorised into always, sometimes, or never. A history of usual exposure to river water was also sought asking for frequency of bathing, playing or swimming, and collecting water from the river. These were categorised as daily, some days, or never.

Physical examination

Local doctors examined the children for any skin conditions as well as lice and scabies. Before the survey the doctors were trained specifically in the diagnosis of skin conditions. All skin findings were photographed, but some photographs did not turn out well enough to be reviewed accurately.

Training of fieldworkers

All personnel were intensively trained to ensure consistency in the survey. A pilot study was carried out before the survey proper to estimate duration of interview and examination (about 15 minutes) as well as clarity and face validity of the questionnaire. The local doctors and fieldworkers were aware that a health survey was being conducted. However, they were blinded to the hypothesis that exposure to effluents from the mill was causing skin problems and ill health.

Fieldwork

The survey was conducted within the period of November to December 1999. Three attempts on three different occasions were made before a household was deemed to be a non-response. Attempts were made to conduct the survey on days such as market day when it was known that most people in the household were present. However, if a house was found to be vacant it was replaced by another house with a higher number but not on the list. Survey quality was assessed by regularly checking questionnaires for incomplete responses or coding errors as well as direct observation of interviewers by the external observers (HCY, JL, WML, SSM, CSE) who accompanied the teams on the field. Treatment for villagers was also initiated on a case needed basis. Approval for the study was obtained from a committee comprising community representatives and members from local non-government organisations. Completion of the examination and survey was done on a voluntary basis with participants having the right to decline.

Table 1 Characteristics of children including findings of skin conditions and recent illness (within the past 2 weeks)

	Rantau Bahru n=144	Sering n=166	Pelalawan n=125
Family size (mean (SD))	2.7 (1.9)	2.9 (2.2)	2.9 (1.9)
Age (mean (SD))	5.68 (3.34)	5.83 (3.44)	5.71 (3.19)
Sex (n (%)*):			
Men	76 (52.8)	85 (51.2)	58 (46.4)
Women	68 (47.2)	81 (48.8)	67 (53.6)
Skin conditions:			
Normal	114 (79.2)	104 (62.7)	107 (85.6)
Dermatitis (n (%)*):			
Localised†	1 (0.7)	5 (3.0)	0
Not localised‡	4 (2.8)	3 (1.8)	2 (1.6)
Total	5 (3.5)	8 (7.4)	2 (1.6)
Other skin conditions (n (%)*):			
Lice	0	15 (9.0)	0
Scabies	0	1 (0.6)	0
Insect bites	5 (3.5)	17 (10.2)	6 (4.8)
Fungal infection	5 (3.5)	18 (10.8)	8 (6.4)
Heat rash	11 (7.6)	18 (10.8)	1 (0.8)
Warts	1 (0.7)	5 (3.0)	0
Old healed scar	4 (2.8)	8 (4.8)	1 (0.8)
Other skin conditions§	3 (2.1)	3 (1.8)	1 (0.8)
Recent illness (n (%)*):			
Diarrhoea	24 (16.7)	34 (20.5)	10 (8.0)
Cough or cold	46 (31.9)	52 (31.3)	28 (22.4)
Fever	51 (35.4)	33 (19.9)	26 (20.8)
Pass out worms	5 (3.5)	12 (7.2)	3 (2.4)
Any recent illness (n (%)*)	74 (51.4)	84 (50.6)	42 (33.6)

*Percentages may add up to more than 100 because some children had more than one disorder; †localised dermatitis includes any excoriated erythematous rash involving less than 1% body surface and only involved a specific part of the body; ‡not localised dermatitis includes skin lesions that presented as excoriated erythematous rash found on body, face, arms or legs and not localised to a specific part of the body; §other skin conditions include lichen simplex chronicus, haematoma after trauma, hypopigmentation, furunculosis, varicella zoster, blister after burn, and birthmark.

Water sampling

At around the time of the village survey (8 November 1999 and 14 December 1999), water samples were collected simultaneously at several locations including 1 km before the water intake (upstream) and 1 km after the waste discharge point (downstream) of the mill, as well as at Sering village (8 km downstream from the mill). Physical, chemical, and biological variables of the river water were analyzed. Scientists who conducted the water analysis were blinded to the source of river water collection points as well as to the results of the health survey.

Data analysis

The SPSS 10.0 was used to analyze the data. Descriptive data were provided. Exposure to river water was assessed by three questions that asked for daily, some days, or no contact through bathing, playing or swimming, and collecting water from the river. Three groups were formed in order of levels of river water exposure. These are (a) any one of the exposures daily or some days (one exposure), (b) any two of the exposures daily or some days (two exposures) or (c) all three exposures daily or some days (all exposures).

Cox's proportional hazards models were used to calculate prevalence rate ratios (PRRs) with 95% confidence intervals (95% CIs) adjusted for age and sex as well as for age, sex, and income. These are used to compare the upstream (Rantau Baru) and downstream (Sering and Pelalawan) villages for skin conditions (dermatitis) and recent ill health (including any diarrhoea, cough or cold, fever, and passing worms in the past 2 weeks, as well as in particular, only diarrhoea). These outcome measures of possible harm were chosen because exposure to water either through contact or ingestion may be associated with these health conditions as well as being a general indication of health. The PRRs (95% CIs) were calculated for specific groups; comprising all children, only children

specifically involved in each of the three groups of contact with river water, and children who drank water directly from the river within each village.

RESULTS

Response rate

Overall the household response rates for all three villages were 100%. Individual response rates for the three villages were Rantau Baru 144/150 (96.0%), Sering 166/169 (98.2%), Pelalawan 125/128 (97.6%). Thus an overall response rate of 97.3% of children 12 years old or less from Rantau Baru, Sering, and Pelalawan completed the questionnaire and examination.

Household data

The average monthly household income of the three villages was less than 1 000 000 rupiah (US\$ 75) for most villagers and households (Rantau Baru 138 (95.8%), Sering 156 (94%), and Pelalawan 121 (98.7 %). Up to two thirds of the villagers had an average household monthly income of less than 200 000 rupiah (US\$ 15) (Rantau Baru: 110 (76.4%), Sering: 71 (42.8%) and Pelalawan: 44 (35.2%). In more than 50% of households in each village, more than half of the household members were able to read. Sering had the least with 91 (54.8%) compared with Pelalawan with 97 (78.9%), and Rantau Baru with 109 (76.2%) households, respectively. Twenty one households (14.6%) in Rantau Baru, 73 (44%) in Sering, and 70 (56.9%) in Pelalawan were supplied with electricity. Nearly all households used unsanitary toilets located over the river (Sering 166 (100%), Pelalawan 125 (100%), and Rantau Baru 137 (95.1%).

Sociodemographic characteristics, skin, and health variables

Table 1 shows that the mean family size, age, and sex of the children in each village were similar. Most children in each

Table 2 Children's exposure to river water through superficial contact and drinking

	Rantau Bahru (n=144) n (%)	Sering (n=166) n (%)	Pelalawan (n=125) n (%)
Bathe in the river:			
Never	5 (3.5)	5 (3.0)	1 (0.8)
Daily or some days	139 (96.5)	161 (97.0)	124 (99.2)
Play or swim in the river:			
Never	73 (50.7)	63 (38.0)	73 (58.4)
Daily or some days	71 (49.3)	103 (62.0)	52 (41.6)
Collect water from the river:			
Never	94 (65.3)	97 (58.4)	85 (68.0)
Daily or some days	50 (34.8)	69 (41.5)	40 (32.0)
Any of the above exposures	139 (96.5)	162 (97.6)	124 (99.2)
Any two of the above exposures	74 (51.4)	109 (65.7)	58 (46.4)
All three of the above exposures	47 (32.6)	62 (37.3)	34 (27.2)
Drinking water:			
Regular source of drinking water:			
River	137 (95.1)	163 (98.2)	123 (100)
Other—for example, well	7 (4.9)	3 (1.8)	0
Drink water directly from the river	19 (13.2)	7 (4.2)	2 (1.6)
Always boil water before drinking	138 (95.8)	164 (98.8)	123 (100)

village did not have any skin conditions. Compared with the other two villages, Sering seemed to have the greatest number of skin conditions with the highest prevalence of dermatitis (4.8%), lice (9.0%), insect bites (10.2%), fungal infection (10.8%), and miliaria (10.8%). Dermatitis was further divided into localised and not localised dermatitis. Localised dermatitis included any excoriated erythematous rash that involved less than 1% body surface area and only involved a specific part of the body. Sering was found to have the highest prevalence (3.0%) compared with the other villages. Not localised dermatitis included any excoriated erythematous rash that was found on the body, face, arms, or legs and was not localised to a specific part of the body. Within this group Rantau Baru had the highest prevalence (2.8%). For any recent illness, Sering and Rantau Baru had a similar incidence of 50.6% and 51.4%, respectively, whereas Pelalawan had the lowest at 33.6%. For diarrhoea, Sering had the highest incidence of 20.5%, then Rantau Baru (16.7%), and Pelalawan (8.0%).

Exposure of children to river water

Table 2 illustrates the exposure of children to river water through various means. Most children in all villages bathed daily or on some days in the river (Sering: 97.0%, Pelalawan: 99.2%, and Rantau Baru: 96.5%). A larger proportion of children in Sering (62.0%) than Pelalawan (41.6%) or Rantau

Baru (49.3%) played or swam in the river daily or on some days. Table 2 also shows the levels of exposure to river water that each child might have. Most children had one exposure to river water, whereas about a half and a third had any two exposures and all exposures with river water, respectively. Compared with Rantau Baru and Pelalawan, children in Sering seemed to have the most contact with river water, 65.7% had two exposures, and 37.3% all exposures to river water. The regular source of drinking water for most villagers was the river with most drinking boiled water. However, some (18 (14.4%) in Rantau Baru, 7 (4.2%) in Sering, and 2 (1.6%) in Pelalawan) reported drinking water directly from the river.

Risk of dermatitis with exposure to river water

Table 3 shows the PRR of dermatitis in all children as well as those with different degrees of contact with river water in the three villages adjusted for age and sex as well as age, sex, and income. Dermatitis was assessed as one group because further stratification led to too few cases for analysis. For analysis including all children it seemed that Sering had the greatest risk (PRR 2.4, 95% CI 0.7 to 7.9) and Pelalawan the lowest (PRR 0.5, 95% CI 0.1 to 3.3) with adjustment for age, sex, and income. However, none of these results were significant. There was also a moderate increase in PRR with only one exposure to river water. However, there did not seem to be an increased

Table 3 Prevalence rate ratios for dermatitis and exposure to river water

	Cases (n (%))*	PRR (95% CI)†	PRR (95% CI)‡
All children:			
Rantau Bahru	5 (3.5)	1	1
Sering	8 (7.4)	2.3 (0.7 to 6.9)	2.4 (0.7 to 7.9)
Pelalawan	2 (1.6)	0.5 (0.1 to 2.5)	0.5 (0.1 to 3.3)
Any one exposure:			
Rantau Bahru	4 (2.9)	1	1
Sering	8 (7.6)	2.8 (0.8 to 9.3)	3.1 (0.8 to 11.4)
Pelalawan	2 (1.6)	0.6 (0.1 to 3.0)	0.6 (0.1 to 3.7)
Any two exposures:			
Rantau Bahru	1 (1.4)	1	1
Sering	3 (4.1)	3.0 (0.3 to 28.8)	1.4 (0.1 to 15.4)
Pelalawan	0 (0)	0	0
All three exposures:			
Rantau Bahru	1 (1.4)	1	1
Sering	0 (0)	0	0
Pelalawan	0 (0)	0	0

*Cases (n (%)) found in each village within the group of children who participated in the aforementioned activity; †PRR, prevalence rate ratio adjusted for age and sex; ‡PRR, prevalence rate ratio adjusted for age, sex, and household income.

Table 4 Prevalence rate ratios for having any illness or diarrhoea and exposure to river water

	Any illness			Diarrhoea		
	Cases (n (%))*	PRR (95% CI)†	PRR (95% CI)‡	Cases (n (%))*	PRR (95% CI)†	PRR (95% CI)‡
All children:						
Rantau Bahru	74 (51.4)	1	1	24 (16.7)	1	1
Sering	84 (50.1)	1.0 (0.7 to 1.4)	1.0 (0.7 to 1.3)	34 (20.5)	1.2 (0.7 to 2.1)	1.3 (0.3 to 5.0)
Pelalawan	42 (33.6)	0.7 (0.5 to 1.0)	0.7 (0.4 to 1.0)	10 (8.0)	0.5 (0.2 to 1.0)	0.8 (0.2 to 2.7)
Any one exposure:						
Rantau Bahru	71 (51.1)	1	1	24 (17.3)	1	1
Sering	82 (50.6)	1.0 (0.7 to 1.4)	1.0 (0.7 to 1.4)	34 (21.0)	1.2 (0.7 to 2.1)	1.0 (0.4 to 2.6)
Pelalawan	41 (33.1)	0.7 (0.4 to 1.0)	0.7 (0.4 to 1.0)	10 (8.1)	0.5 (0.2 to 1.0)	0.9 (0.2 to 3.5)
Any two exposures:						
Rantau Bahru	33 (44.6)	1	1	10 (13.5)	1	1
Sering	53 (48.6)	1.0 (0.7 to 1.6)	1.1 (0.6 to 1.7)	21 (19.3)	1.3 (0.6 to 2.9)	1.1 (0.5 to 2.4)
Pelalawan	18 (31.0)	0.7 (0.4 to 1.2)	0.7 (0.4 to 1.3)	8 (13.8)	1.0 (0.4 to 2.5)	0.7 (0.3 to 1.9)
All three exposures:						
Rantau Bahru	18 (38.3)	1	1	4 (8.5)	1	1
Sering	21 (33.9)	0.8 (0.4 to 1.6)	1.0 (0.5 to 2.0)	7 (11.3)	1.4 (0.4 to 4.6)	1.5 (0.4 to 6.3)
Pelalawan	10 (29.4)	0.7 (0.3 to 1.6)	0.9 (0.4 to 2.0)	3 (8.8)	1.0 (0.2 to 4.7)	1.0 (0.2 to 5.5)
Drinking water directly from the river:						
Rantau Bahru	13 (68.4)	1	1	6 (31.6)	1	1
Sering	4 (57.1)	1.1 (0.3 to 3.6)	1.1 (0.3 to 4.5)	3 (42.9)	1.8 (0.4 to 8.5)	4.9 (0.4 to 63.9)
Pelalawan	1 (50.0)	1.0 (0.1 to 8.7)	1.1 (0.1 to 9.5)	0 (0)	0	0

*Cases (n (%)) found in each village within the group of children who participated in the aforementioned activity; †PRR, prevalence rate ratio adjusted for age and sex; ‡PRR, prevalence rate ratio adjusted for age, sex, and household income.

risk with increased exposure to river water with a PRR of 1.4 (95% CI 0.1 to 15.4) for any two exposures to river water. Furthermore, there were no cases of dermatitis reported in either Sering or Pelalawan in children who had all exposures to river water. Further adjustment for the proportion of the household able to read did not change the results materially.

Risk of general illness and diarrhoea in children with exposure to river water

Table 4 describes the risk of having any of the illnesses (described in table 1) within the past 2 weeks as well as more specifically diarrhoea. There did not seem to be any increased risk in any illness among the three villages for all levels of exposure to river water. For children in Sering there seemed to be an increased risk in diarrhoea with a trend of increasing risk with PRR of 1.0, 1.1, and 1.5, respectively, with increasing levels of exposure to river water. Furthermore, compared with the other two villages, there seemed to be an increased risk of diarrhoea in Sering for children who drank water directly from the river (PRR 4.9, 95% CI 0.4 to 63.9). Compared with Rantau Baru, Pelalawan seemed to be equivalent or lower in risk for any illness and diarrhoea for any degree of exposure. As with dermatitis, further adjustment for household ability to read did not significantly change any of the results.

However, further analysis calculating the PRR of diarrhoea within each village showed that children in both Rantau Baru and Sering who drank water directly from the river had an increased risk of diarrhoea. Thus children in Rantau Baru had an age, sex, and income adjusted PRR of 2.3 (95% CI 0.9 to 5.8) whereas children in Sering had a similarly adjusted PRR of 1.4 (95% CI 0.4 to 5.2). All cases of diarrhoea in Pelalawan were among children who never drank water directly from the river. Assessment of the risk of diarrhoea for increasing levels of exposure to river water showed that children in Rantau Baru and Sering who had two exposures (age, sex, and income adjusted PRR 0.9, 95% CI 0.3 to 2.9 and PRR 0.8, 95% CI 0.3 to 1.9 for Rantau Baru and Sering, respectively) and all exposures (age, sex, and income adjusted PRR 0.4, 95% CI 0.1 to 1.4 and PRR 0.4, 95% CI 0.1 to 0.9 for Rantau Baru and Sering, respectively) had a decreased risk compared with no exposure. However in Pelalawan, two exposures and all exposures led to a greatly increased risk (age, sex, and income adjusted PRR 12.1, 95% CI 1.9 to 78.3 and PRR 1.3, 95% CI 0.2 to 7.2 respectively).

Table 5 Physical, biological and chemical parameters of river water samples at the same period of time as the survey

	Waste point		
	-1 km	+1 km	Sering
Physical and biological:			
Temperature (°C)	29	29	29
Total suspended solid (mg/l)	15	14	11
Turbidity (NTU)*	15.9	18.5	14.2
Coliform MPN/100ml†	8	9	10
Faecal coliform MPN/100ml†	Nil	Nil	6
Chemical:			
pH	5.8	5.8	6.0
Total N as NH ₃	0.28	0.31	0.25
Nitrite	0.01	0.01	0.01
Nitrate	0.3	0.3	0.2
Phosphate	0.01	0.01	0.01
Alkalinity	10.0	8.5	8.2
Ca hardness	2.5	2.1	2.5
Chloride	4.52	4.96	4.62
Residual Cl ₂	Nil	Nil	Nil
COD‡	19	18	14
BOD§	4	3	4

*NTU, nephelometric turbidity unit; †MPN/100ml, most probable number/100 ml; ‡COD, chemical oxygen demand; §BOD, biological oxygen demand.

River water variables

Table 5 shows that the physical, biological, and chemical variables of water samples before the waste point of the mill and at Sering village were essentially similar and within acceptable limits. However, the exception was the presence of faecal coliforms (6 MPN/100 ml) found in the water sample collected at the village of Sering.

DISCUSSION

This survey assessed the prevalence of skin conditions and general health of the people living in three villages along the Kampar River. With the upstream village as a comparison group (Rantau Baru) and the two downstream villages as the group exposed to the effluents of the mill (Sering and Pelalawan) we attempted to find out if exposure to the river water was associated with more adverse outcomes of skin conditions

and illness among the people within each village. If the effluent from the mill was causing harm higher rates of the outcomes as well as an increasing risk with increased exposure to the river water would be found. It would also be expected that the village closest downstream to the mill would have the highest risk (Sering), with a smaller but still increased risk in the village further downstream (Pelalawan), and a smaller risk in the village upstream from the mill (Rantau Baru).

Skin conditions

Skin disorders reported in the exposure to chlorinated dioxins such as chloracne and porphyria cutanea tarda^{8,9} were not identified in any of the children examined. Instead more commonly expected skin conditions such as fungal infection, insect bites, and miliaria were found. These are typical of skin conditions commonly found in the tropics.¹³ The commonest skin problem encountered by pulp and paper workers is dermatitis (both irritant and allergic).⁸⁻¹¹ Thus dermatitis or any non-specific inflammation of the skin was further assessed because it could have been associated with exposure to river water and thus effluent from the mill. The prevalence of dermatitis was found to be the highest in Sering (4.8%), the village closest downstream to the mill. However, compared with Rantau Baru (3.5%), the difference was not great. The downstream village of Pelalawan had the lowest rate (1.6%). This is inconsistent with exposure from the effluent, as if it were a cause, the rate for Pelalawan would be expected to be somewhere between that of Sering and Rantau Baru. Of the dermatitis found, most (5/8 cases) was classified as localised dermatitis. If the effluent in river water were to cause problems it would be expected to be more likely to lead to more cases of generalised dermatitis in the knowledge that exposure in the villagers is usually one of bathing, swimming or playing, or collecting water from the river thus leading to generalised exposure rather than localised to a part. Furthermore, the lack of an increasing trend in number of cases or risk of dermatitis and increasing levels of exposure to river water indicates that the effluents in the river water were unlikely to be causing skin problems.

Other health outcomes

The other outcomes studied were four illnesses (diarrhoea, cough or cold, fever, and passing worms). For any illness that occurred during the last 2 weeks, no significantly increased risk was found for any village with regards to all levels of exposure to river water.

Of the four, diarrhoea was considered to be a more direct and immediate measure of ill health caused by the effluents especially if regular ingestion of the water was to take place. The risk of diarrhoea seemed to be increased in Sering compared with Rantau Baru. A positive trend associated with increased levels of exposure to river water was also evident. However there did not seem to be an increased risk in Pelalawan. This leads to two possibilities; firstly that Pelalawan is too far downstream to be affected by the effluents in this manner, or secondly that the effluents from the mill are not associated with the risk of diarrhoea. This indicates that perhaps factors other than the effluent from the mill have led to an increased risk of diarrhoea. Further analysis showed that the increased risk of diarrhoea within villages might be attributed to either exposure to river water such as in Pelalawan in both two exposures and all exposures, or the drinking of water directly from the river such as in Rantau Baru and Sering. Thus exposure to river water is associated with diarrhoea but unlikely to be due to the effluent from the mill in the river.

Effluents from the mill and water quality

Although the health survey showed no significant association with exposure to river water, assessment of the effluents at the

Main messages

- The health concerns of villagers living in riverside villages about effluent from a pulp and paper mill was investigated in a community and environmental health survey.
- As the rates of dermatitis in upstream and downstream villages were low and not significantly different, and the water quality was within acceptable limits, effluent from the pulp and paper mill was unlikely to be causing skin problems or ill health.
- An incidental finding of an increased risk of diarrhoea associated with drinking water directly from the river is probably due to high faecal coliform content from raw sewage.
- These findings have been communicated to the villagers and public health measures to improve the health of the villagers have been implemented.

Policy implications

- Surveys to assess the possible impact of industrial development should include environmental and health aspects.
- Although findings about the adverse health impact of industrial development may not be important in these surveys, other public health issues may be endemic and these need to be put right.

time of the survey was important to exclude toxins that may be thought to be present. The physical and chemical make up of the water that was sampled before and after the point of effluent discharge at the time of the survey was found to be within acceptable limits with the exception of faecal coliforms in the sample collected at Sering village.^{14,15} This will be discussed later.

Other possible reasons for diarrhoea

Villagers in both Sering (downstream) and Rantau Baru (upstream) who reported drinking water directly from the river had up to twice the risk of diarrhoea compared with a person who did not. There was also an increased risk in Pelalawan from exposure to river water other than drinking directly from the river. Only two children (1.6%) in Pelalawan reported drinking directly from the river, too few to show an effect. The increased risk of diarrhoea may thus be due to factors other than effluent from the mill. It is important to note that almost all the villagers used the river for defecation, bathing, and a source of drinking water. Thus all sewerage was untreated and disposed of raw into the river. Although most villagers boiled the water before drinking, a few still drank directly from the river. This could account for the high faecal coliform count in the river water sample collected at Sering thus indicating that the water is not suitable for direct consumption.¹⁴ Unfortunately water samples were not collected at the same time from Rantau Baru or Pelalawan for similar analysis. In retrospect those findings would have been useful.

It is also likely that other factors came into play such as hygiene practices and socioeconomic and educational status. Further analyses of these variables are needed to assess the most likely predictors of ill health. Meanwhile it is important to advise the villagers to drink only boiled water.

Strengths and limitations

Despite the strengths of a good response rate and that all participants were examined for skin conditions by a medical doctor, there were several limitations to this study.

Recall bias may have occurred in assessing episodes of ill health. An attempt was made to reduce this by asking for only a 2 week recall period. An attempt to reduce bias in claiming

an association of ill health with river water was also made by asking a general health questionnaire rather than direct questions pertaining to health and river water. It is also possible that bias might be found whereby people avoided exposure to river water because they had previously experienced ill health. This would lead to underestimation of the possible effects of the river water. Further studies using the cohort design are thus needed to confirm the findings.

Three local doctors interviewed and examined only the participants within the village who were known to each. This was done to maintain rapport and familiarity for the villagers and achieve a high response rate. To minimise observer bias all the doctors participated in two training sessions in dermatology with public and family medicine health specialists (DK, CSE, JL, HCY) before fieldwork. Field trips were also made to each of the villages (CSE, JL, WML, SSM, HCY each to all three villages) to assess the manner of examination and confirm diagnosis of the local doctor. Finally, diagnosis of skin conditions was made clinically without further investigations such as microscopic examination of skin scrapings, patch testing, or skin biopsy. However, most of the skin conditions were familiar to the doctors and were confidently diagnosed.

CONCLUSIONS

This study has shown that the effluent from the mill is unlikely to be the cause of many skin conditions or ill health. An increased risk of diarrhoea in people who reported drinking water directly from the river in two villages (Sering and Rantau Baru) and other exposures to the river (in Pelalawan) was found. This is probably linked to the faecal coliform content in the river water rather than effluent from the mill.

Communication to the villagers that the effluent from the mill is unlikely to be causing skin conditions and ill health is needed as well as strongly advising villagers not to consume water directly from the river. This has occurred through the community health outreach programme established by the mill in conjunction with local government. The provision of a clean water source in Sering with a deep well and a sand/carbon filter is being constructed. Other sanitary measures such as toilets with proper sewerage disposal would also be beneficial.

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