Epidemiol. Infect. (2002), **128**, 63–71. © 2002 Cambridge University Press
DOI: 10.1017/S0950268801006094 Printed in the United Kingdom

Tattooing and risk for transfusion-transmitted diseases: The role of the type, number and design of the tattoos, and the conditions in which they were performed

S. DE A. NISHIOKA[1,2,3], T. W. GYORKOS[1,2]*, L. JOSEPH[1,2], J.-P. COLLET[1,4] AND J. D. MACLEAN[5]

[1] *Department of Epidemiology and Biostatistics, McGill University, Montreal, Canada*
[2] *Division of Clinical Epidemiology, Montreal General Hospital, 1650 Cedar Av., Room L10 420, Montreal (Quebec), H3G 1A4, Canada*
[3] *Centro de Ciências Biomédicas, Universidade Federal de Uberlândia, Uberlândia, Brazil*
[4] *Centre for Clinical Epidemiology and Community Studies, Sir Mortimer B. Davis-Jewish General Hospital, Montreal, Canada*
[5] *McGill University Centre for Tropical Diseases, Montreal General Hospital, Montreal, Canada*

(*Accepted 5 August 2001*)

SUMMARY

Tattoos have been shown to be associated with transfusion-transmitted diseases (TTDs), particularly hepatitis B virus (HBV) and hepatitis C virus (HCV) infections. Very little is known about the association between different categories of tattoos and TTDs. In a cross-sectional study in Brazil, we studied 182 individuals with tattoos and assessed the odds of testing positive for a TTD according to tattoo type, number, design and performance conditions. Major findings were significant associations between an increasing number of tattoos and HBV infection (odds ratio (OR) of 2·04 for two tattoos and 3·48 for $\geqslant 3$ tattoos), having a non-professional tattoo and testing positive for at least one TTD (OR = 3·25), and having $\geqslant 3$ tattoos and testing positive for at least one TTD (OR = 2·98). We suggest that non-professional tattoos and number of tattoos should be assessed as potential deferral criteria in screening blood donors.

INTRODUCTION

It has repeatedly been shown that tattooing is a risk factor implicated in the transmission of hepatitis B virus (HBV) [1–3] and hepatitis C virus (HCV) [4–6] infections and syphilis [7, 8]. It has also been suggested that tattooing is similarly implicated in the transmission of human immunodeficiency virus infection [9]. Some cross-sectional and case-control studies have detected an association between tattooing and HBV [10–17], HCV [18–27] and HIV [28] infections. However, such associations were not demonstrated in other studies on HBV [29–32], HCV [17, 33–37], and HIV (38) infections. The studies that found an association between tattooing and these infections usually investigated tattoo as a binary (yes or no) variable and did not assess whether one or more specific characteristics of tattoos were important in determining the magnitude of the relative risk estimate. To our knowledge only one study has examined this issue. A Taiwanese case-control study of tattooing and HCV infection showed that tattoos at multiple sites had an odds ratio of 8·2 (95% CI: 1·5, 44·3) whereas tattoos at a single site had an odds ratio of 5·4 (95% CI: 1·4, 21·0). The same Taiwanese study also found that the prevalence of HCV infection was higher among individuals who had non-professionally-made as opposed to professionally-made tattoos.

Particular tattoo designs are more commonly observed in individuals who have certain sexual preferences and others, like conscripts and drug

* Author for correspondence.

abusers, who share a higher risk of HIV, HBV and HCV infections and syphilis than the general population. The 'pachuco' mark, a cross with dots rather than lines, has been used to identify membership in American street gangs. Baden, studying 1000 drug addict cadavers, suggested that it was possible to distinguish between alcoholics and hard and soft drug users based on tattoo designs [39]. The 'pachuco' mark, for instance, was found more often among heroin addicts than other groups. Common tattoos among American prison inmates include names and initials of their gangs, swastikas, and certain tattoos that might indicate their crime [40]. Sexual preference may be shown by a tattoo. Lesbian tendencies and bisexuality are indicated respectively by four dots on the dorsum of the proximal phalanx of a finger on either hand and by a question mark on the left ring finger, whereas tattoos on the buttocks are commonly found among male homosexuals [41]. We are unaware of any epidemiologic study investigating the risk of an infectious disease associated with different tattoo designs and tattoos on different sites of the body.

Having a recent tattoo, usually one performed within the last 12 months, is a deferral criterion for blood donation in several countries, including Brazil [42–44]. The reasoning for this is to cover the window period when serological tests for infections that could be transmitted by tattoos might be negative. Tattoos, however, can be seen as indicators of risk behaviour associated with transfusion-transmitted diseases (TTDs) and, as such, are of potential usefulness in the screening of blood donors. In this context, identification of higher-risk types of tattoos would be of interest.

We report here a study that assessed whether the type (professional *vs.* non-professional), number and design of tattoos, their site, and the conditions in which they were performed were associated with HBV, HCV and HIV infections, syphilis and Chagas' disease. All these infections are also transmissible by the transfusion of blood and blood products. We focus the discussion on the possible utilization of a detailed observation of tattoos during the screening interview for blood donors.

MATERIAL AND METHODS

Over a 22-month period starting in April 1998 we undertook a hospital-based cross-sectional matched study in Uberlândia, southeastern Brazil, aimed at assessing the association between tattoos and TTDs. A detailed description of the material used and the methods applied in this study is reported elsewhere [45].

Briefly, the study was carried out in a teaching reference hospital (Hospital de Clinicas da Universidade Federal de Uberlândia) that provided free-of-charge care for a catchment population of over 1 million persons. Study subjects were adults 18 years of age and over who were admitted to the hospital, came to the outpatient clinic, or who volunteered to donate blood. Age less than 18 years and any condition leading the individual to either transitory or permanent intellectual impairment or physical impossibility to provide blood specimens or information were exclusion criteria for participation in the study. Having at least one permanent ornamental tattoo was the exposure of main interest of the main study. The outcomes of interest were presence of serological markers to HBV, HCV and HIV infections, syphilis or Chagas' disease, or a combination of these infections. Individuals with and without tattoos, whose presence was determined by direct inspection, were pair-matched on age, gender, and main clinical complaint of the exposed individual which motivated admission to the hospital or the outpatient clinic. The recruitment process involved active search for patients with tattoos at the study sites (hospital, outpatient clinic and blood bank), and then a choice of controls from the same sites. The sample size calculations, based on the association between having a tattoo and testing positive for at least one TTD, established that a sample size of 155 individuals with tattoos and 155 without them would have an 80% power of detecting a relative risk of 4, at a significance level of 5%, if the prevalence of the outcome in the unexposed was 3%. Detailed information was obtained about the presence of tattoos, their number, design and conditions under which they were made. All the participants (with and without tattoos) were questioned by a trained interviewer using a piloted questionnaire about exposures to known risk factors to the infections which were the outcomes of interest, and other potential confounders, such as drug use, sexual orientation and history of having been incarcerated, among others. The presence of serological markers was determined by enzyme-linked immunosorbent assay (ELISA) for hepatitis B surface antigen (HBsAg) and antibodies against the hepatitis B core antigen (anti-HBc) for hepatitis B, and antibodies against HCV (anti-HCV), HIV (anti-HIV), and *Trypanosoma cruzi* for, respectively, HCV and HIV infections and Chagas' disease. Other

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

serological tests used were indirect immunofluorescence (IFA) and passive haemagglutination (HA), for Chagas' disease, and VDRL, for syphilis.

In the present study the analysis was restricted to individuals who had one or more tattoos. The exposures of interest were number of tattoos, whether the tattoos were performed by a professional or a nonprofessional tattooist, the tattoo design and the type of instrument and material (needles and dyes) used for tattooing. Separate analyses for each exposure were performed for each outcome studied and also for the presence of at least one marker of syphilis, HBV, HCV and HIV infections. Initially, for each outcome, univariate analysis of the independent variable of main interest and the other covariates was performed. Identification of potential confounders and effect modifiers was made by stratified analysis for each covariate that was shown, on univariate analysis, to be associated with both the exposure and the outcome of interest.

Odds ratio (OR) estimates for each dependent variable and each independent variable of interest, adjusted by known confounders and other covariates thought to be of interest after the stratified analysis, were calculated by unconditional logistic regression [46, 47]. When two variables were highly correlated, only one was included in the models. The models were chosen 'manually', i.e. they were built entering each exposure of interest as an obligate independent variable in a given model, and then entering one covariate at a time, comparing the modification on the OR and the likelihood ratio test. Choice of the models was based on the possibility for confounding rather than a "best predictive" model. No interaction terms were suspected by previous knowledge or by the stratified analysis, and therefore no interaction term was added to the models.

For categorical variables with many 'do not know' responses it was decided that a category for this response should be included instead of excluding these individuals from the analysis. In such situations dummy variables were created, and the reference category was the one initially thought to be the least associated with the outcomes. When other variables with missing values were assessed to see whether they should be included in a model, sensitivity analysis substituting missing values by extreme values was performed to assess the possible impact of the missing information.

Epi-Info. v. 6.04b (Centers for Disease Control and Prevention, Atlanta, GA, USA), and SAS for Windows, release 6.12 (SAS Institute, Cary, NC, USA) were the software packages used for statistical analysis.

Table 1. *Distribution of the study participants by features and conditions in which the tattoos were done*

Variable	Number	Percentage
Done by professional*		
No (at least one)	98	54·1
Yes	83	45·9
Professional instrument*		
No (at least one)	84	46·4
Yes	97	53·6
Electrical instrument*		
No (at least one)	61	33·7
Yes	120	66·3
Disposable needle*		
No (at least one)	59	32·6
Yes	106	58·6
Did not know	16	8·8
New needle†		
No (at least one)	32	19·2
Yes	121	72·9
Did not know	13	7·8
Dye used exclusively for that tattoo*		
No (at least one)	63	34·8
Yes	97	53·6
Did not know	21	11·6
New dye†		
No (at least one)	64	38·5
Yes	81	48·8
Did not know	21	12·6

* $n = 181$.
† $n = 166$.

The study protocol was approved by the Research Ethics Committee of the Montreal General Hospital and by the Research Ethics Committee of the Universidade Federal de Uberlândia. All the participants signed an informed consent form and those who tested positive for any of the infections under study were counselled and referred for further care, as warranted.

RESULTS

Out of the 345 patients recruited for the main study, 182 had tattoos, and these constitute the study population of the present study. All patients invited agreed to participate in the study and were interviewed, but 30 individuals were later excluded either because they were discharged from the hospital before

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

Table 2. *Distribution of selected covariates (categorical variables) assessed as potential confounders*

Variable	Number	Percentage	Total*
Sex (male)	151	83·0	182
Colour (white)	125	68·7	182
Schooling (= 8 years)	136	76·8	177
Smoking (ever)	135	74·2	182
Drug use			
Any†	63	34·6	182
IV	22	12·1	182
Sexual history			
Past history of homosexual contact	30	16·7	180
Homo/bisexual	6	3·3	180
Condom use (always)	40	24·2	165
Has paid for sex	7	4·2	165
Has been paid for sex	4	2·4	165
Police record			
Arrested	71	39·0	182
Incarcerated	14	7·7	182
Blood transfusion			
Has donated blood	90	49·5	182
Has received blood	37	20·3	182
Liver disease history			
Has had jaundice	23	12·6	182
Has had hepatitis	17	9·3	182
STD history			
Any	60	33·0	182
Gonorrhoea	38	20·9	182
HIV	19	10·4	182
Syphilis	3	1·6	182
Pierced ears (presence)	85	46·7	182

* Missing values due to the inadvertent use of a preliminary incomplete version of the questionnaire at the beginning of the study.

† At least one of the following: occasional or frequent use of marijuana, and having ever used crack, inhaled or intravenous cocaine, or heroin.

Table 3. *Positive associations between tattoo site and design and serological markers of syphilis, HBV, HCV and HIV infections*

Exposure	Outcome	OR	95% CI
Tattoo site			
Chest	HBV	5·00	2·19, 11·41
Forearm	HCV	4·14	1·84, 9·26
Forearm	HIV	4·24	1·62, 11·13
Leg	HIV	3·42	1·35, 8·69
Head	Syphilis	32·80	6·31, 170·55
Tattoo design			
Dragon	HBV	5·02	1·59, 15·82
Sun	HCV	2·71	1·05, 6·91
Snake	HIV	4·70	1·51, 14·52
Heart	Syphilis	5·00	1·09, 21·85
Unicorn	Syphilis	18·00	4·78, 67·79

a blood sample for serological tests could be drawn or the samples were inadequate for testing for technical reasons. Serological tests were available for the large majority of the subjects, but were missing in 2 (1·1%) subjects for HIV infection, 1 (0·6%) for HIV infection and 5 (2·7%), for syphilis. Missing data also occurred for the variables: 'professional tattoo' (0·6%), 'age at first tattoo' (1·6%), 'professional tattoo machine' (0·6%), 'electric tattoo machine' (0·6%), 'disposable needle(s)' (0·6%), 'dye(s) for exclusive use' (0·6%), 'new needle(s)' (8·8%), 'new dye(s)' (8·8%), 'schooling' (2·7%), 'homosexual contact in the past' (1·1%), 'sexual preference' (1·1%), 'use of condom' (9·1%), 'paid for having sex' (9·1%), and 'having been paid for having sex' (9·1%). The variables with a percentage of missing data approaching 10% are explained by the inadvertent use of a preliminary incomplete version of the questionnaire early in the study; the only difference between the two versions of the questionnaire was the absence of these questions in the preliminary version. Dichotomous variables which had a very low frequency of one of the categories were excluded from the analysis. This happened, for instance, with the outcome variable 'positive serological test for Chagas' disease' (2 positive tests out of 182).

The subjects' age ranged from 18 to 62 years, with a mean of 29·1 years [standard deviation (S.D.) 7·6]. Weekly alcohol consumption was estimated from figures on ethanol concentration in alcoholic liquors consumed in Brazil [48], and ranged from 0 to 3500 g, with a mean of 212·6 (S.D. 508·0) and a median of 50. A single tattoo was observed in 109 individuals (59·9%), 2 tattoos in 34 (18·7%), and 3 or more tattoos (to a maximum of 22) in 39 (21·4%).

The age at first tattoo ranged from 8 to 40 years, the mean being 18·4 years (S.D. 5·4). The distribution of the study subjects by type of tattoo (professional *vs.* non-professional), and the type and conditions of the devices used for performing the tattoo(s) is shown in Table 1. Roughly half of the patients had at least one tattoo performed by a non-professional. Some of the variables in Table 1 were highly correlated with each other, which was the case between 'disposable needle(s)' and 'new needle(s),' and between 'dye(s) used exclusively' and 'new dye(s).' The most frequently found tattoo designs were: a sun (35; 19·2%), ranking first, a name, word or letter (27; 14·8%),

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

Table 4. *Crude and adjusted* (*by multiple logistic regression*) *OR for non-professional* (*as opposed to professional*) *tattoos and having a positive serological marker for HBV, HCV and HIV infections, syphilis, or at least one of these infections*

Variable	Crude OR	(95% CI)	Adjusted OR	(95% CI)
Hepatitis B HbsAg and/or anti-HBc	1·84	0·87, 3·89	1·52*	0·69, 3·37
Hepatitis C Anti-HCV	2·45	1·06, 5·60	1·41†	0·43, 4·57
HIV Infection Anti-HIV	2·28	0·94, 5·53	1·98‡	0·54, 7·28
Syphilis VRDL	4·65	0·99, 21·87	3·71§	0·74, 18·51
At least one marker for HBV, HCV, HIV or syphilis	3·30	1·70, 6·41	3·25‡	1·39, 7·59

Odds ratios adjusted by: * IV drug use and previous STD; † IV drug use, previous STD, and previous hepatitis; ‡ IV drug use, previous STD, and previous blood transfusion; § previous STD.

Table 5. *Crude and adjusted* (*by multiple logistic regression*) *OR for number of tattoos* (*reference category*: *one tattoo*) *and having a positive serological marker for HBV, HCV and HIV infections, syphilis, or at least one of these infections*

	Two tattoos		Three or more tattoos	
Serological marker	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Hepatitis B HbsAg and/or anti-HBc	2·83 (1·12, 7.14)	2·04 (1·80, 9·97)*	4·24 (0·76, 5·50)	3·48 (1·41, 8·58)*
Hepatitis C Anti-HCV	2·99 (1·07, 8·32)	0·80 (0·17, 3·84)*	5·43 (2·16, 13·67)	1·54 (0·38, 6·20)†
HIV Infection Anti-HIV	3·05 (1·09, 8·49)	0·45 (0·08, 2·44)‡	3·54 (1·34, 9·34)	0·39 (0·07, 2·23)‡
Syphilis VDRL	2·64 (0·56, 12·46)	0·75 (0·12, 4·46)§	3·75 (0·95, 14·77)	1·40 (0·27, 7·28)§
At least one marker for HBV, HCV, HIV or syphilis	4·45 (1·96, 10·09)	2·19 (0·75, 6·34)‡	5·69 (2·58, 12·39)	2·98 (1·03, 8·64)‡

Odds ratios adjusted by: * STD and history of being incarcerated; † IV drug use, previous STD and previous hepatitis; ‡ IV drug use, previous STD, previous blood transfusion and professional tattoo; § IV drug use; previous STD and professional tattoo.

ranking second, and a bird or flower (22 each; 12·1%), ranking third. A skull or the figure of death such as the Grim Reaper (20; 11·5%) were also frequently found. Tattoos were mostly found on the arm (103; 56·6%), back (53; 29·1%), and forearm (35; 19·2%), the total percentage having added to more than 100% because of subjects with more than one tattoo. The distribution of categorical variables that were potential confounders is summarized in Table 2. The frequencies of a positive serological marker for HBV, HCV and HIV infections and for syphilis were, respectively, 39 (21·4%), 32 (17·8%), 28 (15·5%), and 12 (6·8%). At least one positive test was found in 63 (34·6%) subjects.

A few associations between tattoo site and design and certain TTDs were statistically significant (Table 3). Age at first tattoo did not differ between individuals who tested positive or negative for the different outcome diseases. No other continuous variable (age and alcohol use) was a confounder of any of the

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

Table 6. *Crude and adjusted (by multiple logistic regression) OR for tattoos performed with disposable needles (reference category, 'non-disposable needle,' or 'did not know needle status') and having a positive serological marker for HBV, HCV and HIV infections, syphilis, or at least one of these infections*

	Non-disposable needle		Did not know needle status*	
Serological marker	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Hepatitis B				
HbsAg and/or anti-HBc	1·72 (0·81, 3·68)	1·51 (0·62, 3·66)†	1·54 (0·45, 5·31)	1·58 (0·41, 6·09)†
Hepatitis C				
Anti-HCV	1·86 (0·81, 4·27)	1·89 (0·45, 7·94)‡	3·29 (0·98, 11·04)	6·01 (1·05, 34·59)‡
HIV Infection				
Anti-HIV	1·09 (0·45, 2·67)	0·17 (0·03, 1·17)§	2·02 (0·58, 7·10)	2·95 (0·47, 18·44)§
Syphilis				
VDRL	3·50 (0·98, 12·51)	2·09 (0·54, 8·11) ‖	2·13 (0·22, 20·60)	1·16 (0·11, 12·49) ‖
At least one marker for HBV, HCV, HIV or syphilis	2·02 (1·04, 3·93)	1·09 (0·38, 3·17)¶	2·00 (0·68, 5·84)	1·44 (0·36, 5·68)¶

* Category created so that missing information because of 'do not know' answer could be used, avoiding waste of information that would have occurred if these observations were excluded.
OR adjusted by: † IV drug used, previous STD, and previous homosexual contact; ‡ IV drug use, previous STD, previous hepatitis and previous blood donation; § IV drug use, previous STD, previous hepatitis, previous blood donation and professional tattoo; ‖ previous STD; ¶ IV drug use, previous STD, previous blood donation, previous blood transfusion and professional tattoo.

Table 7. *Crude and adjusted (by multiple logistic regression) OR for dye(s) for exclusive use (reference category, 'dye not exclusive' or 'did not know dye status') and having a positive serological marker for HBV, HCV and HIV infections, syphilis, or at least one of these infections*

	Dye not exclusive		Did not know dye status*	
Serological marker	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Hepatitis B				
HbsAg and/or anti-HBc	3·22 (1·49, 6·93)	2·28 (0·98, 5·33)†	1·00 (1·00, 1·00)	0·892 (0·22, 3·56)†
Hepatitis C				
Anti-HCV	6·35 (2·60, 15·49)	2·24 (0·58, 8·68)‡	1·18 (0·23, 6·02)	1·22 (0·19, 8·04)‡
HIV Infection				
Anti-HIV	5·14 (2·00, 13·21)	2·29 (0·52, 10·05)§	2·14 (0·51, 9·08)	4·23 (0·64, 27·96)§
Syphilis				
VDRL	1·94 (0·50, 7·52)	0·51 (0·08, 3·37)†	3·97 (0·81, 19·36)	3·17 (0·55, 18·23)†
At least one marker for HBV, HCV, HIV or syphilis	3·01 (1·54, 5·90)	0·98 (0·38, 2·52) ‖	1·17 (0·41, 3·34)	1·33 (0·34, 5·28) ‖

* Category created so that missing information because of 'do not know' answer could be used, avoiding waste of information that would have occurred if these observations were excluded.
OR adjusted by: † IV drug use and previous STD; ‡ IV drug use, previous STD, previous hepatitis and previous blood donation; § IV drug use, previous STD, previous blood transfusion and professional tattoo; ‖ IV drug use, previous STD, previous blood donation, previous blood transfusion and professional tattoo.

studied associations. Tables 4–7 summarize the crude and adjusted odds ratios of the associations between, respectively, non-professional tattoos, number of tattoos, tattoos performed with disposable needles, and dyes used exclusively for that tattoo, and having a positive serological marker for HBV, HCV and HIV infections, syphilis, or at least one of these infections. Having a non-professional tattoo was shown to be associated with having at least one serological marker of a TTD (OR: 3·25; 95% CI: 1·39; 7·59) (Table 4). Having 2 tattoos as opposed to 1 was associated with HBV infection (OR: 2·04; 95% CI: 1·80, 9·97),

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

whereas having 3 or more tattoos as opposed to 1 was associated with HBV infection (OR: 3·48; 95% CI: 1·41, 8·58), and with having at least one marker of a TTD (OR: 2·98; 95% CI: 1·03, 8·64) (Table 5). No association was demonstrated between TTDs and having tattoos performed with non-disposable needles (Table 6) or using dyes that were not of exclusive use (Table 7).

DISCUSSION

A high proportion of the subjects in this study had at least one non-professional tattoo, and had at least one of their tattoos performed without the use of a disposable or new needle, and without dyes that were new or used exclusively for them. However, the distinction between a professional and a non-professional tattooist was not always clear. For instance, many tattooists use homemade tattoo guns, and therefore the use of an electrical device for tattooing is not always evidence of a tattoo performed by a professional. Other individuals who have the equipment and do a fair amount of tattoos do not see themselves as professional tattooists because they have another source of income. Also, a tattoo gun does not necessarily make its holder a professional tattooist. The answers to questions on the type of needles used are also difficult to interpret, as tattoos performed under standard hygiene conditions do not necessarily require the use of disposable or new needles; they do require the use of adequately sterilized needles. The way different tattooists handle their dyes varies, and the different procedures probably have influenced the answers on whether the dye(s) were used exclusively for a particular tattoo, or whether the dye was new.

The possible misclassification of exposure, as discussed above, and also of the outcomes, given that the serological tests applied particularly in the diagnosis of syphilis and HCV infection are very sensitive but not 100% specific, may have had an influence on the odds ratio estimates. The misclassification of both exposures and outcomes was probably non-differential, and therefore, if present, would have had the effect of reducing OR estimates towards the null. There is no evidence that selection bias has occurred in this study, as enrolment was independent of outcome. The role of confounding was accounted for in the analyses, although it is possible that underreporting of some confounding variables might have occurred. Possible examples are variables that touch on sensitive subjects such as sexual behavior and drug use. Misclassification of an important confounder might have either under- or overestimated the OR estimates [49].

The associations between certain tattoo sites and designs may be due to chance, given the large number of combinations between these variables and the serological markers of the TTDs. Tattoos of dragons were more common among subjects who had been incarcerated in the past, and 'sun' tattoos were more commonly found among drug addicts (data not shown), which may explain the association between these designs and certain TTDs (Table 3). However, tattoos of skulls or of the Grim Reaper, that were suspected *a priori* to be associated with a positive test for a TTD, were actually more common among drug addicts but not among individuals previously incarcerated, and were not associated with any TTD. Goldstein has noted that not every tattoo design has a special meaning; and that most designs are actually banal [41], and Hall, in his study of tattoos among prison inmates, has shown the large variety of tattoo designs in this population [40].

The crude OR estimates (of magnitudes around 3) showed that non-professional tattoos, an increasing number of tattoos, and tattoos performed with dyes that were not exclusively used for the tattooed subject were associated with most positive disease outcomes. These associations became less important after adjustment for confounders, particularly IV drug use and previous STD (Tables 4–7). Associations that persisted after adjustment were between increasing number of tattoos and HBV infection (OR: 2·04 for two tattoos, and 3·48 for three or more tattoos), between a non-professional tattoo and at least one positive test for a TTD, and between three or more tattoos and the same outcome variable. These findings are of interest and have possible clinical relevance. They are evidence that subgroups of individuals within those who sport tattoos are more likely to test positive for TTDs even when confounding variables are adjusted for. The knowledge of this association has implications for the screening of blood donors.

Our previous study showed an association between having a tattoo and testing positive for HCV infection and suggested, but was unable to demonstrate, an association with HBV and HIV Infections [45]. Many other studies, already mentioned in the introduction, have also shown such associations. The findings of this study that non-professional tattoos and an increasing number of tattoos are both associated with

https://doi.org/10.1017/S0950268801006094 Published online by Cambridge University Press

an increased odds of at least a positive serological test for a TTD provide additional evidence that tattoos should be better studied for the purpose of screening blood donors. While assessing the possible usefulness of tattoos, tattoo types and number of tattoos for the screening of blood donors, however, the crude (instead of the adjusted) estimates of association between these variables and at least one positive serological test for a TTD are preferable. This is because the presence and the number of tattoos can be determined objectively, and the quality of the tattoo usually suggests whether or not it was made by a professional, whereas information about some other important risk factors for TTDs are likely to be underreported. Tattoos are therefore surrogates of other indicators of TTDs. In certain settings, depending on the magnitude of the associations between tattoos and TTDs, the prevalences of tattoos, the proportion of positive serological tests for TTDs in the population of blood donors, and the reliability of the information about other risk factors provided by these individuals, it may be possible that information on tattoos, its number, and whether they were professional or not can be used for the deferral of blood donor candidates. Based on the evidence from this study, information about tattoo site and design, and on the type of needle and dye used during the tattooing process are unlikely to be useful for this purpose. The fact that this study was hospital-based and undertaken in a single town may limit the generalization of its findings for other settings within Brazil and elsewhere. Further studies to corroborate our findings are therefore warranted.

ACKNOWLEDGEMENTS

Dr Nishioka was partially supported by a scholarship (process number 200440/94-2) from the Conselho Nacional de Desenvolvimento Cientifico e Tecnológico (CNPq). Support from the Fonds de la Recherche en Santé du Québec (FRSQ) in terms of career award support for Drs Collet, Gyorkos and Joseph is gratefully acknowledged.

REFERENCES

1. Mowat NAG, Brunt PW, Albert-Recht F, Walker W. Outbreak of serum hepatitis associated with tattooing. Lancet 1973; **1**: 33–4.
2. Limentani AE, Elliot LM, Noah ND, Lamborn JK. An outbreak of hepatitis B from tattooing. Lancet 1979; **ii**: 86–8.
3. Goh KT. Hepatitis B surveillance in Singapore. Ann Acad Med Singapore 1980; **9**: 136–41.
4. Abildgaard N, Peterslund NA. Hepatitis C virus transmitted by tattooing needle. Lancet 1991; **338**: 460.
5. Sun DX, Zhang FG, Geng YQ, Xi DS. Hepatitis C transmission by cosmetic tattooing in women. Lancet 1996; **347**: 541.
6. Thompson SC, Hemberger F, Wale E, Crofts N. Hepatitis C transmission through tattooing: a case report. Aust N Z J Public Health 1996; **20**: 317–8.
7. Beerman H, Lane RAG. Tattoo: a survey of the literature concerning the medical complications of tattooing. Am J Med Sci 1954; **227**: 444–65.
8. Long GE, Rickman LS. Infectious complications of tattoos. Clin Infect Dis 1994; **18**: 610–9.
9. Doll DC. Tattooing in prison and HIV infection. Lancet 1988; **1**: 66–7.
10. Leyden JJ, Smith JG Jr, Chalker DK, Rea TH, Tomecki KJ, Levitan M. Serologic survey for markers of hepatitis B infection in dermatologists. J Am Acad Dermatol 1985; **12**: 676–80.
11. Reed BE, Barrett AP, Smith MW. The relationship of tattooing to hepatitis B virus exposure. Aust N Z J Med 1985; **15**: 769–70.
12. Hyams KC, al-Arabi MA, al-Tagani AA, Messiter JF, al-Gaali AA, George JF. Epidemiology of hepatitis B in the Gezira region of Sudan. Am J Trop Med Hyg 1989; **40**: 200–6.
13. Pavli P, Bayliss JA, Dent OF, Lunzer MR. The prevalence of serological markers for hepatitis B virus infection in Australian Naval personnel. Med J Aust 1989; **151**: 71–5.
14. Ko YC, Lan SJ, Chang PY. An increased risk of hepatitis B virus infection from tattooing in Taiwan. Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 1990; **6**: 237–43.
15. Martelli CMT, Andrade ALSS. Cardoso DDP, et al. Soroprevalência e fatores de risco para a infecção pelo vírus de hepatite B pelos marcadores AgHBs e anti-HBs em prisioneiros e primodoadores de sangue. Rev Saude Publica 1990; **24**: 270–6.
16. Sebastian VJ, Ray S, Bhattacharya S, Maung OT, Saini HAM, Jalani HJD. Tattooing and hepatitis B infection. J Gastroenterol Hepatol 1992; **7**: 385–7.
17. Mele A, Corona R, Tosti ME, et al. Beauty treatments and risk of parenterally transmitted hepatitis: results from the hepatitis surveillance system in Italy. Scand J Infect Dis 1995; **27**: 441–4.
18. Kaldor JM, Archer GT, Buring ML, et al. Risk factors for hepatitis C virus infection in blood donors: a case-control study. Med J Aust 1992; **157**: 227–30.
19. Ko YC, Ho MS, Chiang TA, Chang SJ, Chang PY. Tattooing as a risk of hepatitis C virus infection. J Med Virol 1992; **88**: 288–91.
20. Holsen DS, Harthug S, Myrmel H. Prevalence of antibodies to hepatitis C virus and association with intravenous drug abuse and tattooing in a national prison in Norway. Eur J Clin Microbiol Infect Dis 1993; **12**: 673–6.

21. MacLennan S, Moore MC, Hewitt PE. Nicholas S, Barbara JAJ. A study of anti-hepatitis C positive blood donors: the first year of screening. Transfus Med 1994; **4**: 125–33.
22. Neal KR, Jones DA, Killey D, James V. Risk factors for hepatitis C virus infection: a case-control study of blood donors in the Trent Region (UK). Epidemiol Infect 1994; **112**: 595–601.
23. Chang CJ, Ko YC, Liu HW. Seroepidemiology of hepatitis C virus infection among drug abusers in southern Taiwan. J Formos Med Assoc 1998; **97**: 826–9.
24. Balasekaran R, Bulterys M, Jamal MM, et al. A case-control study of risk factors for sporadic hepatitis C virus infection in the southwestern United States. Am J Gastroenterol 1999; **94**: 1341–6.
25. Brusaferro S, Barbone F, Andrian P, et al. A study on the role of the family and other risk factors in HCV transmission. Eur J Epidemiol 1999; **15**: 125–32.
26. Delage G, Infante-Rivard C, Chiavetta JA, Willems B, Pi D, Fast M. Risk factors for acquisition of hepatitis C virus infection in blood donors: results of a case-control study. Gastroenterology 1999; **116**: 893–9.
27. Paraná R, Vitvitski L, Andrade Z, et al. Acute sporadic non-A, non-B hepatitis in northeastern Brazil: etiology and natural history. Hepatology 1999; **30**: 289–93.
28. Estebanez-Estebanez P, Colombo-Gomez C, Zunzunegui-Pastor MV, et al. Carceles y SIDA: factores de riesgo de infeccion por el VIH en las carceles de Madrid. Gac Sanit 1990; **4**: 100–5.
29. Kuberski T, LeGonidec G, Gust ID, Dimitrakakis M, Cantaloube D, Zimmet P. Hepatitis B virus infections in Melanesians and Polynesians in New Caledonia. Am J Epidemiol 1981; **114**: 355–61.
30. Tibbs CJ. Hepatitis B, tropical ulcers, and immunisation strategy in Kiribati. B M J. (Clin Res Ed) 1987; **294**: 537–40.
31. Phoon WO, Fong NP, Lee J. History of blood transfusion, tattooing, acupuncture and risk of hepatitis B surface antigenaemia among Chinese men in Singapore. Am J Publ Hlth 1988; **78**: 958–60.
32. Siebke JC, Wessel N, Kvandal P, Lie T. The prevalence of hepatitis A and B in Norwegian merchant seamen – a serological study. Infection 1989; **17**: 77–80.
33. Kim YS, Ahn YO, Kim DW. A case-control study on the risk factors of hepatitis C virus infection among Koreans. J Korean Med Sci 1996; **11**: 38–43.
34. Conry-Cantilena C, van Raden M, Gibble J. et al. Routes of infection, viremia, and liver disease in blood donors found to have hepatitis C infection. N Engl J Med 1996; **334**: 1691–6.
35. Garner JJ, Gaughwin M, Dodding J, Wilson K. Prevalence of hepatitis C infection in pregnant women in South Australia. Med J Aust 1997; **166**: 470–2.
36. Sun CA, Chen HC, Lu CF, et al. Transmission of hepatitis C virus in Taiwan: prevalence and risk factors based on a nationwide survey. J Med Virol 1999; **59**: 290–6.
37. Murphy EL, Bryzman SM, Glynn SA, et al. Risk factors for hepatitis C virus infection in United States blood donors. Hepatology 2000; **31**: 756–62.
38. Dufour A, Alary M, Poulin C, et al. Prevalence and risk behaviors for HIV infection among inmates of a provincial prison in Quebec City. AIDS 1996; **10**: 1109–15.
39. Anonymous, Symbols: tattoos on teen-age cadavers. Med World News 1973; **14**: 109–10.
40. Hall DK. Prison tattoos. New York: St. Martin's Griffin, 1997.
41. Goldstein N. Psychological implications of tattoos. J Dermatol Surg Oncol 1979; **5**: 883–8.
42. Lim JC, Tien SL, Ong YW. Main causes of pre-donation deferral of perspective blood donors in the Singapore Blood Transfusion Service. Ann Acad Med Singapore 1993; **22**: 326–31.
43. Davis AR. Tattoo parlours and hepatitis C virus infection. Med J Aust 1995; **163**: 556–7.
44. Héma-Québec. Manuel des critères de sélection des donneurs. Manuel de Héma-Québec, Montreal, Quebec, Canada, February 2000.
45. Nishioka SA. Tattoos as indicators of transfusion-transmitted diseases in Brazil: a matched hospital-based cross-sectional study [Doctoral thesis]. Montreal, McGill University, 2000.
46. Hosmer DW, Lemeshow S. Applied logistic regression. New York: John Wiley & Sons, 1989.
47. Kleinbaum DG Logistic regression: a self-learning text. New York: Springer, 1994.
48. Neves MM, Borges DR, Vilela MP. Concentraçãno de etanol em bebidas alcoólicas maís consumidas no Brasil. Gastrenterologia Endoscopia Digestiva 1989; **8**: 17–20.
49. Rothman KJ, Greenland S. Chapter 8: Precision and validity in epidemiologic studies: In: Rothman KJ, Greenland S, eds. Modern epidemiology, 2nd edn. Philadelphia: Lippincott-Raven 1998: 115–34.