The risk of transmission of hepatitis B infection from tattooing and body piercing: a review of the literature

1.0 Introduction

Tattooing can be described as the production of a permanent design on the human body through the introduction of external pigments and/or dyes into the dermis using needles or other sharp instruments, whilst body piercing is defined as "the perforation of the skin and underlying tissues in order to create a tunnel in the skin through which jewellery may be inserted"[1-3].The evidence base indicates that these practices have grown in popularity in recent years but the reported prevalence of tattoos and body piercings varies widely between reported studies. A 2012 online cross-sectional survey in the United States (US) demonstrated a tattoo prevalence of 21% in those aged 18 years and above whilst a study undertaken in Germany in 2005 revealed a tattoo prevalence of 8.5% in individuals aged between 14 – 93 years[4,5]. A report published by the European Union in 2015 estimated tattoo prevalence across Europe at 12% and that up to 24% of individuals living in the US are tattooed[6]. With regard to the prevalence of body piercings, a UK cross-sectional study found a prevalence rate of 10% whilst an Australian study indicated a prevalence rate of 8% and a German study demonstrated a prevalence rate of 6.5%[5,7,8].

The increasing practice of tattooing and body piercing has raised concerns amongst healthcare professionals and policy-makers alike, who recognise the potential risk of transmission of bloodborne viruses through such practices[9]. While there remains no enacted legislation pertaining to tattoo premises in Ireland, the Department of Health is currently engaged in drafting tattooing and body piercing infection control guidelines for practitioners [6]. A review of the literature to examine the risk of transmission of hepatitis B virus (HBV) from tattooing and body piercing to inform this work is prudent in the first instance.

2.0 Methodology

A review of the peer-reviewed and grey literature was undertaken to identify the extent and breadth of the current research evidence pertaining to the risk of transmission of HBV infection through

tattoo application and body piercing, with a particular focus on identifying specific risk factors that may increase the risk of transmission of infection.

A similar methodology to that used in reviewing the evidence to inform the National Hepatitis C Screening Guidelines was adopted in this instance[10]. The PICOS framework was used to guide the search strategy:

- Population: people who have a tattoo or body piercing;
- Intervention: not applicable;
- Comparison: not applicable;
- Outcome: incidence of HBV/ prevalence of HBV;
- Study design: experimental or observational studies, case studies, case reports published between 1 January 1990 and 31 December 2017.

A comprehensive search of the international literature was performed using Medline, Embase, ClinicalKey, PubMed, CINAHL and Cochrane Library electronic databases. A separate search strategy was created to examine the risk of transmission of HBV infection through tattoo application and through body piercing. A search of the grey literature was undertaken using the Google and Google Scholar websites. The search strategies were constructed using free text searches and also MeSH terms and were designed to examine the risk of transmission of HBV infection through tattoo application and body piercing (Tables 1 and 2).

Table 1. Search terms used in Medline search to identify the risk of HBV transmission via tattooing

Search #	Query	Limiters/expanders	Results
S1	hepatitis B OR HBV OR orthohepadnavirus OR hep B OR hepB	Search modes – Boolean/Phrase	102,512
S2	(MM "Hepatitis B+")	Search modes – Boolean/Phrase	53,327
S3	(MM "Orthohepadnavirus+") OR (MM"Hepadnaviridae+")	Search modes – Boolean/Phrase	49,375
S4	risk factor*	Search modes – Boolean/Phrase	957,708
S5	(MM Risk factors") OR (MM "Risk Assessment+") OR (MM "Risk Management+") OR (MM "Risk Taking+") OR (MM "Risk Reduction Behaviour+")	Search modes – Boolean/Phrase	64,375
S6	S1 OR S2 OR S3	Search modes – Boolean/Phrase	102,559
S7	S4 OR S5	Search modes – Boolean/Phrase	1,004,891
S8	transmission OR transmit OR mode of transmission OR acquisition OR acquire* OR transmit*	Search modes – Boolean/Phrase	995,738
S9	(MM "Disease Transmission, Infectious+")	Search modes – Boolean/Phrase	35,075
S10	S8 OR S9	Search modes – Boolean/Phrase	1,003,191
S11	tattoo* OR body art OR body ornament*	Search modes – Boolean/Phrase	5,026
S12	(MM "Body Modification, Non-Therapeutic+")	Search modes – Boolean/Phrase	7,603
S13	(MM "Tattooing")	Search modes – Boolean/Phrase	2,490
S14	S11 OR S12 OR S13	Search modes – Boolean/Phrase	10,097
S15	S6 AND S14	Search modes – Boolean/Phrase	305
S16	S7 AND S15	Search modes – Boolean/Phrase	181
S17	S10 AND S16	Search modes – Boolean/Phrase	113
S18	S10 AND S16	Limiters – Date of Publication: 19900101 – 20171231; Human Search modes – Boolean/Phrase	104
S19	S10 AND S16	Limiters – Date of Publication: 19900101 – 20171231; Human; English Language Search modes – Boolean/Phrase	93

Table 2. Search terms used in Medline search to identify the risk of HBV transmission via body piercing

Search #	Query	Limiters/expanders	Results
S1	Hepatitis B OR HBV OR orthohepadnavirus OR hep B OR hepB	Search modes-Boolean/Phrase	102,573
S2	(MM "Hepatitis B+")	Search modes-Boolean/Phrase	41,408
S3	(MM "orthohepadnavirus+")	Search modes-Boolean/Phrase	16,497
S4	risk factor*	Search modes-Boolean/Phrase	957,708
S5	(MM "Risk Factors") OR (MM"Risk Assessment+") OR (MM "Risk Management+") OR (MM "Risk Taking+") OR (MM"Risk Reduction behaviour+")	Search modes-Boolean/Phrase	64,375
S6	S1 OR S2 OR S3	Search modes-Boolean/Phrase	102,573
S7	S4 OR S5	Search modes-Boolean/Phrase	959,041
S8	Transmission or transmit OR mode of transmission OR acquisition OR acquire* OR transmit*	Search modes-Boolean/Phrase	996,717
S9	(MM "Disease Transmission Infectious+")	Search modes-Boolean/Phrase	35,126
S10	S8 OR S9	Search modes-Boolean/Phrase	1,004,181
S11	Body pierc*	Search modes-Boolean/Phrase	781
S12	(MM "Body Modification, Non-Therapeutic+")	Search modes-Boolean/Phrase	7,606
S13	(MM "Body Piercing")	Search modes-Boolean/Phrase	463
S14	S11 OR S12 OR S13	Search modes-Boolean/Phrase	7,882
S15	S6 AND S14	Search modes-Boolean/Phrase	108
S16	S7 AND S15	Search modes-Boolean/Phrase	45
S17	S10 AND S16	Search modes-Boolean/Phrase	33
S18	S10 AND S16	Limiters – Date of Publication: 19900101-20171231; Human Search modes –Boolean/Phrase	30
S18	S10 AND S16	Limiters – Date of Publication: 19900101-20171231; Human; English Language Search modes –Boolean/Phrase	29

The inclusion criteria were as follows:

- Low endemicity country (defined as population prevalence of HBsAg ≤2%);
- Reports on prevalence/incidence in those with tattoos or body piercing accounting for other risk factors;
- HBV status based on blood or salivary tests as opposed to self-reporting of infection; and
- From 1990.

The exclusion criteria were as follows:

- High or medium endemicity country;
- Articles for which access to the full article could not be obtained and where the abstract contained insufficient information;
- Studies only examining HBV without reference to tattooing or body piercing; and
- Studies published in a language other than English.

Articles were critically appraised using the tools provided by the Critical Appraisal Skills Programme (CASP) and the STROBE checklist for cross-sectional studies[11,12]. The quality of the evidence was categorised in a similar fashion to that used in the National Hepatitis C Screening Guidelines (table 3)[10].

Table 3. Categorisation of evidence[10]

Level of evidence	Type of evidence	Rationale
High	Consistent evidence from well performed randomised, controlled trials, meta-analyses, or overwhelming evidence of some other form	Further research is unlikely to change our confidence in the estimate of benefit and risk.
Moderate	Evidence from randomised, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design	Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
Low	Evidence from observational studies, consensus opinion of experts, case studies, or from randomised, controlled trials with serious flaws, or standard care	Any estimate of effect is uncertain

3.0 Results

3.1 Risk of transmission of HBV infection from tattooing: search results

The above search yielded a total of 363 articles, of which the titles and abstracts were scanned for suitability. A total of seven papers were deemed suitable for inclusion in the review following the application of the inclusion and exclusion criteria (Figure 1). The papers included consisted of one systematic review and meta-analysis, five cross-sectional studies and one case report. Of the five observational studies not included in the systematic review, one paper was published subsequent to the publication date of the systematic review, a study by Nishioka *et al.* appears to have been excluded as it used the same dataset as another more recent study which was included in the systematic review, one study by Oliveira *et al.* appears to have been excluded as it was published in the format of a "Letter to the Editor" and two studies by Préfontaine *et al.* and Long *et al.* were excluded but no information was provided as to why they were excluded[13-17]. The study by Nishioka *et al.* was deemed suitable for inclusion in this review as it provided additional information on risk factors for HBV transmission from tattooing[14]. The study by Olivera *et al.*, whilst in the format of a letter to the editor, provided sufficient information within the body of the text for the article to be critically appraised and was felt to be suitable for inclusion in this review[15]. The articles by Long *et al.* and Préfontaine *et al.* were critically appraised and deemed suitable for inclusion in the review[16,17]. None of the grey literature identified fulfilled the search criteria and was therefore excluded from the review.

Of the seven papers included in this review, two related to the Brazilian population, one to the English population, one to the Dutch population, one to the Canadian population, one to the Irish population and the systematic review and meta-analysis referred to multiple countries (Table 4). Within the primary literature included, three studies derived their sample from the prison population and three from community populations.

3.2 Risk of transmission of HBV infection from tattooing

The global systematic review concluded that there was a significant association between tattooing and HBV infection (OR 1.48, 95% CI 1.30-1.68)[18]. Two further cross-sectional studies in Brazil and Canada that were not included in the systematic review were consistent with these findings however, the Brazilian study did not analyse tattooing as a variable separate from body piercing and therefore the significance of the association found must be questioned[15,16]. The case report by Viswanathan *et al.* indicated that the most likely source of transmission of HBV infection was tattoo application in prison[19]. Nishioka *et al.* identified an increasing risk of HBV infection with an increasing number of tattoos whilst Long *et al.* and Urbanus *et al.* didn't identify any significant associations between HBV infection and tattooing[13,14,17].

3.3 Risk factors for the transmission of HBV infection from tattooing

Jafari *et al.* found a significant association between tattooing and HBV infection with subgroup analysis revealing the strongest association existed between tattooing and HBV infection amongst populations who engage in high-risk behaviours (OR 1.64, 95% CI 1.32-2.03; I^2=0%)[18]. The high-risk populations were described as street youth, sex workers, individuals with HIV, individuals who use drugs, individuals who had tattoos applied using re-used needles and those who acquired their tattoos in non-professional settings. The sub-group analysis showed the next strongest association between tattooing and risk of HBV was in community samples (OR 1.47, 95% CI 1.12-1.92; I^2=58%), followed by hospital samples (OR 1.45, 95% CI 1.07 – 1.97; I^2=30%) and prison samples (OR 1.30, 95% CI 1.01-1.66; I^2=56%). One further cross-sectional study found a significant association between HBV infection and tattoos in a prison population and one case report involving two prisoners sharing a cell concluded that tattooing was a possible route of transmission of HBV infection[16,19]. Long *et al.* found against this conclusion with tattooing not identified as an independent risk factor for HBV infection in injecting or non-injecting drug users in prison[17]. The remaining studies included in this review didn't specifically examine the risk of the transmission of HBV infection from tattooing amongst high-risk populations.

In terms of the setting in which tattoos were acquired, Jafari *et al.* identified a significant association between the transmission of HBV infection and the acquisition of tattoo(s) in a non-professional environment[18]. Nishioka *et al.* demonstrated a significant association between tattoo application in a non-professional setting and testing positive for at least one of five transfusion-transmitted diseases; however the specific association between HBV infection and tattoo acquisition in the non-professional setting was not found to be significant[14]. Viswanathan *et al.* concluded in their case report that HBV transmission from a tattoo gun that had likely been used on more than one individual was a possible route of transmission of HBV infection between two cellmates[19]. The remaining studies included in this report did not examine the setting in which their participants acquired their tattoos.

The association between the number of tattoos and transmission of HBV infection was examined in two cross-sectional studies. Nishioka *et al.* demonstrated a significant relationship between increasing number of tattoos and HBV infection whilst Urbanus *et al.* found against this with the number of tattoos and percentage of body surface tattooed not significantly associated with HBV infection[13,14].

3.4 Risk of transmission of HBV infection from body piercing: search results

The above search yielded a total of 189 articles of which the titles and abstracts were scanned for suitability. A total of five papers were deemed suitable for inclusion in the review following the application of the inclusion and exclusion criteria (Figure 2). The papers included consisted of four cross-sectional studies and one case-control study. A systematic review and meta-analysis by Yang *et al.,* which examined the transmission of HBV infection via body piercing, was excluded due to the reviewer's concerns regarding the methodology employed and the quality of the results obtained. The references of the systematic review by Yang *et al.* were examined to ensure that all publications therein that satisfied the inclusion criteria for this literature review were included.

Of the five papers included in this review, two related to the Canadian population, one to the Brazilian population, one to the U.S. population and one to the Dutch population (Table 5). One of the studies derived its population from adolescents attending two schools, one examined the behaviours of students attending one of eight colleges in Texas, a further study focused on tattoo artists, piercers and people with multiple tattoos or piercings living in the community, one study examined street youths and one study examined blood donors.

3.5 Risk of transmission of HBV infection from body piercing

A Brazilian-based study evaluated the frequency of tattooing and body piercing and their association with risk behaviours and HBV infection amongst school-going adolescents and found a significant association between body modifications (tattooing or body piercings) and anti-HBc marker positivity on multivariate logistic regression (adjusted OR=3.5, 95% CI 1.1-11.2)[15]. However, it is worth noting that the body piercing and tattoo variables were not analysed separately and so the true association between body piercing and HBV infection must be questioned. A cross-sectional study by Roy *et al.* aimed to determine the prevalence of risk behaviours for HBV infection amongst street youths and found that while having at least one body piercing was significantly associated with HBV infection ($p<0.05$) on univariate analysis, it was no longer significant on multivariate logistic regression analysis[20]. Similarly, a cross-sectional study undertaken across eight colleges in Texas by Hwang *et al.* found no significant association between HBV infection and body piercing[21]. Urbanus *et al.* concluded that there was no significant association between acquiring a tattoo or body piercing in an endemic country or having multiple body piercings and HBV infection[13]. A case-control study amongst blood donors in Canada aimed to examine the impact of changes in the deferral period for tattooing and ear and body piercing on blood safety and availability[22]. Neither ear piercing nor body piercing were identified as significant risk factors for HBV infection on multivariate logistic regression analysis. There was no available literature examining the association between HBV infection and the setting in which body piercings were acquired nor examining the risk factors for the transmission of HBV infection from body piercing.

Fig 1. PRISMA flow diagram of review of literature on risk of HBV transmission through tattooing

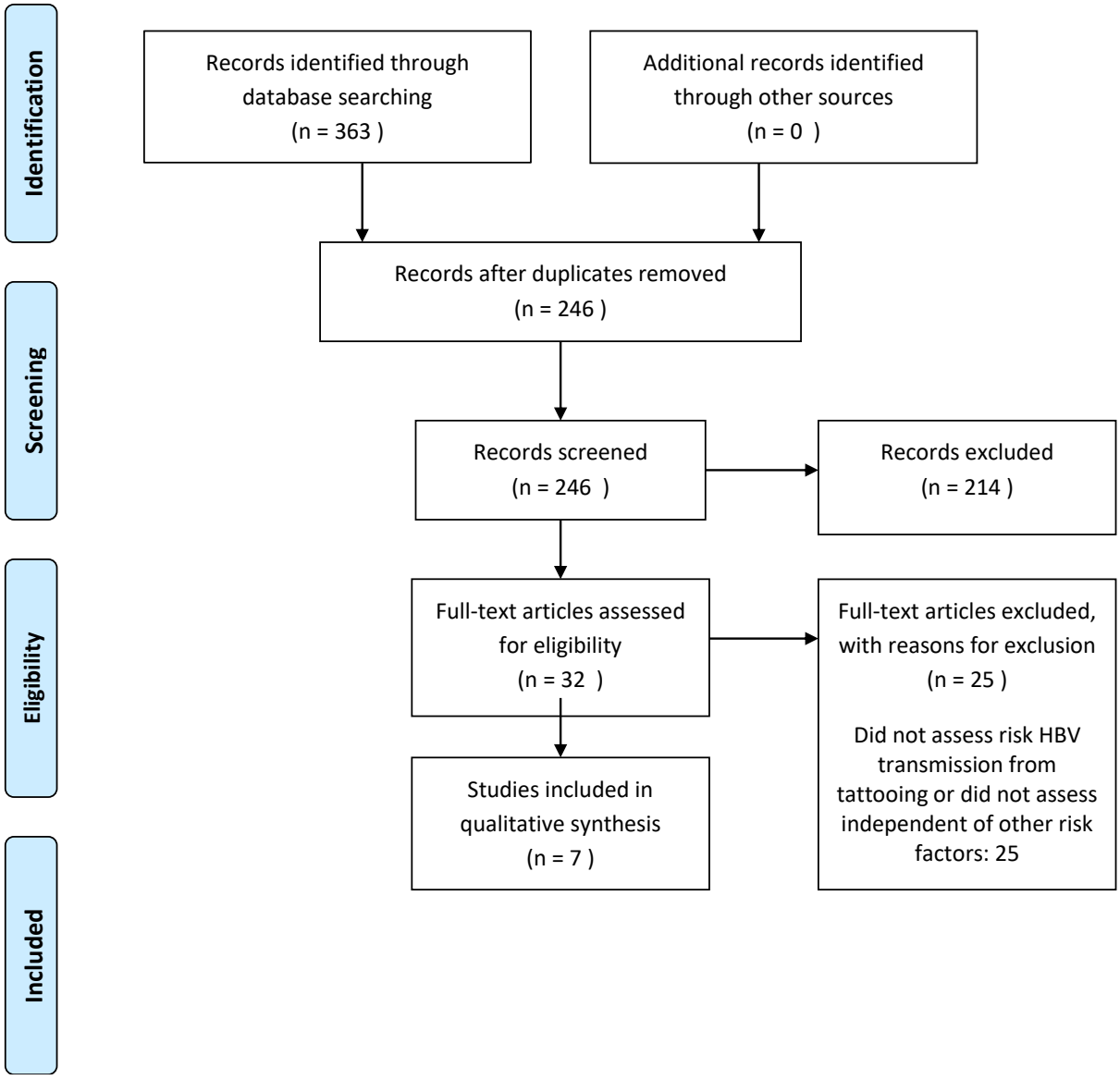

Fig 2. PRISMA flow diagram of review of literature on risk of HBV transmission through body piercing

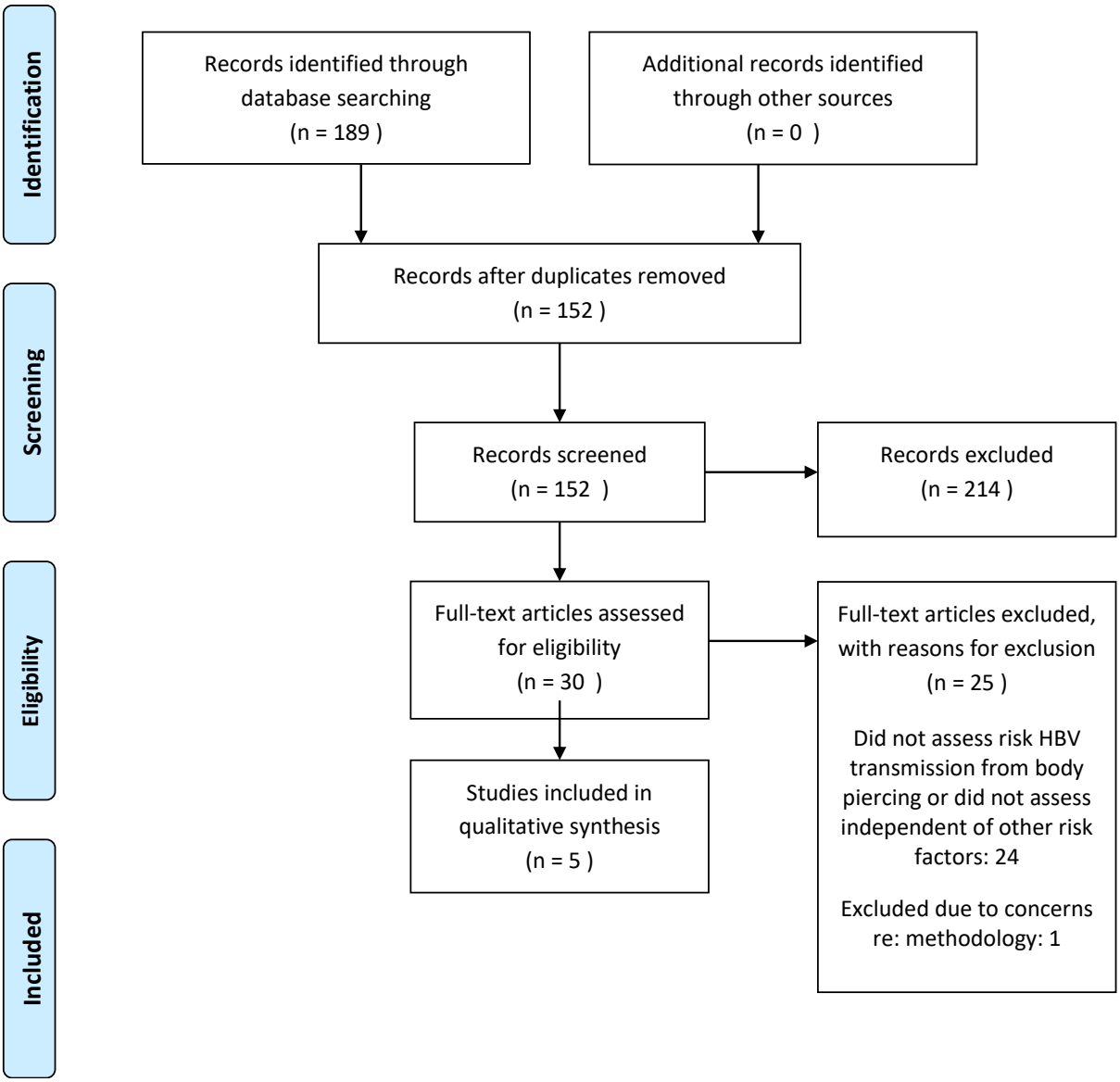

Table 4. The risk of HBV infection from tattooing: characteristics of studies included in review

Author	Sample size	Study design	Country	Sample derived from	Salient findings	Comments	Quality
Jafari *et al.* 2012[18]	42 observational studies in systematic review; 31 included in meta-analysis	Systematic review & meta-analysis	Global		• Aimed to assess the association between tattooing and the risk of transmission of HBV • Pooled OR of the association of tattooing and HBV infection was 1.48 (95% CI 1.30-1.68) • Sub-group analysis by study population type found the strongest association between tattooing and risk of HBV for samples from high-risk groups defined as street youth, sex workers, individuals with HIV, individuals who use drugs, individuals whose tattoos were done using re-used needles, those tattooed in non-professional settings (OR=1.64, 95% CI 1.32-2.03). This was followed in decreasing order by: community samples (OR=1.47, 95% CI 1.12-1.92); hospital samples (OR=1.45, 95% CI 1.07-1.97); prison samples (OR 1.30, 95% CI 1.01-1.66) • Sub-group analysis to examine the effect of study design on the association between tattooing and the risk of HBV infection demonstrated a strong association between tattooing and HBV infection among case-control studies (OR 1.97, 95% CI 1.45-2.69), followed by cohort studies (OR 2.01, 95% CI 1.52-2.67) and cross-sectional studies (OR 1.34, 95% CI	• Observational studies included in review leading to potential for recall bias and social desirability bias • Studies included from 1985 – 2011. Information from tattooing a number of decades ago may not be reflective of current population risk of HBV infection due to changes in practice. • The risk from tattooing may be dependent on the background prevalence of HBV and the uptake rates of vaccination within population sub-groups	High (caveat: limited evidence base - mainly observational studies, heterogeneity)

					1.16-1.54)		
Viswanathan *et al.* (2010) [19]	2	Case report	England	Prison	• Serological confirmation of a 27yo man who had been in prison x 21months at time of diagnosis • Cell mate of case was a confirmed HBV carrier • In the absence of other identifiable risk factors, tattooing was identified as the most likely route of transmission	• Reliance on self-reporting of cases. Potential for incomplete disclosure of risk behaviours by cases	Low
Urbanus *et al.* (2011) [13]	434	Cross-sectional study	Netherlands	Community: tattoo artists, piercers, people with multiple tattoos and/or piercings living in the Netherlands	• This study examined whether tattooing and body piercing are risk factors for HBV/HCV infections amongst tattoo artists, piercers and individuals with multiple tattoos/piercings • Interview and blood test for anti-HBc and anti HCV • There was no significant association found between HBV infection and the following variables: the number of tattoos; percentage of body surface tattooed; having a tattoo in a HBV-endemic country; and being a tattoo artist • An additional analysis which was conducted among tattoo and piercing artists only, confirmed that none of the above variables were significantly associated with HBV infection • Amongst unvaccinated tattoo and piercing artists only, none of the aforementioned tattoo- and piercing-related variables were significantly associated with HBV infection	• Potential for recall bias, social desirability bias • Selection bias • Specific population – findings therefore not generalisable	Low
Oliveira *et al.*	664	Cross-sectional	Brazil	Community: adolescents	• Study aimed to evaluate the frequency of tattooing and body	• Potential for recall bias, social desirability bias	Low

(2006) [15]		study (report in format of letter to the editor)		aged between 12-19 years from two large public schools in one metropolitan region	piercing and their association with risk behaviours and HBV in school-going adolescents • Students interviewed regarding socio-demographic characteristics and risk behaviours (including presence of body modifications such as tattooing/body piercing). Blood samples taken from all participants and screened for anti-HBc • Logistic regression analysis revealed a strong association between body modifications and anti-HBc marker positivity (Adjusted OR=3.5, 95% CI 1.1-11.2)	• Body modifications inclusive of tattooing and piercing – these variables were not analysed separately	
Préfontaine *et al.* (1994) [16]	415	Cross-sectional study	Canada	Prison	• The factors associated with HBV in federal correctional institutions in British Columbia were assessed • Blood samples tested for anti-HBc and HBsAg. Questionnaire completed by 85.3% of those who gave blood samples to identify risk factors • Tattooing had RR of 1.5 (95% CI 1.3-1.8) for HBV. This association remained significant on multivariable logistic regression	• Recall bias, social desirability bias	Low
Nishioka *et al.* (2002) [14]	182	Cross-sectional study	Brazil	Tattooed individuals within a hospital population: admissions, outpatient clinic attendees, blood donors	• Aimed to assess the odds of testing positive for HBV, HCV, HIV, Chagas' disease and syphilis according to tattoo number and type, tattoo design and environment in which tattoos were applied • Questionnaire and serological test for HBsAg • Multiple logistic regression demonstrated a strong association between: an increasing number of tattoos (two tattoos: OR 2.04, 95%	• Efforts made to minimise bias: matching of participants, direct visualisation of tattoo, blood test • ?generalisability	Low

					CI 1.80-9.97; three tattoos: OR 3.48, 95% CI 1.41-8.58) and HBV infection • Multiple logistic regression did show an association between having a tattoo applied by a non-professional and testing positive for one of the above five transfusion-transmitted diseases (OR3.25, 95% CI 1.39-7.59). This analysis also demonstrated a significant association between having three or more tattoos and testing positive for at least one of the five transfusion-transmitted diseases		
Long *et al.* (2001)[17]	607 (97% response rate)	Cross-sectional	Ireland	Prison	• Study aimed to determine the prevalence of antibodies to HBV, HCV and HIV in entrants to Irish prisons and to examine their risk factors for infection • Oral fluid sample and questionnaire re: risk factors • No independent risk factors were identified in individuals who did not inject drugs and who were positive for HBV infection	• Cross-sectional study • High response rate • Social desirability bias, recall bias	Low

Table 5. The risk of HBV infection from body piercing: characteristics of studies included in review

Author	Sample size	Study design	Country	Sample derived from	Salient findings	Comments	Quality
Roy *et al.* (1999)[20]	437	Cross-sectional study	Canada	Street youths	• This study aimed to determine the prevalence of risk behaviours for HBV infection and to estimate the prevalence of past or present HBV infection • Structured interview and blood samples taken for anti-HBc and HBsAg • There was no significant association between HBV infection and tattoos after multivariate logistic regression analysis	• Selection bias • Recall bias, social desirability bias	Low
Oliveira *et al.* (2006)[15]	664	Cross-sectional study (report in format of letter to the editor)	Brazil	Community: adolescents aged between 12-19 years from two large public schools in one metropolitan region	• Study aimed to evaluate the frequency of tattooing and body piercing and their association with risk behaviours and HBV infection in school-going adolescents • Students interviewed regarding socio-demographic characteristics and risk behaviours (including presence of body modifications such as tattooing/body piercing). Blood samples taken from all participants and screened for anti-HBc • Logistic regression analysis revealed a strong association between body modifications and anti-HBc marker positivity (Adjusted OR=3.5, 95% CI 1.1-11.2)	• Potential for recall bias, social desirability bias • Body modifications inclusive of tattooing and piercing – these variables were not analysed separately	Low
Hwang *et al.* (2006)[21]	7,960 completed questionnaire and provided blood sample	Cross-sectional study	USA	Students from eight college campuses in Houston,	• This study aimed to assess whether individuals with a history of cosmetic procedures such as tattooing and body piercing were at increased risk of HBV infection	• Selection bias • Recall bias, social desirability bias	Low

	and of these, 66.4% were included in the analysis			Texas were invited to participate	• Anonymous questionnaire and blood samples taken for anti-HBc and anti-HBs • There was no significant association between HBV infection and body piercings after multivariate logistic regression analysis		
Urbanus *et al.* (2011)[13]	434	Cross-sectional study	Netherlands	Community: tattoo artists, piercers, people with multiple tattoos and/or piercings living in the Netherlands	• This study examined whether tattooing and body piercing are risk factors for HBV/HCV infections amongst tattoo artists, piercers and individuals with multiple tattoos/piercings • Interview and blood test for anti-HBc and anti-HCV • There was no significant association found between HBV infection and the number of piercings • An additional analysis which was conducted among tattoo and piercing artists only, confirmed that the number of piercings and the country in which the piercings were done were not significantly associated with HBV infection • Amongst unvaccinated tattoo and piercing artists only, the number of body piercings or location of the tattoo/piercing were not significantly associated with HBV	• Potential for recall bias, social desirability bias • Selection bias - ?findings generalisable	Low
Goldman *et al.* (2009)[22]	181 cases (response rate amongst cases was 57%); 737 controls (response rate amongst controls was 59%)	Case-control	Canada	Blood donors	• Study aimed to examine the impact of changes in deferral period for tattooing and ear piercing on blood safety and availability • Risk factors for HBV infection in cases compared with matched controls using anonymised survey. Blood tested for HBsAg • Body piercing was not found to be a	• Reliance on self-reporting of risk factors – potential for recall bias, social desirability bias	Low

					significant risk factor for HBV infection on univariate or multiple logistic regression analysis		

4.0 Discussion

The aim of this literature review was to critically appraise the literature examining the risk of transmission of HBV infection from tattooing and body piercing. The findings of this review indicate a potentially increased risk of HBV infection amongst those who acquire tattoos. The sub-group analysis undertaken by Jafari *et al.* indicated that the strongest association between tattooing and risk of HBV was demonstrated for high-risk groups, followed by community samples, hospital samples and prison samples in order of decreasing risk. One further cross-sectional study and case report demonstrated a significant association between tattooing and HBV infection in the prison population. However, it is clear that there is significant heterogeneity within the literature and this is an area in need of further study. There is a dearth of literature examining the risk of transmission of HBV infection from body piercing, and while the available literature examined in this review indicates that there is no increased risk of transmission from this practice, the lack of high quality evidence limits the ability of this author to distil firm conclusions from the evidence base to satisfy the research question.

There were a number of limitations of this review. Firstly, it is important to note that there was a lack of high-quality consistent evidence to definitively support or refute the research question in this instance. Most of the evidence included in this review was observational in nature which does not confirm causation. Furthermore, the nature of this evidence introduces the potential for bias and confounding. This limitation is likely secondary to the ethical and methodological difficulties inherent in undertaking interventional studies to further explore this area. It's likely that the varying study methodologies also contributed to the heterogeneity of findings. However, there was one large, well-conducted systematic review and two further cross-sectional studies and a case report that were consistent in their findings[15,16,18,19]. Moreover, the biological plausibility of transmission of HBV infection from the use of unsterile tattooing and body piercing equipment, a needlestick injury or the exposure of mucous membranes to blood is widely acknowledged within the literature[1,2,14-16,18,19,23]. This conclusion is consistent with other studies which demonstrate a risk of transmission of other bloodborne viruses from tattooing, but not from body piercing [1,24-27].

A further limitation was the exclusion criteria applied to this search which may have limited the scope of the literature reviewed. An explicit search criterion applied was that articles included had to be published in the English language. Furthermore, where full texts were not available, the papers were excluded from the review. It is also worth noting that studies originating from countries where HBV infection is endemic were excluded from this review. Background prevalence of HBV infection

and hepatitis B vaccinations vary widely between countries and this decision was taken in an effort to draw conclusions from the literature that were generalisable to the Irish setting. Nonetheless, all of the above factors must be acknowledged as potential sources of bias in this review.

5.0 Implications for public health

In Ireland, the enhanced surveillance forms for hepatitis B lists "tattooing/body piercing" as one risk factor that can be ticked. In addition, the form prompts for the most likely risk factor or exposure to be indicated. The form is usually completed by the doctor or nurse in the Department of Public Health, or occasionally by the clinician themselves, and so it is their judgement on the most likely risk factor that is recorded.

Between 01/01/2011 and 06/02/2018, there were 18 notifications of HBV infection where tattooing/body piercing was indicated as the most likely risk factor or exposure[28]. It is unclear whether further investigations were undertaken by the regional Departments of Public Health in these instances. Of these notifications, five notifications were acute hepatitis B and 13 were chronic hepatitis B[28]. One case diagnosed with acute HBV infection was born in Ireland and was reportedly infected in Ireland. Three acute cases were reported to have been infected outside of Ireland[28]. The country of infection for the remaining acute case was not stated but the person was born abroad and no dates are stated for when the tattoo was carried out[28].

With regard to the diagnoses of chronic HBV infection, country of infection was stated to be outside Ireland for five of the 13 cases. Three further cases were born outside Ireland[28]. One case reported having been born in Ireland and infected in Ireland[19]. One case was born in Ireland but country of infection was not stated[28]. For the remaining three cases, there was no information on country of birth or country of infection[28].

There was no indication that any of the 18 cases were from the following high risk groups: men who have sex with men, individuals who inject drugs or current/former prisoners although the potential for social desirability bias and interviewer bias during the ascertainment of these data must be acknowledged in these instances.

The evidence base describes the increasing popularity of tattoos and body piercings[7,29]. Irish surveillance data indicate that tattooing and/or body piercing may play a role in the acquisition of some cases of HBV infection, although this can't be definitively proven[28]. Tattooing and body piercing are not asked about separately in the Irish surveillance data. The available literature, albeit limited in quantity and quality, points towards an increased risk of HBV infection in individuals who

have tattoos. There is insufficient literature to support body piercing as a vehicle of transmission of HBV infection, although it has been acknowledged as a biologically plausible route for transmission of infection in the literature.

Further research is required to evaluate the risk of transmission of HBV infection from tattooing and body piercing practices, with a particular focus on identifying vulnerable sub-groups within the population who have a higher risk of HBV infection due the circumstances of the acquisition of their tattoos or body piercings (e.g. settings in which tattoos or piercings were acquired, professional versus non-professional tattoo artists or body piercers). In the absence of high quality evidence, universal precautions should apply and the need for education, regulation and guidance for tattoo artists and body piercers has been recognised[1,9,18].

6.0 Conclusion

This review of the published literature examining the risk of HBV transmission from tattooing and body piercing has found a potentially increased risk of HBV infection in individuals who have tattoos whilst the available literature doesn't support body piercing as a transmission pathway for HBV infection. The strongest association between tattooing and risk of HBV was demonstrated in groups who exhibit high-risk behaviours such as people who inject drugs or individuals who have tattoos applied with re-used needles or applied in non-professional settings. Any further conclusions that can be drawn from the literature are limited by the lack of availability of high-quality, consistent evidence. This is an area in need of further research. The transmission of HBV infection via tattooing and body piercing is widely acknowledged as a potential route of transmission and it is therefore essential that tattoo artists and body piercers employ robust infection control practices at all times. While there remains no enacted legislation pertaining to tattoo premises in Ireland, the tattoo and body piercing infection control guidelines will act as a necessary resource for tattoo artists and body piercers in Ireland.

7.0 References

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